ANEXO I.- Documentos científicos encontrados relevantes para las tecnologías de reactores controlados por tiristores

TÍTULO DEL DOCUMENTO	AUTOR	INSTITUCIÓN	AÑO DE PUBL.	RESUMEN	LINK
Synthetic test circuits for the operational tests of TCR and TSC Thyristor valves	Baoliang Sheng; Oliveira, M.; Bjarme, H.-O.	ABB AB, HVDC, Ludvika	2008	Synthetic test circuits are developed for the operational test of Thyristor Controlled Reactor (TCR) valve and Thyristor Switched Capacitor (TSC) valve. The synthetic test current circuits are independent controllable in current stress and voltage stress applied on the test object. By careful design of circuit parameters those test circuits can produce test stresses on TCR valve or TSC valve equal to or greater than those that are foreseen to appear in service. Tests on several TCR and TSC valves have proved that those new synthetic test circuits are a technical sound and economy saving solution in valve design verification.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4517129
Modern HVDC: state of the art and development trends	Lescale, V.F.	ABB Power Syst. AB, Ludvika, Sweden	1998	After the first commercial HVDC transmission between Gotland and the mainland of Sweden (1954), the whole HVDC technology has experienced a dramatic development. Thyristor valves and IGBT valves have replaced mercury arc valves, air insulated reactors have replaced oil immersed ones. Traditional commutation is being helped by series capacitors, or altogether replaced by PWM technology. Valves are moving out of conventional valve halls to become self-standing, outdoor units. Traditional filters have become double tuned ones and then, for more stringent requirements, on the DC side, active, while on the AC side the move has been towards a high Q factor, electronically tuned filters. Vacuum tubes have replaced relays, to be in turn replaced by transistors, which then progressed to integrated circuits. Functions have been replaced by digital control. The interface for the operators has gone from mimic panels to work stations, greatly improving the flexibility and available information. Fibre optics are replacing more and more of the hard-wired communication in the stations	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=729003
Detailed modeling of static VAr compensators using the electromagnetic transients program (EMTP)	Lee, S.Y.; Bhattacharya, S.; Lejonberg, T.; Hammad, A.; Lefebvre, S.	ABB Power Syst. Inc., Pittsburgh, PA, USA	1992	A detailed model of static VAr compensators (SVC) has been developed for digital simulation of electrical transients. The model is applicable to SVC configurations employing thyristor-switched capacitors (TSCs) and thyristor-controlled reactors (TCRs). A modeling technique based on electromagnetic transients program (EMTP) data modularization is used to represent essential parts of the SVC main circuit and control system. To verify the model, an actual SVC is simulated with the EMTP and the results are compared with the transient-network-analyzer-type simulator using actual SVC controls	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=127088
Detailed modeling of static VAr compensators using the electromagnetic transients program (EMTP)	Lee, S.Y.; Bhattacharya, S.; Lejonberg, T.; Hammad, A.; Lefebvre, S.	ABB Power Syst. Inc., Pittsburgh, PA, USA	1991	A detailed model of static VAr-compensators (SVCs) has been developed for digital simulation of electrical transients. The model is applicable to SVC configurations employing thyristor-switched capacitors (TSCs) and thyristor-controlled reactors (TCRs). A modeling technique based on EMTP data modularization is used to represent essential parts of the SVC main circuit and control system. To verify the model, an actual SVC is simulated with the EMTP and the results are compared with the TNA-type (transient network analyzer) simulator using actual SVC controls	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=169616
Static and dynamic characteristics of the	Kim, S.C.; Kim, H. W.;	Adv. Mater. & Application	2004	IGCT thyristor has many superior characteristics compared with the GTO thyristor. For example, snubberless turnoff capability, short storage time, high turn-on capability, small turn-off gate charge and low total power loss	http://ieeexplore.ieee.org/stamp/stamp.j

2.5kV/500A IGCTs	Seo, K.S.; Zhang, C. L.; Kim, E. D.	Res. Lab., Korea Electrotcchnology Res. Inst., Chnag Won, South Korea		of the application system containing device and peripheral parts such as anode reactor and snubber capacitance. In these characteristics, particularly turn-off capabilities are much important parameter because applications conditions of conventional GTO thyristor are mainly restricted by the limit of these disadvantages of the GTO thyristor. The basic structure of the GCT thyristor is the same as that of the GTO thyristor. This makes the blocking voltage higher and the controllable on-state current higher. The turn-off characteristic of the GCT is influenced by the minority carrier lifetime and the performance of the gate drive circuit. In this paper, we present turn-off characteristics of the 2.5kV/500A PT(Punch-through) type IGCT as a function of the minority carrier lifetime and variation of the doping profile shape of p-base region. Current overshoot characteristics of the IGCT via the doping profile of the p-base region also present.	sp?arnumber=1314583
Thyristorwechselrichter mit sÃ¤ttigbaren drosseln fÃ¼ mittelfrequenzanwendungen	Seelig, T.	AEG-Forschugsinstitut, Frankfurt, Germany	1966	The frequency, which can be attained with conventional static inverters, is limited by the turn-off time of the controlled rectifiers. Resonant circuit inverters with controlled rectifiers and saturable reactors in combination make it possible to generate frequencies whose half-wave duration is equal to or less than, the turn-off time of the controlled rectifiers. When using thyristors for this purpose, resonant circuit inverters can be built for frequencies up to about 25 kc. The inverters described in this paper are suited as medium frequency generators for inductive heating purposes. In this case the inductor coil is a component of the resonant circuit. The workpiece is heated up by an effective frequency much higher than the frequency with which the thyristors are fired.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1065949
Thyristor Converters for Traction DC Motor Drives	Bezold, Karl-Heinz; Forster, Johannes; Zander, Hilmar	AEG-TELEFUNKEN, Berlin, Germany.	1973	Based on tests in laboratories and on German Federal Railways (GFR) trial vehicles type ET 25 as well as on an industrial locomotive type 500 of the Rheinische Braunkohlen AG the subsequent development has been concentrated on the improvement of the power factor Ã‚¿ and the displacement factor cos Ã‚¿ in four vital stages: 1) introduction of half-control, unsymmetrical half-controlled, fully-controlled single-phase bridge connection with specially designed control systems: 2) introduction of sequence connection of several half-controlled bridges; 3) optimization of the so far applied connections for major assemblies such as rectifier transformer, rectifier, and smoothing reactor for improving the power factor; 4) introduction of sector control with self-commutating unsymmetrical bridge for improving the power factor.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4158449
Modelling of current control system to DC transmission links into Microtran program	de Oliveira, H.R.P.; Papaleo, G. K.; Figueiredo, C. E C; De Jesus, N.C.; Libano, F.B.	AES SUL, Seo Leopoldo, Brazil	2001	This work presents the structural design of a power circuit and current control system for high-voltage direct-current transmission links in the electromagnetic transients program Microtran. This simulator is a version of EMTP in which additional resources were included for the simulation of systems containing power semiconductors. To represent the power system, it was used 6-pulses bridges (rectifier/inverter), shocking reactors, line DC and, naturally, AC systems. The control system, elaborated in FORTRAN77 language, endowed the rectifier station of the "constant current control" (CCC), and simulated three feedback control types: proportional, integral, and proportional-integral. The control still foresees an extinction angle supervision of the station inverter, seeking to maintain a high power factor in this converter. Among other real characteristics of HVDC system control, the routine contemplates blockade of the station for minimum and maximum fire angles, besides system of shot of the thyristor type "PIE" (pulse ignition equidistant) which is a modern technique of fire valves for links DC and static VAr systems	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=964798
Ultra fast response	Ohyagi, A.;	Aichi Inst. of	2002	We have proposed a control system in which AC components are derived from instantaneous real power (p) and	http://ieeexplore.iee

control system for active power filter	Ueda, Akiteru; Torii, A.; Takai, H.	Technol., Toyota, Japan		instantaneous imaginary power (q) by a moving average high-pass filter. The response and accuracy of the system are very good in the case of an abrupt load change. In this paper, a new control system having an ultra high speed response is proposed for compensating a reactor input type rectifier. The system adopts a new current detection method responding in one sampling period. The operating performance of the proposed system is confirmed by simulation and laboratory model tests	e.org/stamp/stamp.jsp?arnumber=997617
Application and Operation of a Static Var System on a Power System- American Electric Power Experience Part I: System Studies	Gutman, R.; Keane, J. J.; Rahman, M.E.; Veraas, O.	American Electric Power Service Corporation	1985	American Electric Power's (AEP) Static Var System (SVS) was placed in service at the Beaver Creek Station in eastern Kentucky in November 1980 and has since maintained an excellent record of operation. The purpose of this SVS installation was to provide both steady-state and dynamic voltage control on the 138 kV transmission system. This paper describes the application and operating experience of this unique installation, which is comprised of two thyristor controlled reactors (TCR) and two thyristor switched capacitors (TSC) with an overall dynamic range of Ã‚Â±125 MVAR. These components are connected to the 138 kV transmission system via a 125 MVA, 138/ 8.3 kV transformer. The +125 MVAR upper limit has been extended to +325 MVAR by installing four 50 MVAR, 138 kV capacitor banks which, in effect, function as a steady-state voltage control to optimize the SVS dynamic range.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113313
Application and Operation of a Static Var System on a Power System - Americal Electric Power Experience Part II: Equipment Design and Installation	Gutman, R.; Keane, J. J.; Rahman, M.E.; Veraas, O.	American Electric Power Service Corporation	1985	American Electric Power's (AEP) Static Var System (SVS) was placed in service at the Beaver Creek Station in eastern Kentucky in November 1980 and has since maintained an excellent record of operation. Special design features of this SVS installation, characterized by a coordinated control of two thyristor controlled reactors (TCR), two thyristor switched capacitors (TSC), and four vacuum switched capacitors, allow significant technical and economic advantages as well as flexible and reliable operation. A comprehensive energization and performance test program conducted prior to placing this device in commerical operation, complemented by three years of excellent operating experience, has confirmed that the sophisticated SVS technology can be successfully integrated into a power system. Furthermore, experience indicates that the SVS can be, in many regards, a superior alternative to the more conventional technology, i.e. synchronous condenser, for voltage control purposes.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113314
Modeling Flux Skin Effect on the Harmonic Currents of TCR	Merrikhi, J.; Moghani, J.S.; Fallah, E.	Amirkabir Univ. of Tecnology, Tehran	2006	Test results show that flux skin effect increase the harmonic currents of thyristor controlled reactor (TCR). In previous works, the inductance of TCR was assumed constant, however, because of the flux skin effect the TCR inductance decreases with the frequency. In this paper, the harmonic currents of TCR are calculated with consideration the flux skin effect. Moreover a correction is presented for the conventional formulations of TCR harmonic currents to include the flux skin effect.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4147794
An Application of HVDC to the de-icing of Transmission Lines	Horwill, C.; Davidson, C.C.; Granger, M.; Dery, A.	AREVA T&D Power Electron. Activities, Stafford	2006	Ice accumulation on transmission lines in extreme climatic events can result in severe damage to the lines and towers, with the possibility of being unable to restore the service quickly enough to preserve electricity supplies to customers. To prevent such a situation, Hydro-Quebec TransEnergie are investing in a dedicated "De-icer" installation at its strategically important Levis substation, near Quebec city. The HVDC-based installation, scheduled for handover in August 2006, injects a high direct current into the transmission line to be de-iced. When not being used as a de-icer, the installation operates as a static var compensator (SVC), using the HVDC valves as a thyristor controlled reactor (TCR) in a circuit which minimises the power losses of the valves. The detailed function of the de-icer installation is described in the paper, along with descriptions of the principal	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1668552

				equipments and the circuit topologies used in the two modes	
Compensation of harmonics and unbalance caused by a variable load using a dynamic phase balancer	o hEidhin, Gearoid	AREVA T&D Power Electronic Activities, UK	2005	This talk will briefly describe the phase balancer supplied to ALSTOM at Asfordby in Leicestershire for the test track which is being used for testing the new Pendolino trains. The phase balancer consists of a Thyristor Controlled Reactor (TCR) and an array of single phase filters. Reactive power compensation of the dynamic unbalanced load due to the trains is required along with harmonic suppression in a wide range of network operating conditions. Some test results will also be included.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5553417
A power-electronics-based transmission line de-icing system	Davidson, C.C.; Horwill, C.; Granger, M.; Dery, A.	AREVA T&D, UK	2006	Ice accumulation on transmission lines can cause extensive damage to the lines and towers, as demonstrated during the ice storm of January 1998, which caused serious damage power systems in Eastern North America. The Canadian province of Quebec was worst affected, with over a million consumers losing their electricity supply for some period. To avoid a recurrence of such a situation, Hydro-Quebec TransEnergie is investing in a dedicated power electronic "de-icer" installation. The HVDC-based installation, located at the strategically important Levis substation, near Quebec city, will inject a high direct current into a selected transmission line in order to melt the ice on it. However, operation in this mode is expected to be very infrequent. In the normal situation when the installation is not being used as a de-icer, it operates as a static VAr compensator (SVC), using the HVDC valves as a thyristor controlled reactor (TCR). An innovative main circuit design is used, minimising the power losses of the valves in SVC mode. The principal ratings of the de-icer installation in both de-icer and SVC modes are described in the paper, along with descriptions of the principal equipments and the circuit topologies used in the two modes.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1633629
Shunt-connected reactors and capacitors controlled by thyristors	Torseng, S.	ASEA, Power System Consulting Department, VÃƒÂ¿sterÃƒÂ¥s, Sweden	1981	Two basic schemes for thyristor-controlled static compensators are described, namely, thyristorswitched capacitors (TSC) and thyristor-controlled reactors (TCR). A more advanced scheme using a combination of TSC and TCR is presented. It is shown that this combination gives a greater degree of flexibility in the designing of a compensator. The paper also briefly describes the control system in a compensator comprising both thyristor.controlled reactors, thyristor-switched capacitors and reactors (TSR). One method to damp power oscillations, using TSC with a certain control strategy, is presented. The problem of unbalanced loads and load balancing methods using TSC and TCR aie discussed. It is shown that the combined system (TSC/TCR) generates very low harmonics, because the TSC does not generate any harmonics. Finally, some pictures from the first installations comprising both TSC and TCR are shown	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4643435
Static compensation systems for improving electric power quality	Ali, M.M.; El Bastawisy, B. M.; El Debeiky, S. M.	Atomic Energy Authority, Alexandria, Egypt	1999	Summary form only given. The supply of electrical energy to loads in industrial plants has some undesirable repercussions on the supply network. Depending upon the type of load and its mode of operation, the reactions are usually a reduction in the power factor, system voltage fluctuations, voltage flicker, unbalanced loading of the three phases and harmonic currents, which in turn affect negatively the electric power quality. The subject of this paper is to study and analyze the main reasons for such undesirable reactions and to find the compensation system required for each reaction to reduce its effect to an acceptable level, such as either switched capacitor banks or high response thyristor controlled reactors. To improve the electric power quality, these systems may be augmented by adding filters for eliminating discrete harmonics or harmonic bands.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=826719
Nonlinear thyristor-	Song, Y. H.;	Bath Univ.,	1993	Power systems must be carefully controlled in order to maintain an acceptable power supply quality. Advances	http://ieeexplore.iee

controlled static VAr compensation	Johns, A.T.; Aggarwal, R.K.	UK		in power electronics and control technology have introduced powerful tools to power utilities, and more recently, the concept of flexible AC transmission systems (FACTS) has evolved. One of the major components of the latter is the thyristor-controlled static VAr compensator (SVC). In this paper, a nonlinear feedback method based on differential geometry theory is employed to derive a novel control approach for static VAr compensation (SVC)'s. The paper first constructs the nonlinear model for the power system with SVC control. Special emphasis is placed on the modelling of the thyristor-controlled devices such as the thyristor controlled reactor (TRC). The conditions to algebraically transform the nonlinear model to a linear system are then verified. The linearized model is obtained by feedback linearization, and optimal SVC control laws are then derived for power system stability improvements. The paper concludes by presenting some interesting simulation results	e.org/stamp/stamp.jsp?arnumber=264751
Harmonic domain representation of thyristor controlled reactors	Acha, E.	Brunel Univ., Uxbridge, UK	1991	A new TCR (thyristor controlled reactor) model has been developed by linearising the state equations of the TCR in the harmonic domain. The resulting equations can be interpreted as a harmonic Norton equivalent. They can also be represented in the multiphase harmonic domain frame of reference, where they could combine easily with the frequency dependent admittances of the transmission network and with other linearised components such as saturated transformers, rotating machinery, electric arcs and power convertors. The linearised TCR model is completely general. It is suitable for assessing TCR filtering equipment requirements and for harmonic penetration studies	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=153940
A small scale Static VAR Compensator for laboratory experiment	Taufik; Paet, B.	California Polytech. State Univ., San Luis Obispo, CA	2008	This paper presents a small scale static VAR compensator (SVC) circuit that could be used as either a laboratory demonstration or a laboratory experiment. The small scale SVC lab experiment effectively demonstrates SVCpsilas function in correcting power factor through the use of power thyristors in a phase-controlled circuit. The laboratory setup of the SVC circuit using a thyristor controlled reactor in parallel with a capacitor will discussed in this paper. Results from the lab setup to exhibit firing angle adjustment to inject or absorb VARs into the system will also be described.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4762688
A Combination of Shunt Hybrid Power Filter and Thyristor-Controlled Reactor for Power Quality	Rahmani, S.; Hamadi, A.; Al-Haddad, K.; Dessaint, L.A.	Canada Res. Dept. in Electr. Energy Conversion & Power Electron., Ecole de Technol. Super., Montreal, QC, Canada	2013	This paper proposes a combined system of a thyristor-controlled reactor (TCR) and a shunt hybrid power filter (SHPF) for harmonic and reactive power compensation. The SHPF is the combination of a small-rating active power filter (APF) and a fifth-harmonic-tuned LC passive filter. The tuned passive filter and the TCR form a shunt passive filter (SPF) to compensate reactive power. The small-rating APF is used to improve the filtering characteristics of SPF and to suppress the possibility of resonance between the SPF and line inductances. A proportional-integral controller was used, and a triggering alpha was extracted using a lookup table to control the TCR. A nonlinear control of APF was developed for current tracking and voltage regulation. The latter is based on a decoupled control strategy, which considers that the controlled system may be divided into an inner fast loop and an outer slow one. Thus, an exact linearization control was applied to the inner loop, and a nonlinear feedback control law was used for the outer voltage loop. Integral compensators were added in both current and voltage loops in order to eliminate the steady-state errors due to system parameter uncertainty. The simulation and experimental results are found to be quite satisfactory to mitigate harmonic distortions and reactive power compensation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6557048
A frequency domain model of a thyristor	Osauskas, C.M.; Wood,	Canterbury Univ.,	1998	A frequency domain model of a thyristor controlled reactor (TCR) developed using a transfer function based analysis is described. The model linearises the relationships between the current spectrum generated by a TCR	http://ieeexplore.ieee.org/stamp/stamp.j

controlled reactor	A.R.	Christchurch, New Zealand		and the terminal voltage and firing angle distortions. The relationships are expressed in the form of direct algebraic equations which are verified by dynamic simulation. The frequency dependent admittance of a TCR is developed and also verified. The model provides for a fast and accurate method for the analysis of both integer and noninteger harmonic interactions around a TCR	sp?arnumber=760166
Adaptive Nonlinear Compensation of Reactive Power	Zohdy, M.A.; Lon, N.K.; Cheok, K. C.	Center for Robotics and Advanced Automation, School of Engineering, Oakland University, Rochester, MI 48063	1983	The potential of a new adaptive control for reactive power sources is investigated. In the large disturbance regimes, the adaptive signals supplement the nominal, thyristor activated, reactors and capacitors in manipulating the network voltage. Convergence of the scheme, and its relationship to the inherent system nonlinearities is considered.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4788180
Thyristor-Controlled Reactors Nonlinear and Linear Dynamic Analytical Models	Alves, J.E.R.; Pilotto, L. A S; Watanabe, E.H.	Centra de Pesquisas de Energia Eletrica, Rio de Janeiro	2008	This work presents the development of analytical models for thyristor-controlled reactors (TDRSS). A nonlinear model for the TCR was developed based on the use of generalized switching functions and from this model, a detailed linear model was derived. The linear model allows for the analysis and precise understanding of the behavior of the TCR under small disturbances both in the time and frequency domains, for frequency ranges up to some tens of Hertz. This model clearly shows that the TCR dynamics are operating point dependent. System parameter variations are also correctly considered in the model. With the proposed model, it is possible to design static var compensators (SVC) controllers in an integrated form, avoiding risks of instabilities and guaranteeing a good overall dynamic performance for the system. Validation of the models was done by comparing simulated results obtained with the proposed model with those obtained with a traditional electromagnetic transients program (EMTP).	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4395166
Harmonics control of the 20 MVA PWM inverter fed LSM drive system for the Yamanashi Maglev Test Line	Yamauchi, Y.; Tanitsu, H.; Kitano, J.; Kaga, S.; Tagami, Y.; Otsuka, Y.; Morishima, N.	Central Japan Railway Co., Tokyo, Japan	1997	This paper deals with harmonics control of a 20 MVA PWM inverter-fed LSM drive system for the Yamanashi Maglev Test Line in Japan. Contents include: (1) maintaining current control performance and compensating the resonant characteristics of the LSM load with a high-power filter; (2) developing a novel PWM control method, in order to reduce the lowest and/or second order carrier harmonics caused by asymmetrical PWM multiplication; and (3) reducing the inductive interference caused by zero sequence harmonics with a common-mode reactor	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=645583
Analysis of supplementary controls in damping subsynchronous oscillations	Balasubramanyam, P.V.; Murty, A. S R; Sarkar, B.N.	Central Res. & Testing Lab., Central Power Res. Inst.,	1995	Analysis and damping of torsional oscillations through thyristor controlled reactors (TCR) is presented in this paper. The reactive power control is achieved through TCR at the machine terminals. Generator speed signal is used as the auxiliary signal and the terminal voltage feedback signal as the main control signal for the TCR. The following control strategies for auxiliary control of TCRs have been analysed: (1) analysis of basic system without damping controls; (2) proportional control; (3) proportional control with filter; (4) proportional derivative	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=500795

		Bangalore, India		control filter; and (5) proportional plus integral plus derivative control with filter. The main objective of this paper is to discuss the performance of different control strategies for damping torsional oscillations when a generator is connected to an infinite bus via a double circuit 400 kV transmission line, in which one circuit is series compensated. This configuration is similar to IEEE benchmark two model	
TCR nonlinear and linear dynamic analytical models	Alves, J.E.R.; Pilotto, L. A S; Watanabe, E.H.	Centre de Pesquisas de Energia Etetrica, Rio de Janeiro, Brazil	2004	This work presents the development of both nonlinear and linear analytical models for thyristor controlled reactors (TCRs). The nonlinear model for the TCR was developed based on generalized switching functions and from this model, a detailed linear model was derived. The linear model allows for the analysis and precise understanding of the behavior of TCR under small disturbances both in the time and frequency domains, for frequency ranges of up to some tens of Hz. This model clearly shows that the TCR dynamics are operation point dependent system parameter variations are also correctly considered in the model. With the proposed model, it is possible to design static compensators controllers in an integrated form, avoiding risks of instabilities and guaranteeing a good overall dynamic performance for the system. Validation of the models was done by comparing simulated results obtained with the pro-posed model with those obtained with a traditional electromagnetic transients program (EMTP).	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1372863
Coordinated Controller Design of Multiples SVCs Using Detailed s-Domain Modeling	Lirio, F. L.; Gomes, S., Jr.; Watanabe, E.H.	Centro de Pesquisas de Energia Eletr. - CEPEL, Rio de Janeiro	2007	The objective of this paper is to investigate contributions of SVCs and their associated voltage control loop to the phenomenon of small-signal dynamics of power system in the high frequency range (above 5 Hz). A thyristor controlled reactor model based on tensor analysis in the S-domain is used for the small-signal dynamic studies. This approach results in an analytical model that considers harmonic interaction that occurs when a nonlinear device like SVC is connected to the network. The objective of this paper is to show that a fundamental frequency based model is adequate to analyze the interactions between multiples SVCs with satisfactory precision. Some simulation results based on PSCAD/EMTDC are shown to validate the analytical model.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4275977
Harmonic analysis of a GTO controlled series capacitor operating under unbalanced currents	De Souza, L. F W; Watanabe, E.H.; Pilotto, L. A S	CEPEL, Rio de Janeiro, Brazil	2002	The GTO controlled series capacitor (GCSC), as a dual of the thyristor-controlled reactor (TCR), is supposed to be an excellent transmission line series compensator. Harmonic analysis of the GCSC is presented in this work. The characteristic harmonics are obtained through conventional Fourier analysis. Then, a generalized switching function model is derived. A method is developed to analyze the harmonic content of a GCSC fed by nonbalanced currents. Examples are given of the application of the method to analyze the harmonics of three-phase GCSCs, with individual and equidistant blocking of the GTOs, fed by unbalanced currents. The results show the adequacy of the method to analyze harmonics in the GCSC with phase imbalance.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1221429
A flowing solvent reactor for coal liquefaction with direct electrical resistance heating	Gibbins, Jon; Kandiyoti, Rafael	Chemical Engineering Department, Imperial College, London, England	1991	A flowing solvent reactor for coal liquefaction has been developed, which uses direct electrical resistance heating of the reactor tube wall to achieve rapid, controllable heating. A computerized control system previously developed for a wireâ€ mesh pyrolysis apparatus is used for temperature control; heating rates between 0.1 and 10 K/s, peak temperatures up to 450â€‰Â°C, and isothermal holding times from 5 to 1600 s have been obtained. Alternating current is used for heating, allowing a simple thyristor bridge to be used for power control. Solvent is fed from a pressurized reservoir at up to 100 bars, obviating the need for a supply pump. Using this apparatus the effects of a variety of parameters on primary coal liquefaction processes can be examined; the design of the system and typical results are presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5063953
Degradation	Calazans,	Chesf-	2006	This paper presents a methodology for degradation assessment of power semiconductors, applied in static VAr	http://ieeexplore.iee

Assessment of Power Semiconductors Applied in Static VAr Compensator	A.; da Silva, L.E.B.; Lambert-Torres, G.; Da Silva, V.F.	Companhia Hidro Eletrica do Sao Francisco		compensators (SVC) of the types thyristor switched capacitor (TSC) and thyristor controlled reactor (TCR), that it aims at the improvement of the operational performance of these equipment. The methodology allows the identification of defective semiconductors, and the preventive substitution of these components, in order to prevent that the same ones come to fail in service, causing operational perturbations to the electrical system. The methodology defines the parameters of the semiconductors that can be used for the evaluation of the degradation. The conclusions are based on tests carried on semiconductors, with different states of degradation, from static compensators installed in the system of transmission of CHESF-Companhia Hidro Eletrica do Sao Francisco	e.org/stamp/stamp.jsp?arnumber=4104490
A Pilot Study of a Novel TCSC Scheme for the UHV Transmission Lines	Hu Zhen-da; Dai Chao-bo; Wu Shou-yuan	China Electr. Power Res. Inst., Beijing, China	2012	To solve the problem that the existing thyristor valves may not meet the requirements of the UHV TCSC, a new TCSC is proposed in this paper. The novel TCSC consists of a capacitor and two parallel branches of thyristor controlled reactor (TCR). Obviously, the current over the whole controlled branch is shared by two parallel TCR branches. In the paper, the steady-state mathematical model is derived, and the control strategy is also discussed. The results of the digital simulation verify that the new TCSC model can satisfy the engineering application.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6307257
Withstand Capability Testing and Limitation Measurements on Du/dt and Di/dt of Thyristor Valve of the Controllable Metal Oxide Surge Arrester	Chen Xiujuan; Chen Weijiang; Shen Haibin; He Ziming; Chen Lidong; Li Guofu	China Electr. Power Res. Inst., Beijing, China	2012	Du/dt is voltage rise rate in off-state of thyristor. Di/dt is current rise rate in on-state of thyristor. Du/dt and di/dt are key parameters that determine working security of thyristor valve of the controllable metal oxide surge arrester (CMOA, shortly). Combining with the Jindongnan via Nan yang to Jingmen UHV AC pilot project of China, the maximal values of du/dt and di/dt of thyristor were simulated. Required parameters were put forward. The maximal du/dt was 28.3kV/Î¼s and the maximal di/dt was 87kA/Î¼s. Du/dt and di/dt mustn't exceed critical value du/dt_{crit} and di/dt_{crit}. Though du/dtcrit and di/dt_{crit} could be provided by factory, they should be tested by actual application condition because actual application condition may be different from the testing condition. So, by testing, the maximal withstand capacity of du/dt and di/dt was tested by actual application condition. Comparing test results with required parameters indicated that the maximal withstand capacity of du/dt of 2.0 to 3.0 inch thyristor was not less than 45kV/Î¼s which was more than required 28.3kV/Î¼s. Limiting measurement was not needed. The maximal withstand capacity of di/dt was between 865 A/Î¼s and 910A/Î¼s which was much less than the required 87kA/Î¼s. Limiting measures were needed. Study indicated that di/dt could be limited within allowable range by current limited reactor. However reactor may affect limiting switching over voltage of CMOA. So, appropriate values of reactor should be selected. Study indicated that reactor value might be between 3 and 5 mH. In such range, the current limited reactor has wee influence on CMOA limiting effect on switching over voltage.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6173283
Development of full digital control system of TCR dynamic reactive power compensation based on Simadyn-D	Jiang Jianguo; Dai Peng; Zuo Dongsheng; Me Weimin; Liu Yongcheng;	China Univ. of Min. & Technol., Jiangsu, China	2002	Based on the Simadyn-D digital control system, the full digital control system of thyristor control reactor (TCR) for dynamic reactive power compensation is developed in the paper. This control system consists of Simadyn-D control system containing the voltage regulating loop (internal loop) and the power factor correction loop (external loop), and the thyristor valve groups. An adaptive control method is proposed for following and regulating quickly the voltage fluctuation and the power factor correction. The anti-nonlinearity control strategy is suggested for compensating the nonlinearity of thyristor devices. Some research results are given.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1189875

	Hao Peihua; Zhao Tiechui; Liu Qiang; Wang Shufang				
Analysis of the Conducted Interfering Mechanism within SVC-based substations	Song Wei; Wu Gaolin	Chongqing Electr. Power Test & Res. Inst., Chongqing, China	2010	Wide applications of large capacity FACTS (Flexible AC Transmission Systems) equipment within nowadays high voltage substations result in large amount of broadband electromagnetic emissions, which brings electromagnetic contamination to power grids and the environment, and even causes self-malfunction or unaccepted response of victim devices positioned nearby. The interfering mechanism needs to be clarified before sufficient applicable immunity measures can be taken. In this paper, a simulation model is established to investigate on the conducted mechanism in substations installed with SVC (Static Var Compensator) devices with a view to characterizing the main causes of the conducted interference. The high-frequency macro model for thyristors is established with a nonlinear time-varying resistor to simulate the switching characteristics of the thyristors. Based on the above macro model for thyristors, a concrete model of SVC including TSC (Thyristor-switched Capacitor) and TCR (Thyristor-controlled Reactor) is further proposed. In addition, high-frequency equivalent models for frequency-domain compensation of both CT and PT, based on their calibrated non-flat amplitude-frequency characteristics, are adopted to rectify the emissions levels from the SVC switching. The conducted interferences by simulations are correlated with that from on-site measurements, which indicates that the high-frequency switching characteristics of thyristors are the main causes of conducted emissions.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5449415
Fuzzy logic based automatic capacitor switching for reactive power compensation	So, A. T P; Chan, W.L.; Tse, C. T.	City Polytech. of Hong Kong, Hong Kong	1993	To cope with the growth of load demand, it is known that one of the power utilities in Hong Kong tried to implement an automatic scheme for capacitor switching. However, due to the frequent switching which occurred, resulting in hunting, and the difficulty in determining suitable ON/OFF settings, the scheme was unsuccessful. The authors propose a pragmatic design of a capacitor switching controller which has been successfully tested. Besides power factor, the control signal also incorporates MVAr and the advantages are highlighted. To improve the reliability and robustness of the system, fuzzy logic has been introduced. The performance is described based on both the conventional step control and the continuous TCR/TSC (thyristor controlled reactor/thyristor switched capacitor) control.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=264352
Development of a comprehensive power quality controller for power distribution system	Chunming Tu; Hongbin Pan; Ke Peng; An Luo	Coll. of Electr. & .Inf. Eng., Hunan Univ., Changsha	2008	A comprehensive power quality controller combined with Thyristor Controlled Reactors (TCR) and Resonant Impedance Type Hybrid Active Filter (RITHAF) is proposed in this paper for power distribution system. The RITHAF topology presented in the paper is different from the conventional Active Power Filter (APF). The basic of the new RITHAF topology is to add a Fundamental Series Resonance Circuit (FSRC) in parallel with the secondary of coupling transformer of APF, in order to force the fundamental current flow through the FSRC instead of the APF or the secondary of coupling transformer. By this way, it can reduce the rating VA of the APF greatly. The TCR and the Passive Filter (PF) of the RITHAF makes a Static Var Compensator (SVC), which acts as a classic reactive power compensator for load balancing and power factor correction , while the RITHAF acts as a classic APF which eliminate the harmonics so as to raise power quality and power factor. The main circuit structure is introduced in the paper, also the operation principle and control method are analyzed. The	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4771557

				simulation and experimental results verify the effectiveness and advantage of the comprehensive power quality controller for power distribution system.	
Power Electronic Hybrid System for Load Balancing Compensation and Frequency-Selective Harmonic Suppression	An Luo; Shuangjian Peng; Chuanping Wu; Jingbing Wu; Zhikang Shuai	Coll. of Electr. & Inf. Eng., Hunan Univ., Changsha, China	2012	The proposed power electronic hybrid system which consists of a thyristor-controlled reactor (TCR) and a resonant-impedance-type hybrid active power filter (RITHAPF) is used for compensating reactive power and harmonic current. From the point of the nature of load balancing compensation, the calculation of balancing controlled susceptance based on voltage vector transformation is proposed for the TCR to exactly compensate negative-sequence current caused by asymmetrical loads in industrial field. Because the impedance of a filter inductor, a matching transformer, and passive power filters according to the harmonic current is inductive, the phase of the RITHAPF compensating current through them would be shifted. A Ï€-aimed Smith predictor is established based on the fact that there is a Ï€ delay between the compensating current and the sum of harmonic currents of loads and the TCR. In terms of the proposed predictor and generalized integrators, a frequency-selective predictive current controller is designed for perfectly eliminating the impact of phase shift on the RITHAPF filtering performance. The simulation and industrial application results validate the theoretical analysis.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5936722
A Novel Power Quality Compensator for Negative-Sequence and Harmonic Currents in High-Speed Electric Railway	Lu Fang; An Luo; Xianyong Xu; Houhui Fang	Coll. of Electr. & Inf. Eng., Hunan Univ., Changsha, China	2011	In order to solve the power quality problem of negative-sequence and harmonic currents in high-speed railway traction systems, a novel power quality compensator is proposed, which is constituted by railway static power conditioner (RPC), two thyristor-controlled reactors and two thyristor-controlled 3rd filters. The RPC contains two converters which are connected back-to-back by sharing the DC link and is only used to transfer active power and suppress harmonics. The thyristor-controlled 3rd filters are used to suppress 3rd harmonic current and change the phase angle of power supply current. The thyristor-controlled reactors are as the same used to change the phase angle of power supply current. The proposed power quality compensator has small capacity and low cost. Furthermore, based on the working principle of the proposed power quality compensator, its equivalent electrical models are established in fundamental and harmonic domain respectively. Simulation results are provided to demonstrate that the negative-sequence currents is zero and the THD of power arm current is reduced from 14% to 3%, after the proposed power quality compensator is run.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5748427
The electrical model and parameter design of hybrid railway unified power quality controller (RUPQC)	Yin Zhang; An Luo; Chuanping Wu; Fujun Ma	Coll. of Electr. & Inf. Eng., Hunan Univ., Changsha, China	2010	Negative-sequence and harmonic pollution threats the safe operation of the traction supply system and the utility grid. To overcome the shortage of railway static power conditioner (RPC) for canceling negative-sequence and harmonic current, a novel hybrid railway unified power quality compensator (RUPQC) is proposed to reduce the rating of voltage source inverter (VSI) in the compensator in this paper. The RUPQC is consisted of RPC, thyristor controlled reactor (TCR) and thyristor controlled high-pass filter (TCHF), which are connected to the traction sections in parallel. The general principle of RUPQC is analyzed in this paper, and the electric model of the RUPQC is established. Furthermore, the parameter selection method of RUPQC is discussed. Simulation and experimental results verified the validity of proposed compensator.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5736178
Development of a comprehensive power quality controlling device for power	Hongbin Pan; An Luo; Fei Rong; Zhikang	Coll. of Electr. & Inf. Eng., Hunan Univ.,	2008	A combined harmonics and non-active power compensation circuit structure of a resonant impedance type hybrid active power filter (RITHAF) with injection circuit and a static Var compensator (SVC) is proposed in this paper, which named comprehensive power quality controlling device. The model of the comprehensive power quality controlling device is educed in detail, it can be found from the model that the comprehensive power	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5211761

distribution system	Shuai	Changsha, China		quality controlling device has the advantages of harmonic currents elimination and reactive power compensation. Based on the analysis of the model, a voltage close loop control approach was used correspond to thyristor controlled reactor (TCR) and a new synthesis hysteretic control method which combines the speedy performance of traditional hysteretic control with the zero steady state error of double harmonics integrators was adopted according to RITHAF. At the same time, a simulation using PSCAD and a experiment in the lab was carried out, and the feasibility of the comprehensive power quality controlling device is verified by the model and simulation and experimental results, which has a wide use in engineering.	
Peterson coils based on magnetic control adjustable reactance and its application	Rui Liang; Xue Xue; Chonglin Wang	Coll. of Inf. & Electr. Eng., China Univ. of Mine & Technol., Xuzhou	2008	A novel Peterson coil with three phases and five columns is presented to solve the high-order harmonic induced by regulating the triggering angle of thyristor-controlled reactor (TCR) after analysed the current state and existing problems of automatic resonance Peterson coil, which is based on changing magnetic coupling and flux to adjust inductance The structure of this reactor is different from the traditional model which is by altering the mutual inductance coupling quotiety to adjust inductance. This paper also analyse the harmonics and volt-ampere characteristic of the ASC. The DSP hardware realization and the turning principle of the ASC are also presented. The experiments show that this type of ASC has quick resonance speed, no high order harmonic and accurate tracing and compensating capacitive current automatically.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4636400
A power quality combined compensation system and its application on three-phase large-power and impulse loads	Zhang Dinghua; Gui Weihua; Yang Chunhua; Wang Weian	Coll. of Inf. Sci. & Eng., Central South Univ., Changsha	2008	On account of the capacity of active power filter (APF) is limited, a novel structure of combined compensation system is proposed to solve the question of Jerky loadpsilas power quality, including voltage flicker, harmonic pollution, and power factor low. This combined compensation system is composed of static var compensator (SVC) and active power filter (APF). In this system, the SVC is used for compensating reactive power quickly, as well as for improving three-phase unbalanced degree and negative phase-sequence current caused by impulse load. The APF is used for mitigating harmonics caused by Jerky load and thyristor controlled reactor(TCR). In order to realize decentralized control of SVC and APF, a reasonable topological structure is adopted. The operational principle of system, a new reactive power calculation method and control strategy is presented in detail. The feasibility and validity of the combined compensation system is verified by the waves and data of practical operation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4604957
Reactive power management and voltage control of large Transmission System using SVC (Static VAR Compensator)	Chopade, P.; Bikdash, M.; Kateeb, I.; Kelkar, A.D.	Comput. Sci. & Eng. Dept., North Carolina A & T State Univ., Greensboro, NC, USA	2011	The role of the transmission network in the Power System is to transmit the power generated in the power plants to the load centers and the interconnected power systems. The transmission of electric power has to take place in the most efficient way in addition to providing flexibility in the process. Flexible A.C. Transmission System (FACTS) promotes the use of static controllers to enhance the controllability and increase the power transfer capability. Providing reactive shunt compensation with shunt-connected capacitors and reactors is a well established technique to get a better voltage profile in a power system. Shunt capacitors are inexpensive but lack dynamic capabilities, thus some form of dynamically controlled reactive power compensation becomes essential. This feature is provided by Static VAR Compensator (SVC). The work presented here also compares SVC with fixed capacitor compensation and documents the superiority of SVC using Computer Simulation and its performance for reactive power management and better voltage control.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5752911
Study of Active-Front-End design for the	Finotti, C.; Gaio, E.;	Consorzio RFX,	2011	In order to explore strategies to reduce the high reactive power demand and to improve the current harmonic content injected into the main grid of the ITER experimental reactor, in this paper a different design approach to	http://ieeexplore.ieee.org/stamp/stamp.j

Acceleration Grid Power Supply of ITER Neutral Beam Injector	Toigo, V.	Associazione EURATOM-ENEA per la Fusione, Padova, Italy		the ac/dc conversion system of the Acceleration Grid Power Supply (AGPS) of ITER Neutral Beam Injector based on Active Front End (AFE) solution is investigated. Particular attention has been given to the chosen modulation strategy, different from that normally used in AFE converter for high power application. Finally, the performance of AGPS realized with AFE and reference thyristor rectifiers are compared and discussed.	sp?arnumber=5744709
Thyristor making switch system for plasma startup control in RFX	De Lorenzi, A.; Bettini, P.; Peruzzo, S.; Toigo, V.	Consorzio RFX, Padova, Italy	1999	The necessity of better plasma current control during the startup phase asks for a toroidal loop voltage modulation obtained with the multi step reduction of the transfer energy resistor in the OH circuit. The paper begins by discussing the characteristics of such a modulation and then describes the modifications realized and tested on the power supply and magnet systems to prove the feasibility of such an operation; finally, on the basis of the results obtained, we describe the design of the making switch system, based on a 100 mm thyristor valve	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=849870
Bypass operation of the ITER AC/DC converters for reactive power reduction	Gaio, E.; Piovan, R.; Toigo, V.; Benfatto, L.	Consorzio RFX, Padova, Italy	1997	The paper deals with the analysis of bypass operation of thyristor converters; in particular the transition from normal to bypass operation and vice-versa is investigated in order to evaluate the maximum current unbalance between the converter subunits, to locate the conditions which zero unbalance corresponds to and to derive the implications on the control system design	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=687826
Modelling a static VAr compensator using EMPT	de Lima, A.C.S.; Wanderley, S.S.; Stephan, R.M.	COPPE, Univ. Federal do Rio de Janeiro, Brazil	1995	A digital simulation of a static VAr compensator (SVC) using a thyristor controlled reactor (TCR) and fixed capacitor (FC) is presented. This configuration is widely used in power system applications. The model is tested under EMTP (ATP version)	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=504417
All-Solid-State Power Modulator for Pulsed Corona Plasma Reactors	Hartmann, W.; Romheld, M.; Rohde, K.-D.	Corp. Technol., Erlangen	2007	Atmospheric pressure pulsed corona plasma (PCP) reactors of wire-plate design offer novel solutions to environmental issues and to a number of industrial processes. Emerging applications include indoor air sterilization and odor removal in air conditioning systems, chemical synthesis in non-thermal plasmas, and plasma reforming of gaseous fuels. We previously reported on experimental investigations of a laboratory size, wire-plate plasma reactor for pulsed corona treatment of gas flows. Operation with gas flow, at pulse repetition frequencies of between 10 pps and 200 pps, has been achieved at pulse voltage amplitudes of between 10 and >30 kV, at pulse durations of around 0.3 mus (FWHM). High efficiencies of up to 70 g/kWh have been reported using an all-solid-state pulse generator. In this work, we report on the development of all-solid-state power modulators for use with nonlinear loads like pulse corona plasmas. The pulse generators are based on a fast thyristor switch discharging pulse capacitors, a pulse step-up transformer, and one or two stages of magnetic pulse compression. At pulse repetition rates of up to 200 pps, amplitudes of > 30 kV into a resistive-capacitive load (1 kOmega200 pF) have been achieved, at risetimes of about 80 ns and a pulse width of 0.3 mus. The pulse generator is insensitive to load variations, in particular to sparking in the reactor. An advanced generator version uses two magnetic pulse compression stages resulting in even shorter rise times. The modulator and its performance concerning experimental results will be described in detail when driving a pulsed corona reactor.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4286516
A Novel Strategy of	Xiong Jie;	CSR,	2012	To cope with the serious harmonics and low power factor in electrolysis plant which caused by rectifier, a novel	http://ieeexplore.iee

Harmonic Suppression and Reactive Power Compensation	Peng Qiubo; Pan Hongbin	Zhuzhou CSR Times Electr. Co., Ltd., Zhuzhou, China		compensation strategy for harmonic suppression and power factor correction was proposed in this paper. In this compensation strategy the combined compensation system consists of Static Var Compensator (SVC) and Hybrid Active Power Filters (HAPF). The reactive power can be compensated rapidly by SVC which consist of Thyristor Controlled Reactor (TCR) and Thyristor Switched Capacitor (TSC).The HAPF has the function of suppressing harmonic current caused by SVC and the rectifier devices, also damping the resonance between the passive filter and the equivalent inductance of the power network. The operational principle and control strategy of the compensation system are analyzed in detail and the digital simulation is performed. The feasibility and the validity of the combined compensation system is validated by the theoretic analyze and simulation results.	e.org/stamp/stamp.jsp?arnumber=6307304
COMPASS electrical systems and commissioning	Bayes, D. V.; Hay, J. H.; Martin, M. A.; Richardson, D.	Culham Lab., Euratom/UK AEA, Abingdon, UK	1989	The COMPASS experiment is designed to operate in both pinch and tokamak modes, the latter with both circular and shaped plasma cross sections. In tokamak mode, the primary windings are used as an inductive store with a two-stage opening switch system to transfer the energy to the plasma loop. Three thyristor converters (total power 17 MW) are used to maintain the plasma current to provide vertical equilibrium field, and to produce the required plasma shapes (e.g. dee, ellipse, etc.). For pinch operation, a conventional start-bank/active-crowbar circuit is used to feed a reconfigured winding arrangement. Three high-power (each 250 kW) transistor amplifiers are used to energize other machine windings to provide vertical and radial correction fields for fast control of plasma position. A thyristor rectifier (40 MVA) is used to supply the toroidal-field system (92 kA/turn for a maximum field of 2.1 T). The control system uses programmable controllers controlled by a central computer. The operating interface is through touch-sensitive color monitors	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=102346
A new switched inductor VAR compensator	Marouchos, C.	Cyprus Univ. of Technol., Limassol, Cyprus	2009	A new circuit configuration for the generation of both reactive power and harmonic current is presented. Unlike Thyristor Controlled Reactors (TCR), the voltage across an inductor is pulse-width modulated in such a way to produce the required line current. In this presentation the switched inductor is producing lagging reactive power. In conjunction with a fixed parallel capacitor, good quality variable leading and lagging reactive power can be generated. The modulation of the voltage across the inductor is achieved by two semiconductor switches. A relatively high switching frequency is used shifting the line harmonics to a high order for ease of filtering. The size of the passive filters is potentially reduced bringing the cost and size of the system to more attractive levels. The switching frequency and choice of switching semiconductors can be optimized to keep efficiency high. The Switching Function technique is used throughout to analyze the circuit using Mathcad. A PSPICE model is constructed and an experimental set up is presented. PSPICE circuit and Switching Function PSPICE simulations are presented to support the theory.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5279341
Novel transformer-type adjustable reactor based on two-port network control	Tian, J.; Chen, Q.; Zhang, Y.	DEC R&D CENTER, Dongfang Electr. Corp., Chengdu, China	2012	In order to develop an adjustable reactor with rapid and continuous regulation and limited harmonic output, a novel transformer-type adjustable reactor based on two-port network control is proposed. The secondary windings of transformer consist of several switched windings (SW) and a control winding (CW). The equivalent impedance of transformer's primary winding could be regulated arbitrarily by coarse adjustment and fine adjustment. The secondary winding of the unit under consideration has five sections which can be short circuited by thyristors. The thyristors are operated in such a way as to adjust the number of short-circuited sections in operation at any one time, which is used in coarse adjustment. In addition fine tuning of the system is	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6249153

				provided by current source inverter feeding a secondary control winding, which is used in fine adjustment. The control system is simple and effective based on the two-port network control. The design and implementation approach of novel reactor are discussed in detail, and a 630kVA/6kV prototype is verified to design successful through the impedance calculation. The experimental results are given to verify the continuous tuning, fast response and limited harmonic generation of the novel adjustable reactor.	
Co-Ordination Of Static Var Compenstors With Long Distance Radial Transmission System For Damping Improvement	Ooi, B. -T; Banakar, M. H.	Department of Electrical Engineering McGill University	1984	The capability of static VAR compensators to use supplementary signals for damping improvements has been studied. Damping is shown to be a function of the transmission system loading and a function of the static VAR compensator. The study offers insights as to how static VAR compensators should be co-ordinated with respect to the transmission system. The technology under study is based on thyristor controlled reactor with switched capacitors. Only equal line sections are treated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112509
Time-Sharing High-Frequency High-Power Thyristor Switching DC-DC Converters with Energy-Storage and-Transfer Reactor Links	Nakaoka, M.; Vietson, N. M.; Maruhashi, T.	Department of Electrical Engineering, Kobe University, Rokko, Nada-ku, Kobe, Hyogo, 657, Japan	1979	This paper is mainly concerned with the latest strong technological developments on high-power fast-response switching dc-dc converters controlled by time-sharing/sequencial high-frequency thyristor resonant chopper comprising energy-storage and-transfer reactor assemblies, which can operate over an ultrasonic chopping frequency region in the extent of 20 KHz or more than 20 KHz or so. The possible time-sharing circuit configurations of some thyristorized step-up and-down switching converters relating to new magnetic-power semiconductor combination systems and their unique features are firstly described from a practical point of view and discussed on the basis of power transistor type switching dc-dc convertor. The general procedures of circuit analysis using analytical method and performance evaluations to clarify the operating characteristics and to offer some desirable design data are presented generally. The steady-state open-loop control strategy are elucidated on the basis of the theoretical and experimental results. Furthermore, a new thristorized high-power high-frequency energy-storage step-up switching dc-dc converter using successful time-sharing control technique and load voltage commutation procedures are originally examined and minutely discussed herein.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4793645
Adjustable Speed Drive with a Brushless DC Motor	Sato, Noriaki; Semenov, Vsevolod V.	Department of Electrical Engineering, Nagoya University	1971	The brushless dc motor described consists of a synchronous motor with a rotor position sensor and a three-phase bridge inverter. The commutation in the inverter circuit is performed by the induced voltage of the armature windings. In this situation, since auxiliary commutation devices such as capacitors, inductors, and auxiliary thyristors are not required, the simplest inverter circuit is obtained. However, the commutation ability decreases at low speed and starting difficulty results. A novel starting procedure is described whereby the chopping of the rectifier output voltage is accomplished by control of the delay angle. In order to obtain a rapid interruption of the main circuit current, an auxiliary thyristor antiparalleled to the smoothing reactor is used. Finally, a new method of speed sensing that eliminates the need of a tachogenerator is proposed. Speed stabilization with an accuracy about 5 percent in a speed range of 10:1 is performed with this new control system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4181338
Generalized Analytical Model for a Thyristor-Controlled Variable	Himei, Toyoji; Nakanishi,	Department of Electrical Engineering,	1983	A generalized analytical model is presented for thyristor- controlled variable inductors. The proposed model can represent the performance of various types of thyristor phase-controlled variable inductors (VI's), e. g., conventional, UM-concept, magnetically coupled reactor, and asymmetrically firing control types, by introducing	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4504

Inductor	Senichiro; Funabiki, S.	School of Engineering, Okayama University		two parameters: m and Ã‚Â¿By means of numerical computation using this model, the characteristics of variable inductors can be clarified, and their characteristics can be compared with ease. This analytical model is very useful for deciding circuit configuration and design.	261
Integrated Impedance-Based Pilot Protection Scheme for the TCSC-Compensated EHV/UHV Transmission Lines	He, S.; Suonan, J.; Bo, Z.Q.	Department of Electrical Engineering, Xi"an Jiaotong University, Shaanxi, China	2013	This paper analyzes the characteristics of equivalent dynamic power frequency impedance of the thyristor-controlled series capacitor (TCSC) and the integrated impedance, which is defined as the ratio of the sum of the voltage phasors across the two ends of the transmission line to the sum of the current phasors through the two ends of the same transmission line. The integrated impedance of the transmission line is used to determine whether there is a fault inside the protected line section or not. When an external fault occurs, the integrated impedance reflects the capacitive impedance of the protected line, its imaginary part is negative, and the absolute value of its imaginary part is large. When an internal fault occurs, the imaginary part of the integrated impedance on the fault phase is either a positive value or a small negative value. According to such characteristics, internal faults can be distinguished from external faults. Based on integrated impedance, a novel pilot protection scheme for the transmission line with TCSC and controllable shunt reactor is presented. Digital simulations based on 750-kV transmission systems show that the presented scheme offers high sensitivity and reliability with many advantages over conventional current differential protection.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6480901
Effects of harmonic distortion of the supply voltage on the optimum performance of a thyristor controlled reactor-type compensator	Gutivrrez, J.; Montaño, J.-C.; López, A.; Castilla, M.	Dept. de Ingenieria Electron. de Sistemas e Inf., Seville Univ., Spain	1994	The present work examines the effect of harmonic distortion of the supply voltage on the optimum gating angle of a thyristor controlled reactor-type compensator (TCR) and hence its influence on the power factor (PF) correction. The values of optimum PF are compared with those calculated using conventional formulae (which assume that the voltage waveform is purely sinusoidal). The real and imaginary components of the current spectrum in a TCR are calculated with a view to minimising the RMS value of the supply current, and thus achieving an optimum PF. The formulae have been simplified by assuming that the switching intervals of the TCR are not affected by the distortion of the voltage supply. This assumption allows one to proceed considering only one control parameter. Different cases are shown to justify the use of the model developed.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=300333
EMTP simulation of a digitally-controlled static VAr system for optimal load compensation	Martinez, J.A.	Dept. d"Enginyeria Electrica, Univ. Politecnica de Catalunya, Barcelona, Spain	1995	A procedure for simulating a static VAr system aimed at achieving optimal load compensation is presented. The paper details a new approach for reproducing the performance of digitally-controlled SVCs. The simulation is made using the EMTP (ElectroMagnetic Transients Program); the language MODELS is used for modelling the microprocessor-based control. The aim of the paper is to prove that the control strategy used in this paper is adequate for optimal load compensation and the EMTP is a suitable tool for simulating digitally-controlled systems. Test results illustrate how the control strategy can improve the power factor and balance line currents	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=400923
Power-quality improvement in reactive power control using FC-TCR circuits	Gutierrez, J.; Montano, J.C.; Castilla, M.; Lopez, A.	Dept. of Appl. Phys. III, Escuela Superior de	2002	Reactive power compensation using fixed capacitor (FC) and thyristor controlled reactor (TCR) circuit is studied. The goal is the minimization of the RMS and THD values of the line current, controlling the firing angle value of the TCR branch. Some changes in the conventional architecture of the conventional FC-TCR compensator were necessary to achieve it. We show that substitution of the reactor by a switched tapped-reactor forces the	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1185388

		Ingenieros, Seville, Spain		thyristor-firing angle to be small, improving the power factor (PF) and the total harmonic distortion of the line current (THDI). We denote this new architecture as 'fixed capacitor-thyristor switched reactor-thyristor controlled reactor' (FC-TSR-TCR). In the case of nonsinusoidal voltage supply, the above quantities, PF and THDI, are remarkably improved by substituting fixed capacitor by a fixed LC serial branch (FLC-TSR-TCR). These changes are also effective with nonlinear loads. For simulation purposes, FC-TSR-TCR and FLC-TSR-TCR compensator models, and linear and nonlinear loads, represented respectively by RL circuits and ideal current sources, have been considered. For several illustrative cases, an optimization algorithm is applied in each half-cycle of the voltage source, and optimum values of firing angles are obtained satisfying condition of minimum rms value of the line current. PF and THDI are calculated in the considered cases to show the performance of the FLC-TSR-TCR compensator.	
High current regulated, variable DC power supplies for simulating power transients expected in nuclear reactors	Kulkarni, R.D.; Bisht, D.S.; Bhaumik, P. K.; Vyas, H. P.; Sinha, R. K.	Dept. of Atomic Energy, Bhabha Atomic Res. Centre, Mumbai, India	2000	The paper highlights the design and control of DC power supplies used for direct heating applications in the experimental facilities for simulating various kinds of power transients like reactor decay power curve, loss of coolant accident, reactor setback and stepback patterns, etc. expected in nuclear reactors. High current regulated thyristor controlled DC power supplies designed have superior response than those of power transients. The DC power has been controlled by using programmable ramp generator which generates the reference voltage proportional to the square root of power and feeds to the control circuit of the power supply for simulating the power transients precisely.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=854216
Design of a microprocessor-controlled personal static VAr compensator (PSVC)	Zemerick, S.; Klinkhachorn, Powsiri; Feliachi, A.	Dept. of Comput. Sci. & Electr. Eng., West Virginia Univ., Morgantown, WV, USA	2002	A prototype personal static VAr compensator (PSVC) has been designed for load power factor correction for both residential and commercial applications. The PSVC demonstrates the two key benefits of power factor correction, which include decreased power costs and increased system capacity. The PSVC also demonstrates conventional static VAr compensator (SVC) principles that are routinely applied by power utilities. The PSVC prototype consists of two main branches-a TSC (thyristor switched capacitor) branch and a TCR (thyristor controlled reactor) branch. A microprocessor is responsible for calculating the displacement power factor and for executing the fuzzy logic control scheme for the two branches. The PSVC is currently being evaluated using an inductive load and an AC motor. Test results are presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1043633
Prototype design of a personal static VAr compensator	Zemerick, S.A.; Klinkhachorn, P.; Feliachi, A.	Dept. of Comput. Sci. & Electr. Eng., West Virginia Univ., Morgantown, WV, USA	2002	A prototype personal static VAr compensator (PSVC) has been designed and implemented for load power factor correction for both residential and commercial applications. The PSVC demonstrates the two key benefits of power factor correction, which include decreased power costs and increased system capacity. The PSVC also demonstrates conventional static VAr compensator (SVC) principles that are routinely applied by power utilities. The designed PSVC prototype consists of two main branches-a TSC (thyristor switched capacitor) branch and a TCR (thyristor controlled reactor) branch. A microcontroller is responsible for calculating the displacement power factor and for executing the fuzzy logic control scheme for the two branches. The PSVC is being evaluated using an inductive load and an AC motor. Test results are presented in this paper.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1027057
Comparison Analysis of AC Voltage Controllers Based on	Ashour, H.A.; Ibrahim, R.A.	Dept. of Electr. & Comput.	2006	This paper introduces a detailed comparison between possible connections of AC voltage controllers. For each configuration, the experimental setup is implemented and the corresponding simulation program is presented using Simulink under Matlab. The simulated and experimental instantaneous voltage and current waveforms in	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4115

Experimental and Simulated Application Studies		Control Eng., Arab Acad. for Sci. & Technol., Alexandria		case of resistive and inductive loads are matched well, validating the simulation comparison for analysis. The comparison analysis includes the required number of devices and isolated gate signals, which determines the complexity and the size, hence the overall cost. Also harmonic spectrum, total harmonic distortion, effective rms value, dc offset and the control range are compared to specify the performance. The implementation of a fixed-capacitor thyristor controlled reactor (FC-TCR) and three phase induction motor starters (SOFT STARTER) as two application case studies of AC voltage regulators has been discussed. Experimental and simulation results have been obtained and well correlated, showing the effectiveness of such configurations in the fields of control of reactive power flow and in the field of controlling the starting performance of three phase induction motor	489
An efficient switched-reactor-based static VAr compensator	Hua Jin; Goos, G.; Lopes, L.	Dept. of Electr. & Comput. Eng., Concordia Univ., Montreal, Que., Canada	1994	A new static VAr compensator is presented in this paper. To overcome the problems of large low-order harmonics and slow response associated with conventional thyristor-controlled-reactor based compensators, a pulse-width-modulated (PWM) AC converter is used to control the reactances of switched reactors. Yet unlike the PWM static VAr compensators previously reported in the literature, the proposed compensator has a simpler structure and its gating signals are easier to implement. Moreover, it does not require synchronization with the AC mains. The proposed concept was verified through a 1 kVAr prototype and the measured experimental results prove that either leading or lagging reactive power can be achieved through simply duty cycle control	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=297917
An efficient switched-reactor/capacitor-based static VAr compensator	Jin, K.; Joos, G.; Lopes, L.A.	Dept. of Electr. & Comput. Eng., Concordia Univ., Montreal, Que., Canada	1992	A novel static VAr compensator is presented. To overcome the problems of large low-order harmonics and slow response associated with conventional thyristor-controlled-reactor-based compensators, a pulse-width-modulated (PWM) AC converter is used to control the reactances of switched reactors/capacitors. Compared with the PWM static VAr compensators previously reported in the literature, the proposed compensator has a simpler structure and its switch gatings are easier to implement. Moreover, it does not require synchronization with the AC mains. The proposed concept was verified through a 1 kVAr prototype, and the measured experimental results prove that either leading or lagging reactive power can be achieved through simple duty cycle control	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=244312
Benchmark systems for simulation of TCSC and SVC	Johnson, B.K.	Dept. of Electr. & Comput. Eng., Idaho Univ., Moscow, ID, USA	2002	This paper presents modeling guidelines for producing benchmark models suitable for use in electromagnetic transients programs for two thyristor-controlled reactor (TCR) based compensators, the static VAr compensator (SVC) and the thyristor controlled series capacitor (TCSC). Basic modeling procedures for representing the power electronic circuit lower level controls, and outer level controls are presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=985047
Solid state reactive power modulation for enhancement of maximum power	Hussain, B.; Behera, A.K.	Dept. of Electr. & Comput. Eng., Illinois	1991	An application of a solid-state static VAr compensator (SSSVC) to modulate the reactive power requirement in the system by controlling the voltage profile of the network is shown. The mathematical model for a single-machine infinite bus is developed based on a prior optimized switching pattern for various modulation indexes which, when applied to the inverter to control the output voltage, enhance the power system dynamics. It is	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=162692

transfer and stability in an interconnected power system		Inst. of Technol., Chicago, IL, USA		demonstrated that the steady-state stability of a power system can be improved by effective modulation of the reactive power in the system. Voltages and power flows are locally measured at the SSSVC location and conditioned for proper utilization as control signals for the SSSVC to improve the damping of interties	
Dynamic static VAr compensation and stability of HVAC-An outlook and trend	Hussain, B.; Behera, A.K.	Dept. of Electr. & Comput. Eng., Illinois Inst. of Technol., Chicago, IL, USA	1990	Static VAr compensators are reviewed for their application in transmission line compensation and load compensation. Emphasis is given to the application of thyristor controlled reactors and thyristor switched capacitors. After a quick review of the application of static VAr compensators, a detailed theoretical analysis of the reactive power requirement is made. A mathematical model of the compensator is established for the possible controllable parameters. In the theoretical analysis, both symmetrical line and radial line systems are considered. Stability of a transmission line is analyzed for reactive power compensation. Present trends are discussed for finer continuous reactive power control. Solid state reactive power compensation without the need for large capacitors and reactors is seen to be the most probable candidate. Solid state devices for high power capability and transient response along with other reactive power requirements are also discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=151352
Development of a state variable-based static compensator model	Gole, A.M.; Sood, V.K.	Dept. of Electr. & Comput. Eng., Manitoba Univ., Winnipeg, Man., Canada	1990	The development and implementation of a static VAr (volt-ampere reactive) compensator (SVC) model for digital transient simulation packages are described. The SVC model consists of a 12-pulse thyristor controlled reactor (TCR) with a thyristor switched capacitor (TSC). The equations for the circuit are obtained in state variable form using graph theory techniques and result in accurate, numerically stable solutions. The switching of the TSC capacitors has been modeled in a novel manner that saves on storage and computation time. The method of interfacing the model to a power system transients program is discussed. The transients program can be used to model large power systems external to the SVC model. A demonstration of the use of the SVC model in a power system simulation with the EMTDC packager is presented.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=131204
Accurate calculation of thyristor-controlled series compensator impedance	Baghzouz, Y.; Black, J.	Dept. of Electr. & Comput. Eng., Nevada Univ., Las Vegas, NV, USA	1999	This paper derives an accurate analytical expression of the fundamental-frequency impedance of a thyristor-controlled reactor when used as part of a transmission line series compensator. The formula is a function of thyristor firing angle, line inductance, and compensator capacitance. A numerical example illustrates the accuracy of two approximate expressions at different levels of line compensation	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=756128
Utilization of three-phase thyristor-controlled AC/DC converters for reactive power compensation with minimum losses	Deib, D. A.; Hill, H.W.	Dept. of Electr. & Comput. Eng., Ohio Univ., Athens, OH, USA	1995	This paper presents a new control method for three-phase, thyristor-controlled reactors for reactive power compensation applications. A conventional AC/DC, three-phase, phase-controlled, bridge power converter is utilized. A relatively small inductance is used for a discontinuous rated inductor current. This results in reducing the inductor size, cost and loss, and greatly reduces the power converter switching losses. Experimental results are shown to demonstrate the validity of the proposed method	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=469086

AC/DC control for thyristor-controlled reactors for reactive power compensation	Deib, D. A.; Hill, H.W.; Shepherd, W.	Dept. of Electr. & Comput. Eng., Ohio Univ., Athens, OH, USA	1994	This paper presents a new phase-control method for thyristor-controlled reactors to realise reactive power compensation. Instead of using the conventional two switch AC controller, an AC/DC full-wave bridge can be utilized. This allows the inductor current to be unidirectional, resulting in reduced core losses. The AC/DC control, with a relatively small inductance, results in reduced inductor size and losses. Also, the small inductance allows a nearly sinusoidal current to flow in the inductor, which results in reduced AC line current harmonic distortion. The paper includes experimental comparisons between the proposed and the conventional compensators	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=397803
Modelling and control of thyristor-controlled series compensators	Ghosh, A.; Ledwich, G.	Dept. of Electr. & Comput. Eng., Queensland Univ., Brisbane, Qld., Australia	1995	A linearised discrete-time model of a thyristor-controlled series-compensated transmission line is presented, in which a thyristor-controlled reactor (TCR) is used as the compensating device. The discretisation is performed at the peaks of the capacitor voltage of the series compensator. Since these peaks are broad, rather than sharp spikes, they are quite good indicators of variations in the fundamental component. During transients this will result in variation from uniform sampling. However, the system degenerates to a uniform sampled system in the steady state, and thus all the standard tools for the stability analysis of a standard discrete-time model can be applied. As a part of the linearised model, two different output equations are determined. They are the line current, which is in quadrature with capacitor voltage, and the real power flowing through the line. These output equations are then used for control design. The model developed is validated through digital computer simulation studies, in which the robustness of the closed-loop system is investigated through eigenvalue plots as a function of the operating points	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=388365
Negative-phase-sequence reduction with adjacent static reactive-power compensators	Ledwich, G.; George, T.A.	Dept. of Electr. & Comput. Eng., Queensland Univ., Qld., Australia	1994	Static reactive power (VAr) compensators (SVCs) can be used to reduce negative phase sequence (NPS) voltages by balancing, for example, phase-to-phase-connected loads. In such cases, they are effective until their controlled elements, usually thyristor-controlled reactors, reach their operating limits. Once this happens, NPS currents flow in the system and produce NPS voltages. If several load balancing SVCs are located in close electrical proximity, adjacent load balancing SVCs are able to absorb some of this uncompensated NPS current, reducing the overall NPS voltage profile. The mutual support thus provided should be considered when designing the ranges of such load balancing SVCs. The paper describes how to quantify the mutual support in a system with multiple load balancing SVCs	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=321049
Microprocessor controlled reactive power compensator for loss reduction in radial distribution feeders	Kearly, J.; Chikhani, A.Y.; Hackam, R.; Salama, M.M.A.; Quintana, V.H.	Dept. of Electr. & Comput. Eng., R. Mil. Coll., Kingston, Ont., Canada	1991	A new real-time reactive power compensation scheme for distribution feeders is proposed. A network of data acquisition interfaces and microcontrolled fixed capacitor biased thyristor controlled reactors measures the reactive component of the load current at each feeder node and injects optimal levels of leading compensation current. The degree of compensation is determined by a dynamic approach, optimizing the total dollar savings which result for VAr compensation. Load currents are sampled every 3 s and compensation currents every 5 s and recalculated every 10 min. System response time is rapid enough to react to real-time load variations and closed loop control of thyristor firing angles enables adjustment for dynamic voltage fluctuations and compensator dissimilarities. A model compensation network was constructed and successfully tested in a laboratory environment	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=97731
Dynamic modeling of a TCSC with	Perkins, B.K.; Iravani,	Dept. of Electr. &	1997	Conventional subsynchronous resonance (SSR) study methods such as eigenanalysis require a linear dynamic model of each device. FACTS devices such as thyristor-controlled series capacitors (TCSC) are difficult to	http://ieeexplore.ieee.org/stamp/stamp.j

application to SSR analysis	M.R.	Comput. Eng., Toronto Univ., Ont., Canada		model due to their nonlinear switching behaviour. Linearizing the TCSC steady-state average model is inadequate as this does not model the passive damping associated with the open-loop operation of a TCSC. The proposed approach exploits the fact that the thyristor controlled reactor associated with the TCSC is switched in a regular pattern. A linear model is obtained by linearizing the half-period map associated with sampling the TCSC capacitor voltage twice every cycle. Such an approach models the passive damping which varies with the steady-state conduction angle of the TCSC. It is shown that passive damping has a significant effect on the modal damping of the torsional modes associated with subsynchronous resonance phenomena	sp?arnumber=627867
Linearized harmonic domain model for three-phase thyristor controlled reactor	Orillaza, J.R.C.; Wood, A.R.	Dept. of Electr. & Comput. Eng., Univ. of Canterbury Christchurch, Christchurch	2008	This paper presents a linearized harmonic domain model developed as a small-signal frequency transfer matrix of a three-phase thyristor controlled reactor (TCR). The transfer from the supply voltage to the reactor current is analyzed as separate effects produced from two causes, namely: (1) change in AC voltage; and (2) change in thyristor switching instant which allows controls to be modelled. The model is implemented as a tensor matrix and validated with results obtained from a time-domain simulation. This model is an important advance towards the development of a full harmonic state-space model of a TCR.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4813093
Harmonic State-Space Model of a Controlled TCR	Orillaza, J.R.C.; Wood, A.R.	Dept. of Electr. & Comput. Eng., Univ. of Canterbury Christchurch, Christchurch, New Zealand	2013	This paper presents a harmonic state-space (HSS) model of a three-phase thyristor-controlled reactor (TCR) in a voltage-control application. In using the HSS description, the importance of incorporating the effect of harmonic interaction on the dynamics of a power system containing a TCR or other flexible ac transmission system controllers is illustrated. Although nonlinear in nature, the significant effect of switching instant variation is included in the linearized model. The model size is minimized with the selection of the minimum necessary set of harmonic frequencies. To validate the HSS models, the steady-state harmonics and the step response were validated with a PSCAD/EMTDC simulation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6327630
Reduced harmonic state space model of TCR	Orillaza, J.R.C.; Wood, A.R.	Dept. of Electr. & Comput. Eng., Univ. of Canterbury Christchurch, Christchurch, New Zealand	2010	This paper presents a harmonic state-space model of a three-phase thyristor controlled reactor. In this description, both the transient and steady-state response of individual harmonics are quantified. The results were validated using a strictly time-domain simulation. A further development of the model is the use of characteristic harmonics of the power converter to reduce the number of harmonics incorporated into state-space equations; this development effectively reduces computational burden.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5625438
Switching Instant Variation in Harmonic State-Space modelling of power electronic	Orillaza, J.R.; Hwang, M.S.; Wood, A.R.	Dept. of Electr. & Comput. Eng., Univ.	2010	In classical harmonic domain (HD) modelling, a frequency transfer matrix is used to describe the frequency coupling across a power electronics device. This is normally based on switching functions using pre-defined switching instants. These are usually arrived at via an iterative process. In extending HD to Harmonic State-Space (HSS) where transient harmonic variation can be modelled, it is imperative to have a linear model for	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5710793

devices		of Canterbury, Christchurch, New Zealand		Switching Instant Variation (SIV) which is either produced autonomously due to input variation or introduced from the control algorithm. Control contributes significantly to system stability and must be modelled for correct system representation. This paper presents these types of SIV in the context of developing an HSS model for a three-phase Thyristor Controlled Reactor (TCR) and a High Voltage Direct Current (HVDC) Converter.	
Harmonic mitigation in a Virtual Air Gap Variable Reactor via control current modulation	Dolan, D.S.L.; Lehn, P.W.	Dept. of Electr. & Comput. Eng., Univ. of Toronto, Toronto, ON	2008	A Virtual Air Gap Variable Reactor is a device that is capable of producing a continuously variable reactance with a better dynamic response and without introducing the harmonics created by the thyristor switching of a TCR. This paper presents a method of harmonic mitigation that can be applied to a laboratory prototype Virtual Air Gap Variable Reactor (VAG-VR) which further improves on the low harmonics already achieved. The method utilizes control current modulation such that the DC auxiliary current is modulated with a 2nd harmonic component. It is seen that the 3rd harmonic can be reduced in the range of 60% - 96% as compared to using the DC auxiliary current without modulation. The 5th and 7th harmonics also show a modest reduction. This improvement is in addition to the improvements that have already been achieved by the VAG-VR as compared to the thyristor controlled reactor (TCR).	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4595983
Power flow and transient stability models of FACTS controllers for voltage and angle stability studies	Canizares, C.A.	Dept. of Electr. & Comput. Eng., Waterloo Univ., Ont., Canada	2000	This paper presents transient stability and power flow models of thyristor controlled reactor (TCR) and voltage sourced inverter (VSI) based flexible AC transmission system (FACTS) controllers. Models of the static VAr compensator (SVC), the thyristor controlled series compensator (TCSC), the static VAr compensator (STATCOM), the static synchronous source series compensator (SSSC), and the unified power flow controller (UPFC) appropriate for voltage and angle stability studies are discussed in detail. Validation procedures obtained for a test system with a detailed as well as a simplified UPFC model are also presented and briefly discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=850192
Characteristic performance of thyristor controlled reactor used in reactive power control	Fouda, S. S.; Salama, M.M.A.; Chikhani, A.Y.	Dept. of Electr. & Comput. Eng., Waterloo Univ., Ont., Canada	1993	The performance characteristics of the basic type of static, thyristor-controlled shunt compensators are presented. In particular, the effects of the natural frequency of the compensators and the firing angle of the thyristor are studied. An inherent dependency between a TCR natural frequency and the circuit power frequency is demonstrated. According to this dependency, TCR circuits with a natural frequency that is a multiple of the circuit power frequency exhibit an increase in the harmonics of the circuit	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=332344
Nonlinear dynamics and switching time bifurcations of a thyristor controlled reactor circuit	Rajaraman, R.; Dobson, I.; Jalali, S.G.	Dept. of Electr. & Comput. Eng., Wisconsin Univ., Madison, WI, USA	1996	We study a thyristor controlled reactor circuit used for static VAR control of utility electric power systems. The circuit exhibits switching times which jump or bifurcate as fold or transcritical bifurcations. We study the nonlinear dynamics of the circuit using a Poincare map and demonstrate that the Poincare map has discontinuities and is not invertible. The circuit has multiple attractors, moreover, the basin boundary separating the basins of attraction intersects with the Poincare map discontinuities. These novel properties illustrate some of the basic features of dynamical systems theory for thyristor switching circuits	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=545842
Stability of ideal thyristor and diode	Dobson, I.	Dept. of Electr. &	1995	This paper analyzes the stability of a general RLC circuit with ideal thyristors or diodes and periodic sources. Applications include high power thyristor controlled reactor and bridge rectifier circuits. The periodic steady	http://ieeexplore.ieee.org/stamp/stamp.j

switching circuits		Comput. Eng., Wisconsin Univ., Madison, WI, USA		states of the circuit are analyzed using a Poincare map and transversality conditions are given to guarantee the smoothness of the Poincare map. A simple and exact formula for the Jacobian of the Poincare map is proved. Account is taken of the varying state space dimension as diodes switch on and off. When the transversality conditions fail, switching times can jump or bifurcate. Examples show that these switching time bifurcations can cause instability of thyristor circuits and mode changes of diode circuits. The simplification of the Jacobian formula is used to explain why the switching time bifurcations occur and are not predicted by the eigenvalues of the Jacobian. Periodic orbits of ideal diode circuits are proved to be stable using Jacobian and incremental energy methods. A source of damping in switching circuits is identified	sp?arnumber=414825
Damping and incremental energy in thyristor switching circuits	Rajaraman, R.; Dobson, I.	Dept. of Electr. & Comput. Eng., Wisconsin Univ., Madison, WI, USA	1995	Thyristor controlled reactors provide controllable inductances in utility power lines and are increasingly used for static var control and flexible AC transmission. The size of a perturbation from a nominal periodic steady state can be measured by its incremental energy. This paper shows that incremental energy of a small perturbation increases when a thyristor switches on and decreases when a thyristor switches off. This observation aids in understanding how perturbations are damped by thyristor switchings and highlights some problems with representing the small signal dynamics of thyristor controlled reactors with impedances	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=521508
Instabilities due to bifurcation of switching times in a thyristor controlled reactor	Jalali, S.G.; Dobson, I.; Lasseter, R.H.	Dept. of Electr. & Comput. Eng., Wisconsin Univ., Madison, WI, USA	1992	The authors describe two bifurcation instabilities of a thyristor controlled reactor (TCR) circuit in which switching times suddenly change and system stability is lost. The instabilities are unexpected because they are quite different from what might be expected from conventional theory in that they occur without the usual indications such as eigenvalues of a Jacobian matrix crossing the unit circle. The instabilities are explained and their mechanisms are illustrated by the simulation of a static volt-ampere-reactive (VAr) example with realistic parameters. In particular, it is shown how distortion of voltage and current waveforms can cause a thyristor switch-off time to disappear or a new thyristor switch-off time to suddenly appear. The consequence of the sudden change in switch-off times is that stable periodic operation of the circuit is lost and a transient will occur until the circuit settles down to a new steady state	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=254834
Pulse multiplication in parallel convertors by multitap control of interphase reactor	Villablanca, M.E.; Arrillaga, J.	Dept. of Electr. & Electron. Canterbury Univ., Christchurch, New Zealand	1992	It has already been shown that the shape of the circulating current of parallel convertor configurations can be controlled by the use of thyristor controlled taps, and that such action can be used to increase the number of pulses. This technique, referred to as DC ripple re-injection, is generalised and it is shown, theoretically and experimentally, that it is possible to increase the number of pulses by any specified multiple of the basic pulse configuration	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=119057
Fuzzy Based Grid Voltage Stabilization in a Wind Farm Using Static VAR Compensator	Vanitha, V.; Shreyas, S.; Vasanth, V.	Dept. of Electr. & Electron. Eng., Amrita Sch. of Eng.,	2009	When a squirrel cage induction type wind electric generator (WEG) is connected to power grid, due to variations in load and wind speed, there will be fluctuations in the grid voltage. In this paper, the effect of load and wind speed variations on real power supplied and reactive power consumed by the WEG as well as voltage on the grid are studied. The voltage variation in the grid is controlled by reactive power compensation using shunt connected static VAR compensator (SVC) comprising thyristor controlled reactor (TCR) and fixed capacitor	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5328104

		Coimbatore, India		(FC). The TCR is operated automatically by a fuzzy logic controller (FLC). The complete system is modeled using MATLAB SIMULINK. Results show an appreciable improvement in the grid voltage by compensating the reactive power.	
Naturally commutated thyristor-controlled high-pulse VAr compensator	Arrillaga, J.; Brough, R. D.; Duke, R.M.	Dept. of Electr. & Electron. Eng., Canterbury Univ., Christchurch, New Zealand	1995	An alternative to the thyristor controlled reactor for use in static VAr compensators is proposed based on the ability of the AC/DC power convertor to absorb controllable reactive power. The standard three-phase bridge configuration is modified, using the concept of DC ripple reinjection, to achieve high pulse operation without the need for passive harmonic filtering. A 36-pulse scaled-down test system is used to verify the theoretical predictions	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=373004
Monitoring the quality of electrical energy and improving it using thyristor controlled reactor	Irmak, E.; Colak, I.; Sagiroglu, S.; Kose, A.; Kabalci, E.	Dept. of Electr. & Electron. Eng., Gazi Univ., Ankara, Turkey	2012	In this paper, an experimental application focused on energy quality observation is developed and power factor correction for the electrical power systems is simulated. The required parameters are obtained from the system by electronic cards and then transferred to the computer. As the controller a (DAQ) Data acquisition card is used and also a user-friendly interface is prepared for computing and managing all of the information to show power quality, event detection and power metering. The interaction between user interface and the system is supplied via OPC server communication. Powerful capabilities for the measurement, analysis and monitoring of electrical energy has been obtained by using real-time data.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6477326
Fast extraction of positive-sequence current from harmonically corrupted three-phase currents for TCR compensator control systems	Ho, P.T.; Tso, S.K.	Dept. of Electr. & Electron. Eng., Hong Kong Univ., Hong Kong	1990	The authors discuss a practical scheme for extracting the magnitude of the positive-sequence component from harmonically corrupted three-phase currents found in modern energy systems. The scheme is cost-effective, fast, and simple in design, with the novel combination of software processing and digital and analog circuits. The scheme has been successfully applied to a microprocessor-based thyristor-controlled reactor (TCR) control system and is suitable for similar real-time applications that already include one or more processing units. It is demonstrated that the scheme is adequately fast for the TCR control system because the extraction delay is typically less than half a cycle. The scheme is especially suitable for microprocessor-based control systems because the averaging function can be advantageously performed by software.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=45847
The behaviour of TSR-based SVC and TCR-based SVC installed in an infinite bus system	Gelen, A.; Yalcinoz, T.	Dept. of Electr. & Electron. Eng., Nigde Univ., Nigde, Turkey	2008	In this paper, effects of both Thyristor Switched Reactor-based Static VAr Compensator (TSR-based SVC) and Thyristor Controlled Reactor-based Static VAr Compensator (TCR-based SVC), which are two of shunt Flexible AC Transmission Systems (FACTS) devices, on load voltage in a single-machine infinite bus (SMIB) system are investigated. The modeling and simulation of TSR-based SVC and TCR-based SVC are verified using the Matlab7.04Ã‚Â® SimPowerSystems Blockset. A six-pulse generator is used to control of TSR in the SVC. A fuzzy logic controller is used to control of TCR-based SVC. The studied power system consists of a synchronous generator connected to an infinite bus and a static load. The results show that improvement on reactive power compensation and load bus voltage regulation could be achieved by using the TSR-based SVC and TCR-based SVC.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4736670
Integrated control scheme for generators	Mahran, A. R.; Hogg,	Dept. of Electr. &	1991	The authors describe the application of modern control theory to design a control scheme for a generator and a VAr compensator in a power system. The objective is to extend the operational margins of stability, whilst	http://ieeexplore.ieee.org/stamp/stamp.j

and VAr compensators in power systems	B.W.; Sharaf, S.M.; Serag, A.M.	Electron. Eng., Queen''s Univ., Belfast, UK		satisfying control requirements by introducing an integrated multi-variable controller to control both the generator exciter and the firing angle of the thyristor-controlled reactor of a TCR-FC compensator. The system dynamics are modelled in terms of measurable state variables and control inputs. This is achieved by using unbiased recursive least squares identification. On the basis of this identified model, the synthesis of an integrated optimal controller is achieved by minimizing a quadratic performance index using dynamic programming techniques. The effectiveness of the controller has been evaluated by computer simulation over a wide range of operating conditions and disturbances. System behaviour under transient conditions is assessed by examining the response to three-phase short circuits	sp?arnumber=154077
Vector-controlled double-inverter-fed wound-rotor induction motor suitable for high-power drives	Kawabata, Yoshitaka; Ejiogu, E.; Kawabata, Takao	Dept. of Electr. & Electron. Eng., Ritsumeikan Univ., Kyoto, Japan	1999	In this paper, the principle and the results of an experimental study concerning a new high-power inverter drive system are presented. One usual method of supplying large vector-controlled AC drives is by three-level inverters configured with 6-in 6-kV 6-kA gate-turn-off thyristors. These inverters can be adopted for drives that have ratings less than several thousand kilowatts. However, in the case of drives rated more than several thousand kilowatts, two inverters have been combined using interphase reactors. However, interphase reactors have problems of acoustic noise and high losses and, in addition, are bulky and expensive. To overcome these problems, a new configuration using a wound-rotor induction motor and two current controlled pulsewidth modulation inverters is proposed. In this configuration, the outputs of the two inverters are combined electromechanically in the machine and, as a result, novel features can be obtained	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=793366
High-power drive using a wound rotor induction motor and two current controlled inverters	Kawabata, Yoshitaka; Ejiogu, E.C.; Nishiyama, K.; Kawabata, Takao	Dept. of Electr. & Electron. Eng., Ritsumeikan Univ., Kyoto, Japan	1997	New configurations for high-power and high-performance motor drives suitable for steel rolling mills are presented. Three-level inverters, using 6 inch GTOs, can deliver 10,000 kVA output. In the case of drives rated more than several thousands kW, this capacity is still insufficient. Usually, for such drives, two three-level inverters have been combined using bulky, expensive inter-phase reactors. To solve these problems, a new configuration using wound-rotor induction motors and two inverters, is proposed. In this configuration, the outputs of the two inverters are combined directly within the machine. The novel features that can thus be obtained are explained	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=638242
New open-winding configurations for high-power inverters	Kawabata, Takao; Ejiogu, E.C.; Kawabata, Yoshitaka; Nishiyama, K.	Dept. of Electr. & Electron. Eng., Ritsumeikan Univ., Kyoto, Japan	1997	New configurations of high-power inverters suitable for AC motor drives and static VAr controllers are presented. A usual method of supplying large AC drives rated at more than several thousands of kilowatts is to combine the outputs of two inverters using inter-phase reactors. However, such inter-phase reactors have several disadvantages such as losses and acoustic noise. To solve these problems, several new configurations which combine two different type of inverters or converters to both terminals of the open windings are presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=648991
Dynamic performance analysis of a hybrid wind turbine generator system	Fujii, Y.; Hasegawa, C.; Tatsuta, F.; Nishikata, S.	Dept. of Electr. & Electron. Eng., Tokyo Denki Univ., Tokyo	2008	The dynamic performances of a hybrid wind turbine generator system using a shaft generator system are investigated. The hybrid system consists of a wind turbine and generator, a rectifier, a current-source thyristor inverter, a synchronous generator driven by a prime mover and a duplex reactor. The configuration of the hybrid wind turbine generator system is explained first, and a dynamic model of the hybrid system is developed. The dynamic performances of the system when the wind velocity is changed are then discussed. Finally, a control system to keep the output voltage and power of the whole system constant is introduced, and it is shown that	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4771127

				these outputs can be controlled almost constant independent of wind velocity.	
Novel plasma reactor using honeycomb ceramics driven by a fast Si-thyristor for environmental applications	Ibuka, S.; Nakamura, T.; Murakami, T.; Kondo, H.; Yasuoka, K.; Ishii, S.	Dept. of Electr. & Electron. Eng., Tokyo Inst. of Technol., Japan	2001	A novel plasma reactor using honeycomb ceramics for NO decomposition was proposed. Using rod-cylinder electrodes configuration with the honeycomb ceramics, a barrier discharge type reactor was fabricated with a PET sheet as an insulator. The uniform discharges in the honeycomb ceramics were successfully obtained using a high voltage pulse generator with a fast SI-thyristor. NO removal experiment in N/sub 2/ was carried out with the reactor. The surface condition of the ceramics greatly influenced the NO removal characteristic. The NO removal efficiency of the reactor was estimated to be 295 eV/molecule at the maximum NO removal rate.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1001741
TCR and SR compensators in composite electromagnetic transient simulation	Nguyen, T.T.; Derek Humpage, W.	Dept. of Electr. & Electron. Eng., Western Australia Univ., Perth, WA, Australia	1989	Following the recent development of a detailed, electromagnetic transient model for saturated reactor (SR) compensators, the present paper is devoted to companion investigations related to the alternative form of compensators based on thyristor-controlled reactors (TCRs). A model is developed for TCR compensators which provides a similar degree of detail in representation to that of the earlier SR compensator model and is of equal rigour in its derivation. It makes comprehensive provision for representing TCR compensators of any given pulse-order, control-objective function and control-system design in a very wide range of studies related to transient modes of operation. Drawing on established z-plane methods of numerical electromagnetic transient analysis in power-network systems, a unified formulation is achieved, which combines the nonlinear elements of SR models with the time-varying branches by which thyristor switching in TCR compensators is represented. Representative study results are given for a section of a transmission system which includes both SR and TCR compensators at the one control location, so that one complements the other.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=18948
Static VAR compensator-based voltage control implementation of single-phase self-excited induction generator	Ahmed, T.; Nishida, K.; Soushin, K.; Nakaoka, M.	Dept. of Electr. & Electron. Syst. Eng., Yamaguchi Univ., Japan	2005	A single-phase static VAR compensator (SVC) is proposed to regulate smoothly the output voltage of a single-phase self-excited induction generator (single-phase SEIG) driven by a variable-speed prime mover (VSPM) due to inductive load and prime mover speed variations. A PI feedback closed-loop voltage regulation scheme is presented to adjust the equivalent excitation capacitance of the single-phase SVC. The SVC is composed of a fixed excitation capacitor (FC), thyristor switched capacitor (TSC) and thyristor controlled reactor (TCR). The steady-state single-phase SEIG output voltage and the TCR triggering angle responses of the proposed scheme are simply evaluated and discussed. A small-scale single-phase SEIG voltage control prototype is designed in order to verify system viability and assess its performance. System dynamic operation is studied based on experimental results. Simulation and experimental results prove system practical effectiveness in terms of fast response and high performance.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1421131
Terminal voltage regulation characteristics by static var compensator for a three-phase self-excited induction generator	Ahmed, T.; Noro, O.; Hiraki, E.; Nakaoka, M.	Dept. of Electr. & Electron. Syst. Eng., Yamaguchi Univ., Japan	2004	In this paper, the practical impedance approach steady-state analysis in the frequency domain for the three-phase self-excited induction generator (SEIG) with squirrel-cage rotor is presented along with its operating performance evaluations. The three-phase SEIG is driven by a variable-speed prime mover(VSPM) in addition to a constant-speed prime mover (CSPM) such as a wind turbine and a micro gas turbine for clean alternative renewable energy in rural areas. The basic steady-state characteristics of the VSPM are considered in the three-phase SEIG approximate equivalent circuit and the operating performance of the three-phase SEIG coupled with a VSPM and/or a CSPM are evaluated and discussed online under the conditions related to the speed changes of the prime mover and the electrical inductive load power variations with simple computation	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1315787

				processing procedures. A three-phase SEIG prototype setup with a VSPM is implemented for small-scale clean renewable and alternative energy utilizations. The experimental performance results give good agreement with those obtained from the simulation results. Furthermore, a proportional-integral (PI) closed-loop feedback voltage regulation of the three-phase SEIG driven by the VSPM on the basis of the static var compensator (SVC) composed of the thyristor phase-controlled reactor in parallel with the thyristor switched capacitor and the fixed-excitation capacitor bank is designed and considered for the wind generation as a renewable power conditioner. The simulation analysis and experimental results obtained from the three-phase SEIG with SVC for its voltage regulation prove the practical effectiveness of the additional SVC with the PI-controller-based feedback loop in steady-state operation in terms of high performance with low cost.	
A new hybrid series active filter configuration to compensate voltage sag, swell, voltage and current harmonics and reactive power	Hamadi, A.; Rahmani, S.; Al-Haddad, K.	Dept. of Electr. Energy Conversion & Power Electron., Ecole de Technol. Super., Montreal, QC, Canada	2009	This paper proposes a new system configuration for a series hybrid power filter (SHPF) realized for all harmonic types of loads. The series hybrid filter consists of a small rated series active power filter (SAPF) and a shunt passive filter with variable inductance using a thyristor control reactor (TCR). The DC voltage available at the load side of a typical voltage harmonics source, such as a diode bridge rectifier followed by a capacitor, is utilized as a source of DC power for the SAPF. To increase the filtering performance of the shunt passive filter, SAPF is control in such a way that it increases the network impedance at the harmonic frequency. This also helps to avoid any series or parallel resonance that may occur. The shunt passive filter together with a TCR is used to support the variable load reactive power demand as well to tackle the current harmonics generated by non-linear load. The performance of proposed series hybrid power filter is validated through MATLAB/Simulink simulation study and successfully utilized to compensate the voltage sag, voltage swell, voltage harmonics, current harmonics and load reactive power demand.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5218895
Microprocessor-based control of an SVC for optimal load compensation	Gomez Exposito, A.; Gonzalez Vazquez, F.; Izquierdo Mitchell, C.; Gonzalez Garcia, T.; Madronal, F.d.P.	Dept. of Electr. Eng, Seville Univ., Spain	1992	An open-loop control strategy is presented for optimal compensation of arbitrary loads by means of thyristor-controlled reactors. Real-time implementation of this technique on a microprocessor-based working prototype is also described. Simulation and experimental results show that, using the proposed scheme, abrupt load changes are always compensated within the next cycle	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=127071
Harmonic analysis of systems with static compensators	Xu, W.; Marti, J.R.; Dommel, H.W.	Dept. of Electr. Eng., British Columbia Univ., Vancouver, BC, Canada	1991	Static VAr compensators with thyristor-controlled reactors generate harmonics. Due to the voltage regulation characteristics of the compensator, the generated harmonics depend on unknown thyristor firing angles and the network load flow conditions. The inclusion of load flow dependent firing angle determination in the author's computer-based multiphase harmonic load flow (MHLF) technique (see ibid., vol.6, no.1, p.174-82, 1991) is described. It uses a novel conduction angle adjustment scheme. This general and simple scheme can easily be used for the analysis of other nonlinear elements with control characteristics. Various case studies are presented to demonstrate the performance and application of the technique. Field test comparisons are included	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=131061

A multiphase harmonic load flow solution technique	Xu, W.; Marti, J.R.; Dommel, H.W.	Dept. of Electr. Eng., British Columbia Univ., Vancouver, BC, Canada	1991	The operation of nonlinear devices under unbalanced load conditions may cause harmonic problems in power systems. A computer-based multiphase harmonic load flow solution technique for analyzing such problems is described. The harmonic load flows are obtained from iterations between the Norton equivalent circuits of the nonlinear elements and the linear network solutions at harmonic frequencies. Harmonics generated by static VAr compensators with thyristor-controlled reactors under unbalanced load conditions are used to illustrate the method	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=131060
Harmonics and Dynamic Response of a Virtual Air Gap Variable Reactor	Dolan, D.S.L.; Lehn, P.W.	Dept. of Electr. Eng., California Polytech. State Univ., San Luis Obispo, CA, USA	2012	As more sustainable energy generation is integrated into power grid, the control of power flow in an efficient and effective manner becomes more and more essential. A new innovative device is presented that allows the control of line power flow without the high harmonics and efficiency losses of traditional methods. This paper presents the dynamic response and the harmonics of a laboratory prototype Virtual Air Gap Variable Reactor (VAG-VR) and compares them with those of a thyristor controlled reactor (TCR). Variable Reactors have many applications in the power industry. Their use allows control of line power flow, voltage regulation, as well as damping of power oscillations and sub synchronous resonances. A variable reactor is most commonly implemented as a TCR by switching in and out a constant reactance to achieve an averaged variable reactance. By using a virtual air gap, implementation of a continuously variable reactance is possible with a better dynamic response and without introducing the harmonics created by the thyristor switching of a TCR.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6209150
Preventing of transient voltage instability due to induction motor loads by static condenser	Liu Haijun; Huang Wenying; Renzhen	Dept. of Electr. Eng., Chongqing Univ., China	1994	A new digital simulation method for the study of transient voltage stability in electric power systems is presented in this paper. With the aid of this simulation method, transient voltage instability prevention due to the presence of large induction motor loads at the terminals of long transmission lines by the static condenser (statcon), is analysed. The simulation results are compared with those of the thyristor controlled reactor/fixed capacitor static VAr compensator (SVC). It is demonstrated from the simulation results that the statcon is practical in preventing transient voltage instability	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=467211
Improved power regenerative controls by using thyristor rectifier bridge of voltage source inverter and a switching transistor	Matsui, K.; Mizuno, U.; Murai, Y.	Dept. of Electr. Eng., Chubu Univ., Kasugai, Japan	1992	A few improved techniques of regenerative control for the voltage source inverter are described. In the proposed equipment, the thyristor rectifier bridge can be also utilized for regeneration through a DC reactor or capacitor. For the first converter mentioned, a novel pulse-width-modulated (PWM) strategy is proposed in which the polarity of the sawtooth carrier waveforms is reversed alternately at every 60Â° interval of the fundamental frequency to reduce the harmonics in quantity. For the next proposed type, a modified Cuk converter method is described for regeneration, whose output current becomes a perfectly zero ripple. The third purpose is to propose a novel frequency analysis method using the switching function. The validity of its theory is confirmed experimentally	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=158823
Power regenerative controls by utilizing thyristor rectifier of voltage source inverter	Matsui, K.; Tsuboi, K.; Muto, S.	Dept. of Electr. Eng., Chubu Univ., Kasugai, Japan	1992	A novel technique of regenerative control for the voltage source inverter is described. In the proposed equipment, the rectifier bridge can be also utilized for regeneration through the medium of the DC reactor. For the other proposed type, a modified Cuk converter method is mentioned. The output current waveforms are analyzed by a new frequency analysis approach, using the switching function. The correctness of the theory has been experimentally confirmed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=148447
A dual thyristor	Matsui, K.;	Dept. of	1991	A converter is presented which can reduce harmonics like the conventional 12-pulse converters with input three	http://ieeexplore.iee

converter reducing harmonics of power supply without input transformer	Tsuboi, K.; Muto, S.; Iwata, K.	Electr. Eng., Chubu Univ., Kasugai, Japan		phase transformers. This circuit has the center tapped reactor which controls the DC link current, at different two values. The converter need not use the input three phase transformer that usually makes the cost higher. The proposed circuit has commutation with the capacitor whose commutation is executed successfully with constant reverse bias time. Secondly, the idea of current control with the center tapped reactor is developed for a single phase novel rectifier circuit which reduces the lower order harmonics in the power system.<<ETX>>	e.org/stamp/stamp.jsp?arnumber=178348
Power regenerative controls by utilizing thyristor rectifier of voltage source inverter	Matsui, K.; Tsuboi, K.; Muto, S.	Dept. of Electr. Eng., Chubu Univ., Kasugai, Japan	1989	A technique for the regenerative control of a voltage source inverter is described. In the proposed equipment, the rectifier bridge is utilized for regeneration through a medium of a DC reactor. Another type of regenerative control that involves a modified Cuk converter method is described. A frequency analysis approach using the switching function is used in order to analyze the output current waveforms. The appropriateness of this theory is experimentally confirmed.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=96752
Development of an analytic state-space description of power systems including thyristor controlled series compensation	Weindl, C.; Herold, G.	Dept. of Electr. Eng., Erlangen-Nurnberg Univ., Germany	2000	The paper describes a method to create an analytic state-space description of power systems including thyristor controlled series compensated lines. It utilizes the periodicity of all state variables in steady-state operating mode. The system representation is based on four physically conceivable and periodic switching states which can be distinguished in stationary operation mode. The entire system, consisting of the surrounding three-phase network, the thyristor controlled reactor and the optionally switched compensation capacitors is represented in complex space-phasor networks for each of the possible switching states. In this way, the resulting state-space description considers the eigenvalues and switching sequence of the complete network structure. The respective linear independent circuits can be coupled into linear inhomogeneous boundary value problems for each operating mode which can be solved as a whole. Therefore the time functions of all state variables are obtained by a closed loop calculation	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=896859
A phase-controlled 12-pulse rectifier with unity displacement factor without phase shifting transformer	Blauth, Y.B.; Barbi, I.	Dept. of Electr. Eng., Fed. Univ. of Rio Grande do Sul, Porto Alegre, Brazil	1998	This paper presents a three-phase 12-pulse phase-controlled rectifier with unity displacement factor, low line current harmonic content, two quadrant operation and the absence of a phase shifting transformer. The circuit is composed by two three-phase 6-pulse rectifiers parallel connected by four balancing reactors. One is a conventional thyristor rectifier with a lag firing angle (Î±). The other is an active rectifier composed by GTOs or IGBTs and diodes, operating with a lead (and symmetrical) firing angle (-Î±). The 12-pulse operation with line frequency modulation provides a 5-level line current with reduction or cancellation of certain harmonics. Circuit operation, theoretical analysis, key equations, along with experimental and simulation results are presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=654016
An implementation and switching characteristics comparison of power semiconductor based Marx generator using by SI-Thyristor and IGBT	Jung-Ho Park; Bong-Seong Kim; Kwang-Cheol Ko	Dept. of Electr. Eng., Hanyang Univ., Seoul, South Korea	2010	An employment of power semiconductor switch on the pulsed power applications becomes a reasonable due to its faster repetitive operating frequency, semi-permanent life, good reliability, and simple switching control by low signal modulation. Especially, at hard switching condition on the pulsed power application, series connection control methods of power semiconductor are generally preferred. However, in a certain case of pulse power application such as IEC (Inertial Electrostatic Confinement), high voltage switch that is composed of series connected power semiconductor has possibility to be unstable because of rapid impedance change on the reactor. Thus, we studied switching characteristics of Marx generator using by IGBT and SI-Thyristor. The Marx generator used IGBT was constructed and experimented. And SI-Thyristor driving circuit was designed and tested.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5958362
Passive Control on the	Wang Li-	Dept. of	2011	The passive control method that apply the passive power filter (PPF) to suppress negative effect of the Thyristor	http://ieeexplore.iee

Negative Effect of Thyristor Switched Capacitor (I)	guo; Xia Yu; Ren Xiang; Xu Dian-guo; Xu Zhuang	Electr. Eng., Harbin Inst. of Technol., Harbin, China		Switched Capacitor (TSC) is given in this paper, in order to improve zero-crossing voltage detection algorithm of controller of TSC. The study aims to suppress transient surge of reactive power induced by the TSC to a point of common coupling (PCC) of the power distribution system. In order to avoid parallel resonance of TSC with PPF to equivalent reactor of the PCC, differential equations that described dynamic behaviors of TSC with PPF are derived by network thermodynamics modeling method. The results show that by proposing method total harmonic distortion (THD) of the current of 6.3kV bus may be decreased to 2% from 17.49%.	e.org/stamp/stamp.jsp?arnumber=5748810
Effects of the Quality Factor of reactor on the TCSC characteristics and the Dual Impedance Solution Phenomenon	Hai-shun Sun; Shijie Cheng; Lin Jiang; Jianguo Zhao; Jia Ma; Jinyu Wen	Dept. of Electr. Eng., Huazhong Univ. of Sci. & Technol., Wuhan	2006	This paper investigates how the reactor's quality factor (labeled as Q at power frequency) affects the characteristics of TCSC and what principle should be followed in designing an experimental TCSC setup. Since no close-form representation of the fundamental frequency impedance (EFFI) against the firing angle can be obtained considering the quality factor of the reactor, detailed electromagnetic transient simulation is employed for the investigation. Results show that, under the same firing condition, the EFFI of TCSC using reactor with low Q value may present considerable resistance component compared with that of the ideal case when Q is infinite. Moreover, it is found that the EFFI of the TCSC using a reactor with limited Q can be either inductive or capacitive for a specified firing angle when it is fired in a line current reference mode. This so-called dual impedance solution phenomenon is analyzed in detail in the paper.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4116225
Design, simulation and realization of the filter for high power NPC inverter	Li Weibo; Mao Chengxiong; Lu Jiming; Fan Shu; Duan Xianbo	Dept. of Electr. Eng., Huazhong Univ. of Sci. & Technol., Wuhan, China	2002	The paper presents a three-level pulse-width modulation (PWM) technique for AC/DC/AC converter with high voltage (line to line voltage is up to 6000 volts) and high power (up to 2500 kilowatts) for the pump of the power plant. In the inverter, a capacitor voltage compensator is adopted to balance the neutral point voltage for maintaining good quality voltage waveforms on the output of the inverter. A common-mode voltage reactor (CMVR), a three-phase LC-filter and the neutral-point-clamped (NPC) technique are employed in order to eliminate the bad impact of the common-mode voltage (CMV), to reduce the harmonic contents of the inverter output voltages. In the inverter side, the integrated gate commutated thyristor (IGCT) has been adopted as the output switches in this equipment. Computer simulation results based on MATLAB environment are given to confirm the proposed methods which are suitable for designing the high voltage and high power inverter applied to induction motor drive.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1053610
State space simulation and accurate determination of fundamental impedance characteristics of a TCSC	Ghosh, A.; Joshi, A.; Mishra, M.K.	Dept. of Electr. Eng., Indian Inst. of Technol., Kanpur, India	2001	A new method of derivation of the fundamental impedance characteristics of a thyristor controlled series compensator (TCSC) is discussed in this paper. This derivation uses the state space model of a fixed capacitor-thyristor controlled reactor (FC-TCR) circuit. It is assumed that the FC-TCR circuit is supplied by a constant AC current source. The fundamental TCSC characteristics are then derived by the step-by-step solution of state equation. In this derivation we present two methods-one assuming that the TCR reactor has infinite Q-factor and the other assuming that it has finite Q-factor. The derived fundamental characteristics are verified through digital computer simulation studies and some experimental results are also presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=917224
A combined system of passive filter and TCR for power quality improvement in a 25-kV electrified railway	Salehifar, M.; Ranjbar, M.; Amirahmadi, A.; Shoulaie, A.	Dept. of Electr. Eng., Iran Univ. of Sci. & Technol.,	2009	a new configuration is proposed to mitigate power quality problems in traction system. Proposed configuration is a combined system of single tuned passive filter and a thyristor controlled reactor. This configuration is cheaper and easier to implementation. It decreases power losses in supply system considerably through optimal compensation of reactive power. Also its control strategy is simple. A phase locked loop is proposed in control system which can work in case of harmonic voltage and noisy conditions; it has not been used yet in such	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5412115

system		Tehran, Iran		systems practically. A fuzzy controller determines the firing angle of the thyristor controlled reactor and provide voltage profile at desired value. Validity of this configuration is confirmed through simulation results with Matlab program.	
A compact algorithm for three-phase three-wire system reactive power compensation and load balancing	San-Yi Lee; Wei-Nan Chang; Chi-Jui Wu	Dept. of Electr. Eng., Kao Yuan Junior Coll. of Technol. & Commerce, Kaohsiung, Taiwan	1995	A compact control algorithm for reactive power compensation and load balancing with the static VAr compensator (SVC) in three-phase three-wire power systems is developed in this paper. Each phase susceptance of the SVC can be obtained from a very simple function of voltage and power signals which are measured by a three-phase voltage transducer and two single-phase active and reactive power (P-Q) transducers at the load bus. The calculation of compensation susceptances is based on the criterion of a unity power factor and zero sequence currents after compensation. A simulation is made, as the first stage, to show the validity of the proposed compensation algorithm. Then, a laboratory size microcomputer-based SVC, which consists of thyristor-controlled reactors (TCRs) and fixed capacitors (FCs), is designed and implemented. Simulation and experiment results show that the algorithm is very suitable for online control of the SVC which is designed for phase balancing and power factor correction	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=500753
Reactive power compensation and load balancing for unbalanced three-phase four-wire system by a combined system of an SVC and a series active filter	Lee, S.-Y.; Wu, C.J.	Dept. of Electr. Eng., Kuang Wu Inst. of Technol. & Commerce, Taiwan, China	2000	A combined reactive power compensation method of a static VAr compensator (SVC) and a series active filter is described for unbalanced three-phase four-wire distribution feeders with harmonic distortion. The SVC which consists of Î”-connected thyristor-controlled reactors, Y-connected thyristor-controlled reactors and passive filters, acts as a classic reactive power compensator for load balancing and power factor correction. The small rating active filter is used to improve the filtering characteristics of the passive filter in the SVC and suppress possible resonance between the system impedance and the passive filter. Simulation results performed by the Electromagnetic Transients Program show that the proposed reactive power compensation configurations can effectively balance currents, correct power factor and eliminate harmonic currents	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=894425
Improved current control dynamics at the point of inflection in tokamak coil power supply	Il-Han Choi; Seung-Ho Song; Seung-Gi Jeong; Jong-Seok Oh; Jungwan Choi; Jae-Hak Suh	Dept. of Electr. Eng., Kwangwoon Univ., Seoul, South Korea	2010	Tokamak coil power supply for superconductivity coil of ITER(International Thermonuclear Experimental Reactor) requires fast dynamic performance of di/dt and smooth changeover of current direction. To meet the specification high performance this power supply is designed for 12-pulse thyristor dual converter with interphase reactor(IPR). The study about improving current control transient response had been progressed in the ac-dc thyristor converter when the sign of current reference changes from positive to negative or vice versa. When the gradient of the current reference changes, an additional feedforward compensator is proposed in this paper to supply the voltage change in the load inductance. For practical implementation of the derivative of current reference, a low pass filter is designed and tested in case of the reference signal contains noise.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5543870
Theoretical equation for frequency response of thyristor-controlled reactor	Kakimoto, N.; Nakamura, M.; Nagai, T.	Dept. of Electr. Eng., Kyoto Univ., Japan	1999	Static VAr compensators (SVC) and thyristor-controlled series capacitors (TCSC) are composed of thyristor-controlled reactors (TCR) and capacitor banks. We derive theoretical equations for TCR admittance, which are important in studying harmonic instability and subsynchronous resonance.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=826731
Investigation on the behavior and harmonic voltage	Sawetsakulanond, B.; Kinnares, V.	Dept. of Electr. Eng., Mahanakorn	2008	This paper proposes the investigation on the behavior and harmonic voltage distortion of terminal voltage regulation by static var compensators for three phase, 2.2 kW, 220/380 V, 8.7/5 A, 4-poles, self-exited induction generators (SEIG). Consideration of capacitance for the SEIG based on equivalent circuit model under steady -	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4747

distortion of terminal voltage regulation by static var compensators for a three phase self-exited induction generator		Univ. of Technol., Bangkok		state load conditions and a power flow diagram is given. Two types of a Fixed capacitor, Thyristor controlled reactor (FCTCR) static var compensator are used for terminal voltage regulation. Comparative performance of the SEIG and harmonic voltage distortion under dynamic and steady-state operation with pure resistive is given. Research results can be guidelines for the development of effective wind induction generators for electricity generation system.	056
A static compensator model for use with electromagnetic transients simulation programs	Gole, A.M.; Sood, V.K.	Dept. of Electr. Eng., Manitoba Univ., Winnipeg, Man., Canada	1990	A static VAr compensator (SVC) model based on state variable techniques is presented. This model is capable of being interfaced to a parent (or host) electromagnetic transients program, and, in particular a stable method of interfacing to the EMTDC program is described. The model is primarily that of a thyristor-controlled reactor. (TCR) and a thyristor-switched capacitor (TSC). Capacitor switchings within the TSC have been handled in a novel way to simplify storage and computation time requirements. During thyristor switching, the child SVC model is capable of using a smaller timestep than the one used by the parent electromagnetic transients program; after the switching, the SVC model is capable of reverting back to a (larger) timestep compatible with the one used by the parent program. Other features considered include the modeling of a phase-locked-loop-based, valve firing system. An application of this model to the simulation of a SVC controlling the AC voltage of the inverter bus of a back-to-back HVDC (high-voltage direct current) tie is presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=57982
A multi-module PWM switched-reactor-based static VAr compensator	Lopes, L. A C; Joos, G.; Boon-Teck Ooi	Dept. of Electr. Eng., McGill Univ., Montreal, Que., Canada	1996	This paper presents a variable reactance-type static VAr compensator (SVC) which employs force-commutated switches as well as thyristors. The proposed compensator employs thyristor switched capacitors (TSC) and a fixed capacitor bank to control, in steps, the amount of reactive power generated. Fine adjustment of the reactive power generated and also the reactive power absorbed by the SVC are obtained with N modules of a new four-switch (force-commutated) PWM controllable reactor. These are controlled with phase shifted carriers in order to achieve harmonic cancellation. The features of this multi-module PWM SVC are analyzed using switching functions and confirmed with simulation results	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=548629
An economic comparison between incorporation of FACTS devices and Demand Response programs for ATC enhancement	Shayesteh, E.; Yousefi, A.; Moghaddam, M.P.; Yousefi, G.-R.	Dept. of Electr. Eng., Modares Univ., Tehran	2008	In this paper an economic comparison between using FACTS devices and demand response programs implementation for the enhancement of available transmission capacity is addressed. In order to reach to this target first, direct load control program, as the most common demand response program, is considered. Then, enhancement of ATC by using of TCSC, shunt capacitor and shunt reactor is investigated. Finally, an economic analysis for the above ATC enhancement resources is performed and an economic feasibility study is conducted. The proposed method is evaluated by numerical studies based on IEEE 30-bus test system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4763307
Developing static reactive power compensators in a power system simulator for power education	Wei-Nan Chang; Chi-Jui Wu	Dept. of Electr. Eng., Nat. Taiwan Inst. of Technol., Taipei, Taiwan	1995	This paper describes a newly installed laboratory module microcomputer-based static reactive power compensator (SVC) in detail to teach students how an SVC affects system voltage, load balancing, power factor, and transmission line losses. The SVC is merged into an old power system simulator for extensive power engineering education. The structure of the SVC is thyristor controlled reactors with fixed capacitors (TCR-FC). Two control algorithms, feedback control and feedforward control, are developed and compared. For the purpose of program flexibility and portability, a VME-Bus based microcomputer is used to synthesize the controller of the SVC. Several suggested experiments are given to show the effects of the SVC on distribution	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=476036

				system compensation. The SVC greatly promotes the performance of the power system simulator.	
Damping of synchronous generator by static reactive power compensator with digital controller	Wu, C.J.; Lee, Y.-S.	Dept. of Electr. Eng., Nat. Taiwan Inst. of Technol., Taipei, Taiwan	1991	A static reactive power (VAr) compensator (SVC), constructed by fixed capacitors (FC) and thyristor controlled reactors (TCRs), is designed and implemented to improve the damping of the synchronous generator. A digital proportional-integral (PI) controller is synthesised by the Motorola M68HC11 single chip microprocessor board to modify the reactive power compensation of the SVC from adjusting the conduction angle of the thyristors. The SVC is placed at the generator bus terminal with the speed deviation (Î”Ï‰) as the feedback signal for the PI controller. The pole assignment method is used to determine the gains of the PI controller. Results from digital simulation and the implementation test show that the SVC with the PI controller can greatly enhance the damping of the system oscillation caused by disturbances. Although the PI controller is designed at a special operation point, it can also provide a good damping effect at other operation conditions. The voltage profile of the generator is also improved by the SVC	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=92947
A new method for balancing a three-phase induction motor supplied by a single-phase source	Yaw-Juen Wang; Zhou, H.	Dept. of Electr. Eng., Nat. Yunlin Univ. of Sci. & Technol., Touliu, Taiwan	2011	A three-phase induction motor (IM) powered by a single-phase supply is working under a very unbalanced condition, necessitating it to be derated to avoid overheating. To improve the performance of single-phase powered IMs, a new circuit scheme is proposed in this paper. The proposed circuit scheme is inspired by the traditional Steinmetz connection which employs a capacitor to connect the motor's third terminal to either of the two terminals of the single-phase source supplying the motor. The proposed scheme uses two sets of static var compensators (SVCs), a parallel combination of a thyristor-controlled reactor and a capacitor, as a phase balancer. By properly choosing the element values of the two SVCs, this new scheme allows the motor to operate under a perfect balanced three-phase voltage condition.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6497758
Online power factor improvement of induction motors	Haque, Syed Enamul; Malik, Nazar H.; Smiai, M.S.	Dept. of Electr. Eng., NED Univ. of Eng. & Technol., Karachi, Pakistan	1988	A description is given of the design and implementation of a simple scheme to achieve online and dynamic power-factor improvement of single and three-phase induction motors subjected to variable loads. The proposed scheme uses a fixed-capacitor thyristor-controlled-reactor type of static compensator along with associated control circuits. The results show that under all loading conditions, a power factor of almost unity is achieved automatically. The waveform of supply current can be kept almost sinusoidal. The response time of the scheme to motor load changes is quite reasonable. Details regarding design, implementation, analysis and operation of such dynamic power-factor compensators are provides.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=25257
Studies on power conditioning system for SMES in ITER	Ise, T.	Dept. of Electr. Eng., Osaka Univ., Japan	2001	The International Thermonuclear Experimental Reactor (ITER) draws huge power from utility power grid and it may cause some problems in the power system. Especially, the power required to control the movement of plasma caused by some instabilities of the plasma is suitable for compensation by SMES, because the time duration is a few seconds although the required power is around 100 MW. In this system, the design of the power conditioning system is one of the keys. As a power conditioning system, two systems were studied; one is the system using line commutation and light triggered thyristors, another is the system of multi-series converters using forced commutation and gate turn-off devices such as GTOs. Feature of the former circuit is the inter-phase DC reactor-less configuration. Thyristor rectifiers are directly connected in parallel at DC side, primary side windings of rectifier transformers are connected in series in order to ensure equal sharing of current between rectifiers. Reactive power can be compensated by TSC (thyristor switched capacitors). The performances of two proposed circuits were studied by computer simulation	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=920220

Analysis of flicker generation in DC arc furnaces	Mattavelli, P.; Perna, M.	Dept. of Electr. Eng., Padova Univ., Italy	1999	This paper presents an analytical method to evaluate instantaneous flicker sensation due to sinusoidal perturbation of arc parameters in DC electrical arc furnaces (EAF) including most of the important design and control parameters. The method is based on the modeling in the frequency domain of the linearized dynamic behavior of the main components of DC EAF, such as the AC/DC thyristor rectifiers, thyristor controlled reactors (TCR), and reactive power transducer. This approach is a useful tool for understanding the impact of different design parameters on voltage fluctuation and for deriving design criteria for the parameters of current regulators, harmonic filters, smoothing chokes, synchronizing scheme, and reactive power transducers.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=826602
Waveform distortion impact of TCSC in FCL mode on transmission line protection	Khederzadeh, M.	Dept. of Electr. Eng., Power & Water Univ. of Technol. (PWUT), Tehran, Iran	2009	This paper presents the impact of waveform distortion of Thyristor-Controlled Series Capacitor (TCSC) operating as a Fault Current Limiter (FCL) on transmission line distance protection. Although the poor waveform and the high valve stress of TCSC in inductive boost mode is less attractive for steady state operation, it is more desirable for limiting the fault current by increasing the inductance of the line higher than the parallel combination of the capacitor and the reactor. This mode of TCSC operation is accompanied by high current distortion which can seriously affect the commercial distance relay functionality not suitably designed for such circumstances. Simulation results show the extent of waveform distortion. A real relay widely applied in power systems is used for testing. The results indicate poor behavior of the relay when TCSC operates as a FCL.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5276039
Intelligent static VAr compensator control for supply loading optimization	Van Harmelen, G.L.; Enslin, J. H R	Dept. of Electr. Eng., Pretoria Univ., South Africa	1992	A digitally adaptive static Var compensator (SVC) controller for supply-side loading minimization is proposed. The control scheme is based on a model reference control structure where a model (which includes its nonlinear behavior) for the thyristor controller reactor is present within the digital signal processor. This allows minimization software to use time-domain samples of three-phase line voltages and load currents to minimize the supply side loading (i.e., maximize power factor). This type of control uses the minimization of a cost function and therefore this same controller automatically also compensates for imbalance in a multiphase supply	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=624441
Adaptive control of a TCR for hybrid compensators using the energy distribution optimization approach	Van Harmelen, G.L.; Enslin, J. H R	Dept. of Electr. Eng., Pretoria Univ., South Africa	1991	An energy related approach for the interpretation and subsequent compensation of electrical power networks is introduced. It is proposed that optimum supply utilization is brought about by the correct time distribution of the energy drawn from the source and supplied to a load. Hybrid compensators are proposed in order to perform cost-effective energy redistribution between the source, the load, and the compensators. A time-domain-based digital adaptive control technique for TCRs (thyristor controlled reactors) in such a compensation system is described. An optimum reactive current is calculated in the time domain, and a linear extrapolation predictor is further implemented in real time to estimate future values of the firing angles for the thyristors. This feature is implemented in order to improve the dynamic response of the system for changing load conditions	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=162693
A microprocessor-controlled variable impedance adaptive fault current limiter	King, E. F.; Chikhani, A.Y.; Hackam, R.; Salama, M.M.A.	Dept. of Electr. Eng., R. Mil. Coll., Kingston, Ont., Canada	1990	The design and modeling of a microprocessor-controlled variable-impedance fault current limiter is described. The limiter consists of an LC series circuit tuned to be of minimum impedance at the supply frequency. A thyristor-controlled reactor is shunt connected across the capacitor. By varying the firing angle of a thyristor pair, the impedance of the limiter is varied to allow the necessary current limitation so that the system is protected and all circuit-breaker relays can operate. The fault current limiter is modeled using a digital computer and validated in the laboratory with a prototype test setup	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=103679
An expert microprocessor	Paziuk, L. A.; Chikhani,	Dept. of Electr. Eng.,	1989	A microprocessor-controlled voltage regulation system capable of controlling the voltage level on distribution feeders to reduce energy consumption and power demand was successfully built and tested in a laboratory	http://ieeexplore.ieee.org/stamp/stamp.j

controlled voltage regulator for energy conservation and demand reduction in distribution feeders	A.Y.; Hackam, R.	R. Mil. Coll., Kingston, Ont., Canada		environment. The compensator consists of a thyristor-controlled reactor (TCR) biased by a fixed capacitor. The reactive power injected into the feeder by the compensator is continuously controlled by adjusting the firing angle of the thyristors in the TCR, which results in continuous control of the feeder voltage level. The ability of the controller to distinguish between various types of loads and regulate the load voltage to a particular value for a specific load type was also successfully demonstrated. Harmonic suppression of the third and fifth-order harmonic currents produced by the TCR is also carried out using separate shunt filters. The filters also serve to provide the capacitive biasing of the compensator	sp?arnumber=35650
Effects of system parameters on the steady-state characteristics of a DC transmission system including wind turbine generating systems	Yamashita, K.; Nishikata, S.	Dept. of Electr. Eng., Salesian Polytech., Tokyo, Japan	2012	A DC transmission system including wind turbine generating systems has been proposed and its steady-state characteristics have been analyzed for a tested system. In this paper, in order to obtain more general results, the steady-state characteristics of the proposed system under average-constant conditions are analyzed. Furthermore, the effects of the system parameters such as duplex reactor inductances and synchronous machine short-circuit ratio on the characteristics of the system are revealed. It is shown that when the short-circuit ratio of the synchronous compensator at the receiving-end circuit is large, the kVA capacity of the synchronous compensator can be reduced. Finally, appropriate system parameters are discussed in detail.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6401999
Microprocessor-based control of an SVC for optimal load compensation	Exposito, A.G.; Vasquez, F.G.; Mitchell, C.I.; Garcia, T.G.; Madronal, F.d.P.	Dept. of Electr. Eng., Seville Univ., Spain	1991	An open-loop control strategy for optimal compensation of arbitrary loads by means of thyristor-controlled reactors (TCRs) is presented. Real-time implementation of this technique on a microprocessor-based working prototype is described. Simulation and experimental results show that, using the proposed scheme, abrupt load changes are always compensated within the next cycle	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=169619
Modeling of facts and custom power devices in distribution network to improve power quality	Sahoo, A.K.; Thyagarajan, T.	Dept. of Electr. Eng., SSN Coll. of Eng., Chennai, India	2009	Electromagnetic transient studies have always played an essential role in the analysis of electrical power systems. They provide priceless information relating to the behaviour of the system in the event of different forms of transient phenomena, which can hardly be achieved by other means. In this paper, an electromagnetic transient model of Fixed Capacitor/ Thyristor Controlled Reactor (FC-TCR) is developed and applied to the study of transients due to load variations. The work is then extended to custom power equipment, namely Distribution Static Compensator (D-STATCOM) and Dynamic Voltage Restorer (DVR) aimed at enhancing the reliability and quality of power flows in low voltage distribution networks. A new PWM based control scheme that requires only voltage measurements and no reactive power measurements has been proposed for both the custom controllers. PSCAD/EMTDC simulation tool is used for model implementation and to carry out extensive simulation studies. Comprehensive results are presented to assess the performance of each device as a potential custom power solution.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5442720
The research of optimal control system of SVC for reactive compensation of	Ding Renjie; Cao Zheng; Fan Miao	Dept. of Electr. Eng., Tsinghua Univ.,	2010	It is an effective method to adopt Steinmetz circuit to eliminate the unbalanced three-phase components for reactive compensation in distribution networks. However, the compensation capacity for a three phase circuit with a single phase load is great. This article proposes an optimal algorithm with the target of minimizing the total compensation capacity, and designs a new type control system with a kind of FC-TCR SVC. The	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5573990

single-phase load		Beijing, China		precondition for applying the optimal algorithm is analyzed, and then the analytical results are deduced. The dynamic simulations are carried on the platform MATLAB/SIMULINK and the results show that this algorithm has an obvious advantage in decreasing the compensation capacity without breaking the compensation claims.	
A new reliable supplied gate drive circuit for SCRs with breakover diodes for protection	Jun Zhang; Renjie Ding; Haitao Song	Dept. of Electr. Eng., Tsinghua Univ., Beijing, China	2004	A gate drive circuit for silicon controlled rectifiers (SCR) is presented which provides the combined functions of reliable firing performance, overvoltage protection to the device with a breakover diode (BOD), and status report of both the firing circuit and the SCR to the controller for judgement. In order to save cost and space, the gate drive circuit is self supplied eliminating auxiliary power supply. The gate drive circuit is isolated from the controller and the gate pulse generator with optic fibers for safety. The design has already been successfully applied in a thyristor-controlled reactor (TCR), and some experimental results are presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1329972
Design and implementation of a new kind of FC-TCR controller based on multiprocessor and digital phase shift triggers	Renjie Ding; Jun Zhang; Yong Min; Zhiqiang Shi; Haitao Song; Yuwei Zhao	Dept. of Electr. Eng., Tsinghua Univ., Beijing, China	2004	The design and implementation of a new kind of fixed-capacitor-thyristor-control led reactor (FC-TCR) controller based on multiprocessor (a DSP and a microcontroller) and digital phase shift triggers are presented. All the necessary software schemes required for the design and implementation of this FC-TCR controller based on multiprocessor and digital phase shift triggers are developed in detail. The advantages and features of the controller are highlighted and demonstrated. Experimental results from this control system are presented to confirm the theoretical analysis, software and hardware design.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1348914
Study on combined system of hybrid power filter and controlled reactor	Yi Zhang; Xinjian Jiang; Dongqi Zhu	Dept. of Electr. Eng., Tsinghua Univ., Beijing, China	2003	This paper presents a combined system of hybrid power filter and controlled reactors for compensating the reactive power and harmonic current under the condition of three-phase four-wire system. A delta-connected thyristor controlled reactor is used to eliminate fundamental negative-sequence current, and a Y-connected thyristor controlled reactor is used to compensate fundamental zero-sequence current. The instantaneous reactive power theory is modified for three-phase four-wire system. Adopted this theory, negative-sequence current and zero-sequence current can be detected accurately and rapidly.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1273882
An analytical mathematical model for describing the dynamic behavior of the thyristor controlled series compensator	Dongxia Zhang; Luyuan Tong; Zhongdong Yin; Zhonghong Wang	Dept. of Electr. Eng., Tsinghua Univ., Beijing, China	1998	The thyristor controlled series compensator (TCSC), composed of a capacitor in parallel with a thyristor controlled reactor (TCR), is a variant topology circuit. For such circuits there is no universal method to build the analytical mathematical model. The paper focuses on building an analytical model by the method of â€œtopologyâ€ to describe the dynamic behavior of TCSC. Based on the model, the steady-state model is derived and the dynamic characteristics are discussed. The model is verified by digital simulation and the method can be extended to similar devices and be used for optimizing the control systems	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=728998
Research on the magnetic valve thyristor controlled reactor	Yin Zhongdong; Chen Weixian; Chen Jianye; Wang Zhonghong;	Dept. of Electr. Eng., Tsinghua Univ., Beijing, China	1998	The magnetic valve thyristor controlled reactor (MVTCR) is presented and its configuration and working principle are described in this paper. It is set up for the mathematical models based on equivalent electrical circuit and magnetic circuit by using an analytical method to calculate steady-state characteristics. The characteristics of the reactor are shown by numerical simulations. Some interesting features of MVTCR are revealed in the paper. As an example, model tests of a prototype of 1 kVA, 0.4 kV reactor are performed to support the theoretical results	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=703478

	Wong Manchung				
Research on voltage regulation of magnetic valve controlled reactor based on thyristor	Liu Hong; Yin Zhongdong; Chen Weixian	Dept. of Electr. Eng., Tsinghua Univ., Beijing, China	1998	The magnetic valve controlled reactor and its automatic voltage regulation apparatus are introduced in the paper. First, its special configuration, working principle and characteristics are presented. The feature of the controlling system is analyzed. Finally, the results of the voltage regulating model test are given	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=729048
A Hybrid Passive Filter Configuration for VAR Control and Harmonic Compensation	Hamadi, A.; Rahmani, S.; Al-Haddad, K.	Dept. of Electr. Eng., Univ. du Quebec, Montreal, QC, Canada	2010	This paper proposes a novel topology for a three-phase hybrid passive filter (HPF) to compensate for reactive power and harmonics. The HPF consists of a series passive filter and a thyristor-controlled-reactor-based variable-impedance shunt passive filter (SPF). A mutual-inductance design concept is used to reduce the series passive filter inductance rating. The special features of the proposed HPF system are as follows: 1) insensitivity to source-impedance variations; 2) no series or parallel resonance problems; 3) fast dynamic response; and 4) significant size reduction in an SPF capacitor. The performance of the proposed HPF system is validated by simulation, as well as by experimentation, under different load conditions. Experimental and simulation results show that the proposed system can effectively compensate all voltage and current harmonics and reactive power for large nonlinear loads.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5313857
Symmetrical follow-up reactive current compensator	Hanzelka, Z.; Pirog, S.	Dept. of Electr. Eng., Univ. of Min. & Metall., Krakow, Poland	1993	The FC/TCR (thyristor controlled reactor) static compensator of which the TCR is formed by a thyristor bridge shorted on the DC side with no impedance is presented. It is fed from an AC supply network through a transformer with high voltage shorting, or a standard transformer provided with additional series reactors. The various operating conditions of such a system are analyzed. The operating efficiency of the compensator is examined in the time and frequency domains	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=290740
Fault component integrated impedance-based pilot protection scheme for the TCSC compensated EHV/UHV transmission line	He Shien; Suonan JaLe; Kang Xiaoning	Dept. of Electr. Eng., Xi'an Jiaotong Univ., Xi'an, China	2011	This paper presents a new pilot protection scheme based on fault component integrated impedance (FCII) of transmission line with thyristor controlled series capacitor (TCSC) and controllable shunt reactor (CSR) through the fault analysis of transmission line with TCSC and CSR. The FCII is defined as the ratio of the sum of the fault component voltage phasors across the two terminals in the transmission line to the sum of the fault component current phasors through the same line. It can be used to identify if there is a fault on the line or not. If the fault is out of the line, the FCII reflects the line capacitive impedance that has greater amplitude; if the fault is on the line, it reflects the system and line impedance that has relatively smaller amplitude. We can distinguish between internal faults and external faults according to the calculated value of amplitude of FCII. The new pilot protection can be easily set and is not sensitive to compensation level and dynamics of TCSC and CSR after being applied in the TCSC compensated transmission lines. The FCII based protection has the ability of fault phase selection. It is hardly under the influence of capacitive current and immune to higher fault transition resistance. The effectiveness of the new scheme is validated by simulations with ATP and Northwest China 750 kV project data.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6180456
A novel phase-control	Shou Bao	Dept. of	1999	A novel phase-controlled series compensation scheme is presented which is dual to the thyristor controlled	http://ieeexplore.iee

topology to improve characteristics of thyristor controlled series compensation in AC transmission systems	Zou; Czarkowski, D.	Electr. Eng., Yunnan Polytech. Univ., Kunming, China		reactor (TCR). The proposed scheme is called a thyristor controlled capacitor (TCC). The advantages of the TCC scheme in comparison to the TCR one are as follows: the inductor is not needed in the TCC, the VA rating of the capacitor is reduced, semiconductor switches are turned on at low di/dt and turned off at zero voltage, voltage and current ratings of switches are reduced by 40%, low voltage and peak current stress allows for use of a conventional series capacitor, the control algorithm is simple and the reactance of the TCC segment can be controlled continuously, voltage harmonics are reduced by about 50%, response time is not longer than two periods of the fundamental frequency. A salient feature of the TCC scheme is its greater than TCR ability to mitigate subsynchronous resonance and power swing, and to control power flow. The disadvantages of the TCC are that GTOs must be used in place of SCRs and inductive reactance of the series segment cannot be obtained without additional series reactors. The novel TCC topology has been validated by Pspice simulations	e.org/stamp/stamp.jsp?arnumber=787476
Combined system for reactive power control in wind farms	Bayod, A.A.; Dominguez, J.A.; Mur, J.; Melero, J.J.	Dept. of Electr. Eng., Zaragoza Univ., Spain	2002	Operation of wind turbine installations may affect the steady-state voltage in the connected network. The voltage fluctuations imposed by the wind farm will depend on the characteristics of the grid. This paper presents a combined system of a capacitor, a thyristor controlled reactor (TCR) and a small-rated active filter (PWM-VSI) whose goal is to obtain a regulation of reactive power in wind farms with a generation of harmonic currents very reduced. The electrical analysis and filtering characteristics are discussed theoretically and several situations are simulated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1182926
On modeling of high-voltage short circuit current limiter in East China Power Grid	Song Han; Xue-yan Mao; Li-quan He	Dept. of Electr. Eng., Zhejiang Univ., Hangzhou, China	2010	This paper establishes a model of HV-SCCL for electromechanical transient simulation using user-defined program of PSASP software. This model decides whether or how thyristor protected series compensation (TPSC) would be switched on or off and consequently controls the capacitive reactance value, through comparing periodically line current and its variation rate with the corresponding short-circuit current (SCC) threshold. The effectiveness of the proposed model is proved in a 4-machine system. Furthermore, its effects for limiting SCC and influences on system stability under conditions of different reactance parameters of SCCL are presented and analyzed in (East China Power Grid) ECPG. The results indicate that parameter selection of reactor in the SCCL applied to transmission line should not only consider an anticipative SCC limiting factor but also take into account those restrictions of series compensation degree, while the reinserting time of TPSC is also one of the critical elements required special attention in stability studies.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5589462
A study on modeling of high-voltage short circuit current limiter in electromechanical transient simulation	Song Han; Xue-yan Mao; Yong Chang	Dept. of Electr. Eng., Zhejiang Univ., Hangzhou, China	2010	A model of FACTS based high voltage short circuit current limiter(HV-SCCL) applicable for electromechanical transient simulation of large power grid is established with the user-defined program of PSASP software, which developed by China Electric Power Research Institute(CEPRI). Through comparing periodically line current and its variation rate with the corresponding short-circuit current (SCC) threshold, this model decides whether thyristor protected series compensation(TPSC) would be switched on or off and consequently control its capacitive reactance value. The effectiveness of the proposed model is proved in a 4-machine system. Furthermore, its effects for limiting SCC and influences on system stability under conditions of different reactance parameters of SCCL are presented and analyzed in East China Power Grid (ECPG).The results indicate that parameter selection of reactor in the SCCL applied to transmission line should not only consider an anticipative SCC limiting factor but also take into account those restrictions of series compensation degree, while the reinserting time of TPSC is also one of the critical elements required special attention in stability	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5666436

				studies. Furthermore, the observed dynamic behaviors imply that its impacts on small signal stability should be concerned especially when the protection failure or delayed reclosing of TPSC happens, which are being studied.	
The controllable impedance range of TCSC and its TCR reactance constraints	Zheng Xu; Guibin Zhang; Haifeng Liu	Dept. of Electr. Eng., Zhejiang Univ., Hangzhou, China	2001	In this paper, the steady state characteristics of the thyristor controlled series capacitor (TCSC) is analyzed in time domain and frequency domain. Based on this, the controllable impedance range of the TCSC and its TCR reactance constraints are studied. It is shown that the key point to select the reactance of the TCR is to determine the ratio of the reactance of the series capacitor to that of the TCR. The concept of impedance sensitivity factor (ISF) of the TCSC is presented and it is proved that the ISF is the main factor determining the controllable impedance range of TCSC. The relationship between the reactance ratio of the series capacitor to the TCR, the ISF, and other operation performances of the TCSC are also studied	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=970181
A sort of harmonic suppression and reactive power compensation device	Liu Jianben; Shan Yufei; Li Yongquan; Wang Huajun; Li Xin; Chen Qiaofu	Dept. of Electr. Machinery & Control, Huazhong Univ. of Sci. & Technol., Wuhan	2008	Phased rectifier thyristor commutate circuit will bring serious harmonic pollution to electric power system. If connect the ordinary settled single tuning passive filter, the harmonic current may be increased, even bring parallel syntony. In allusion to the harmonic problem of a certain steel factory in ZheJiang province, this paper design a project that connect a series reactor at the high voltage side, and the passive filter is parallel connection at the low voltage side. The passive filter adopt the thyristor switch to dynamic plunge and secede, with no process of transition. The reliability of the device is very good, and the compensate effect is also very well.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4771089
A novel variable reactor with transformer and inverter control	Dayi Li; Jun Tian	Dept. of Electr. Machines & Drives, Huazhong Univ. of Sci. & Technol., Wuhan	2008	In the paper, a novel principle of variable reactor with a transformer and inverter control is proposed. A transformer with air gap is chosen and its primary winding is connected in series or parallel in power utility, the primary winding current of the transformer is detected and functioned as the reference signal. A voltage source PWM inverter is applied to produce a voltage, which is a controlled voltage and energized across the secondary winding of the transformer. According to the transformerpsilas voltage equations, when the controllable voltage and the primary winding current satisfied a certain condition, the equivalent impedance of primary winding varies continuously along with the controlled voltagepsilas amplitude. Many types of flexible ac transmission system (FACTS) equipments, e.g., fault current limiter (FCL), power system unified load flow controller (UPFC), thyristor controlled series capacitor (TCSC), can be implemented in terms of the novel principle. Besides this, the stability condition is analyzed when the variable reactor is connected in series with a resistance-inductive load. The validity of the theory is proved by the simulation results.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4771579
Formula for the effect of a static VAr compensator on synchronising torque coefficient	El-Emary, A.A.	Dept. of Electr. Power & Machines, Cairo Univ., Giza, Egypt	1996	A static VAr compensator (SVC), constructed by a fixed capacitor (FC) and a thyristor controlled reactor (TCR), is designed and implemented to improve the damping of a synchronous generator, as well as controlling the power system voltage. The SVC is placed at the generator bus terminal, with the speed and voltage deviation as the feedback signals. In this paper, a formula has been developed showing the effect of SVC on synchronising torque coefficient, such that damping is improved and the system voltage is controlled. A simplified analysis of the effect of SVC on the stability of a machine connected to an infinite bus, as well as a simplified 21 bus real power system, is presented. Results from digital simulation show that the SVC can greatly enhance the damping of power system oscillations caused by disturbances. Also, the voltage profile of the generator is controlled by	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=556759

				the SVC	
Thyristor controlled reactor and its effect on distribution network	Mu Longhua; Wang Chonglin; Meng Qinghai	Dept. of Electr. Power Eng., China Univ. of Min. & Technol., Xuzhou, China	2001	A thyristor controlled reactor is introduced. The structure of this reactor is different from the traditional model as it is the integration of a traditional grounding transformer and reactor. A reactor with three phases and five columns can realize automatic trace and compensation for the capacitive charging current to ground of distribution network by the method of thyristor controlled inductive current of secondary winding. Furthermore, the neutral grounding via reactor will change distribution of the one-phase to ground fault current significantly. The present ground-fault protection cannot be applied to this kind of distribution network. A novel method of ground-fault protection is also presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=975313
Implementation of Shunt Active Power Filter for Dynamically Distorted Load Conditions Using Goertzel Algorithm	Karvekar, Sushil; Patil, Dadgonda	Dept. of Electrical Engineering, Walchand College of Engineering, Sangli, India	2013	In this paper the shunt active power filter (SAPF) under varying harmonic conditions is considered. The control technique used for reference current generation consists of Goertzel algorithm. The Goertzel Algorithm calculates the fundamental component of load current under non sinusoidal conditions with high speed and accuracy of response. The variation in harmonics is realized by changing the firing angle of Thyristor Controlled Reactor (TCR). The SAPF can be used for both single phase and 3 phase loads and can directly be connected to utility. The shunt active power filter controlled by Goertzel Algorithm is realized using MATLAB/Simulink. The simulation results meet the IEEE 519- 1992 recommended harmonic standard limits with minimum computations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6528918
The use of switching functions and Walsh series to calculate waveform distortion in thyristor controlled compensated power circuits	Rico, J.J.; Acha, E.	Dept. of Electron. & Electr. Eng., Glasgow Univ., UK	1998	A new model based on the Walsh series for assessing the steady state operation of three-phase thyristor controlled reactors (TCRs) is presented in this paper. The model represents the TCR as an admittance matrix which interfaces easily with other power plant components in the network. Clearly, the admittance matrix representation is not confined to Walsh domain but rather it is valid for any orthogonal approximation of functions having the operational properties used in this paper. However, the switching functions which characterise the operation of TCRs are better represented by the Walsh series and they have been used in this paper. This is a new development in power systems analysis. Other orthogonal series expansions such as Fourier series and Hartley series have been used elsewhere. The Walsh transform possesses the important operational properties of the product, coefficient and integration matrices. The relevant aspects of the interaction between the TCR and the electric network are analysed. A three-phase TCR and a transmission network represented by a Thevenin equivalent are used for this purpose	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=714510
Harmonic domain modelling of three phase thyristor-controlled reactors by means of switching vectors and discrete convolutions	Rico, J.J.; Acha, E.; Miller, T. J E	Dept. of Electron. & Electr. Eng., Glasgow Univ., UK	1996	The main objective of this paper is to report on a newly developed three phase TCR model for SVC which is based on the use of harmonic switching vectors and discrete convolutions. This model is amenable to direct frequency domain operations and provided a fast and reliable means for assessing 6- and l2-pulse TCR plant performance at harmonic frequencies. The use of alternate time domain and frequency domain representations is avoided as well as the use of FFTs. In this approach, each single phase unit of the TCR is modelled as a voltage-dependent harmonic Norton equivalent where all the harmonics and cross-couplings between harmonics are explicitly shown. This model is suitable for direct incorporation into the harmonic domain frame of reference where all the busbars, phases, harmonics and cross-couplings between harmonics are combined together for a unified iterative solution through a Newton-Raphson technique exhibiting quadratic convergence	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=517534

Swift time domain solution of electric systems including SVSs	Garcia, N.; Medina, A.	Dept. of Electron. & Electr. Eng., Univ. of Glasgow, UK	2003	This contribution deals with the application of Newton methods based on the Poincare map to accelerate the convergence to the limit cycle and to obtain the periodic steady state solution of electric networks containing static VAr systems (SVS). A three-phase time domain model for the SVS and the inclusion of the control system required for its automatic operation are presented. This is the first time that a full closed-loop control system has been included in a harmonic-oriented method. Furthermore, a model for the thyristor valves based on elementary functions is presented together with a scheme for determining the switching instants of the valves. Simulation results are compared against measurements taken in the laboratory in a TCR circuit.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1208377
A new combination of Shunt Hybrid Power Filter and Thyristor Controlled Reactor for harmonics and reactive power compensation	Rahmani, S.; Hamadi, A.; Al-Haddad, K.	Dept. of Energy Conversion & Power Electron. CRC-ECPE, Ecole de Technol. Super., Montreal, QC, Canada	2009	This paper proposes a new combination of a three-phase shunt hybrid power filter (SHPF) and a thyristor controlled reactor (TCR) for compensating harmonic currents and reactive power. The SHPF consists of a small-rated voltage source inverter (VSI) in series with a 5th harmonic tuned LC passive filter. The rating of the VSI in the SHPF system is much smaller than that in the conventional shunt active power filter because the passive filter takes care of the major burden of compensation. The task of reactive power and harmonic compensation is shared by the combination of the SHPF and the TCR. The tuned passive filter and the TCR form a shunt passive filter (SPF) to compensate reactive power and consequently the SHPF is used to eliminate harmonic currents. The control of the SHPF is based on a nonlinear control technique method. The dynamic model of the SHPF system is first elaborated in the stationary `abc' reference frame and then transformed into the synchronous orthogonal `dq' reference frame. Proportional-integral (PI) controllers are utilized to control the SHPF input currents and dc-bus voltage. The proposed combination provides the reactive power and harmonic currents required by the nonlinear load, thereby achieving sinusoidal supply currents in phase with supply voltages under dynamic and steady state conditions. The simulation results are discussed, and the performance of the topology is therefore evaluated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5420375
Harmonic generation by HVDC schemes involving converters and static VAr compensators	Yacamini, R.; Resende, J.W.	Dept. of Eng., Aberdeen Univ., UK	1996	The paper makes use of interactive harmonic analysis (IHA) to examine the harmonic behaviour of an HVDC scheme. The scheme is treated as a complete system including HVDC converters, static VAr compensators, system impedance and harmonic filters. It is shown that the type and performance of the controller can have a significant effect on harmonic behaviour. The paper illustrates, by analytical and computational analysis, the effect of equally pulse spaced (EPS) controllers and voltage zero crossing (VZC) type for both the above power electronic circuits. The EPS has clear advantages for 6 and 12 pulse HVDC converters but has little influence on the behaviour of thyristor controlled reactors. The need to represent the complete systems is highlighted by example	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=488063
Neural network approach to identification and control of sub-synchronous resonance in series compensated systems	Nagabhushana, B. S.; Chandrasekharaiah; Lai, L. L.; Vujatovic, D.	Dept. of High Voltage Eng., Indian Inst. of Sci., Bangalore, India	1999	The development of a precise mathematical model for SSR is a complicated process, especially, in power systems involving multiple generators and series compensated transmission lines. Further, the analysis of the SSR phenomenon for the entire operating range is computationally intensive. In view of these situations, it is envisaged that neural networks can be effectively employed to design SSR countermeasures. This paper presents such a contribution. Examples on systems with thyristor controlled shunt reactor are used to illustrate the benefit gained from this approach	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=792767
The Harmonic	Chen Yang;	Dept. of Inf.	2009	In power system, simulation is an effective method to analyze complex circuits. This paper first analyzes the	http://ieeexplore.iee

Characteristic Analyzing of Reactive Power Compensation Equipment Based on PSCAD	Zai-lin Piao; Chun-Ling Chen; Tong-Yu Xu	& Electr. Eng., Shenyang Agric. Univ., Shenyang		harmonic characteristic of the reactive power compensation equipment TCR (thyristor controlled reactor) in theory, then validates analysis results and gives the way of improving its performance in simulation software PSCAD (power system computer aided design). Practice proves that the model system built in PSCAD has excellent application value and the software PSCAD is very competent in harmonic analyzing and processing.	e.org/stamp/stamp.jsp?arnumber=4918883
Virtual instrument measures harmonic filter duty	Benton, J. S.	Dept. of Protection & Control, Georgia Power Co., Atlanta, GA, USA	1995	Harmonic filters for a static VAr compensator (SVC) suppress power frequency harmonics generated by the nonlinear characteristic of the thyristor controlled reactors and electric arc furnace loads. SVC filters also provide the 60 Hz capacitive current needed by the SVC to reduce bus voltage flicker. Following reactor and capacitor failures the reliability of the SVC filter was improved. The first step was to measure the SVC filter stresses which was performed using a virtual instrument. The measurement equipment consisted of a personal computer equipped with two analog-to-digital (4/D) input boards, two signal conditioning input boards, and commercially available instrument and control software capable of configuring these basic hardware components for user defined instrumentation and analysis. Virtual instruments were used to sample, store, analyze, and display 32 channels of high speed data for 55 minutes of the combined furnace heat cycle. The author discusses the virtual instrument software, measurement and analysis technique, and statistical analysis	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=468318
An EMTP simulation of the HVDC power system of a fusion energy machine	Taylor, E.A.; Goldberg, Saul; Jackson, M.	Dept. of Water & Power, Los Angeles, CA, USA	1989	In order to predict the effects of a fusion energy project's magnet current requirements on the harmonics and power factor at the power system's supply line source, a detailed three-phase converter model, including the overlap angle, is presented. This converter model is contained within the transient analysis control systems (TACS) portion of the electromagnetic transients program (EMTP). Using TACS variables to control the firing of the individual thyristors, an average load current can be requested, and the delay angle is internally compensated to produce the desired result. Load currents of various durations and amplitudes can be requested. Such a model allows the user to carry out realistic computer studies of typical high-voltage DC systems. The converter representation is then incorporated into an overall EMTP system model. Block diagrams of the converter model are provided. Simulation results utilizing the computer model compare favorably with theoretical expectations and with data resulting from previous fusion energy experiments.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=96779
Load rebalancing by TCR's technology: theory and model simulation	Quaia, S.; Tosato, F.	Dipartimento di Elettrotecnica Elettronica ed Inf., Trieste Univ., Italy	1991	Load rebalancing offered by proper reactive power management, employing the thyristor controlled reactor, fixed capacitor (FC-TCR) technique is discussed. By means of the static VAr compensator, three objectives can be simultaneously achieved: voltage regulation, power factor improvement, and load rebalancing. An electric system model is presented, and computer simulation results are discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=162119
Reactive power compensation by TCR technology: simulation for large electrical loads control	Tosato, F.; Quaia, S.; Rabach, G.	Dipartimento di Elettrotecnica, Elettronica ed Inf.,	1989	It is noted that the ability of an FC-TCR (fixed-capacitor thyristor controlled reactor) compensator to change its reactive power within the theoretical time of half a period requires, as a prerequisite, the setting up of a proper control function. In other words, the firing angle Î± of the thyristors in antiparallel has to be related to properly detectable input variables, i.e. load reactive power. The theoretical and computer-simulation approaches to this problem are examined and compared. The equations describing the relation between Î± and the load reactive	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=50003

		Trieste Univ., Italy		power are introduced. The whole system is then modeled and simulated by computer, and the results are compared with the theoretical ones. The control curves obtained theoretically agree well with those obtained by simulation. It is concluded that the proposed analytical approximating equation offers quite good results for practical purposes	
Analytical model for stability analysis in high power ac/dc converters applied to the ITER case	Finotti, C.; Gaio, E.; Benfatto, I.; Mankani, A.D.; Tao, J.	Dipt. di Energia Elettr., Univ. di Padova, Padua, Italy	2012	The ITER experiment is an international project that aims to prove the viability of energy production by a nuclear fusion reactor. The fusion reactions are achieved by heating a plasma up to million of Celsius degree and confining it by means of appropriate magnetic fields, which interact with the charged particles of the plasma. In ITER the magnetic fields will be produced by the currents flowing in the superconducting coils supplied by ac/dc converters based on thyristor technology. The ITER power supply system may consume a total active and reactive power respectively up to 500 MW and 950 Mvar; a Static Var Compensation system with nominal power of 750 Mvar based on Thyristor Controlled Reactor + Tuned Filter (as fixed capacitor) was selected to reduce the reactive power demand from the grid. In this paper an analytical approach has been considered to study the interactions between the ITER power supply system and the grid, taking the starting points from the methods developed for the HVDC applications, which is a large scale thyristor based converter system usually installed with reactive power compensation equipment. This model aims to evaluate the strength of the electrical network feeding the ITER power supply system by sensitivity analysis allowing the calculation of some index as the Critical Short Circuit Ratio and the Voltage Sensitivity Factor.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6381207
Current control of 12-pulse regenerative converter for 20 kA magnetic power supply	Se-Jong Jeong; Seung-Ho Song	Div. of Electron. & Inf., Chonbuk Nat. Univ., Jeonju, South Korea	2003	High current magnetic power supply for superconductivity coil of a tokamak requires fast dynamic performance of di/dt and smooth change over of current direction. To meet the specification high performance DSP-based controller is designed for 12-pulse thyristor dual converter with interphase transformer (IPT). Not only the total current of Y and /spl Delta/ converter units but also the difference for those should be regulated fast and accurately. Proportional and integral controller is designed for difference current control and the controller output is compensated to /spl Delta/ converter. A new algorithm for the calculation of the initial firing angle is proposed for the minimization of nonideal effect during the change over of dual converter currents.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1179223
Force-Commutated Reactive-Power Compensator	Walker, Loren H.	Drives Systems Operations, General Electric Company, 1501 Roanoke Boulevard, Salem, VA 24153.	1986	A reactive-power compensator (RPC) is a type of static var compensator (SVC) that is used to dynamically correct power factor to prevent voltage variation (flicker) in ac power sources due to large dynamic loads. It also minimizes total source current. Thus the application of an RPC or SVC to a load may allow addition of substantial new load to existing feeders or substations. A reactive-power compensator suited to industrial ratings (1.0-25 MVA) is described. It utilizes a force-commutated current-source bridge to provide both leading and lagging reactive power. The ability to operate both leading and lagging can reduce by 2:1 the ratings of the RPC itself and the capacitors and magnetics associated with it. The characteristics of the power circuit, the means used to control it, and the resulting dynamic performance is described. Speed of response compares favorably to the thyristor-controlled reactors now in common use as SVC's at higher MVA ratings. This RPC is suited to compensate any balanced three-phase dynamic load.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4504840
Optimum Switching of TSC-TCR Using GA	Kulkarni, D. B.; Udupi, G.	E & C Dept, Gogte Inst.	2009	Indian distribution systems are facing various power quality problems such as low power factor, harmonic distortion and reliability. SVC such as TSC-TCR is commonly used for balancing reactive power and correcting	http://ieeexplore.ieee.org/stamp/stamp.j

Trained ANN for Minimum Harmonic Injection	R.	of Technol., Belgaum, India		power factor. TSC-TCR type of compensators can compensate reactive powers of all the three phases independently by controlling the thyristors used in conjunction with TSC and delta connected Thyristor controlled reactors. TSC-TCR which are installed in distribution lines compensate unbalanced reactive power but while doing so the TCR injects harmonic currents of odd order into the point of common coupling. TSC-TCR types of SVCs have lower cost and moderately complex control strategy as compared to STATCOMs. This paper proposes a new method of controlling the injected harmonics of TSC-TCR system by using genetic algorithm based ANN training. The scheme can be effectively used at the existing TSC-TCR installations to reduce harmonic injections while catering to fluctuating loads.	sp?arnumber=5395075
ANN-Based SVC Switching at Distribution Level for Minimal-Injected Harmonics	Kulkarni, D.B.; Udupi, G. R.	E & C Dept., Gogte Inst. of Technol., Belgaum, India	2010	Electrical distribution system suffers from various problems, such as reactive power burden, unbalanced loading, voltage regulation, and harmonic distortion. Though DSTATCOMS are ideal solutions for these systems, they can be costly and have complexity compared to other reactive power compensation solutions. Phasewise-balanced reactive power compensations are required for fast-changing loads needing dynamic power factor correcting devices leading to terminal voltage stabilization. Static var compensators (SVCs) are preferred for these loads due to low cost and simple control strategy. These SVCs, while correcting power factor, inherently create harmonics due to the nonsinusoidal currents caused by the operation of thyristor-controlled reactors. This paper proposes minimizing the harmonics injected into the distribution systems with the operation of TSC-TCR-type SVC used in conjunction with fast-changing loads at the LV distribution level. The fuzzy logic system and ANNare used to solve this nonlinear problem, giving optimum triggering delay angles used to trigger thyristors in TCR. The scheme is attractive and can be used at SVC installations in distribution systems for steady-state reactive power compensation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5484645
Nonlinear dynamics and switching time bifurcations of a thyristor controlled reactor	Rajaraman, R.; Dobson, I.; Jalali, S.	Electr. & Comput. Eng. Dept., Wisconsin Univ., Madison, WI, USA	1993	The authors study a thyristor controlled reactor circuit used for static volt ampere reactive (VAR) control of electric power systems. The circuit exhibits switching times which jump or bifurcate. The nonlinear dynamics of the circuit are studied using a PoincareÂ´ map and it is demonstrated that the PoincareÂ´ map has discontinuities and is not invertible. These novel properties illustrate some of the basic features of dynamical systems theory for switching circuits	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=394191
New configuration of high-power inverter drives	Kawabata, Takao; Kawabata, Y.; Nishiyama, K.	Electr. & Electron. Dept., Ritsumeikan Univ., Kyoto, Japan	1996	New configurations for high-power and high performance drives suitable for steel rolling mill drives are presented. Three-level inverters using 6 inch, 6 kV, 6 kA GTOs, can deliver 10000 kVA output. But in case of drives rated more than several thousands of kW, this capacity is still insufficient. Usually, two three-level inverters are then combined using bulky, expensive inter-phase reactors. To meet these problems, a new configuration using the wound rotor induction motor and two inverters is proposed. In this configuration, the outputs of the two inverters are combined electromechanically in the machine; then novel features suitable for high-power drives can be obtained	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=551054
Design, Implementation and Operation of a New C-	Gercek, C.O.; Ermis, M.;	Electr. & Electron. Eng. Dept,	2010	In this research work, the transient overvoltage suppression capability and harmonic filtering performance of C-type 2nd harmonic filters are optimized by using two-stage damping resistors; one is permanently connected to the filter circuit, while the other one is switched on by back-to-back connected thyristors during furnace	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5616

Type 2nd Harmonic Filter for Electric Arc and Ladle Furnaces	Ertaş, A.; Kose, K.N.; Unsar, O.	Middle East Tech. Univ., Ankara, Turkey		transformer and Harmonic Filter (HF) energization periods. However in conventional C-type 2nd HFs there is only one damping resistor, which is permanently connected to the filter circuit. In conventional designs, either the filtering performance is maximized or transient overvoltage suppression capability is enhanced or a compromise is made between these two objectives. This new configuration of C-type 2nd HF has been applied to a sample iron and steel plant in which two LFs are in operation. For this purpose, an SVC system has been designed and installed which is composed of a thyristor controlled reactor, a 3rd HF and the new C-type 2nd HF configuration proposed in the paper. The results of field tests and simulation studies show that the proposed C-type 2nd HF configuration gives much better results than conventional designs.	744
Development of a laboratory model of hybrid static VAr compensator	Jayabarathi, R.; Sindhu, M. R.; Devarajan, N.; Nambiar, T. N P	Electr. & Electron. Eng. Dept., Amrita Vishwa Vidyapeetham Deemed Univ., Coimbatore	2006	With the steady increase in the demand for electric power, there is an expansion in the transmission and generation capacity of the existing power systems. For the enhancement of the power transfer capability, voltage stability and also the dynamic stability of the existing transmission corridors, flexible AC transmission systems (FACTS) are now being extensively used. The shunt type of FACTS controllers are used to either absorb or inject vars into the system thereby providing appropriate reactive power compensation. This paper deals with the design, fabrication and testing of hybrid static VAr compensators comprising of thyristor controlled reactor (TCR) and thyristor switched capacitor (TSC). They are designed to be applied on the existing scaled down laboratory model of a long transmission line. The test results of the TCR and TSC demonstrate their capability to improve the system performance	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1632507
Design, Implementation, and Operation of a New C-Type 2nd Harmonic Filter for Electric Arc and Ladle Furnaces	Gerçek, C.O.; Ermis, M.; Ertas, A.; Kose, K.N.; Ünsar, O.	Electr. & Electron. Eng. Dept., Middle East Tech. Univ., Ankara, Turkey	2011	In this paper, the transient overvoltage suppression capability and harmonic filtering performance of C-type 2nd harmonic filters (HFs) are optimized by using two-stage damping resistors; one is permanently connected to the filter circuit, while the other one is switched on by back-to-back connected thyristors during furnace transformer and HF energization periods. However, in conventional C-type 2nd HFs, there is only one damping resistor, which is permanently connected to the filter circuit. In conventional designs, either the filtering performance is maximized or transient overvoltage suppression capability is enhanced or a compromise is made between these two objectives. This new configuration of C-type 2nd HFs has been applied to a sample iron and steel plant in which two ladle refining furnaces are in operation. For this purpose, an static var compensation system has been designed and installed, which is composed of a thyristor-controlled reactor, a 3rd HF, and the new C-type 2nd HF configuration proposed in this paper. The results of field tests and simulation studies show that the proposed C-type 2nd HF configuration gives much better results than conventional designs.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5767551
Artificial neural network application for prediction of reactive power compensation under line outage contingency	Rai, A.; Babu, D.S.; Venkataramu, P.S.; Nagaraja, M.S.	Electr. & Electron. Eng., GGITM, Bhopal, India	2013	Static VAR Compensator is a variable impedance device where the current through a reactor is controlled using back to back thyristor connected valves. In this paper a successful attempt has been made to design an ANN architecture which predicts the quantum of compensation to be provided to the system for a specific line outage contingency in order to improve the system performance. The study is carried out on an IEEE-30 bus system using MATLAB software.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6527681
Combined System for Harmonic Suppression and Reactive Power	An Luo; Zhikang Shuai; Wenji	Electr. & Inf. Eng. Coll., Hunan Univ.,	2009	In this paper, a combined system of static Var compensator (SVC) and active power filter (APF) was proposed. The system has the function of power factor correction, voltage stability, and harmonic suppression. The SVC, which consists of delta-connected thyristor-controlled reactor (TCR) and Y-connected passive power filter (PPF),	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4694

Compensation	Zhu; Shen, Z.J.	Changsha		is mainly for voltage stability and power factor correction. The small rating APF is used to filter harmonics generated by the nonlinear load and the TCR in the SVC and to suppress possible resonance between the grid and the PPFs. The configuration and principle of the combined system were discussed first, and then, the control method of the combined system was presented. An optimal nonlinear proportional-integral control was proposed to improve the dynamic response and decrease the steady-state error of the SVC. Harmonic detection with precompensation method and improved generalized integrator control were proposed to improve the performance of APF. The new combined system is compared to classical SVC. It is implemented in a 200-kVA prototype in the laboratory. Simulation and experimental results show that the proposed combined configuration can effectively stabilize system voltage, correct power factor, and suppress harmonic currents.	015
Research on TCR type SVC system and MATLAB simulation	Zheng Shicheng; Fang Sian; Zhang Gaoyu	Electr. & Inf. Sch., AnHui Univ. of Technol., Ma"Anshan, China	2010	In this paper, the principle of Static Var Compensator (SVC) is analyzed in detail, and a kind of SVC system which consists of Thyristor Controlled Reactors (TCR) and Fixed Capacitor (FC) is designed. Bridge rectifier and L-R circuit is used to simulate the symmetrical three-phase load. Based on instantaneous reactive power theory, the SVC system signals are detected rapidly and precisely. In order to maintain the stability of the client node voltage and satisfy the requirements of system power factor, the voltage and admittance double loop control strategy is adopted, and the well-behaved steady-state effects is obtained. The break of node voltage caused by load disturbance or any other factors is restrained, and system power factor is well improved too. Finally, the SVC model is established under the environment of MATLAB simulation.The simulation results show that the proposed system can stabillize the fluctuation of power grid voltage and raise power factor, and the merits of fast response speed and high precision are verified.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5516668
High technology in a new power system to Broken Hill Mines	Lowe, S.K.; Holden, M. E K; Lucas, J. M.; Ellen, R. P.	Electr. Comm. of New South Wales, Sydney, NSW, Australia	1988	A new multi-million-dollar high-voltage power-supply system involving the longest radial line in Australia, with two back-to-back DC links, several very-fast-acting dynamic voltage-control devices, employing state-of-the-art electronics and high-power thyristor technology, plus a multiplicity of modern high-voltage substation plant and equipment, has been planned, designed and progressively installed to supply essential power to the remote-Australian primary industry at the lead/zinc/silver mines at Broken Hill. The authors describe various aspects of the new supply system, in particular, the electrical installations at the mines and in Elcom's system. The technical problems are discussed. The authors also describe the design and commissioning of the frequency converters and of the static VAr compensators consisting of thyristor controlled reactors	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=14720
A new topology of fault-current limiter and its parameters optimization	Zhengyu Lu; Daozhou Jiang; Zhaolin Wu	Electr. Eng. Coll., Zhejiang Univ., Hangzhou, China	2003	A new topology of faulty current limiter (FCL) is presented in the view of power system and power electronics. The new FCL consists of a conventional SCR bridge FCL, a fault-current let-through reactor and a ZnO arrestor. The proposal FCL overcomes the limitation of GTO FCL and SCR Bridge FCL and is more compatible with a modern power system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1218335
Control of an SVC for the load balancing and power factor correction with a new	Mokhtari, M.; Golshannavaz, S.; Nazarpour,	Electr. Eng. Dept., Urmia Univ., Urmia, Iran	2010	A compact algorithm based on power analysis for reactive power compensation as well as load balancing through the static var compensator (SVC) in three-phase three-wire system is developed in this paper. The structure of the SVC is thyristor controlled reactors with fixed capacitors (TCR-FC). By the proposed algorithm the required compensation susceptances for each phase of the SVC is obtained from a very simple function of	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5624723

algorithm based on the power analysis	D.; Farsadi, M.			voltage and reactive power signals which are measured from the network. The salient feature associated with the proposed method is that the circuit representation of system load is not required and the load is recognized just by its active and reactive consumptions. The load's type and connection, hence, do not matter and this method is valid for the case of active loads too. The validity and performance of the new approach are analyzed via a numerical example and the obtained simulation results are thoroughly discussed.	
SCT dimensions optimization by harmony search algorithm	Bina, M.T.; Samsami, H.; Beheshti, S.	Electr. Eng. Fac., K. N. Toosi Univ. of Technol., Tehran, Iran	2010	In this paper, Controlled Shunt Compensator of Transformer type (CSCT) is introduced as a new shunt compensator and harmonic component of its current is presented. A filter block in tertiary winding of the CSCT is used to suppress these harmonics. It is demonstrated that operation of the filter block is influenced by the arrangement of the windings and their dimensions. Then two possible arrangements of the CSCT windings are considered and the best arrangement and CSCT winding dimensions will be determined using harmony search method.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5598361
A Thyristor Controlled Neutral Grounding Reactor for Medium Voltage Power Networks	Qingquan Jia; Ning Wang; Daoshen Lin; Hua Zhang; Xiaoming Han	Electr. Eng. Inst., Yanshan Univ., Qinhuangdao	2005	An auto-regulated arc-extinguishing reactor (AER) was proposed in this paper. This AER has an autotransformer structure, whose primary winding acts as a main reactor, whose common winding and tertiary winding exert regulating functions. The common winding connects thyristor switched capacitors and performs gross regulating function. The tertiary winding is designed to have high leakage reactance with the main winding. The leakage reactance is controlled with a thyristors to exert a fine regulating. The AER operate at far away from resonant state in power system normal situation. When line to ground fault occurs, the AER regulates its parameters automatically and rapidly to achieve resonance with the network. The operation, the parameter determination, and the control scenarios of the AER are depicted in this paper. The proposed AERs are with advantages as large-scale continuous adjustability, low harmonics, superior linearity, and superior compensating effects	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1547139
Verification of firing angles of static var compensator with alternating current electric arc furnace	Vashi, A.	Electr. Eng., Sardar Vallabhbhai Nat. Inst. of Technol., Surat, India	2012	Non linear and chaotic loads like alternating current electric arc furnace (AC EAF) lead to power quality issues like poor power factor, harmonic generation etc. Static var compensator (SVC) is perfect solution for mitigating the above mentioned threats to power quality. The SVC behaves like shunt connected variable impedance which either generates or absorbs reactive power in parallel to the AC EAF. This generation and consumption of reactive power is balanced by thyristor controlled reactor by varying the firing angles of thyristors and control the current passing through the reactors. This review presents MATLAB simulation of thyristor controlled reactor with the SVC. This review also verifies firing angles of thyristor controlled reactor of the SVC so that reactive power drawn by AC EAF load at various power stages from the system is almost zero in line with actual field practice for nearly unity power factor operations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6184733
Use of a saturating choke in the series capacitor compensation of distribution lines	Barr, R.A.; Platt, D.	Electr. Power Consulting Pty Ltd., Culburra, NSW, Australia	1997	Series capacitors can increase the power carrying capacity of subtransmission and distribution lines by reducing voltage regulation. When considering series capacitor compensation of distribution lines and subtransmission lines careful consideration needs to be given to capacitor location, ferroresonance, ohmic reactive value, transient behaviour, short circuit withstand and capacitor protection. Conventional design approaches include shunt connected resistors, spark gaps, metal oxide varistors, thyristor controlled reactors and bypass switches. The use of a saturating choke and damping resistor to control ferroresonance, transients, and through-fault currents is described. A small-scale laboratory nonlinear single-phase ferroresonant circuit was constructed with	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=581132

				realistic per unit component values. Both 3rd and 2nd subharmonic ferroresonance modes were predicted by modelling and generated in practice. Choke and damping resistor parameters were selected by modelling to eliminate all the unwanted ferroresonant states. Experimental work confirmed that all the unwanted ferroresonant states were eliminated from the laboratory circuit. The transient and short circuit performance of the system is considered. The proposed arrangement offers an effective countermeasure to ferroresonance for series compensated distribution lines. The system also allows some control of system fault levels and transient circuit behaviour. The technique is simple, effective and requires no sophisticated control, protection or bypass switch systems	
Thyristor controlled ground fault current limiting system for ungrounded power distribution systems	Sugimoto, S.; Neo, S.; Arita, H.; Kida, Y.; Matsui, Y.; Yamagiwa, T.	Electr. Power Res. & Dev. Center, Chubu Electr. Power Co. Inc., Nagoya, Japan	1996	A thyristor controlled ground fault current limiting system (TGCL) was proposed to prevent one-line ground fault current rises due to increased capacitance to ground. Basic components of the TGCL are a main ground fault current limiter, which rapidly adjusts a compensating reactor level for the capacitance to ground, and the TGCL's controller. Control is ensured by an in-phase control method for zero-phase sequence voltage and current. The method determines the direction of ground faults and the compensating reactor level. The fast control which can be realized shows the TGCL is a valuable protecting system for high ground fault current distribution systems	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=489355
Chengxian 220kV Thyristor Controlled Series Compensation: Parameters Design, Control & Overvoltage Protection	Guo Jianbo; Chen Gesong; Lin Jiming; Li Baiqing; Wang Weizhou	Electr. Power Res. Inst. of China, CEPRI, Beijing	2005	A new thyristor controlled series compensation (TCSC) has been successfully applied at the 220 kV Chengxian substation of Bikou-Chengxian-Tianshui transmission system in Gansu power system. This paper introduces some technical considerations on TCSC, including parameter design of the thyristor controlled reactor, metal oxide varistor (MOV) and damping circuits, basic control strategy of TCSC, transient recovery voltage of circuit breaker, sub-synchronous resonance (SSR), operation condition of thyristor valve and switching surge on the transmission line with TCSC	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1546992
Comparative analysis between conventional voltage control using reactors and continuous voltage control using TCR in the Romanian transmission grid	Constantin, M.; Eremia, M.; Toma, L.	Electr. Power Syst. Dept., Univ. “Politeh.” of Bucharest, Bucharest, Romania	2013	This paper deals with voltage regulation issues based on compensation reactors in the 400 kV network of the Romanian Transmission Power System. For secure operation reasons, voltage regulation plays an important role in a power system. As over- or under-voltages occurs due to the reactive power surplus or deficit, shunt reactors are employed to maintain the voltage within admissible limits. Currently, 100 MVAr reactors are switched on/off to regulate the voltage in the 400 kV nodes. However, large voltage spikes are experienced, causing dangerous stress on the switching equipment. The aim is to adapt the actual fixed reactors in some power system nodes with thyristor controlled reactors (TCR) or a combination of a smaller fixed reactor and a TCR. Dynamic simulations and load flow calculations have been carried out to show these differences using Eurostag and Neplan simulation software on the Romanian Power System database.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6652236
The various operating conditions, harmonics effects and stability of thyristor controlled	Uzunoǧlu, M.; Kocatepe, C.;	Electr.-Electron. Fac., Yildiz Tech. Univ.,	2000	There has been a rapid increase in the use of thyristor controlled reactor (TCR) in the power system. TCRs cause to take place nonsinusoidal components in energy systems because of using power electronic elements within the TCRs. Any one of harmonic components of nonsinusoidal quantities can cause resonance in the system. In this paper, TCR's are studied for various working conditions and also as a harmonic source. In	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=888760

reactor	Yumurtaci, R.; Gulez, K.	Istanbul, Turkey		addition, system stability is studied in the case of nonsinusoidal quantities in the system	
A computer study of battery energy storage and power conversion equipment operation	Beck, J.W.; Carroll, D.P.; Gareis, G. E.; Krause, P.C.; Ong, C. M.	Electric Power Research Institute, Palo Alto, California	1976	This paper presents and discusses results from a computer simulation of a battery energy storage/converter system connected to a representative utility substation. Switching of load, voltage waveforms, voltage levels, fault conditions, and power flow reversal are investigated for both line- and forced-cornmutated converters in the application. The interactions among the battery, the converter and its controls, and the substation are discussed. The investigations have pointed out areas in which further consideration must be given to component selection for the battery/utility interface equipment, for example, dc reactor sizing, harmonic filtering, power factor control, thyristor firing control, and dc current interruption.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1601800
Thyristor controlled reactors for reactive power compensation in radial distribution feeders: a developed approach	Khattab, H. M.; Mekhamer, S.F.; Mahmoud, A. M A	Electrical Power and Machines University	2004	First Page of the Article <img class="img-abs-container" style="width: 95%; border: 1px solid #808080;" src="/xploreAssets/images/absImages/01374616.png" border="0">	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1374616
SVC model for voltage control of a microgrid	Bogonez-Franco, P.; Balcells, J.; Junyent, O.; Jorda, J.	Electron. Eng. Dept., Univ. Politec. de Catalunya, Barcelona, Spain	2011	Low power renewable sources, connected to low voltage micro-grids, are becoming more and more common. Since there is a high degree of uncertainty on the availability of such sources, this causes problems of stability and makes difficult to guarantee the power quality (PQ) in all the points of the grid. Such kind of problems, are well known in medium voltage (MV) networks, where the proposed solutions to fix the stability and PQ problems are based on the control of reactive power flow in the grid. The equipment to perform such control function ranges from the simple capacitor banks driven by electro-mechanical contactors, through the Static Var Compensators (SVC) based on the combination of Thyristor Switched Capacitors (TSC) and Thyristor Controlled Reactors (TCR) or SVC combined with Active Power Filters (APF). This paper describes the design and implementation of a low power SVC prototype model, sizeable to higher power levels. It has been designed to compensate variations of the line voltage of a microgrid in a range of Â±2%. The prototype can compensate 3kVAr capacitive and 1 kVAr inductive and is able to operate in a grid with a rated voltage of 400 V, phase to phase.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5984407
Cost-effectiveness of hybrid and unified compensators of nonactive power in networks	Blajszczak, G.; Boake, I.; Van Wyk, J.D.	Energy Lab., Rand Afrikaans Univ., Johannesburg, South Africa	1994	The components of nonactive power in a power system can be compensated separately by different switching convertors, or simultaneously by one convertor. Costs of compensator components and the operational costs are discussed for both cases. The estimates are made based on data of physical compensating systems. The hybrid compensator consists of fixed capacitors, a thyristor controlled reactor and a force compensated six pulse bridge voltage-fed converter	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=277974
Frequency-adaptive by-pass filter for saturable reactor	Nguyen, T.T.; Goodridge,	Energy Syst. Centre, Western	1991	An adaptive form of a bypass filter is proposed. The filter is based on online detection of the subharmonic modes which bypass filters are to counter and a thyristor switching array by which filter parameters are related to subharmonic mode frequencies. Extensive simulation studies have confirmed the significant increases in	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7670

compensators	A. R.	Australia Univ., Crawley, WA, Australia		damping which frequency-adaptive bypass filtering can achieve in comparison with that of the fixed-parameter form of filter so far used, especially when mode frequencies approach the supply frequency	8
Using a static VAr compensator to balance a distribution system	Jen-Hung Chen; Wei-Jen Lee; Mo-Shing Chen	Energy Syst. Res. Center, Texas Univ., Arlington, TX, USA	1996	An algorithm for applying a fixed capacitor-thyristor controlled reactor (FC-TCR) type of static VAr compensator (SVC) in the distribution system to dynamically balance a system is introduced. With a newly developed individual phase control scheme, an SVC can reduce negative sequence current caused by the load to improve system balance. Since the control circuit is governed by a microcomputer, which replaces the traditional discrete load switching and makes the capability of rapid and dynamic balancing of the system become possible. In addition, the power factor can be improved simultaneously by selecting an appropriate amount of capacitive/inductive compensation. This paper presents a mathematical model for computer simulation and control of a delta connected SVC to achieve the purpose of negative sequence reduction. Some computer simulation and scaled laboratory test results are discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=563896
Negative sequence current reduction for generator/turbine protection	Wei-Jen Lee; Ho, T.-Y.; Liu, J.-P.; Liu, Y.-H.	Energy Syst. Res. Center, Texas Univ., Arlington, TX, USA	1993	The authors present a feasible method for negative sequence current reduction at the generator terminal through a special function static VAr compensator (SVC). A specially designed fixed-capacitor thyristor-controlled reactor SVC is used. Computer simulation and laboratory test results show that it can effectively reduce negative sequence current at a generator terminal. Since this compensation circuit is operated in an unbalanced mode, both characteristic and noncharacteristic harmonics will appear in the system; careful design of the harmonic filtering circuits is thus necessary	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=299171
Reactive compensation techniques to improve the ride-through capability of wind turbine during disturbance	Chompoo-inwai, C.; Yingvivatanapong, C.; Methaprayoon, K.; Wei-Jen Lee	Energy Syst. Res. Center, Univ. of Texas, Arlington, TX, USA	2005	World wind energy capacity expanded at an annual rate of 25% during the 1990s. The total world wind turbine installation capacity was approximately 40 000 MW at the end of 2003. Germany has the highest installed capacity of over 10 000 MW, while Denmark, where the wind energy accounts for more than 13% of electricity consumed, has the highest wind energy level per capita. The United States is catching up in the development of wind farms, with several large-scale wind generation projects currently being materialized. Even though there is significant progress in the wind generation technology, most of the currently installed wind turbines utilize induction generators to produce the electricity. Since the induction generators do not perform voltage regulation and absorb reactive power from the utility grid, they are often the source of voltage fluctuations. It is necessary to examine their responses during the faults and possible impacts on the system stability when the percentage of the wind generation increases. This paper compares the steady-state voltage profile and the voltage ride-through capabilities of the induction-generator-based wind farms with different reactive compensation techniques.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1432988
Analysis and simulation of possible bifurcation and subharmonic oscillation in	Ghadiri, A.M.; Rostami, M.; Parvizi, A.	Eng. Fac., Shahed Univ., Tehran	2008	Thyristor controlled reactor (TCR), which is typically linked by a coupling transformer to the gird, is widely used as a continuously variable reactive power compensator in electric power systems. This paper focuses on anomalous nonlinear phenomena in a TCR system, called switching time bifurcation, and is showed the possibility of subharmonic and interharmonic oscillations accompanied with the switching time bifurcation and synchronous resonances. Also impact of capacitor banks on occurrence of bifurcation phenomenon has been	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4762749

transformer coupled TCR system				considered. It has been shown that the correct selection of the shunt capacitor may prevent or reduce bifurcation phenomenon.	
Analytic state-space description of networks including static VAr compensators	Weindl, C.; Herold, G.	Erlangen-Nurnberg Univ., Germany	1999	In this paper an approach for the calculation of networks, including current converter bridges is generalized to systems including static VAr compensators (SVCs). It utilizes the periodicity of all state variables in steady-state operating mode again. The entire system, consisting of the entire 3-phase network, the thyristor controlled reactor, the optionally switched capacitors and filter circuits is represented in complex space phasor components for each switching status. The resulting state space description considers the eigenvalues and switching sequence of the complete network structure. The respective linear independent circuits are coupled into a linear inhomogeneous boundary value problem which can be solved as a whole. Therefore the time functions of all state variables are obtained analytically. By further signal processing the harmonic load, power flows, reactive compensation factors and stationary resonance conditions can be calculated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=826605
A contribution for modeling static VAr compensators in iterative harmonic analysis	Mayordomo, J.G.; Izzeddine, M.; Zabala, L.	Escuela Tecnica Superior de Ingenieros Ind., Univ. Politecnica de Madrid, Spain	1998	Static VAr compensator (SVC) with thyristor-controlled reactors (TCR) are used to control the voltage at bus SVC, while the nonlinear harmonic source is connected to the TCR busbar. This specific situation requires special treatment of the voltage control characteristic in the iterative harmonic analysis (IHA). A voltage control characteristic reduced to the TCR busbar is proposed. Under this condition, the operating point of the TCR in the IHA is treated in a way so the firing angle is adjusted to satisfy the voltage regulation characteristic. In this paper, a frequency domain TCR model is presented by means of a set of analytical expressions for harmonic currents and their sensitivities with respect to the harmonic voltages. An additional nonlinear equation is also derived for obtaining the firing angle under distorted voltage. A scheme of checking coherent operating points of TCR is also included for IHA	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=759901
Load and voltage balancing in harmonic power flows by means of static VAr compensators	Mayordomo, J.G.; Izzeddine, M.; Asensi, R.	Escuela Tecnica Superior de Ingenieros Industriales, Univ. Politecnica de Madrid, Spain	2002	In special applications, static VAr compensators (SVCs) with thyristor-controlled reactors (TCRs) are used to balance unbalanced loads or to eliminate voltage unbalances at the terminals of the SVC. In both cases, load balancing and voltage balancing, the TCR can present a significant unbalanced behavior which produces important quantities of noncharacteristic harmonics. In this paper, the formulation and solution of the load and voltage balancing problems are developed for harmonic power flows obtained from a combination of two blocks: (1) a conventional load flow (CLF) and (2) an iterative harmonic analysis (IHA). In both blocks, the treatment of load and voltage balancing is described in detail. Load flow (LF) calculations and harmonic analysis show the presence of noncharacteristic harmonics in these two situations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1022801
Dual scheme based mathematical modeling of Magnetically Controlled Shunt Reactors 6â€“500 kV	Bazilev, Boris; Bespalov, Victor; Dyagileva, Svetlana; Makarov, Petr;	ESKO Ltd., Moscow, Russian Federation	2012	Topicality of mathematic modeling of Magnetically Controlled Shunt Reactors (MCSR) as a network element using common existing software elements is shown in the article. Principles of the MCSR dual scheme creation as a thyristor controlled reactor or a static var compensator (in case of modeling of Source of Reactive Power, including a MCSR and a capacitor bank) are explained. Principles of development the mathematic model of the MCSR dual scheme are demonstrated. Example of development and application of MCSR dual mathematical model for calculating steady-state modes of high-voltage electric grid is shown. The potential of the MCSR dual mathematic model application for development of the algorithm of MCSR (SRP) automatic control at the point of connection to electrical grid is assessed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6256197

	Makarova, Maria; Oleksyuk, Boris				
Filter design for harmonic reduction in high-voltage booster for railway applications	Zanotto, L.; Piovan, R.; Toigo, V.; Gaio, E.; Bordignon, P.; Consani, T.; Fracchia, M.	EURATOM/ ENEA, Padova, Italy	2005	This paper presents the design of the power section of a 25-kV, 50-Hz, 10-MVAr single-phase static var compensator (SVC) for railway applications. It is based on a third harmonic filter, on a low-pass filter for harmonic reduction, and on a saturable reactor connected in series with the thyristor-controlled reactor. Harmonic filtering is the crucial aspect of the system because of the very stringent limitations imposed on the harmonic current generation due to railway signaling requirements. The effectiveness of this innovative solution in reducing the grid harmonic current injection is shown in the paper and the advantage, in terms of system efficiency, is underlined. The system was successfully constructed and installed at the end of 2002, and the commissioning will be completed during 2003.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1375103
Time domain accelerated periodic steady-state solution of systems containing TCRs	Garcia, N.; Medina, A.	Fac. de Ingenieria Electr., UMSNH, Michoacan, Mexico	2000	The undesired harmonic effects of a three-phase TCR are analyzed in this paper. The basis of a simple model for the description of the dynamic behaviour of a three phase TCR is presented. Two Newton techniques to accelerate the convergence to the limit cycle are described and applied to obtain the periodic steady-state solution of the electric network. The two Newton methodologies and the brute force alternative are compared in terms of total number of cycles and CPU time required to obtain the steady-state solution	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=891433
Efficient computation of the periodic steady-state solution of systems containing nonlinear and time-varying components: application to the modeling of TCRs	Garcia, N.; Medina, A.	Fac. de Ingenieria Electrica, Ciudad Univ., Morelia, Mexico	2000	The application of two Newton techniques to obtain the periodic steady-state solution of electric networks with nonlinear and time-varying components such as TCRs is described in this paper. The entire system is solved in the time domain using a brute force procedure and with two Newton methodologies. These are based on a numerical differentiation (ND) and direct approach (DA) process, respectively, which accelerate the convergence of the time domain computations to the limit cycle. Comparisons are made between both approaches in terms of the required number of full cycles and CPU time to obtain the periodic steady state solution for the entire network containing nonlinear magnetising branches and a TCR	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=897759
Voltage Sag Compensation of Point of Common Coupling (PCC) Using Fault Current Limiter	Jafari, M.; Naderi, S. B.; Hagh, M.T.; Abapour, M.; Hosseini, S.H.	Fac. of Electr. & Comput. Eng., Univ. of Tabriz, Tabriz, Iran	2011	In this paper, voltage sag compensation of point of common coupling (PCC) using a new structure of fault current limiter (FCL) is proposed. The proposed structure prevents voltage sag and phase-angle jump of the substation PCC after fault occurrence. This structure has a simple control method. Using the semiconductor switch (insulated-gate bipolar transistor or gate turnoff thyristor at dc current rout leads to fast operation of the proposed FCL and, consequently, dc reactor value is reduced. On the other hand, the proposed structure reduces the total harmonic distortion on load voltage and it has low ac losses in normal operation. As a result, other feeders, which are connected to the substation PCC, will have good power quality. Analytical analysis and simulation results using PSCAD/EMTDC software and experimental results are presented to validate the effectiveness of this structure.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5989883
Modelling and controller design of an	Rahman, M.A.;	Fac. of Eng. & Appl. Sci.,	1996	A method to analyze the steady-state performance of a stand-alone permanent magnet synchronous generator driven by a diesel engine is presented. The proposed method is based on equivalent d-q circuits and the phasor	http://ieeexplore.ieee.org/stamp/stamp.j

isolated diesel engine permanent magnet synchronous generator	Osheiba, A.M.; Radwan, T.S.; Abdin, E.S.	Memorial Univ. of Newfoundland, St. John''s, Nfld., Canada		diagram of such a generator under steady-state conditions. A fixed capacitor-thyristor controlled reactor scheme is used to regulate the generator terminal voltage by controlling the thyristor ignition angle. Furthermore the overall system dynamics are modelled in terms of state variables and control inputs. Based on a reduced order linearized model, digital optimal state and output feedback controllers are designed by minimising a quadratic performance index using the dynamic programming technique. The objective of the controller is to maintain the load voltage and frequency constant under varying load conditions. The controller's effectiveness is assessed by examining the closed-loop system response to sudden load changes	sp?arnumber=507185
Capacity improvements for rural single wire earth return systems	Wolfs, P.	Fac. of Eng. & Phys. Syst., Central Queensland Univ., Rockhampton, Qld.	2005	The single wire earth return, (SWER), system is a low cost power distribution method that finds international use in rural areas, it is a key technology for the extension of grid systems. In Australia, SWER systems can cover vast areas. A single SWER system may typically supply 100 kW to several dozen customers and may extend more than 300 km. Recent changes in the Australian retail energy market structure and significant load growth are driving a requirement for new low cost methods of capacity improvement. Shunt reactors are often used in SWER systems to compensate for line charging current effects. As voltage regulation is the determining capacity factor, the replacement of fixed shunt reactors with controllable reactors provides an opportunity to significantly increase the system capacity. A case study of the North Jericho SWER system is presented which shows a capacity increase of approximately 85% can be achieved	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1627214
Capacity Enhancement for Aging Distribution Systems using Single Wire Earth Return	Wolfs, P.; Hosseinzadeh, N.; Senini, S.T.	Fac. of Sci. Eng., Health at Central Queensland Univ., Rockhampton, QLD	2007	Single wire earth return systems, (SWER), are the low cost technology for rural power distribution and have global application. In the Australian setting, voltage regulation is becoming the determining factor for older SWER systems. In long systems, directly connected shunt reactors are used to compensate the effects of line to ground capacitance. The replacement of fixed shunt reactors with controllable reactors provides an opportunity to approximately double the capacity of an aging infrastructure. Three case studies based on the North Jericho system are presented and a range of practical implementation issues are discussed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4275333
Voltage stabilization for wind generation integration in western Texas grid	Bostrom, A.; Hassink, P.; Thesing, M.; Halonen, M.; Grunbaum, R.	FACTS, ABB, Sweden	2009	The McCamey Area is a sparsely populated part of western Texas, where the penetration of wind power production to date has grown to 750 MW and is expected to grow well over 1 GW in the next few years. To improve and maintain system stability, three Static Var Compensators (SVCs) have been installed in the power grid, owned and operated by American Electric Power (AEP). This paper presents the SVC design and control features developed to ensure reliable reactive support to the wind farm power export at steady state conditions as well as during transient disturbances in the network.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5211206
GCSC - gate controlled series capacitor: a new FACTS device for series compensation of transmission lines	Watanabe, E.H.; De Souza, L. F W; De Jesus, F.D.; Alves, J. E R; Bianco, A.	Fed. Univ. of Rio de Janeiro, Brazil	2004	Controllable series compensation is a useful technique to increase the efficiency of operation of existing transmission lines and improve overall power system stability. Up to date, the TCSC is the most adopted solution whenever controllable series compensation is required. This paper introduces the gate controlled series capacitor (GCSC), a novel FACTS device for series compensation. The principle of operation and some prospective applications of the equipment are presented. Special attention is given to the duality of the GCSC with the well-known thyristor controlled reactor, used for shunt compensation. It is shown that the GCSC can be more attractive than the TCSC in most situations. Simulation results illustrate the time response of the equipment and its ability to control power flow in a transmission line. Finally, technology issues regarding high	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1432516

				power self commutating valves are discussed.	
Performance analysis of static TCR compensators for load balancing under asymmetrical voltages	Farias, V.J.; De Oliveira, J.C.; Silveira, J. C P; Miskulin, M.S.	Fed. Univ. of Uberlandia, Brazil	1991	The use of a phase independent thyristor-controlled reactor (TCR) compensator to balance asymmetrical loads is a well-known subject. However, if the control strategy is based on balanced supply voltage conditions and if this does not occur the required compensation may fail or it can exhibit inaccuracy. A new formulation to evaluate the necessary TCR phase susceptances under unbalanced voltage conditions is proposed. By using this technique, computational investigations and practical discussions are carried out to establish a comparison to the classical method results. The discrepancies between the two approaches with reference to the degree of asymmetry are highlighted	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=169617
Using a static VAr compensator to balance a distribution system	Jen-Hung Chen; Wei-Jen Lee; Mo-Shing Chen	Formosa Plastics Co., TX, USA	1999	An algorithm for applying a fixed capacitor-thyristor-controlled reactor (FC-TCR) type of static VAr compensator (SVC) in a distribution system to dynamically balance such a system is introduced. With a newly developed individual phase control scheme, an SVC can reduce negative-sequence current caused by the load to improve power system balance. The control circuit is governed by a microcomputer, which replaces the traditional discrete load switching and makes the capability of rapid and dynamic balancing of the system possible. In addition, the power factor can be improved simultaneously by selecting an appropriate amount of capacitive/inductive compensation. This paper presents a mathematical model for computer simulation and control of a delta-connected SVC to achieve the purpose of negative-sequence reduction. Some computer simulation and scaled laboratory test results are discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=753620
50-kJ Ultracompact Pulsed-Power Supply Unit for Active Protection Launcher Systems	Spahn, E.; Sterzelmeier, K.; Gauthier-Blum, C.; Brommer, V.; Sinniger, L.; Grasser, B.	French-German Res. Inst. of St.-Louis (ISL), St. Louis	2009	The impulsive acceleration of active protection elements such as armor plates or other terminal ballistics interception devices can preferably be realized by single-stage electromagnetic launcher systems using pancake coils. The technology with controlled multipartite coil assemblies represents a new supplementary topic in the entire field of ballistics. However, the essential condition is the availability of modular high-energy-density pulsed-power supply units with low volume and weight. During the last years, modular structured energy packs have been built up at ISL as a basic installation for various applications in the field of pulsed-power electronics; in particular, they are developed to feed active protection launcher systems. Each power supply module comprises one energy storage capacitor, a thyristor stack, a corresponding number of crowbar diodes, and a well-designed coaxial power line serving as a pulse-forming network and current-limiting reactor. To provide high flexibility, these modules can be triggered separately and independently by fiber-optic transmitters with an overall jitter lower than 50 ns. This paper describes the basic design of a 50-kJ energy pack and the further developed setup with a strongly reduced overall height obtained by using a novel multichip thyristor. Additionally, a 2-D steerable launcher system supplied by these modules will be presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4773552
50 kJ Ultra-Compact Pulsed-Power Supply Unit for Active Protection Launcher Systems	Spahn, E.; Sterzelmeier, K.; Gauthier-Blum, C.; Brommer, V.; Sinniger, L.; Grasser, B.	French-German Res. Inst. of St.-Louis, St. Louis	2008	The impulsive acceleration of active protection elements such as armour plates or other terminal ballistics interception devices can preferably be realized by single-stage electromagnetic launcher systems using pancake coils. The technology with controlled multipartite coil assemblies represents a new supplementary topic in the entire field of ballistics. But the essential condition is the availability of modular high energy density pulsed power supply units with low volume and weight. During the last years modular structured energy packs have been built up at ISL as a basic installation for various applications in the field of pulsed power electronics, in particular they are developed to feed active protection launcher systems. Each power supply module comprises	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4657573

				one energy storage capacitor, a thyristor stack, a corresponding number of crow-bar diodes and a well-designed coaxial power line serving as a pulse forming network and current limiting reactor. To provide high flexibility these modules can be triggered separately and independently by fiber optic transmitters with an overall jitter lower than 50 ns. The paper presented describes the basic design of a 50 kJ energy pack and the further developed set-up with a strongly reduced overall height obtained by using a novel multichip thyristor. Additionally a two dimensional steerable launcher system supplied by these modules will be presented.	
Active armor protection-conception and design of steerable launcher systems fed by modular pulsed-power supply units	Sterzelmeier, K.; Brommer, V.; Sinniger, L.	French-German Res. Inst., Saint-Louis, France	2001	The impulsive acceleration of active protection elements such as armor plates or other terminal ballistics interception devices can be realized by single-stage electromagnetic launcher systems using pancake coils. The technology with controlled multipartite coil assemblies represents a new topic in the field of ballistics with a high growth potential. During 1999 a separate test facility with modular structured energy packs (3Ã—50 kJ) was built at ISL as a basic installation for testing reinforced or armored coils and multiple-coil systems. Each power supply module comprises one energy storage capacitor, a thyristor stack adapted to maximum charging voltage, a corresponding number of crow-bar diodes and a coaxial power line serving as a pulse forming network and current limiting reactor. To provide high flexibility these modules can be triggered independently by fiber optic transmitters with an overall jitter lower than 50 ns. Three packs are designed for a maximum charging voltage of 10.75 kV. First measurements have shown that peak currents up to 120 kA per module and current slew rates of more than 2.5 kA/Î¼s can be generated. The paper describes the test facility and the prototype arrangement of a steerable launcher system with two orthogonally assembled pancake coils fed by two modular pulsed power supply units. The selection of the launch direction is defined by a short delay between the trigger pulses, so that the usual propagation delay time implied by inertia is avoided. First investigations and results concerning steerability and electromechanical efficiency are presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=911829
Study on the influence of TCSC structure and control on SSR damping using an improved s-domain model	Jusan, F.C.; Gomes, S.; Taranto, G.N.	Furnas Centrais Eletricas, Rio de Janeiro, Brazil	2010	This paper investigates the influence of basic TCSC main circuit structure and control on subsynchronous torsional damping of a nearby turbine-generator. An improved s-domain model based on dynamic phasor approach was used to obtain the results presented in the paper. The study is conducted on the System-1 of the IEEE Second Benchmark Model. Detailed eigenvalue analyses are carried out in order to evaluate the effect of the proportion of TCSC to FSC, Boost Factor and size of TCSC reactor on subsynchronous damping. The influence of constant current controller and synchronization system (PLL) parameters is also investigated. Finally, a simple Subsynchronous Damping Controller (SSDC) is added to the TCSC main control in order to demonstrate that the SSR damping capability of TCSC may be enhanced by proper modulation of firing angle. The results obtained in the time domain simulations are validated through PSCAD/EMTDC simulations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5762854
Symmetrical GTO current source inverter for wide speed range control of 2300 to 4160 volt, 350 to 7000 hp, induction motors	Espelage, Paul M.; Nowak, J.M.; Walker, Loren H.	GE, Salem, VA, USA	1988	A line of variable-speed 2300-4160 V, 350-7000 hp induction-motor drives for either fan or constant torque load applications is described. The drives are current-sourced, consisting of one or two six-pulse thyristor phase-controlled source converters in series, a DC link reactor, a six-pulse, symmetric-GTO (gate-turn-off), load inverter, a three-phase load capacitor in parallel with the induction motor. The drive features a wide speed range of operation, high inverter efficiency, and good motor current and voltage waveshape over the speed range.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=25079
A 20 MVA amplifier for	Crookes, R.	GEC	1994	A four quadrant switching amplifier rated at 20 MVA and with a voltage response time of 25 Î¼s depending on	http://ieeexplore.iee

a fusion research experiment	W.; Subramaniam, T. K.; Ballad, J.P.; Hay, J. H.; Edwards, D. C.	Alsthom Eng. Res. Centre, Stafford, UK		circuit conditions, has been designed, built and tested. Five GTOs are connected in parallel in each arm of a bridge circuit to produce an output capability of Â±2 kV and Â±10 kA. The purpose of the amplifier is to study the control of plasma current disruptions in a Tokamak fusion experiment and this means it only needs to be rated for short (<100 ms) current pulses. Comprehensive monitoring is provided and seventy signals are monitored at 50 Î¼s intervals	e.org/stamp/stamp.jsp?arnumber=341579
Design and reliability of 2 kV, 10 kA pulse rated GTO amplifiers for fusion applications	Robinson, D.	GEC Alsthom Eng. Res. Centre, UK	1994	The author describes how, in order to control the vertical position of a plasma in a fusion experiment, a gate turn off thyristor (GTO) bridge was constructed to apply a bipolar voltage of up to 2kV to a control coil. This was designed to rapidly control 10 kA of current supplied from a capacitor bank. The response time of the applied voltage was tobe less than 50Î¼s so that the GTO was considered an ideal device for this application in terms of its switching speed and blocking voltage capability. As the maximum switchable current capability of each GTO was 3kA, a number of GTOs were connected in parallel to achieve the switchable current rating required	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=341600
Analysis of GTO-based static VAr compensators	Trainer, D.R.; Tennakoon, S.B.; Morrison, R.E.	GEC Alsthom T&D Power Electron. Syst. Ltd., Stafford, UK	1994	The growing availability of high-power gate turn-off thyristors (GTOs) has meant that power electronic convertor circuits can be manufactured with the ability to both absorb and generate reactive power. These circuits constitute the next generation of static VAr compensators (SVCs) which may eventually supersede the conventional thyristor-controlled reactors (TCRs) and thyristor-switched capacitors (TSCs) used in power systems at present. The paper gives an analysis of both 6-pulse and 12-pulse GTO-SVCs based on voltage-source convertor circuits, and equations are derived that describe the performance of each circuit. In addition, the conditions leading to circuit resonances are discussed together with possible methods of avoiding the problems	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=336348
Digital computer studies and some test results for a static VAr compensator in the UK transmission network	Gardner, D.; Haddock, J. L.; Thanawala, H. L.; Young, D. J.	GEC ALSTHOM Transmission & Distribution Projects Ltd., Stafford, UK	1991	Several SVCs of 150/-75 MVAr rating are being installed in the 400 kV transmission network in the south of England. The SVC transformer as well as the TCR, TSC and filter circuit components are subject to a variety of transient overvoltages which are limited by gapless metal oxide surge arresters. The authors describe subsequent digital studies which are used to determine the severest transient stresses to which various surge arresters could be subjected. Such studies involve investigations of lightning transients, SVC energisation and fault application/clearance events. A further set of studies involving digital analysis of the basic control system is also discussed which uses eigenvalue methods. Where comparison between analytical methods, simulator test results and site measurement has been possible, agreement is shown to be good	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=153924
A range of directly connected TCRs to reduce voltage disturbances	Baker, M. H.; Macleod, N.M.; Young, D. J.	GEC Alsthom Transmission & Distribution Projects Ltd., Stafford, UK	1991	A description is presented of a range of thyristor values which have been produced for direct connection to supply systems at up to 38 kV, thus obviating the need for a step down transformer at these voltages. A number of examples illustrate these two systems and their applications to the compensation of pulsed loads, arc furnaces, mine winders and both conventional and cyclo-convertor fed steel mill drives	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=153063
Design and	Baker, M. H.;	GEC	1991	The 150 MW back-to-back HVDC convertor station at McNeill is the first interconnection between the western	http://ieeexplore.iee

experience of a back-to-back HVDC link in western Canada	Burgess, R. P.	Alsthom Transmission & Distribution Projects Ltd., Stafford, UK		and central electrical networks of Canada and allows Alberta Power and SaskPower to trade energy and share the standby capacity of the two networks. At the heart of the convertor station is a new generation of liquid cooled thyristor valves and electronic controls. In addition to the latest convertor technology McNeill also has many design features which represent advances to DC power transmission. These include: thyristors cooled directly by an ethylene/glycol solution which provides frost protection down to -50Â°C; no DC reactor between the two HVDC valve groups; and stable steady state operation and good post-fault recovery when operating under very weak AC system conditions. The McNeill convertor station has now been in service for 18 months and, of some 60 stations so far commissioned around the world, is the first to demonstrate a capacity for truly unmanned operation	e.org/stamp/stamp.jsp?arnumber=154157
Phase-locked oscillator control system for thyristor-controlled reactors	Ainsworth, J. D.	GEC Transmission & Distribution Projects Ltd., Stafford, UK	1988	The thyristor-controlled reactor (TCR) is used for AC voltage control on transmission lines and industrial busbars. It has a relatively simple main circuit and its performance depends very much on its control system. The phase-locked oscillator type of control system is now universally used for HVDC convertors, and is being introduced for the TCR. The form of this control described is of the `zero-delay' type, without control filters or other lags, and gives freedom from harmonic instability and a good combination of stability at other frequencies, with fast response. Examples of applications are described briefly	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6356
Analysis of thyristor DC chopper power converters including nonlinear commutating reactors	McMurray, W.	General Electric R&D Center, Schenectady, NY	1970	Dc chopper power converters are used to control the power supplied to a dc load from a dc source. In a battery-powered vehicle, for example, a dc chopper can control the dc series traction motor. Thyristors are favored for the switching element in high power applications. The particular circuit described here can be used as a voltage step-down converter or a voltage step-up converter and uses two auxiliary thyristors to turn off the main power thyristor. The behavior of the step-up circuit is described by exactly the same equations as the step-down circuit when the input voltage is replaced by the load voltage and the load current is replaced by the input current. The analysis treats the general case where saturating reactors are used to soften the commutation of current in the power semiconductors. The nonlinear characteristics of these reactors are approximated by two linear segments when molybdenum-Permalloy powder cores are used. Linear or square-loop cores are included by the theory as special cases. A design synthesis based on the analytical equations is best performed with the aid of a computer.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1066710
Improved power regenerative controls by using thyristor rectifier bridge of voltage source inverter and a switching transistor	Mizuno, U.; Matsui, K.; Murai, Y.	Gifu Univ., Japan	1990	Techniques for the regenerative control of a voltage source inverter are described. In these techniques, the thyristor rectifier bridge is used for regeneration through a DC reactor or a capacitor. The first method of regenerative control uses a pulse-width modulation (PWM) strategy in which the polarity of the sawtooth carrier waveforms are reversed alternately every 60 degrees in order to reduce the harmonics of output waveforms. The second method uses a modified Cuk converter technique for regeneration. The output current of the Cuk converter is shown to have a zero ripple. A frequency analysis method using a switching function is proposed and applied to the PWM current.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=152302
Harmonic modelling in Hartley's domain with particular reference to three phase thyristor-	Acha, E.; Rico, J.J.; Acha, S.; Madrigal, M.	Glasgow Univ., UK	1997	The main objectives of this paper are to present a new frame-of-reference based on the use of Hartley's transform and to present a three-phase thyristor controlled reactor (TCR) harmonic model which uses Hartley's domain. Solutions using the new frame-of-reference are between two to four times faster than solutions using an established frame-of-reference based on Fourier's transform because Hartley's transform makes use of the real	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=634182

controlled reactors				plane as opposed to the complex plane. Harmonic switching vectors in Hartley's domain have been developed for maximum computer efficiency. Their use, combined with discrete convolution operations, provide cleaner and faster operations than those afforded by the fast Hartley transform. The TCR model is completely general and caters for any kind of plant imbalances, e.g. uneven firing angles and inductances. Network imbalances are accounted for via the excitation voltage. The new frame-of-reference accommodates any number of buses, phases, harmonics and cross-couplings between harmonics. It provides a reliable and efficient means for the iterative solution of power systems harmonic problems through a Newton-Raphson method which exhibits quadratic convergence	
Small-scale wind turbine coupled single-phase self-excited induction generator with SVC for isolated renewable energy utilization	Ahmed, T.; Ogura, K.; Soshin, K.; Hiraki, E.; Nakaoka, M.	Graduate Sch. of Sci. & Eng., Yamaguchi Univ., Japan	2003	In this paper, the static VAR compensator (SVC) composed of the fixed excitation capacitor(FC) in parallel with the thyristor switched capacitor (TSC) and the thyristor controlled reactor (TCR) is applied to regulate and stabilize the generated terminal voltage of the single-phase self-excited induction generator (SEIG) for the passive load variations and the prime mover speed changes. The conventional fixed gain PI controller is employed to adjust the equivalent capacitance of the single-phase SVC in the output of the single-phase SEIG. The closed-loop terminal voltage responses due to different inductive passive load disturbances in the single-phase SEIG using the single-phase SVC with the PI controller are considered and discussed herein. A prototype setup for the single-phase SEIG with SVC voltage regulation feedback control scheme is implemented. The experimental results of this power conditioner are illustrated and give good agreements with the digital simulation results.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1283003
Characteristics and Modeling of Harmonic Sources-Power Electronic Devices	Task Force,; Chang, G.	Harmonic Working Group; National Chung Cheng University	2001	This paper presents a review of characteristics and modeling of major power electronic types of harmonic sources for the power system harmonic analysis. The power electronic switching types of harmonic sources to be reviewed include static power converters, static var compensators (SVCs), and cycloconverters. Discussions and comtnents for applications of these harmonic sources in harmonic modeling and simulation also will be described.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4311573
Saturable reactor control of glass melt furnace	Kubiczki, C.; Wetzel, F.R.	Henry F. Teichmann Inc., McMurray, PA, USA	1989	The application of a saturable-reactor control system to an existing glass furnace, for melting a glass of composition between a soda-lime and a borosilicate, is described. The factors that influenced the selection of the specific equipment design are discussed as well as the performance characteristics that were achieved. A phase imbalance has been observed. It is concluded that the best way to reduce this phase imbalance would be to redesign the furnace for 100% bottom electrodes. Given the present arrangement, an SCR autotap system would improve control. This change would provide a higher power factor over a wide operating range without manual tap changers.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=96824
A multiple PW GTO line-side converter for unity power factor and reduced harmonics	Sukegawa, T.; Kamiyama, K.; Takahashi,	Hitachi Ltd, Ibaraki, Japan	1992	A multiple PWM GTO line-side converter with low switching frequency has been developed for industrial uses needing both higher capacity and higher performance. The multiple converter is composed of two GTO converter units connected in parallel through an interphase reactor. The switching frequency of the GTO thyristors in the multiple converter can be reduced to a quarter of that in the single converter. It is verified by simulations and experiments with a 2750 kVA GTO converter and inverter system with a 500 Hz switching	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=175281

	J.; Ikimi, T.; Matsutake, M.			frequency that the system has: (1) a unity power factor, (2) reduced harmonics, (3) bidirectional power flow, and (4) speed regulatory performance equal to that of an advanced cycloconverter drive system. Analogies between inverter control and converter control are also studied for the development of the converter control	
Newly Developed Thyristor Chopper Equipment for Electric Railcars	Tsuboi, Takashi; Izawa, Shoji; Wajima, Koichi; Ogawa, Takuzo; Katta, Takehiko	Hitachi, Ltd., Tokyo, Japan.	1973	In the chopper control system for electric railcars, it is effective to adopt high operational frequency of the chopper for achievement of the following: 1) decrease of higher harmonic current induced in the trolley wire, 2) reduction of weight for reactors and capacitors in the traction circuit, and 3) improvement of control response. Through development of reverse-conducting thyristors with very short turn-off time and a repulsion type two-phase chopper, we finally realized production of a new standard high-frequency chopper equipment with regenerative braking for 1500-V dc railcars. Technical achievements mentioned previously were completely realized as a result of adoption of high frequency, 660 Hz, in the equipment. The newly developed standard high-frequency chopper equipment for 30 cars were delivered to the Chiyoda Line of Teito Rapid Transit Authority in Tokyo, and they have been operated satisfactorily in revenue service since March 1971. This paper also describes: 1) the chopper circuit using fast-switching reverse-conducting thyristors and series saturable reactors, 2) analysis of commutation circuit and methods of suppressing reapplied forward voltage increasing rate (dv/dt) and shortening commutation period, 3) the composition of the traction circuit including the protection system, such as protection for overvoltage at the regenerative braking, and 4) test results on the Chiyoda Line of Teito Rapid Transit Authority.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4158395
Assuring continuous input current using a smoothing reactor in a thyristor frequency converter for induction metal melting and heating applications	Shenkman, A.; Axelrod, B.; Chudnovsky, V.	Holon Acad. Inst. of Technol., Israel	2001	The approximate analysis of a thyristor frequency converter for induction heating and melting is described. The method for calculating the smoothing reactor inductance, which will provide the continuous mode of inverter input current operation, is proposed. The laboratory prototype of the above converter has been made and examined. The results of the experiments are in good agreement with the theoretical calculations	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=969415
Design and simulation of a control system with a comprehensive power quality in power system	Lawu Zhou; Shanjun Qi; Lijun Huang; Zhiguang Zhou; Yinghao Zhu	Hunan Univ., Changsha	2007	A comprehensive power quality controller combined with thyristor controlled reactor (TCR) and hybrid active power filter (HAPF) is described in this paper for substations in power system. The HAPF topology presented in the paper is to add a small inductor in parallel with the active power filter (APF) controlled as a current source, in order to force the fundamental current flow through the additional inductor instead of the APF. HAPF acts as a classic reactive power compensator for load balancing and power factor correction. By resolving the equations of a single-phase lossless transmission line and the scheme's main circuit structure and its operation principle, the relationship between the line voltages, the line length, the load and the compensation degree is analyzed. A control system of the line voltage with a HAPF is designed employing the dynamic reactive power compensation theory and utilizing the engineering design method. Then the simulation model is constructed by MATLAB/PSB. The simulation results demonstrate that the voltage-control system can rapidly regulate the output power of a HAPF, and can keep the line voltage stabilization and verify the effectiveness and advantage of the comprehensive power quality controller for substations in power system while the transmitted power might change.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4412260

A static compensator model for the EMTP	Lefebvre, S.; Gerin-lajoie, L.	Hydro-Quebec, Varennes, Que., Canada	1992	A static voltampere-reactive (VAr) compensator (SVC) model based on nodal analysis, is presented. The model is integrated in the electromagnetic transients program (EMTP) with minimal interface error and by taking into account initialization. The model is basically a generic compensator using thyristor controlled reactors. The models are modular to represent adequately compensators of different designs while being detailed enough for predicting possible harmonic interactions between the AC system and the SVC. Typical applications on the Hydro-Quebec system are described	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=141749
Effects of voltage-waveform distortion in TCR-type compensators	Montano, J.-C.; Gutierrez, J.; Lopez, A.; Castilla, I.M.	I.R.N.A.S., Seville, Spain	1993	The effect of system voltage distortion on the performance of a thyristor controlled reactor (TCR) type of compensator is examined. Toward this end, the real and imaginary values of harmonic current through the TCR, and the optimal gating angle that controls it, are calculated with a view toward minimizing the RMS value of the supply current and to achieving an optimum power factor (PF). The precision of the formulae obtained, assuming an equal conduction angle of the thyristors in the two half periods, is compared with the results achieved using two different methods for simulating the TCR, one by means of a Pascal program and the other with PSPICE. The optimum PF values, calculated by analytical methods that use the conventional formulation (which assumes that the voltage waveform is sinusoidal), are compared with those obtained using the formulation developed here	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=232217
Thyristor (SCR) Chopper Control System for Transportation Equipment	Zeccola, Richard A.; Weiser, Earnest F.	IBM Corporation	1969	This paper describes the circuit design used for the application of power semiconductors to the control of dc power in a traction motor system. Type SPM designates a series field traction motor SCR control, providing smooth tractive effort control in motoring and in dynamic braking of 500Ã‚Â¿1000 hp (continuously rated) rapid transit car drives. Thyristors are switched by a feedback current control system utilizing a fixed-frequency variable pulse width technique. Armature series reactors and line filter requirements are minimized by a multistage scheme. Both armature and field currents are modulated for full speed range control. Third rail system extreme voltage transients are accommodated by system features. Development and tests of sample equipments on the Chicago Transit Authority system are described. This demonstrator became the first semiconductor chopper propulsion equipment to be placed in revenue service in the United States. Service began in September 1967 on the Chicago Transit Authority's Skokie Line. A similar 1000-volt equipment was supplied San Francisco Bay Area Rapid Transit for test track evaluation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4181057
Design of TCSC for classroom and research applications on an analog model power system	Yedidi, V.K.; Johnson, B.K.	Idaho Univ., Moscow, ID	2006	This paper discusses the development of a thyristor controlled series capacitor (TCSC) with closed loop controls for use with the analog model power system (AMPS) at the University of Idaho (UI). An overview of the AMPS is presented. The TCSC circuit and characteristics are discussed in brief. Next the determination of TCSC parameters are discussed. With these parameters the possible modes of operation of TCSC were simulated. Then potential closed loop control schemes were discussed and simulated in ATP. With this background the realization of the TCSC in hardware is discussed. Finally the hardware results are compared with that of simulated results	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1709583
Two-folded implementation of a 12-pulse TCR with dissimilar transformers	Kose, N.; Mutluer, B.; Ermis, M.; Terciyanli,	Inf. Technol. & Electron. Res. Inst., Sci. & Tech.	2004	This paper is devoted to the design and implementation of a 12-pulse thyristor controlled reactor (TCR) system, which constitutes a low-cost solution to the reactive power compensation problem of a ladle furnace in Iskenderun iron and steel plant (ISDEMIR). Design objectives and elimination of 5th and 7th harmonic current components produced by 6-pulse TCRs are met by connecting two sets of 6 kV, 6 MVAr TCRs to the 34.5 kV	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1348452

for a ladle furnace: reactive power compensation and power system redundancy	A.; Gultekin, B.; Bilgin, F.; Ermis, C.; Hasbay, S.; Deyifli, M.; Ahi, T.	Res. Council of Turkey, Ankara, Turkey		ladle furnace bus by the use of two separate converter transformers with delta- and wye-connected secondaries. The effects of dissimilarities between the two sets of 6-pulse TCRs on the harmonic current content of the resulting 12-pulse TCR system are also presented in this paper. Both reactive power compensation and power system redundancy objectives are met by using two separate and dissimilar transformers instead of a single transformer with identical Î”-and Y-connected secondaries for connection to 6-pulse TCRs, resulting in a two-folded design. One of these transformers is chosen as a sufficiently large unit with two identical Î”-connected secondaries to supply the ladle furnace in emergency or during maintenance periods of main transformer. In normal operation mode of the resulting ladle furnace power system, the 12-pulse TCR implemented in the project gives quite satisfactory results in reactive power compensation and nearly meets harmonic standards currently used in the country.	
Comparison of thyristor-controlled reactors and voltage-source inverters for compensation of flicker caused by arc furnaces	Garcia-Cerrada, A.; Garcia-Gonzalez, P.; Collantes, R.; Gó mez, T.; Anzola, J.	Inst. de Investigacion Tecnologica, Univ. Pontificia Comillas, Madrid, Spain	2000	The objective of this paper is to compare the performance of thyristor-controlled reactors (TCR) and shunt-connected PWM voltage source inverters (PWM-VSI) for compensation of flicker caused by arc furnaces. First of all, arc-furnace principles are presented in order to explain the main characteristics of the problem. Secondly, traditional TCR control are analyzed. An improved measuring procedure is suggested to enhance TCR performance showing that it achieves faster compensation than more traditional methods. Thirdly, PWM-VSI control for flicker compensation is described in detail using Park's transformation. The analysis shows how real and reactive power control can be decoupled. Continuous-time and discrete-time models are considered. Finally, a TCR control and a PWM-VSI control are compared by simulation using data and measurements from a real arc-furnace installation. The analysis considers three different periods of the production cycle: (a) bore-down, (b) fusion, and (c) refining. It is clear from the results obtained that a shunt-connected PWM-VSI is better than a TCR for flicker compensation. This can be easily justified noting that the bandwidth of the PWM-VSI control system is far better than that of the TCR control. However, the control system for a PWM-VSI inverter is more complicated than that of a TCR. Besides, the latter uses a better-established technology than the former	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=891507
A shunt active power filter applied to high voltage distribution lines	Hafner, J.; Aredes, M.; Heumann, K.	Inst. fur Allgemeine Elektrotech., Tech. Univ. Berlin, Germany	1997	The high requirement of rated power of an active power filter leads to high costs and limits the range of operation especially for high voltage applications. To overcome these problems, a combined system of a passive filter, using only one LC filter tuned to the lowest typical line current harmonic, and a shunt active power filter, sharing the filter capacitor to be decoupled from the fundamental line voltage, is proposed. These features strongly decrease the rated power of the active filter which is controlled only to suppress the harmonics of higher order and to eliminate resonance effects between the line impedance and the passive filter	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=568249
Vacuum Circuit Breakers in Flexible AC Transmission Systems	Wenzel, T.; Leibfried, T.	Inst. of Electr. Energy Syst. & High-Voltage Technol., Karlsruhe Inst. of	2012	This paper shows two applications for using vacuum circuit breakers (VCBs) in flexible ac transmission systems in the high-voltage (HV) power grid. This is first a mechanically switched reactor, which is series connected to a thyristor-controlled series compensator in order to enhance the inductive working range. Nevertheless, the switching frequency of VCBs is limited by their mechanical properties. In order to achieve a higher switching frequency, more VCBs are switched in parallel to each other. Second, a device is investigated, which consists of mechanically switched capacitors and a mechanically switched reactor. It is connected to a node in the HV system in order to enhance the voltage quality and to avoid a voltage collapse. Since VCBs are mainly available in the medium-voltage range, a transformer is used to connect the mechanically switched device to the HV	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6093713

		Technol., Karlsruhe, Germany		system. In this paper, it could be shown that the mechanically switched series reactor is able to enhance the damping progress of power oscillations and that the mechanically switched device using VCBs can stabilize the voltage of the node in case of disturbances, such as faults in the power system. Furthermore, the electrical stress on the VCBs has been assessed for different simulation cases with PSCAD.	
Enhancement of the inductive operating range of a TCSC in the High-Voltage Grid using a mechanically switched series reactor	Wenzel, T.; Gaertner, T.; Leibfried, T.	Inst. of Electr. Energy Syst. & High-Voltage Technol., Karlsruhe Inst. of Technol., Karlsruhe, Germany	2010	This Paper shows one of the possibilities to use Vacuum Circuit Breakers (VCBs) in flexible AC transmission systems in the High-Voltage Grid. A mechanically switched reactor, which is series connected to a TCSC in order to enhance the inductive working range is investigated. VCBs are used as switching elements as they can be switched more often without maintenance compared to other circuit breakers. Nevertheless, the switching frequency is strongly limited by their mechanical properties. In order to extend the application range to faster events like damping of power oscillations, more VCBs are switched in parallel to each other. Hence a higher periodically switching ability could be achieved. In this paper, it could be shown that the mechanically switched series reactor is able to enhance the damping of power oscillations. Furthermore the electrical stress on the VCBs and on the reactors for different simulation cases has been assessed. The simulation is performed with PSCAD.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5650034
A Novel Combined System Using Cascaded Active Power Filter and Static Var Compensator for High-Power Applications	Chen Junling; Li Yaohua; Wang Ping; Yin Zhizhu; Dong Zuyi	Inst. of Electr. Eng., Chinese Acad. of Sci., Beijing, China	2011	As a compromise between economy and good performance, this paper adopts the combined system using cascaded active power filter (APF) and static var compensator(SVC) to compensate reactive power and harmonic currents simultaneously for high-power applications. The SVC is constructed by fixed capacitor (FC) and thyristor controlled reactor (TCR), and the APF is constructed by a cascaded multi-level voltage source converter and its filter reactor. SVC acts as a classic reactive power compensator for load balancing and power factor correction, and APF is used to compensate the harmonic current. Firstly, the circuit topology and the principle of the combined system are introduced in detail. Then filtering characteristics using the novel control method are analyzed. Furthermore, the steady state and dynamic waveforms show that good performance and system stability of the combined system are achieved.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5747903
A novel control method for a combined system using active power filter and static var compensator	Chen Junling; Li Yaohua; Wang Ping; Gao Congzhe; Jiang Xinjian; Yin Zhizhu; Dong Zuyi	Inst. of Electr. Eng., Chinese Acad. of Sci., Beijing, China	2010	As a compromise between economy and good performance, this paper adopts the combined system using active power filter (APF) and static var compensator (SVC) to compensate reactive power and harmonic currents simultaneously. The SVC is constructed by fixed capacitor (FC) and thyristor controlled reactor (TCR), and the APF is constructed by a voltage source converter and its filter reactor. SVC acts as a classic reactive power compensator for load balancing and power factor correction, and APF is used to compensate the harmonic current. The analysis and comparisons are studied for several combined systems in detail, while the control methods of APF and SVC and SVC's construct are taken into account. And then an outstanding combined system and its control method are proposed. The steady state and dynamic waveforms show that good performance and system stability of the combined system are achieved.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5664292
A new harmonic power flow method based on the	Madrigal, M.; Acha, E.	Instituto Tecnologico de Morelia,	2002	In this paper an instantaneous power flow (IPF) solution method for analysing the harmonic power flow problem is proposed. The IPF uses the instantaneous power balance to formulate the problem. The methodology uses the harmonic domain as a frame-of-reference and the Newton-Raphson method. This method is fully formulated	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1221

instantaneous power balance		Mexico		in the frequency domain and applicable to systems which also contain nonlinear elements and FACTS devices. The method also offers a flexible and modular formulation which shows excellent convergence properties. The IPF is developed, implemented and proved with simple examples for linear and nonlinear concentrated loads and the thyristor controlled reactor (TCR) in the control of reactive power.	513
High current DC choppers in the metals industry	Scaini, V.; Ma, T.	Inverpower Controls Ltd., Burlington, Ont., Canada	2000	The recent market introduction of larger power switching devices has made the use of DC-to-DC converters, previously used in lower power applications, commercially viable. The DC-to-DC converter, otherwise known as a DC chopper, has made inroads to applications where conventional thyristor and saturable reactor diode rectifiers were in use, in applications such as electro-winning, DC arc furnaces, graphite resistive heating, plasma torches and smelting. The DC chopper system has many operational benefits over conventional diode or thyristor rectifiers, such as: low output ripple; fast dynamic response; reduced flicker generation; high line power factor over its whole power operating range; minimal harmonic distortion of the AC feeder, without the use of harmonic traps; elimination of power factor correction equipment usually associated with thyristor rectifiers; higher system efficiencies over total output power range; and reduction in over all system size and cost. These benefits and the application of chopper supplies as they apply to the metals industry are described in this paper	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=883194
The impacts of FACTS and other new technologies on power system restoration dynamics	Adibi, M.M.; Martins, N.; Watanabe, E.H.	IRD Corp., MD, USA	2010	A number of years ago when FACTS applications had generated a great deal of enthusiasm, a paper was prepared predicting its applications in the power system restoration. It was predicted that many of the FACTS applications such as thyristor controlled shunt reactors, phase/voltage regulators, STATCOM, SVC, SSSC and thyristor controlled braking resistors (TCBR) were equally applicable to power system restoration. Recognizing that during restart and reintegration phases of restoration, a power system often consists of one or more islands, most of the automatic controls have tripped or deactivated, and the system is primarily under manual control. And that during these two restoration phases, transient/dynamic instability, sustained/transient over-voltages, load-generation imbalance and reactive power imbalance occur more often. It was hoped that FACTS technologies could eliminate or mitigate many of these restoration problems resulting in a significant reduction in restoration duration and damage to equipment. Not all the former paper's predictions have materialized. This paper revisits the FACTS applications that have been developed since, and describes a number of new technologies such as PMU that also can be used in restoration.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5589897
Reactive power compensator with switched-LC networks	Montaño, J.-C.; Castilla, M.; Gutierrez, J.; López, A.	IRNAS, CSIC, Servilla, Spain	1995	Static compensators based on thyristor controlled reactors (TCR) are well suited for power factor correction under sinusoidal supply voltage and time-varying load situations, but they inject unwanted harmonic currents in the electric lines. Passive RLC networks can be the best choice to avoid this problem, but they are unable to follow load changes. Thus, a new reactive power compensator consisting of a set of parallel LC branches, which can be automatically switched, is proposed. This permits operation under nonsinusoidal conditions and time-varying loads. A control system, which measures the equivalent admittance on the load side, and sets the optimal LC configuration to minimize the reactive component of the line current, has been used. So, the synthesized compensator presents an equivalent harmonic-susceptance which is approximately equal (as given by its discrete structure) to that of the load (with opposite sign) within the adequate frequency margin. The results of numerical simulation and experimental results are presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=497037
Power factor	Montano, J. -	IRNAS,	1996	A new reactive power compensator consisting of a set of parallel LC branches, which can be automatically	http://ieeexplore.iee

optimization with switched-LC networks	C; Gutivrrez, J.; Castilla, M.; López, A.	CSIC, Sevilla, Spain		switched, is proposed. This permits operation under nonsinusoidal conditions and time-varying loads. A control system, which measures the equivalent admittance on the load side, and sets the optimal LC configuration to minimize the reactive component of the line current, has been used. Thus, the synthesized compensator presents an equivalent harmonic-susceptance which is approximately equal (as given by its discrete structure) to that of the load (with opposite sign) within the appropriate frequency range. Numerical simulation and experimental results are presented	e.org/stamp/stamp.jsp?arnumber=551248
Effect of harmonic distortion of the supply voltage on the optimum gating angle of a TCR-type compensator	Montano, J.C.; Gutivrrez, J.; Castilla, M.; Lopez, A.	IRNAS, Sevilla, Spain	1993	The authors examine the effect of harmonic distortion of the supply voltage on the optimum gating angle of a thyristor-controlled reactor-type compensator (TCR) and hence its influence on the power factor (PF) correction. The values of optimum PF are compared with those calculated using conventional formulae (which assume that the voltage waveform is purely sinusoidal). The formulae have been simplified by assuming that the switching intervals of the TCR are not affected by the distortion of the voltage supply. This assumption allows one to proceed by considering only one control parameter	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=379469
Harmonic instability in phase controlled rectifiers	Galloway, J.	J.H. Galloway & Assoc., Broolfield, CT, USA	1999	The phenomenon of harmonic instability in phase-controlled power converters has been known for a long time. The subject was discussed by Ainsworth in the context of high voltage DC converters back in the 1950s. Harmonic instability is the abnormal operation of a power converter system due to the harmonic voltage distortion of the power source caused by the harmonic currents of the converter system itself. This effect is often found in power converters such as rectifiers but is often not recognized for what it is. The consequences can range from mild overheating and increased acoustic noise, severe instability and system shutdown, to transformer failure. Phase-controlled rectifiers are the most common type in industrial use today. They include thyristor process rectifiers, large motor drives and saturable core reactor controlled rectifiers. This paper discusses the elements of the feedback loop that causes harmonic instability, and lists symptoms by which it can be recognized. A more detailed look is taken at the zero crossing type of triggering control, as this is the most common type in use today, in both analog and digital implementations. Steps to avoid or to fix the system problems are discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=806434
Factory and site tests on the 25 MW GTO power amplifier for the control of the JET plasma vertical position	Bonicelli, T.; Baigger, P.; Hrabal, D.; Klein, R.; Marchese, V.; Mondino, P.-L.; Ostrom, R.; Shaw, S.; Timmert, H. P.; Zullo, G.	JET Joint Undertaking, Abingdon, UK	1993	The vertical position of the JET plasma is normally unstable and feedback stabilisation is therefore needed. A new power amplifier (fast radial field amplifier-FRFA) based on GTO inverters has been procured to cope with configurations characterized by plasma having a high degree of vertical instability, beyond the stabilising capability of the phase controlled thyristor power converter used so far. The new power amplifier is composed of four identical subunits which can be connected in two different configurations to achieve output voltages up to 10 kV (at 2.5 kA) and output currents up to 5 kA (at 5 kV). The amplifier is characterised by a peak output power of 25 MW and by switching frequencies of the individual GTOs of 1 kHz. The series connection of more inverters allows more voltage levels (up to nine) to be made available on the load. The paper presents the results of the extensive series of tests on a dummy load performed on the amplifier both at factory, where a complete subunit was assembled, and at the JET sites. The tests included the achievement of the full performances and the assessment of the correct operation of all the required control modes	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=265102
On-line simulation of the junction	Bonicelli, T.; Ostrom, R.;	JET Joint Undertaking,	1993	A new high power (25 MW) amplifier system based on gate turn-off thyristors (GTOs) has been procured to be used as a power amplifier in the control system of the vertical position of the JET experiment. The new amplifier	http://ieeexplore.ieee.org/stamp/stamp.j

temperature for the thermal protection of high power gate turn-off thyristors used in pulsed duty inverters	Baigger, P.; Timmert, H. P.	Abingdon, UK		is characterised by a nominal duty cycle of 30 s every 600 s. The power dissipation in each GTO can reach peaks of almost 8.1 kW for short periods. The switching frequency of each GTO and the current during the execution of a JET pulse are somewhat unpredictable. It was therefore felt necessary to provide the power devices with a thermal protection which has to be reasonably accurate in order not to unnecessarily limit the performances of the amplifier. At the same time it should be reasonably simple and cost effective. An on-line simulation/calculation of the junction temperature was therefore studied and adopted: the conduction losses, the turn-on and turn-off losses are taken into account; the direction of the output current together with the knowledge of which GTOs are in the ON status determine if the current is flowing in the GTO's or in the freewheeling diodes. A detailed description of the model used and of the hardware realisation of the simulation is given in the paper	sp?arnumber=264919
A case study on the alternative solutions for the load flow problem in a 50 kV cable grid	Fu, Y. H.; Groeman, J. F.; Van der Geest, H.; Zee, H.	KEMA T&D Power, Netherlands	2001	This paper describes a case study on the alternative solutions for a load flow problem in a Nuon 50 kV cable grid in North Holland. This part of the cable grid is typically parallel fed with short distances. The grid is designed to be operated safely under the condition when one of the cable links is out of service, the so-called N-1 condition. Under a certain circumstance, this grid will have an overload problem due to unbalanced load flow, meaning some cables are overloaded while others are under loaded. The transmission capacity of this grid will be insufficient from the year 2015 anyway, under N-1 condition. The ultimate solution is to lay extra cables in this grid, but this is a very costly option. The purpose of this paper is to present the alternative solutions studied to solve the load flow problems so that the investment of laying extra cables can be postponed after year 2010. Three alternative solutions have been studied: inserting a variable impedance, inserting a phase shifting transformer and inserting a UPFC. The effects of the three alternative solutions, both positive and negative, have been compared. The best solution among them has resulted from the technical aspects, operational aspects and economical aspects.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=988428
A combined system of APF and SVC for power quality improvement in microgrid	Tuo Dong; Linchuan Li; Zhengbo Ma	Key Lab. of Minist. of Educ. on Smart Grid, Tianjin Univ., Tianjin, China	2012	Among the factors influencing power quality of microgrid, harmonic current brought by power electronic devices and load with considerable reactive power demand are the most significant. This paper introduces a combined system of Active Power Filter (APF) and Static Var Compensator (SVC) to improve power quality of microgrid. In the combined system, APF, installed at the outlet of the micro source inverter, mitigates harmonic current. Its current detection method is ip-iq, and tracking method is Deadbeat Control and Space Vector Pulse Width Modulation (SVPWM); SVC, which is set near the load of microgrid, comprising Thyristor Controlled Reactor (TCR) and Thyristor Switched Capacitor (TSC), supplies reactive power, relives voltage variation, and reduces power loss on the transmission lines. As for SVC, we adopt closed-loop control and use Proportional-Integral (PI) method to regulate the compensatory susceptance, and then find the corresponding trigger angle in a given table. APF and SVC, performing respectively, improve the power quality of microgrid together. Simulation results show the effectiveness of the combined system later in this paper.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6612554
A novel low harmonic dynamic static var compensator resaerch	Renzhong Shan; Zhongdong Yin;	Key Lab. of Power Syst. Protection & Dynamic	2009	A novel SVC topology is proposed in this paper, firstly a multi-winding transformer is adopt to realize 12 ripple, secondly the 5th harmonic filter on system bus as the fundamental reactive power compensation, and control thyristor controlled reactor (TCR) to realize inflow system reactive power, thirdly modularization design is adopted, according to the compensation reactive power only one TCR module is phase controlled. Finally, the	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5138431

	Xiangning Xiao	Monitoring & Control under Minist. of Educ., North China Electr. Power Univ., Beijing		experimental result shows that the novel TCR without an additional filter has the advantages of low harmonic, good static and dynamic performance, small volume and etc, compared to traditional TCR.	
A Novel Structure of Dynamic Reactive Power Source	Zhongdong Yin; Jianhua Zhang; Xiangning Xiao; Zhengpai Cui; Yunbo Long	Key Lab. of Power Syst. Protection & Dynamic Security Monitoring & Control	2005	This paper puts forward a novel topology of controllable reactor, the structure is based on many small capacity thyristor controlled reactor (TCR) modules and a three-windings transformer connecting to system. The transformer secondary adopts duplex winding structure and each has multi-bank TCR modules being in delta connection. In this topology, the harmonic current injected into the power system is very small. It not only possesses all the functions a traditional TCR has, but also has many other merits such as occupying small floor space, generating little loss, easy implement control and protection scheme, and high reliability etc. A 500 kVar industrial prototype is under construction in Langfang, Hebei province of P.R.China. Digital simulation based on EMTDC/PSCAD and field test were carried out to verify the perfect harmonics characteristics of topology proposed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1546777
Development of Dynamic Var Compensator Based on 12-pulse Thyristor Controlled Reactor	Long Yunbo; Yu Han; Cui Zhengpai; Zhang Jianhua	Key Lab. of Power Syst. Protection & Dynamic Security Monitoring & Control, North China Electr. Power Univ., Beijing	2006	This paper analyzes characteristic harmonic currents of TCR and presents a method to reduce the harmonics by means of phase-shift transformer. It also introduces the constitution and implements methods of compensating device. Some key solutions for developing TCR device are introduced, such as reactive currents detection, control algorithm and the realization of controller based on ATmegal28 microcomputer. Finally, the data of field test is analyzed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4153026
Simulation and Test Study on Module Based Controllable Shunt Reactor	Ke Li; Zhongdong Yin	Key Lab. of Power Syst. Protection & Dynamic Security Monitoring, North China Electr. Power Univ.,	2010	This paper puts forward a TCR module based new type shunt high voltage reactor, which consists many small capacity thyristor controlled reactor modules and via three-windings transformer connecting to system. The secondary windings of transformer adopt duplex winding structure and each has multi-bank TCR modules being in delta connection. In this topology, the harmonic current injected into the power system is limited remarkably. A 500 kvar/10 kV industrial prototype was developed, and digital simulation based on EMTDC/PSCAD and field test were carried out to verify the characteristics of topology proposed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5449219

		Beijing, China			
Operation of a Fixed Capacitor-Thyristor Controlled Reactor (FC-TCR) Power Factor Compensator	Haque, S.E.; Malik, N.H.; Shepherd, W.	King Saud University	1985	A fixed capacitor-thyristor controlled reactor (FC-TCR) type of power factor compensator with thyristor-controlled series R-L load is analysed using an approximate and also a more exact circuit. The variation of power and power factor before and after compensation is examined for both cases. It is shown that considerable power factor improvement can be achieved in the circuit for low values of load thyristor firing- angle. However, for higher values of firing-angle, any improvement is obtained at the expense of additional. power losses.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113238
Analysis and Performance of a Fixed Filter-Thyristor Controlled Reactor (FF-TCR) Compensator	Haque, S. Enamul; Malik, Nazar H.	King Saud University College of Engineering Electrical Engineering Department P.O. Box 800, Riyadh 11421 Saudi Arabia	1987	A fixed Filter-Thyristor Controlled Reactor (FF-TCR) type of compensator is proposed to improve the power factor of a single phase thyristor-controlled inductive load and it is shown that this compensator gives better power factor improvement than the more generally used FC-TCR type of compensator. Analysis is carried out for the exact equivalent circuit of an FF-TCR compensator containing two filter branches tuned to the third and the fifth harmonics respectively. It is shown that with an FF-TCR compensator the power factor improvement is much better when the source impedance is large. However, even with a small source impedance, a reasonable improvement in power factor is realised. It is further shown that even when the source impedance is large the distortion in the terminal voltage waveform is kept within reasonable limits. The analytical results are verified experimentally.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4335123
Analysis and Performance of a Fixed Filter-Thyristor Controlled Reactor (FF-TCR) Compensator	Haque, S. Enamul; Malik, Nazar H.	King Saud University, Riyadh, Saudi Arabia	1987	First Page of the Article <img class="img-abs-container" style="width: 95%; border: 1px solid #808080;" src="/xploreAssets/images/absImages/05527242.png" border="0">	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5527242
Operation of a Fixed Capacitor-Thyristor Controlled Reactor (FC-TCR) Power Factor Compensator	Haque, S.E.; Malik, N.H.; Shepherd, W.	King Saud University, Riyadh, Saudi Arabia	1985	First Page of the Article <img class="img-abs-container" style="width: 95%; border: 1px solid #808080;" src="/xploreAssets/images/absImages/05526639.png" border="0">	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5526639
High-power switching regulator type DC-DC converters controlled by time-sharing high-frequency thyristor choppers with energy-storage and -transfer reactors	Nakaoka, M.; Vietson, N. M.; Maruhashi, T.; Nishimura, M.	Kobe University, Kobe, Japan	1979	This paper is concerned with the latest technologies on high-power switching dc-dc converters controlled by time-sharing high-frequency thyristor chopper with energy -storage and -transfer reactor coupling links, which can operate over an ultrasonic chopping frequency region in the extent of 20KHz or more than 20KHz. The possible circuit configurations of new thyristor type switching step-up and down dc-dc converters relating to magnetic-power semiconductor devices and their unique features are described and discussed from a practical point of view. The general procedures of circuit analysis and performance evaluations to offer the desirable design data are presented, and the steady-state open-loop control characteristics and a closed-loop control policy are elucidated on the basis of the theoretical and experimental results. Thyristor type high-frequency	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1060502

				switching step-up dc-dc converter using time-sharing control technique is also originally examined and discussed herein.	
Analysis on thyristor controlled series capacitor for subsynchronous resonance mitigation	Tae Kyoo Oh; Zhi-zhong Mao	Korea Electrotechnol. Res. Inst., Changwon, South Korea	2001	The thyristor controlled series capacitor (TCSC) is expected to mitigate subsynchronous resonance (SSR) providing a continuously variable series capacitance. The computer simulation studies and tests in prototype installations in the literature showed that TCSC is neutral to SSR, but which has not been proven rigorously to date. In this paper, an algorithm to calculate the subsynchronous voltage across TCSC due to a subsynchronous current is developed under the assumption that charge reversals take place at the center of conduction angles instantaneously, and it is shown that TCSC would exhibit an impedance characteristic of a reactor at subsynchronous frequencies if the center of conduction angles is at the ideal zero crossing of capacitor voltage. Some significant observations for TCSC characteristics are obtained by theoretical analysis and computer simulation studies	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=931672
Anomalous phenomenon of conduction angle in TCR-SVC and its control	Toyoshima, R.; Funaki, T.; Hikihara, T.	Kyoto Univ., Japan	2004	Static VAr compensator (SVC) with thyristor controlled reactor (TCR) is widely used as a continuously variable reactive power compensator in electric power systems. Recently, unexpected sudden jumps of conduction angle were reported depending on the change of firing angle in TCR. This anomalous phenomenon named the switching time bifurcation is due to the nonlinearity caused by switching operation. Authors have studied the switching time bifurcations in a TCR-SVC circuit experimentally, numerically and theoretically, and clarified that the occurrence of bifurcations depends on the resonant frequencies and damping parameters of the circuit. In addition, they showed the possibility of subharmonic oscillations accompanied with the switching time bifurcation in experiments and simulations. The detailed analysis leads the onset of subharmonic oscillation subject to the initial conditions of state values at the instant of firing. This implies uncoordinated firing angle control might happen to generate subharmonic oscillations, and the coordinated firing angle operation is necessary to avoid subharmonic oscillations. Then, this paper proposes the firing angle regulation scheme so as to keep the initial conditions out from the domain of subharmonic oscillation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1355076
Analysis of a three phase TSC-TCR static VAr compensator by recurrences theory	Thomas, P. Y.; Conard, J.P.; Labrique, F.; Buyse, H.	Lab. d"Electrotech. et d"Instrum., Katholieke Univ., Leuven, Belgium	1994	Thyristor switched capacitor-thyristor controlled reactor (TSC-TCR) static VAr compensators are today widely used for supporting the voltage in AC distribution systems. In this paper, the stability of the closed loop part of such a compensator is investigated by using the recurrences theory. The nonlinear behaviour of the system is highlighted	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=380969
Nonlinear stability analysis of a TCR system with an integral control loop of the reactive power	Buyse, H.; Labrique, F.	Lab. d"Electrotech. et d"Instrum., Univ. Catholique,	1991	A stability analysis is made of a single-phase thyristor controlled reactor (TCR) system with an integral control loop for the reactive power. The nonlinear aspects of the dynamics of the system and their influence on its stability have been taken into account by using recurrence equations	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=162082

		Louvain, Belgium			
A DC controlled reactor using thyristors	Dewan, S.B.; Segsworth, R. S.; McKinney, M.	Marathon Electron Research Ltd., Oakville, Ont., Canada	1969	Saturable reactors are used widely to obtain an inductance dependent on the dc current in the control winding. These saturable reactors generate harmonics that may cause undesired harmonic resonances. This paper develops an inductor arrangement that generates negligible harmonics and the inductance varies almost linearly with dc voltage. The arrangement basically consists of a binary arrangement of inductors and a vernier inductor. The vernier inductor is used to provide smooth transition between discrete switching of the binary inductors. A control scheme using analogue and digital techniques is developed to monitor the firing of the thyristors for the switching arrangement. The system is analyzed and the experimental results are compared with the theoretical results. The system developed has maximum utilization of the thyristors and the maximum inductive kVA that can be controlled is limited by maximum available ratings of the thyristors.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1066580
Power supply and protection system for plasma stabilisation in the ASDEX Upgrade tokamak	Wieczorek, A.; Blaumoser, M.; Fink, R.; Oswald, J.; Schwarz, J.; Vogtle, K.H.	Max-Planck-Inst. fur Plasmaphys. (IPP), EURATOM, Garching, Germany	1992	ASDEX Upgrade is a diverter-type tokamak commissioned in the spring of 1991 at IPP, Garching. The highly elongated plasma (elongation factor=1.6) requires a sophisticated plasma stabilisation system for both horizontal and vertical position control. A system of passive and active coils serves as a means of stabilising the plasma. The two active coils are powered by two 4-quadrant thyristor convertors at a power level of about 30 MVA. An exact model of the power supply system is used. A thyristor breaking system prevents the active coils from being overcharged by currents induced in the active coils in the event of a fast plasma disruption, where the plasma current of 2 MA decays within several milliseconds. A pyrobreaker serves as a back-up solution if the thyristor protection system fails	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=121775
Co-Ordination of Static Var Compensators With Long Distance Radial Transmission System for Damping Improvement	Ooi, B. -T; Banakar, M. H.	McGill University, Montreal, PQ, Canada	1984	The capability of static var compensators to use supplementary signals for damping improvement has been studied. Damping is shown to be a function of the transmission system loading and a function of the static var compensator The study offers insights as to how static var compensators should be coordinated with respect to the transmission system. The technology under study is based on thyristor controlled reactor with switched capacitors. This paper is concerned with the capability of the static var controller to provide damping in radial long distance transmission lines. It is well known that the lack of positive damping sets a limit to the power transferable across a transmission line By use of supplementary feedback signals, the static var compensator can be made to enhance the system damping. This paper seeks to answer the following questions: 1) For a given design of the supplementary signal feedback, are there any operating regions in which negative damping is encountered? 2) What is the effect of an individual static var compensator in providing damping for a transmission system with multiple compensation systems? 3) What is the analytical model of a static var compensator which uses the thyristor controlled reactor technology? 4) How should the elements of the static var compensator be designed in conjunction with the transmission system when the objective is to improve damping? These questions are answered in the context of a radical line with equally spaced SVC stations as modelled in Fig. 1.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5525477
Simulation of Static-Var System (SVS) Performance on a	McGranaghan, M.F.; Rocamora,	McGraw-Edison Company	1982	A real-time hybrid static-var system model designed to aid in efficiently analyzing the performance of static, thyristor-controlled compensation schemes on a transient network analyzer is described. The types of studies required to develop a static-var system specification are outlined. Use of the real-time, hybrid model to evaluate	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111

Transient Network Analyzer	R.G.; Koepfinger, J. G.	Power Systems Group		different compensation schemes, including thyristor-controlled reactors and thyristor-switched capacitors, and to optimize control system characteristics based on the response to system disturbances is delineated. Results of transient network analyzer simulations for tra nsmission system application are presented in the form of plots of the controlled bus voltage, the controlled reactor currents, the error voltage calculated by the control system, and the control system output. A parametric anaylsis of the control system response for a particular system disturbance is also illustrated.	752
Reactive optimization control for the wind farm with static var compensator (SVC)	Jian-Hong Zheng; Jie-Feng Li	Mech. & Electr. Dept, Tangshan Vocational & Tech. Coll., Tangshan, China	2012	This paper first describes the grid-connected characteristics of wind power system. Then the reactive compensation for the wind farms using static var compensator (SVC) is proposed to improve the grid-connected capacity and the operation performance of the wind farms, so as to make the grid-connected quality of the wind farms can be ensured. At last, the reactive optimization control for the wind power system is studied and the compensation effect is analyzed at the end of this paper.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6244445
Preventing AC Drive Failures Due to Commutation Notches on a Drilling Rig	Hoevenaars, A.H.; Evans, I.C.; Desai, B.	Mirus Int. Inc., Brampton, ON, Canada	2013	The operation of offshore drilling rigs and production platforms requires the extensive use of variable-speed drives. Historically, this involved dc drives almost exclusively, but more recently, ac drives have begun to find their way onto these facilities. Often, combinations of dc and ac drives are used. Silicon-controlled rectifier- or thyristor-bridge-based dc drives will distort the supply voltage by creating commutating notches. These notches can become quite deep if the source is weak, the dc drive load is heavy, and line reactors are not installed. Excessive voltage notching can cause operational problems and/or failures in other loads connected to the bus. When system resonance causes the ringing of these notches, the problem becomes even more severe. One such susceptible load is the ac drive. Wide-spectrum filters designed to reduce the harmonic currents being drawn by the ac drive can also be used to protect the drive from the harmful effects of commutation notching and other associated disturbances.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6480828
Preventing AC drive failures due to commutation notches on a drilling rig	Hoevenaars, A. H.; Evans, I.C.; Desai, B.	Mirus Int. Inc., Mississauga, ON, Canada	2009	The operation of offshore drilling rigs and production platforms requires the extensive use of Variable Speed Drives. Historically this involved DC drives almost exclusively, but more recently, AC drives have begun to find their way onto these facilities. Often it is a combination of DC and AC drives that are used. Silicon Controlled Rectifier (SCR) or thyristor bridge based DC drives will distort the supply voltage by creating commutating notches. These notches can become quite deep if the source is weak, the DC drive load is heavy and line reactors are not installed. Excessive voltage notching can cause operational problems and/or failures in other loads connected to the bus. When system resonance causes ringing of these notches, the problem becomes even more severe. One such susceptible load is the AC drive. Wide spectrum filters designed to reduce the harmonic currents being drawn by the AC drive can also be used to protect the drive from the harmful effects of commutation notching and other associated disturbances.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5297179
Harmonic current and reactive power compensation with an active filter	Takeda, M.; Ikeda, K.; Teramoto, A.; Aritsuka,	Mitsubishi Electr. Co., Kobe, Japan	1988	A static VAr compensator (SVC) using an active filter has been developed that compensates reactive power, harmonic current, negative-phase current, and voltage fluctuations. The system configuration is described, and five types of control scheme for the filter, which are based on practical applications for various loads, and the performance characteristics for each type of control are analyzed. The active filter is shown by simulation to be	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=18259

	T.			more effective for suppressing arc-furnace flicker than the TCR (thyristor-controlled-reactor) SVC.<<ETX>>	
Numerical investigation of the effect of valve reactor design on thyristor stress in a HVDC thyristor valve	Tadokoro, M.; Yamamoto, T.; Shoji, Y.; Yamaji, K.; Irokawa, H.	Mitsubishi Electr. Corp., Hyogo	1996	The overvoltage on the thyristor elements is of particular interest for practical design. Dependence of the behavior of the overvoltage on characteristics of the anode reactor was investigated mostly by numerical simulation by transient voltage program. The point in the valve, to which the core of the anode reactor is connected, critically changes the voltage that appears on the thyristor elements. The stray capacitance of the winding to the core is another important characteristic value. A structure supported thyristor valve for DC transmission of Â±500 kV, 2800 MW was developed with the aid of the understanding about this voltage behavior	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=545954
High-voltage multiple phase thyristor chopper for traction motor control	Ohno, Eiichi; Akamatsu, Masahiko	Mitsubishi Electric Corporation, Amagasaki, Japan	1967	The dc chopper drive of traction motors using thyristors has many advantages such as the improvement of efficiency, stepless control of motor current, and the elimination of mechanical contactors and the associated maintenance. A considerable amount of literature has been published concerning chopper circuitry and its application to dc motor control. There are some problems to be solved, however, for the actual application in electric railways ; the first is the realization of a high-voltage chopper, the second is the reduction of inductive interference, and the third is the reduction of weight and cost of chopper equipment. The characteristics of a multiple phase chopper circuit which has been developed for traction motor control systems are described. The multiple phase chopper with common load has proved to have the excellent property of reducing the higher harmonic components both in input current and in output current. This results in reducing the inductive interference and minimizing the weight of the smoothing reactor.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1066050
Experimental Study of Some Variable Impedance Type FACTS Devices	Agrawal, J.G.; Joshi, K. D.	M-Tech IV SEM IPS, G.H.Raisoni Coll. of Eng., Nagpur, India	2011	In this paper experimental results of different types of SVC namely TCR, GCSC, FC-TCR are presented. The experiments are carried out in the FACTS lab of Electrical Engineering Department at G.H.Raisoni College of Engineering, Nagpur, India. The effect of Fixed Capacitor- Thyristor controlled reactor (FC-TCR) on the transmission line is studied and the readings are recorded with SVC connected at the midpoint of transmission line. The operating V-I area of SVC is also plotted.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6120575
Modification of the JT-60 poloidal field power supply for high triangularity divertor operation	Matsukawa, M.; Terakado, T.; Okano, J.; Nobusaka, H.; Miura, Y.; Neyatani, Y.; Kimura, T.	Naka Fusion Res. Establ., JAERI, Ibaraki, Japan	1997	This paper describes the modification of the poloidal field power supply for the high triangularity divertor operation in JT-60. The power supply was mainly modified so as to change the combination of the thyristor converters and the poloidal field coils. After this modification. Stable divertor plasmas with a triangularity up to 0.4 at a plasma current of 2 MA were successfully obtained. However, an overcurrent of the thyristor converters in the horizontal field power supply had been often observed due to the oscillation of the voltage control command and natural commutation property of the thyristor converters in conjunction with MHD instabilities. This serious problem has been solved by introducing the rate limit control for the output voltage of the converters. In addition, it was demonstrated that both horizontal and vertical positions of the divertor X-point can be controlled simultaneously, which may be useful for the W-shaped semi-closed divertor operation	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=687099
Design and testing of power supplies for the high power gyrotron	Tsuneoka, M.; Fujita, H.; Nagashima,	Naka Fusion Res. Establ., JAERI, Ibaraki,	1991	The authors report on the design and test results of the JAERI gyrotron test facility at Naka which was originally intended for testing the high-power klystron. The AC GTO (gate turn-off thyristor) switch, the series regulator tube, and the high-speed protection system are applied for the power supply system. The AC GTO switch is able to break the current of 4500 A without any damaging surge voltage. The switch is also able to control the	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=218874

	T.; Cho, Y.; Yamane, T.; Hayakawa, S.; Ohtsuka, S.; Harada, K.; Yoshida, T.; Shibuya, T.; Ishibashi, M.	Japan		DC output voltage within Â±5% at the cathode voltage of the regulator tube. The series regulator tube system is able to rise within 200 Î¼s and keeps the flat-top voltage within Â±0.13% at the cathode voltage of -80 kV for 1 ms. The high-speed interlock system realizes turn-off performance of 6 Î¼s and a reliable and safe operation of the gyrotron. The authors have demonstrated the operation of 440 kW during 1 ms using a short pulse gyrotron at 120 GHz	
Effects of FACTS controller line compensation on power system stability	Tan, Y. L.; Wang, Y.	Nanyang Technol. Inst., Singapore	1998	In this letter, the effects of line compensation of an single-machine infinite-bus power system using fixed-capacitor thyristor-controlled reactor-type or SVC for transient stability enhancement are analyzed. In particular, a novel method for analysis of line compensation by an SVC is presented. The maximum power transfer, for line compensation by FACTS controllers can be written in the form=(1-k) where is the maximum power transfer for the uncompensated line and k is the degree of compensation. The analysis revealed that the effectiveness of the SVC for stability enhancement is increased if the degree of compensation of the line is increased.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1236741
Effects of FACTS controller line compensation on power system stability	Tan, Y.L.; Wang, Y.	Nanyang Technol. Inst., Singapore	1998	In this letter, the effects of line compensation of an SMIB power system using FC-TCR type TCSC or SVC for transient stability enhancement are analyzed. In particular, a novel method for analysis of line compensation by an SVC is presented. The maximum power transfer, P_{emax} for line compensation by FACTS controllers can be written in the form P_{emax}=P_{max}/(1-k) where P_{max} is the maximum power transfer for the uncompensated line and k is the degree of compensation. The analysis revealed that the effectiveness of the SVC for stability enhancement is increased if the degree of compensation of the line is increased	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=691726
Design of an online microprocessor based individual phase control of a static VAr compensator	Chen, D.K.C.; Lee, Yuang-Shung; Chi-Jui Wu	Nat. Taiwan Inst. of Technol., Taipei, Taiwan	1991	An online individual control scheme of the static VAr compensator (SVC) which is constructed using thyristor controlled reactors (TCR) and switched capacitors (SC) is designed to correct power factor and balance three phase line currents. At each sampling instant, the loading conditions are measured by the active power and reactive power (P-Q) transducers between any two phases at the load bus terminal. The compensation value of each phase of the SVC is calculated by three analog adders and sent to the micro-controller which is synthesized by a M68HC11EVM microprocessor board. Then the micro-controller determines the on/off connection of the capacitors and the firing angle of the thyristors in each phase. Test results show that with the cooperation of the SVC, the power factor can be maintained approximately at unity and the line currents viewed at the load bus are balanced. It is noted that with the benefits of power factor correction and balance improvement, the additional power loss caused by the SVC is negligible	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=154056
Flicker Suppressor by Thyristor	Masuda, M.; Matsumoto, S.; Shintomi, T.	National Laboratory for High Energy Physics	1977	One of the difficulties which are encountered by direct connection of the accelerator to the utilities is the effect of pulsed reactive power on the utilities with respect to the customer's interference and the system stability. To suppress the voltage flickers caused by the pulsed reactive power, several types of machines have been investigated, namely capacitor banks with thyristor switches, series capacitors, saturable reactor and reactor with thyristors. Among these, the reactor with thyristors was employed in KEK accelerator with respect to	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4328926

		Oho-machi, Tsukuba-gun, Ibaraki, 300-32, Japan		performance, maintenance, technical feasibility and economical point. The actual operation of reactive power control by ignition angle of thyristor was satisfactory. The swing of 14 MVAr reactive power was stabilized within ??5% and the voltage flicker was suppressed from 3% to 0.5% which is enough less than the permissible value suggested by the electrical company. The harmonic current which is associated with thyristor was absorbed to ac filters that was also served as the reactive power compensator.	
An intelligent voltage controller for static VAr compensators	Sharaf, A.M.; Snider, L.A.	New Brunswick Univ., Fredericton, NB, Canada	1994	The paper presents a novel AI-rule based intelligent controller for a fixed capacitor-thyristor controlled reactor (FC-TCR) static VAr compensator (SVC). The intelligent voltage regulator is based on the concept of the error excursion plane where the stabilizing action is scaled by the magnitude of the excursion voltage error vector, in order to ensure adequate compensation. The proposed rule based voltage regulator is validated using ATP/EMTP and is compared with an optimized conventional proportional plus integral voltage controller. The proposed rule based design is robust and tolerates system parameter variations as well as modelling inaccuracies, since the control level is only scaled by the location of the voltage excursion error vector in the (e_v-e˙_v) error plane. The scheme is validated for two large system contingencies comprising load rejection and a three phase short circuit fault followed by loss of a transmission line	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=287876
Analysis of TSR-based SVC for a Three-Phase System with Static and Dynamic Loads	Gelen, A.; Yalcinoz, T.	Nigde Univ., Nigde	2007	In this paper, the effect of the thyristor switched reactor-based static VAr compensator (SVC), which is one of flexible AC transmission systems (FACTS) controllers, to load voltages has been proposed in the three-phase system at static load and dynamic load conditions. The design and testing of TS R-based SVC are verified using the MATLAB/Simulink 7.04reg and Power Systems Toolbox. The results show that significant improvement on reactive power compensation and bus voltage regulation could be achieved by using the TSR-based SVC. Also, harmonic levels generated by TSR-based SVC do not cause to instability in the test system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4287305
A single DC reactor type fault current limiting interrupter for three-phase power system	Usui, K.; Nomura, T.; Satoh, T.; Yamaguchi, M.; Fukni, S.; Yokoyama, K.; Nagasawa, T.	Niigata Univ., Japan	2001	The authors propose a single DC reactor type fault current limiting interrupter (FCLI) for a three-phase power system. The device uses a single high temperature superconducting (HTS) coil that operates in conjunction with a modified half control bridge composed of thyristors and diodes connected to a transformer's secondary windings. One variety is an automatic interrupter, which automatically blocks fault current through the application of DC bias current to the bridge. Another is a gate interrupter, which does the same thing by locking the thyristor's gate pulses. The authors examine the results of various simulations on a new device that both limits and interrupts fault current in a three-phase power system	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=920277
Thermal design, modeling and simulation of air forced cooling heat sink for Thyristor Controlled Reactor (TCR)	Asadi, M.; Arezi, B.	Niroo Res. Inst. (NRI), Tehran, Iran	2011	Cooling is important for appropriate operation of the power electronic devices. In low power applications, the cooling is done by air forced systems. Air forced cooling systems in low power valves are more reliable and simpler than water cooling systems. This paper examines air forced cooling model of the power electronic devices precisely with thermal transfer equations. This paper focuses on dimensions of heat sink and its channels in details and also, a flow chart for design of heat sink is presented based on air velocity and dimensions of channels. This paper calculates and simulates a case study. Finally, the results of simulations based on ANSYS, are compared with calculation results.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5742495
Design of a computer	Souli, A.;	Nucl. Res.	2012	This paper aims to present the design of a computer code (HPFCODE) of the power flow and losses in power	http://ieeexplore.iee

code â€œHPFCODEâ€ to evaluate the influence of the harmonics in the electrical networks	Hellal, A.	Center of Birine, Birine, Algeria		systems under the influence of harmonics, using the GUI in MATLAB. After describing the program was run for two networks IEEE 6 nodes and IEEE 14 nodes. The power flow by Newton-Raphson method was calculated as the loss of active and reactive power in the lines, respectively, where the loads are linear and nonlinear (Static Var Compensator (SVC), Thyristor controlled Reactor (TCR), and Unified Power Flow Control (UPFC)).	e.org/stamp/stamp.jsp?arnumber=6195256
Design procedure of firing angles for harmonic reduction in a thyristor-controlled reactor by asymmetrical firing control	Funabiki, S.; Himei, T.	Okayama University, School of Engineering, Department of Electrical Engineering, Okayama, Japan	1985	A thyristor-controlled reactor (TCR) has been investigated and developed for a VAR compensator. Its application to industry is put into practice. This system has, however, inherently a disadvantage of generating many lower-order harmonic currents. Some countermeasures to reduce harmonics have been proposed up to the present day. The TCR based on an asymmetrical firing control (AFC-type TCR) has been already proposed for one of the positive countermeasures by the authors. The paper presents the systematic design procedure of the setting of firing angles which satisfy the design specifications of the TCR; that is, each harmonic, the total content of the harmonics and the capacitances of the thyristor and reactor. The use of computer-aided design (CAD) for the choice of firing angles is developed in accordance with the above procedure. Furthermore, the limit of harmonic reduction of the TCR based on an asymmetrical firing control and the effect of multiplexing units on the harmonic reduction are also discussed for the use of CAD.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4646573
Modeling and Analysis of a TCR-FC Reactive Power Compensator Using the Harmonic Domain	Garcia, H.; Madrigal, M.	PGIIE, Inst. Tecnol. de Morelia, Morelia, Mexico	2009	This paper presents a methodology for steady-state and transient analysis in electrical networks, the methodology is applied to reactive power compensation using thyristor-controlled reactor with fixed capacitor (TCR-FC). The method is based on the use of dynamic harmonic domain (DHD) and associated discrete circuit models. The dynamic harmonic domain is a natural approach for conducting dynamic and steady-state studies of the evolution of harmonics in electrical networks. On the other hand, the associated discrete circuit models facilitate the transient analysis of large electrical networks.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5341941
Investigation into the advancement of FACTS and their implementation impact on a utility	El Sayed, H. I.; Johnson, B.K.; Lai, L. L.; Tse, Norman	Planning Dept, Qatar Elec/Water Corp, Qatar	2009	The main objective of this paper is to investigate the advancement of the FACTS, both in the technology development and applications. The paper will survey different FACTS devices available, review and compare their different applications in power systems. It will investigate the ability of FACTS to improve power transfer and voltage control will be reviewed in light of different types of compensation, series, shunt at midpoints, single or multi-function etc. FACTS definite impacts on a utility network with anticipated advantages and disadvantages will be explored.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5528296
Operation of the Alcator C-MOD power system	Fairfax, S.A.; Daigle, J.; Bertolino, V.; Paranay, J.; XiWen Zhong	Plasma Fusion Center, MIT, Cambridge, MA, USA	1993	The energy storage and power conversion system for Alcator C-MOD is designed to supply up to 500 MJ to the experiment at peak powers in excess of 300 MVA. The experiment requires flexibility in the control of magnet currents to achieve simultaneous shaping, ohmic drive, and position control with a small set of uncompensated PF magnets. The relatively modest budget and limited manpower make issues of maintenance and reliability extremely important to the eventual success of the experiment. These requirements resulted in a power system design with many unique features. A total of 11 conversion systems power the 14 magnets of the tokamak to provide nearly complete flexibility in plasma shaping and control. Five thyristor circuit breakers are used to initiate the plasma. Four of the PF converters utilize circulating current configurations to maintain plasma position control as the magnet currents pass through zero. The TF converter incorporates transformer tap-changing circuitry to reduce alternator loads during peak demand periods. Many converters have solid-state	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=518464

				fuse loss and conduction monitor circuits that allow continued operation when only 1 device in a parallel bank fails. The same circuits detect commutation failures and protect the converters from these potentially destructive faults. Unique design features can sometimes lead to new and unforeseen problems in operation or maintenance. This report will discuss the initial operating experience of the Alcator C-MOD power system from preliminary acceptance testing through plasma operations. The performance of the thyristor circuit breakers, commutation and conduction monitor circuits, circulating current power supplies, and tap-changing TF supply will be presented and compared with expectations. The overall performance and reliability of the power system will be examined as well	
Thyristor DC circuit breakers for Alcator C-MOD	Fairfax, S.; Sueker, K.	Plasma Fusion Center, MIT, Cambridge, MA, USA	1991	The Alcator C-MOD PF (poloidal field) system requires DC circuit breakers in five PF magnets for plasma initiation. A design based on standard 77-mm SCRs and diodes was chosen for several reasons. Bypass switches and other mechanical components were avoided to reduce maintenance costs and achieve high reliability on five separate systems. The circuit breakers will carry the full charging current pulse as well as the reverse swing current. Standard phase control devices offer superior current-carrying capability, low cost, and commonality with the devices, gate drives, and mounting hardware used in the magnet power supplies. Phase control SCRs have a longer turn-off time and require a large counterpulse capacitor band than inverter thyristors. The net cost of the additional capacitance is very small in a single-pulse, low duty-cycle system. Design values and simulations for three switches are presented. Switch sections are rated 2 kV maximum interrupting voltage with bipolar current ratings of 50, 25, and 15 kA. A pulse-forming network provides the required 400 Î¼s turn-off pulse to the SCRs. The design is strongly influenced by the parasitic inductance in bus and circuit components	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=218863
Real time control system for the National Spherical Torus Experiment (NSTX)	Neumeyer, C.; Gates, D.; Gibney, T.; Hatcher, R.; Kaye, S.; Marsala, R.; Mueller, D.; Oliaro, G.; Ramakrishnan, S.	Plasma Phys. Lab., Princeton Univ., NJ, USA	1999	The NSTX is a new national facility for the study of plasma confinement, heating, and current drive in a low aspect ratio, spherical torus (ST) configuration. The ST configuration is an alternate magnetic confinement concept which is characterized by high Î² (ratio plasma pressure to magnetic held pressure) and low toroidal field compared to conventional tokamaks, and could provide a pathway to the realization of a practical fusion power source. The NSTX depends on a real time, high speed, synchronous, and deterministic control system acting on a system of thyristor rectifier power supplies to 1) establish the initial magnetic field configuration; 2) initiate plasma within the vacuum vessel; 3) inductively drive plasma current; and 4) control plasma position and shape	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=842601
National Spherical Torus Experiment (NSTX) power supply real time controller	Neumeyer, C.; Hatcher, R.; Marsala, R.; Ramakrishnan, S.	Plasma Phys. Lab., Princeton Univ., NJ, USA	1999	The NSTX is a new national facility for the study of plasma confinement, heating, and current drive in a low aspect ratio, spherical torus (ST) configuration. The ST configuration is an alternate magnetic confinement concept which is characterized by high Î² (ratio plasma pressure to magnetic field pressure) and low toroidal field compared to conventional tokamaks, and could provide a pathway to the realization of a practical fusion power source. The NSTX defends on a real time, high speed, synchronous, and deterministic control system acting on a system of thyristor rectifier power supplies to 1) establish the initial magnetic field configuration; 2) initiate plasma within the vacuum vessel; 3) inductively drive plasma current; and 4) control plasma position and shape	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=849838

Load monitor for the TFTR motor-generator sets	Neumeyer, C.; Awad, M.; Baker, E.; Bronner, G.; Ramakrishnan, S.	Plasma Phys. Lab., Princeton Univ., NJ, USA	1989	Two parallel-operated motor-generator (MG) sets are used to provide pulsed AC power to the Tokamak Fusion Test Reactor (TFTR). The MG sets are vertical shaft machines adapted for the pulsed duty; each is nameplate-rated 475 MVA, 13.8 kV, 0.7 pF, 60 Hz, 7 s, and can deliver 2.25 GJ of energy during an excursion from 87.5 Hz to 60 Hz once every five minutes. In order to better quantify the machines' actual operating limits, a study was undertaken to determine what subset of all conceivable performance-limiting factors might come into play to limit the overall machine performance envelope throughout the nominal range of speed and power factor, with consideration of pulsed operation. Seven critical factors were identified: (1) instantaneous stator current, (2) stator winding temperature, (3) instantaneous field current, (4) field winding temperature, (5) exciter thyristor junction temperature, (6) prospective stator overvoltage, and (7) instantaneous torque. An MG load monitor will be built to provide real time monitoring of all seven quantities by direct measurement and simulation, where necessary. The preliminary design of the MG load monitor is described	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=102258
A linear displacement power factor compensator	Nunes, J. V R; Braga, R. A M; Libano, F.B.; Muller, S.L.	Pontificia Univ. Catolica do Rio Grande do Sul, Brazil	2004	Nowadays, the consumer of energy has the concern in operating with a value of power factor inside of a value stipulated by the energy concessionaries. It is know that the power factor is related with the displacement power factor and the total harmonic distortion. The present work has as main objective the development and implementation of a linear compensator of displacement power factor objectifying to attenuate the negative impact traditionally caused by the discrete control of the reactive power at the fundamental frequency. In this work, the implementation of a compensator is made using a static compensation structure of reactive power (static VAr compensator - SVC) called TCR-FC (thyristor controlled reactor-fixed capacitor). The prototype of this kind of SVC is composed by a fixed capacitor (FC) in parallel with a fixed reactor in series with a bidirectional ac thyristor valve (or switch) (TCR). The proposed structure can be a single-phase or three-phase compensator. In the three-phase configuration, the compensator can be connected in wye or delta. The development of a linear control of reactive power can solve problems generated by the frequent switching of capacitor banks and makes possible the dynamic compensation of the flow of reactive power in the electrical system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1355548
Design and Implementation of a Current-Source Converter for Use in Industry Applications of D-STATCOM	Bilgin, H.F.; Ermis, M.	Power Electron. Dept., TUBITAK Space Technol. Res. Inst. (TUBITAK UZAY), Ankara, Turkey	2010	This paper deals with the design and implementation of the power stage of a forced-commutated current-source converter (CSC) for use in industry applications of distribution type static synchronous compensator (D-STATCOM). The power semiconductors are switched at 500 Hz according to the switching patterns generated by selective harmonic elimination method for the elimination of the most significant four low-order harmonics. The possibility of using various power semiconductors in CSC is examined both theoretically and experimentally. The requirement of bipolar voltage-blocking capability is achieved by the use of an asymmetric integrated gate commutated thyristor (IGCT) and a fast-recovery diode instead of a single symmetrical device, which maximizes the converter power rating and makes natural-air cooling realizable. Determination of optimum dc-link reactor in view of the power quality standards and design of optimum turn-on and turn-off snubbers in view of the chosen power semiconductor characteristics are shown to be critical design issues in the paper. Design principles are verified by both laboratory tests and field tests conducted on two different industrial D-STATCOM prototypes. It has been shown that an IGCT-based CSC can be successfully used in industry applications of D-STATCOM systems by designing the power stage according to the proposed principles.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5420007

Commissioning of a 225 Mvar SVC incorporating A Â±75 Mvar STATCOM at NGC's 400 kV East Claydon substation	Horwill, C.; Totterdell, A. J.; Hanson, D.J.; Monkhouse, D. R.; Price, J. J.	Power Electron. Syst., ALSTOM T&D Ltd, UK	2001	In view of the many system planning uncertainties faced by the UK National Grid Company (NGC), there is a clear need for readily relocatable reactive power compensation systems with enhanced system performance. To date 12 relocatable SVCs (RSVCs) have been installed as part of a planned programme of work to meet these changing system needs. Developments in the rating capabilities of gate turn-off (GTO) thyristors have enabled power electronic converters using GTOs to be proposed as serious competitive alternatives to the well proven thyristor controlled reactor (TCR) and thyristor switched capacitor (TSC). GTO-based STATCOM convertors have a number of benefits which are of value to NGC, such as reduction in required site area and ease of relocation. The authors describe the East Claydon project, which is viewed as an important step towards long-term objectives which could see the deployment of a range of compact power electronic devices on NGC's system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=988415
Power Supply for NSTX Resistive Wall Mode Coils	Ramakrishnan, S.; Neumeyer, C.; Marsala, R.; Hatcher, R.; Baker, E.	Princeton Plasma Phys. Lab., NJ	2005	The National Spherical Torus Experiment (NSTX) has been designed and installed in the existing facilities at Princeton Plasma Physics Laboratory (PPPL). Most of the hardware, plant facilities, auxiliary sub-systems, and power systems originally used for the Tokamak Fusion Test Reactor (TFTR) have been used with suitable modifications to reflect NSTX needs. Until 2004, the NSTX power system was feeding twelve (12) circuits in the machine. In 2004, resistive wall mode (RWM) coils were installed in the machine to suppress resistive wall modes and to correct error fields. There are six of these coils installed around the machine on the mid-plane. Since these coils need fast and accurate controls, a switching power amplifier (SPA) has been procured, installed and commissioned along with other circuit components. One of the existing thyristor rectifiers is used as the DC source to the SPA. The controls for the RWM have been integrated into the overall computer control of the DC power systems for NSTX. This paper describes the RWM power supply for NSTX	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4019020
Power supply changes for NSTX Resistive Wall Mode Coils	Ramakrishnan, S.; Neumeyer, C.; Mozulay, R.; Baker, E.; Hatcher, R.; Lawson, J.; Que, W.; Zhao, X.	Princeton Plasma Phys. Lab., Princeton, NJ, USA	2013	The National Spherical Torus Experiment (NSTX) has been designed and installed in the existing facilities at Princeton Plasma Physics Laboratory (PPPL). Most of the hardware, plant facilities, auxiliary sub-systems, and power systems originally used for the Tokamak Fusion Test Reactor (TFTR) have been used with suitable modifications to reflect NSTX needs. Prior to 2004, the NSTX power system was feeding twelve (12) circuits in the machine. In 2004 the Resistive Wall Mode (RWM) Coils were installed on the machine to correct error fields. There are six of these coils installed around the machine in the mid-plane. Since these coils need fast and accurate controls, a Switching Power Amplifier (SPA) with three sub-units was procured, installed and commissioned along with other power loop components. Two RWM Coils were connected in series and fed from one SPA sub-unit. After the initial RWM campaign, operational requirements evolved such that each of the RWM coils now requires separate power and control. Hence a second SPA with three sub-units has been procured and installed. The second unit is of improved design and has the controls and power components completely isolated. The existing thyristor rectifier is used as DC Link to both of the Switching Power Amplifiers. The controls for the RWM are integrated into the overall computer control of the DC Power systems for NSTX. This paper describes the design changes in the RWM Power system for NSTX.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6635283
Voltage sag and swell generator with thyristor controlled	Chung, Y.H.; Kwon, G. H.; Park, T. B.;	R&D Center, LG Ind. Syst. Co. Ltd,	2002	This paper describes a new economical sag/swell voltage generator suitable for the evaluation of high power custom power devices such as DVR (dynamic voltage restorer) and DSTATCOM (distribution static compensator). Proposed system was designed to generate the several power quality disturbances in MVA	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1067

reactor	Lim, G. Y.	Kyunggi-Do, South Korea		power ratings-sag, swell, under voltage, over voltage and harmonic distortions. The sag and the under voltage can be generated by voltage drop across a reactor, while its magnitude and durations can be controlled by the firing angle of TCR (thyristor controlled reactor). In the case of the swell and the over voltage, we need a step-up transformer. Output of the step-up transformer is regulated by TCR to obtain nominal voltage level. At any given instant, if the firing angle of TCR is retarded or stopped, then we can obtain the swell voltage or the over voltage disturbance. Also we can generate harmonic current by controlling firing angles of TCR, while keeping the system voltage level within the specified limits. In this paper, two identical three-phase wye-connected TCRs are connected to the secondary windings of two step-down transformers, one operated from wye-wye transformer, the other from delta-wye transformer. Harmonic filters (11th and 13th) are added to reduce the voltage distortion when TCRs are operated. Simulation results are given for several cases of voltage sag and swell generations. Design guidelines are given for the TCR. Finally, conclusions are given.	870
Voltage sag and swell generator for the evaluation of custom power devices	Chung, Y.H.; Kwon, G. H.; Park, T. B.; Lim, K. Y.	R&D Centre, LG Ind. Systs. Co. Ltd., KyungKiDo, South Korea	2003	This paper describes a new economical sag/swell voltage generator suitable to the evaluations of high power custom power devices such as DVR (Dynamic Voltage Restorer) and DSTATCOM (Distribution Static Compensator). Proposed system was designed to generate the several power quality disturbances in MVA power ratings - sag, swell, under voltage, over voltage and harmonic distortions. The sag and the under voltage can be generated by voltage drop across a reactor, while its magnitude and durations can be controlled by the firing angle of TCR (Thyristor Controlled Reactor). In the case of the swell and the over voltage, we need a step-up transformer. Output of the step-up transformer is regulated by TCR to obtain nominal voltage level. At any given instant, if the firing angle of TCR is retarded or stopped, then we can obtain the swell voltage or the over voltage disturbance. Also we can generate harmonic current by controlling firing angles of TCR, while keeping the system voltage level within the specified limits. In this paper, two identical three-phase wye-connected TCRs are connected to the secondary windings of two step-down transformers, one operated from wye-wye transformer, the other from delta-wye transformer. Harmonic filters (11th and 13th) are added to reduce the voltage distortion when TCRs are operated. Simulation results are given for several cases of voltage sag and swell generations. Design guidelines are given for the TCR. Finally, conclusions are given.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1271036
Control of the Thyristor-controlled Reactor for Reactive Power Compensation and Load Balancing	Wangha Lee; Taewon Kim	Res. Inst. of Ind. Sci. & Technol., Pohang	2007	This paper proposes a control method for the thyristor-controlled reactor (TCR) to improve the dynamic response using a fast detection method. The method is based on the substitution of conventional filtering by an efficient, faster and simpler process with a lower computational burden. This method guarantees that the compensation process will perform within 1/4 cycle of the fundamental line period. Due to its fast response, the proposed method makes it possible to apply a rapid changing load such as an electric arc furnaces. The proposed controller utilities feed forward and closed loop control techniques. The feed forward control is the direct calculation of the TCR reference current to compensation for reactive power and unbalanced load. The feed forward control enhances the dynamic response of the system along with the fast detection method. Analysis and experimental results from a 3 kVA prototype are presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4318399
Collective dimming of discharge lamps with	Miao-miao Cheng;	Res. Lab. for Nucl.	2011	Discharge lamps which include HID lamps (High intensity discharge lamps) and fluorescent lamps take up more than 90% of the lighting market. Traditional thyristor voltage control is difficult for discharge lamps dimming due	http://ieeexplore.ieee.org/stamp/stamp.j

improved input power factor using MERS-PFC converter	Mustapha, I.B.; Takanori, I.; Shimada, R.	Reactors, Tokyo Inst. of Technol., Tokyo, Japan		to their negative impedance characteristics. Especially, it is common to operate the HID lamps in 100% lighting state even unnecessary. Simple dimming control is desired to meet users' requirements and achieve energy saving as well. This paper proposes a collective dimming method for discharge lamps based on a principle of frequency control. The energy saving effect have been proved by experimental results. Then, a new configuration for the frequency converter is proposed with a power factor correction circuit which is named MERS-PFC (Magnetic Energy Recovery Switch-Power Factor Correction) converter. This method has the following advantages: 1) collective control for paralleled lamp groups by one power device; 2) simple control mechanism and easy to realize; 3) soft-switching current continuous mode power factor correction being realized by MERS-PFC converter.	sp?arnumber=6064153
Design and construction of thyristor DC circuit breakers for Alcator C-MOD	Sueker, K.H.; Fairfax, S.A.	Robicon Corp., Pittsburgh, PA, USA	1991	The detailed design of the Alcator C-MOD thyristor DC circuit breakers required extensive simulation and careful consideration of parasitic elements as well as device recovery and turn-on limitations. Simulations were performed both on commercially available packages and with direct solution of circuit equations with custom programs. The need for high reliability and minimum device count resulted in the choice of 77-mm devices normally used in phase control applications. The circuit uses up to 12 parallel paths to carry pulsed currents as high as 50 kA. Maximum interrupting voltages of 2 kV are supported by devices rated 4.4 kV. Each SCR is shunted by a diode in series with an air core decoupling reactor. The counterpulse capacitor is discharged through one or two SCRs and utilizes a pulse forming network to quickly reduce the main SCR current to zero, and then provide a relatively low and stable reverse voltage during the commutation interval. All devices are mounted with radial symmetry. The diode reactors are subject to modest forces under normal conditions but large lateral forces when adjacent paths are lost	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=218862
Investigations of an advanced form of series compensation	Helbing, S.G.; Karady, G.G.	Salt River Project, Phoenix, AZ, USA	1994	This paper provides a comprehensive investigation of an advanced form of series compensation (ASC). The basic model consists of a series capacitor connected in parallel with a thyristor-controlled reactor (TCR). Proper selection of the thyristor firing angle increases the equivalent series compensation by developing a â€œloop flowâ€ current through the series capacitor. The mathematical equations describing the voltages and currents through the capacitor, inductor, and thyristors are developed, analyzed, and later verified using the EMTP analysis program. Additionally, a model circuit was constructed to verify the analytical and computer results. The analysis revealed that the ASC circuit approaches its steady state compensation level gradually, approximately 8-10 cycles at higher levels. The analysis also revealed the significant effect of the reactor size on the ASC operating characteristics and on component sizing	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=296276
A Functional Model of Thyristor Based on MATLAB for High Power Circuit Simulation	Feng Gao; Hui Lin	Sch. of Autom., Northwestern Polytech. Univ., Xi"an, China	2012	A novel functional subcircuit model based on MATLAB/Simulink for high power circuit simulation is proposed in this paper. The model can overcome the limitation of PSPICE model in high power system and remedy the deficiency in transient analysis of the Simulink model in toolbox. It described the static and dynamic process of thyristor correctly in the simulation of a high power thyristor controlled reactor (TCR) system. A good practicality of the proposed model has been observed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6307372
A novel IGCT-based Half-controlled Bridge	Wanmin Fei; Yanli Zhang	Sch. of Electr. &	2006	A novel IGCT-based half-controlled bridge-type fault current limiter is proposed in this paper. By substituting the half-controllable SCR in the rectifier bridge with self-turn-off device IGCT, the uncontrolled lime of the converter	http://ieeexplore.ieee.org/stamp/stamp.j

Type Fault Current Limiter		Autom. Eng., Nanjing Normal Univ.		bridge can be reduced from half a cycle to the delay time of the current measuring circuit. If the maximum current in the dc reactor is preset, the inductance, volume, weight and cost of the DC reactor can be reduced to one 32th of what it is in the SCR-based bridge type FCL in three phase power systems approximately. The magnetization time of the DC reactor is reduced. The control method is very simple. The dynamic performance of the proposal FCL can be improved. Topology and control strategies of the proposal FCL are described in detail. Simulations under each short circuit fault mode are carried out. An experimental model is constituted and tested. Simulation and experiment results proved the practicability and validity of the new FCL	sp?arnumber=4778168
Design of static VAr compensator using a general reactive energy definition	Liberado, E.V.; Souza, W.A.; Pomilio, J.A.; Paredes, H.K.M.; Marafao, F.P.	Sch. of Electr. & Comput. Eng., Univ. of Campinas, Campinas, Brazil	2013	This paper describes a methodology to design Static VAr Compensators (SVC) using the reactive energy definition from Conservative Power Theory. Application of this methodology is presented through simulations of local and distributed compensation approaches. Results show effective compensation of reactive current and load unbalance. Harmonic distortion caused by thyristor controlled reactor has been suitable attenuated by passive filters designed in combination with the SVC.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6604455
A control algorithm for reactive power compensation of ferroalloy furnace base on spline interpolation	Wenchao Jia; Xin Zhao	Sch. of Electr. & Electron. Eng., Changchun Univ. of Technol., Changchun, China	2010	The TCR (Thyristor-Controlled Reactor) model of SVC (Static Var Compensation) is designed reactive power compensation. It is mainly used to solving voltage fluctuation, flick and three phases unbalance and so on about network power quality problem. The problem is evocable by the impulse load of arc furnace and rolling mill. Arc furnace is characterized by low voltage, big current and nonlinear load. That determine reactive power becomes bigger comparably and efficiency factor is low too. In this paper take TCR and FC as reactive power compensation that is more and more popular now. Reactance current is controlled by charging trigger angle. The effect of reactive power compensation is influenced by calculate precision of trigger control angle. The spline interpolation function as a calculation method of thyristors trigger control angle is made use of in this paper. The method is verified that calculation volume low, applicability better and precision high by computer simulation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5610275
A hybrid controllable shunt reactor of transformer type	Hongfa Ding; Xianzhong Duan		2004	This paper presents a hybrid controllable shunt reactor of transformer type (HCSRT) to solve the harmonic problem of the thyristor-controlled reactor (TCR). The proposed device has advantages of both the controllable shunt reactor of transformer type (CSRT) and static VAr generator (SVG). The HCSRT uses a voltage source inverter (VSI) to replace the bidirectional thyristor valve of the CSRT to control the output current of the regulating winding. By introducing duplicate winding ratings, the reactance of HCSRT can be continuously and smoothly regulated in the total of the N-th power of 2 steps with N control windings. A hybrid static VAr compensator of transformer type (HSVCT), capable of compensating both the inductive and capacitive reactive powers, is also presented in this paper. Theoretical analysis and simulations demonstrate advantages of HCSRT and HSVCT, including fast transient response, wide regulating region, minor harmonic pollution and high cost-performance ratio.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1460179
Suppression of transmission system	Choi, S.S.; Jiang, F.;	Sch. of Electr. &	1996	The role of a variable series compensator in a multimachine infinite-bus system is investigated. The proposed compensator comprises a combination of thyristor-switched capacitors (TSCs) and a thyristor-controlled reactor	http://ieeexplore.ieee.org/stamp/stamp.j

oscillations by thyristor-controlled series compensation	Shrestha	Electron. Eng., Nanyang Technol. Univ., Singapore		(TCR). The role of the TSCs is to suppress large power oscillations while that of the TCR is to damp out small power perturbations. A performance index to quantify the overall power imbalance in the system is proposed and is used to formulate the control strategies for the TSCs and TCR. The coordination between the control actions of the TSCs and TCR is established on the basis of the magnitudes of the power oscillations. Computer simulations show that the proposed scheme is effective in suppressing power flow oscillation in transmission networks	sp?arnumber=488072
Synthesis of wide frequency model of HVDC valve elements	Lei Liu; Xiang Cui; Xuelian Gao	Sch. of Electr. & Electron. Eng., North China Electr. Power Univ., Beijing	2008	High voltage direct current (HVDC) converter station generates radio frequency (RF) electromagnetic noise by the periodic turn-on and turn-off of the valve. This noise can affect the performance of adjacent communication, control and computer equipments and can interfere with carrier system operation. In order to calculate and predict the RF noise produced by the valve ignition, it is essential to develop accurate models of valve equipments (thyristor, snubber circuit, equalized capacitance, saturation reactor) over a broad frequency range. After measuring the frequency dependent impedance of the elements, the wide frequency model of valve elements can be set up with rational approximation and Brune synthesis method. At last by comparing the numerical results with EMTP ensure the efficiency and accuracy of the model.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4559911
Calculation of overvoltage distribution in HVDC thyristor valves	Haifeng Sun; Xiang Cui; Lei Qi; Qi Wang	Sch. of Electr. & Electron. Eng., North China Electr. Power Univ., Beijing, China	2010	Thyristor valves are the core components in HVDC transmission system. These valves in the system are exposed to various overvoltages both external and internal. So it is important to analyze the characteristic of the converter valves under different overvoltages. Wide-band equivalent circuits of the valve components such as thyristor, saturable reactor are obtained based on impedance measurement. And stray capacitances of valve sections in valve tower are included in these wideband models. Based on these models, overvoltage distributions in the valve tower are calculated and analyzed under different kinds of surges, including switching, lightning and fast front. To illustrate the effects of shielding plate, three different cases are calculated and analyzed. And some useful conclusions are presented in this paper.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5475883
The application of SVC for the power quality control of electric railways	Ma Jianzong; Wu Mingli; Yang Shaobing	Sch. of Electr. Eng., Beijing Jiaotong Univ., Beijing, China	2009	Electric railways are pollution sources of power quality in the public power system. The low power factor and current harmonics caused by AC-DC locomotives have been difficult problems needed to be deal with for a long time in China. Some countermeasures have been taken by the railway authorities to improve the power qualities in recent years. This paper presents the performance of the SVC, which is a combination of passive filters and thyristor controlled reactor, based on the measured data of power qualities of An-ding traction substation of Beijing-Shanghai electrified railway. The different operational manners of the compensator are compared with the measured data of three-phase unbalance and total harmonic distortion. The SVC technique has shown a promising solution to the improvement of power quality of electric railways. The compensator topology and relevant parameters should be given enough attention in engineering application to obtain an optimal effect.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5347939
Harmonic analysis based on the matrix model of nonlinear element	Yuanyuan Sun; Weijie Zheng; Tao Yu	Sch. of Electr. Eng., Shandong Univ., Jinan	2008	This paper presents a new method to calculate the harmonic conditions for systems including switching-mode electronic nonlinear elements. The method is based on the harmonic coupled admittance matrix models for nonlinear elements. A thyristor controlled reactor (TCR) was used as an example of the nonlinear element to demonstrate the performance of the proposed method. Since the admittance model for the nonlinear TCR element is linear, a linear network solution in harmonic domain is sufficient to obtain the harmonic results. This paper also investigates the impact of high harmonic voltage distortions on the accuracy of the coupled	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4608353

				admittance model and the associated harmonic power flow results. An iterative method was proposed to improve the original linear network solution accuracy for cases involving very high amount of harmonic voltage distortions.	
A New Method to Model the Harmonic Generation Characteristics of the Thyristor Controlled Reactors	Yuanyuan Sun; Weijie Zheng; Wilsun Xu	Sch. of Electr. Eng., Shandong Univ., Jinan	2007	This paper presents a model to represent the harmonic generating characteristics of the thyristor controlled reactor (TCR). The model transforms the time domain nonlinear characteristics of the TCR into a frequency domain linear admittance matrix. The matrix couples the TCR harmonic voltages and currents and it does not vary with the harmonic conditions of the system. This paper presents the theoretical basis and analytical derivation of the model. Comparison of the matrix model results with the time domain simulation results is used to verify the validity and accuracy of the proposed model.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4538587
The Mechanism Research on Dual Impedance Solutions of TCSC	Kejun Li; Jianguo Zhao	Sch. of Electr. Eng., Shandong Univ., Ji"nan	2007	TCSC dual solution phenomenon is demonstrated by both digital simulation and dynamic experiment. Phasor diagram analysis of TCSC shows that even though quality factor remaining constant, the phase difference between capacitor voltage and line current decreases with the increasing of thyristor conduction current, which incurs the decrease of reactor current's amplitude and width. Further, the thyristor conduction block is pointed out to be the mechanism of TCSC dual solution phenomenon. Reactor branch current and equivalent quality factor determine the degree of block. Both amplitude and width of the current are blocked when thyristor triggering synchronized by line current. Only amplitude is blocked synchronized by capacitor voltage. This explains why impedance dual solution phenomenon is easy to occur in the mode of line current synchronization.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4275591
Research on Impedance Characteristics of Thyristor Controlled Series Capacitor	Kejun Li; Jingguo Ren; Jianguo Zhao; Lin Niu	Sch. of Electr. Eng., Shandong Univ., Jinan, China	2010	The desired impedance of Thyristor Controlled Series Capacitor (TCSC) is usually obtained by adjusting the firing angle and it is of great importance to make clear the relationship between the two quantities. The relationship between firing angle and conduction angle is proposed in this paper considering the influence of the thyristor conduction characteristics and the equivalent resistance in the reactor branch. In the derivation of the fundamental-frequency impedance, it is found out that there are dual solutions corresponding to the same firing angle in most steady operation area of TCSC. One is inductive and the other is capacitive. This phenomenon is demonstrated by both digital simulation and dynamic emulation experiment. Some conclusions and experiment results can provide reference to engineering exploitation and bottom control design of TCSC.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5449220
Principle and simulation of the self-tuning passive filter	Liu Zhizhen; Yang Zhijian; Zhang Xin	Sch. of Electr. Eng., Shandong Univ., Jinan, China	2005	This paper presents a new self-tuning passive filter which uses the thyristor controlled reactor (TCR) as a variable reactor. The equivalent inductance of the variable reactor is automatically changed by adjusting the thyristor's triggering angle to make the filter always keep at the resonance state along with the deviation of the inductance and capacitance, and the filter can finish the self-tuning process. The theoretical analysis and simulation of this filter are given. The simulation results show that this new self-tuning passive filter is suitable for harmonics mitigation for most of power electronic equipments.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1518703
Dual solutions analysis of TCSC in quasi-steady-state operation	Kejun Li; Jianguo Zhao; Wilsun Xu; Dong Yan	Sch. of Electr. Eng., Shandong Univ., Jinan, China	2004	Thyristor controlled series capacitor (TCSC) is expected to control line power flow, improve system stability, and enhance power transfer capability. The bottom control is the basis for TCSC applications, in which the relationship between frequency impedance and firing angle is the key factor. In this paper, the expression between firing angle and conduction angle is ascertained considering the resistance effects of reactor and thyristor valves firstly. Then the dual solutions phenomena is discovered and analyzed. This paper also points out that TCSC can just move along one branch of frequency impedance curve and do not step to the other one if	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1460014

				only the firing angle is changed. Finally, the digital simulation and the data of dynamic simulation experiment all support the existence of dual solution phenomenon. Many conclusions and experiment results can provide reference for TCSC design.	
A comprehensive power quality controller for substations in power system	Xiao Zhang; Yue Wang; Wanjun Lei; Jun Yang; Xiaohua Tang; Weibin Si; Jie Hou	Sch. of Electr. Eng., Xi"an Jiaotong Univ., Shaanxi, China	2006	A comprehensive power quality controller combined with thyristor controlled reactor (TCR) and hybrid active power filter (HAPF) is described in this paper for substations in power system. The HAPF topology presented in the paper is different from the conventional HAPF. The basic of the new HAPF topology is to add a small inductor in parallel with the active power filter (APF) controlled as a current source, in order to force the fundamental current flow through the additional inductor instead of the APF. By this way, it can reduce the VA rating of the APF greatly. The TCR together with the passive filter part of the HAPF makes a static Var compensator (SVC), which acts as a classic reactive power compensator for load balancing and power factor correction. The small rating active filter is used to improve filtering characteristics of the passive filter in SVC and suppress possible resonance between the system impedance and the passive filter. The paper introduces the scheme's main circuit structure and its operation principle, mainly analyzes the control method and principle. Through modeling and simulation, the results verify the effectiveness and advantage of the comprehensive power quality controller for substations in power system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1620778
Novel pilot protection scheme for transmission line with TCSC and TCR	Jiale Suonan; Shien He; Xiaoning Kang	Sch. of Electr. Eng., Xi"an Jiaotong Univ., Xi"an, China	2010	Through fault analysis of Thyristor Controlled Series Capacitors (TCSC) compensated transmission line, a novel pilot protection scheme for transmission lines with TCSC and Thyristor Controlled Reactor (TCR) is presented. It is based on integrated impedance, which is defined as the ratio between the sum of voltage phasors and the sum of current phasors at two terminals of the transmission lines. The integrated impedance of the transmission lines is used to determine whether there is a fault inside the line or not. When an external fault occurs, the integrated impedance reflects the capacitance impedance of the protected line, its imaginary part is negative, and the absolute value of its imaginary part is large. When an internal fault occurs, the imaginary part of the integrated impedance on the fault phase is either a positive value or a small negative value. According to such characteristics, internal faults can be distinguished from external faults. The new scheme can be easily set and has the ability of fault phase selection, its behavior can hardly be influenced by capacitive currents, TCSC or TCR, and it can endure greater fault resistance. Digital simulations based on 750 kV transmission systems show that the presented scheme has high sensitivity and reliability.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5666127
One Phase to Three Phase Converter Based on Thyristor Controlled Reactor	Shi-Long Chen; Hong-Chun Shu	Sch. of Electr. Power Eng., Kunming Univ. of Sci. & Technol., Kunming	2009	The technology of converting one phase AC to three phase AC should be widely used in electric railway and mountainous area which is out of the way. But the technology has not been solved well for a long time. It is necessary to find a one phase to three phase way to satisfy those occasions which need no-high request and reasonable price. This paper introduces the basic theory of converting one phase AC to three phase AC , and gives out two theory schemes to realizes it, introduces the working theory of TCR (Thyristor Controlled Reactor). According to the theory of one phase AC to three phase AC and the theory of TCR, give out the one phase to three phase converter based on TCR. Educes the one phase to three phase converter which is conformable to electric railway and mountainous area which is out of the way. At last, the simulation with MATLAB/Simulink is gived out to validate the controlling strategy.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4918559
Research of new	Kang Ming-	Sch. of	2011	As an important component of FACTS family, Because it can increase power transmitting capacity and control	http://ieeexplore.iee

controlled series compensation using variable structure control based on TCT	cai; Dong Xin-zhou	Electron. & Opt. Eng., NUST, Nanjing, China		power flow, TCSC has great significance to improve operation reliability and flexibility of the power system and link performance. This paper analyzed the merits of TCT type controlled reactor and structured TCT type controlled series compensation. To verify the effectiveness of the proposed method, the simulation with single machine infinite system is conducted. And the simulation results show that the controller provides high-performance dynamic characteristics and robustness and the transient response of power system effectively improved.	e.org/stamp/stamp.jsp?arnumber=6180539
Modelling of large nonlinear loads and thyristor controlled shunt compensators	Tang, C. K K; Turner, D.R.	Sch. of Eng. & Appl. Sci., Durham Univ., UK	1991	The experimental modelling of large nonlinear loads (such as arc furnaces), their supply systems and reactive shunt compensation is described. The laboratory model can be programmed to draw a load current which is a scaled copy of a system load or any other waveform that may be required. The modelling of the compensator is based on a thyristor controlled shunt reactor (TCR), using a fast, but very simple, integral of voltage controlling algorithm. The ability of the equipment to model a 56 MVA electric arc furnace is described and it is shown that to model such a load mathematically, a degree of randomness has to be introduced into the synthesised current waveform	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=99218
Analysis on principle of operation of arc-suppression coil based on thyristor controlled reactor	Wang Chonglin; Liang Rui; Liu Jianhua; Zhang Dongliang; Xue Xue	Sch. of Inf. & Electr. Eng., China Univ. of Min. & Technol., Jiangsu	2005	In distribution systems the following grounding ways, i.e. non grounding, arc-suppression coil grounding and arc suppression coil via small resistance grounding, are often applied. Because each grounding way has its own features, therefore, it is necessary to carry out technical economical comparison before select ion for the particular case. In 6 kV coalmine power system, the transmission lines mostly are cables, the grounding current is almost capacitive current, so arc-suppression coil grounding is widely used in coalmine power system. This paper presents a new type of arc-suppression coil, then focus on study of the compensatory principle of arc-suppression coil with three phases and five columns. The structure of this arc-suppression coil is different from the traditional mode, and it is the integration of the traditional grounding transformer and arc-suppression coil. The arc-suppression coil with three phases and five columns can realize automatic trace and compensation for grounded fault capacitive current of power system by the method of regulate the thyristor triggering angle to control the inductive current of second winding. The wave shape of the arc-suppression coil with three phases and five columns is also analyzed and calculated in this paper	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1574991
Implementing TCSC device in Kalpakam - Khammam line for power flow enhancement	Prudhviraj, G.V.T.; Raghu; Meikandasivam, S.; Vijayakumar, D.	School of Electrical Engineering, Vellore Institute of Technology, INDIA	2013	Thyristor controlled series capacitor (TCSC), the first generation of flexible AC transmission system (FACTS), can control the line impedance through the series introduction of a thyristor controlled reactor across a fixed capacitor with the transmission line. Application of TCSC controller is to control the power flow, to damp out the power oscillations or to improve the transient stability. This paper concentrates only on power flow control over the transmission line using TCSC device. A 3 phase 400 kV Kalpakam and Khammam transmission line is considered for this analysis. Results are analyzed for sudden increase in load for cases without and with implementing TCSC controllers. The complete system is modeled in MATLAB/SIMULINK platform.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6528932
Discrete-Event Systems Supervisory Control for a Dynamic Flow Controller	Afzalian, A.A.; Nabavi Niaki, S.A.; Iravani, M.R.;	Shahid Abbaspour Univ. of Technol., Tehran	2009	This paper presents supervisory control of a dynamic flow controller (DFC) based on the discrete-event systems (DES) theory. A DFC can be considered as a flexible AC transmission system controller and includes a mechanically-switched phase-shifting transformer, a multimodule thyristor-switched capacitor, a multimodule thyristor-switched reactor, and a mechanically switched capacitor. Owing to the inherent discrete switching nature of a DFC, its components are modeled as finite automata; then, a DES supervisory control is designed to	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4483684

	Wonham, W.M.			implement the control logic of the DFC system in different modes of operation (i.e., ldquoautomaticrdquo and ldquoauto/manualrdquo). It is shown that the specifications are controllable and the synthesized supervisors are nonblocking in both modes and the modular supervisors nonconflict in auto/manual mode.	
Voltage flicker compensation using STATCOM	Joorabian, M.; Mirabbasi, D.; Sina, A.	Shahid Chamran Univ. of Ahvaz, Ahvaz	2009	Voltage flicker is considered as one of the most severe power quality problems (especially in loads like electrical arc furnaces) and much attention has been paid to it lately. Due to the latest achievements in the semiconductors industry and consequently the emergence of the compensators based on voltage source converters, FACTS devices have been gradually noticed to be used for voltage flicker compensation. This paper covers the contrasting approaches; dealing with the voltage flicker mitigation in three stages and assessing the related results in details. Initially, the voltage flicker mitigation, using FCTCR (fixed capacitor thyristor controlled reactor), was simulated. Secondly, the compensation for the Static Synchronous Compensator (STATCOM) has been performed. In this case, injection of harmonics into the system caused some problems which were later overcome by using 12-pulse assignment of SATCOM and RLC filters. The obtained results show that STATCOM is very efficient and effective for the flicker compensation. All the simulations have been performed on the MATLAB Software.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5138604
Analysis of the Conducted Interfering Mechanism within SVC-based substations	Li Zhang; Lou, Jie; Qingmin Li; Qingquan Li	Shandong Univ., Jinan	2007	In this paper, a simulation model is established to investigate on the conducted mechanism in substations installed with SVC (Static Var Compensator) devices with a view to characterizing the main causes of the conducted interference. The high-frequency macro model for thyristors is established with a nonlinear time-varying resistor to simulate the switching characteristics of the thyristors. Based on the above macro model for thyristors, a concrete model of SVC including TSC (Thyristor-switched Capacitor) and TCR (Thyristor-controlled Reactor) is further proposed. In addition, high-frequency equivalent models for frequency-domain compensation of both CT and PT, based on their calibrated non-flat amplitude-frequency characteristics, are adopted to rectify the emissions levels from the SVC switching. The conducted interferences by simulations are correlated with that from on-site measurements, which indicates that the high-frequency switching characteristics of thyristors are the main causes of conducted emissions.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4413526
A novel fault current limiter with series compensation	Xingyuan Li; Min Zheng; Hongchao Liu	Sichuan Univ., Chengdu, China	2002	In this paper, a fault current limiter (FCL) with series compensation is proposed. It is composed of a limiting reactor and a compensation capacitor that is parallel with a by-pass reactor controlled by GTO. The FCL can not only control fault current, but also perform series compensation. The good performance of this device is proved by simulation, it will be a practical protection device for power systems in the future.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1067774
Design considerations for the Eddy County static VAr compensator	Tyll, H.K.; Huesmann, G.; Habur, K.; Stump, K., Sr.; Elliott, W.H.; Trujillo, F.E., Sr.	Siemens AG, Erlangen, Germany	1994	This paper describes the steps for the design of the static VAr compensator at (SVC) Eddy County. The specified system requirements on operating range, loss evaluation and harmonic performance led to an SVC configuration which contains one thyristor switched capacitor (TSC) branch, one thyristor controlled reactor (TCR) branch for continuous reactive power control and two double tuned filter branches. The system voltage of the SVC secondary bus was optimized to 8.5 kV based on thyristor equipment capabilities. The paper shows the voltage and current stresses of the thyristor valves taking into account system faults for the TCR branch and misfiring effects on the TSC branch. The approach for filter design considering the harmonic performance requirements and resulting component ratings are shown. The Eddy County SVC commenced commercial operation in April 1992	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=296254

Digital protection schemes of advanced series compensators	Pereira, M.; Renz, K.; Unterlass, F.	Siemens AG, Erlangen, Germany	1993	The world's first advanced series compensator (ASC) with controllable series impedance as a flexible AC transmission (FACTS) device has started commercial operation. The protection for this three-phase ASC scheme is based on the protection of conventional fixed series compensators. Under overload conditions operation can be prolonged by interactions with ASC controls. Thorough digital and transient network analyzer (TNA) tests have been made to verify the correct behaviour. Field tests proved these results	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=292656
Matching site and power system requirements design of the two Pelham SVCs	Tyll, H.; Thumm, G.; Stober, R.; Winfield, M.	Siemens AG, Erlangen, Germany	1993	This paper describes the design and layout for the two SVCs installed in the Pelham substation, north of London. Both SVCs of equal size and design have a nominal rating of -75 MVAr to 150 MVAr and are connected to the National Grid 400 kV system. The specified system requirements on operating range, harmonic performance and loss considerations led to an SVC configuration which contains one thyristor switched capacitor (TSC) branch, one thyristor switched reactor (TCR) branch for continuous reactive power control and a single tuned filter branch for harmonic limitation. The system voltage of the SVC secondary side was optimised to 14 kV based on thyristor equipment capabilities. The paper shows the voltage and current stresses of the thyristor valves taking into account system faults for the TCR branch and misfiring effects for the TSC branch. The approach to filter design considering the harmonic performance requirements is described. The Pelham SVCs commenced commercial operation in summer 1992	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=264748
Advanced series compensator enhances flexibility for AC transmission systems	Rent, K.; Thumm, G.; Weiss, S.	Siemens AG, Erlangen, Germany	1993	The innovative combination of conventional fixed series capacitors and thyristor-controlled reactors as a flexible AC transmission (FACTS) device commenced commercial operation in 1992. This advanced series compensation (ASC) system offers several advantages in comparison with conventional fixed series capacitors. This new technology achieves additional system flexibility by direct power flow control, continuous control of the compensation level and improved capacitor bank protection. Further advantages include control of transmission line overload conditions, and subsynchronous resonances (SSR) mitigation. Intensive transient network analyser and field tests proved the ASC behaviour predicted by digital studies	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=292657
System studies and basic design for an advanced series compensation scheme (ASC)	Christl, N.; Lutzelberger, P.; Sadek, K.	Siemens AG, Erlangen, Germany	1991	A new innovative advanced series compensation (ASC) scheme will be supplied by Siemens for installation in the 230 kV Kayenta substation by the Western Area Power Administration USA (WAPA) in early 1992. This scheme includes thyristor controlled reactors in parallel with a three-phase capacitor bank, which represents significant progress in terms of flexible AC transmission systems (FACTS). The authors describe the theory and equipment used for the ASC scheme. The following aspects of the ASC are discussed: steady state behaviour and impedance variation dependence on firing angle and line current; bang-bang control and modulation of firing angle to damp power oscillations at different frequencies; elimination of spark gaps and reduction of MOV energy using the ASC scheme; advantages of digital control and protection for the ASC scheme; fast reinsertion of the capacitor bank after fault clearing in the AC network; and smooth reinsertion of the capacitor bank	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=154057
Thyristor control for fault current limitation	Renz, K.; Thumm, G.; Weiss, S.	Siemens AG, Germany	1995	Fast growing power networks with increasing fault levels may require the use of fault current limiting techniques. Thyristor-controlled schemes which insert a reactor or an inductive impedance can effectively reduce and limit fault currents. Several possibilities are well known, such as switched reactors and controlled series compensation. Other technologies, e.g. SMES and UPFC, are still under development or under study	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=405172
Switching time bifurcations in a	Jalali, S.; Dobson, I.;	Siemens Energy &	1996	Thyristor controlled reactors are high power switching circuits used for static VAR control and the emerging technology of flexible AC transmission. The static VAR control circuit considered in the paper is a nonlinear	http://ieeexplore.ieee.org/stamp/stamp.j

thyristor controlled reactor	Lasseter, R.H.; Venkataramanan, G.	Autom. Inc., Atlanta, GA, USA		periodically operated RLC circuit with a sinusoidal source and ideal thyristors with equidistant firing pulses. This paper describes new instabilities in the circuit in which thyristor turn off times jump or bifurcate as a system parameter varies slowly. The new instabilities are called switching time bifurcations and are fold bifurcations of zeros of thyristor current. The bifurcation instabilities are explained and verified by simulation and an experiment. Switching time bifurcations are special to switching systems and, surprisingly, are not conventional bifurcations. In particular, switching time bifurcations cannot be predicted by observing the eigenvalues of the system Jacobian. We justify these claims by deriving a simple formula for the Jacobian of the Poincare map of the circuit and presenting theoretical and numerical evidence that conventional bifurcations do not occur	sp?arnumber=486445
A stability model for the advanced series compensator (ASC)	Jalali, S.G.; Hedin, R.A.; Pereira, M.; Sadek, K.	Siemens Energy & Autom. Inc., Atlanta, GA, USA	1996	This paper develops an accurate and general stability model for the ASC (thyristor controlled reactor). The model is valid for both the capacitive and inductive regions of the ASC operation. It is accurate in that the instantaneous voltage and current waveforms and also the fundamental component of the capacitor voltage (needed for stability) are determined every half-cycle by solving the differential equations of the ASC circuit. The model is capable of incorporating any control algorithms. The validity of the model is demonstrated by comparing the model with the Electromagnetic Transient Program (EMTP) digital simulations using step time of 10 Î¼s	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=489377
The power supply and control system for the MM-2U neutral beam injector	Wang, D.T.; Xu, X. W.; Li, X. Y.; Lu, D. L.; Jiang, S. F.; Sun, M. D.; Li, H. J.; Yuan, B. S.; Liu, M. Z.	SIP, Chengdu, China	1993	A single injector with one ion source has been constructed, which is provided for researching the stability effect of the sloshing ion distribution in the magnetic mirror experiment facility (MM-2U) by oblique injection of neutral beam. The neutral beam injector (NBI) can deliver 80 kW of neutral beam power at energy of 25 keV with 50 ms for MM-2U. In the present paper, a testing power supply for the neutral beam injector with injecting power up to 200 kW is described. A thyristor switch modulator applied to an arc power supply, it is capable of delivering 10 to 1000 A DC pulses at 20 to 100 V and pulse length up to 2 s with a duty cycle of 1/100. Both switching-on and switching off times of the circuit are less than O.5 ms. A high power vacuum tube TM-703F is used as the switch/regulator of the accel power supply, specifications of the circuit are as follows: output pulse voltage 50 kV, pulse current 30 A, pulse width 50 ms. Both the rise and fall times are less than 25 Î¼s, fluctuation of the pulse flat top less than 1%. A programmable controller by a DBJ-Z80 computer is applied to control the sequence of the power supply. The power supply and control system have been operated for 5 years successfully	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=518470
A unified Newton-Raphson technique for AC-DC power flow analysis with thyristor controlled series capacitor	Kaewmanee, J.; Sirisumrannukul, S.	Sirindhorn Int. Thai-German Grad. Sch. of Eng., King Mongkut"s Univ. of Technol. North Bangkok,	2008	This paper presents a unified Newton-Raphson method to solve an AC power flow problem with the presence of a DC link and a tyristor controlled series capacitors (TCSC). A DC link provides an economical way to interconnect areas with long-distance separation or those with different frequencies or incompatible frequency control. A TCSC, a series capacitor bank shunted by a thyristor-controlled reactor, provides fast and reliable power flow control. The presence of a DC link and a TCSC introduces complexity in power flow calculation. It is therefore proposed in this paper the unified Newton-Raphson technique for solving the AC part, the DC part and the TCSC part simultaneously. The methodology is demonstrated by a modified IEEE 14-bus power system with result and discussion.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4600584

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Study on the arc-suppression coil based on sectional TCR	Chen Zhongren; Zhang Bo; Mei Ni	South China Univ. of Technol., Guangzhou, China	2009	A kind of arc-suppression coil based on sectional TCR is designed to overtake some limitations of preset arc-suppression coils and follow-up arc-suppression coils in application, i.e. tuning mechanics of preset arc-suppression coil is complex and its tuning is slow, while follow-up arc-suppression coil generates abundant harmonic in tuning. The arc-suppression coil has the same reactors in parallel with the thyristors acted as switches. Two schemes to control the arc-suppression coil are proposed. Firstly, one section of reactor generates inductive current by controlling thyristors' trigger angle, and the other sections of reactors generate inductive current by controlling thyristors fully conducting or fully turning-off. In the control mode, only a small quantity of harmonics is generated and capacitive current of the electric power network can be compensated completely in single-phase grounding fault. Secondly, all the thyristors in parallel with reactors are used as the switches, and harmonic content is generated least. The arc-suppression coil designed is tested in simulator network and the result shows that it has advantages of fast tuning rate, good accuracy of capacitive current measurement. Therefore, it has certain application value and extension potential.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5157837
Plasma position control system in HL-1M tokamak	Yuan Baoshan; Yan Kailin; Li Shiming; Tan Manqio; Wang Shangbing; Chen Xiaoguang; Jin Qinghua; Qi Wanli	Southwest Inst. of Phys., Chengdu, China	1993	The HL-1M tokamak is the modification device of HL-1. In this paper, the consideration for plasma equilibrium and the design of the coil, power supply and control circuits for the plasma position control system in HL-1M tokamak are presented, four-quadrant thyristor converter (FQTC) with the circulating current for the power supply of the fast vertical field (FF) coils and the control circuits are described, the commissioning results for the FF power supply with a dummy coil are given	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=518324
Feedback control of the plasma position in HL-1 tokamak	Yuan, B.; Jiao, B.; Yang, K.; Jin, Q.; Jiang, Y.; Tan, M.; Wang, S.	Southwestern Inst. of Phys., Sichuan	1991	A feedback control system is installed in the HL-1 tokamak with a thick copper shell (<e1>d</e1>=5 cm). The control field coils outside the copper shell are fed by a six-pulse thyristor rectifier. The power supply is operated by a pulse-width-modulated regulator which consists of a dual-mode circuit without dead zone and a PID circuit. The operation on the HL-1 shows that the horizontal and vertical plasma positions can be controlled to Â±2 mm	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=218737
Harmonic reduction in the static VAR compensator by sequence control of transformer taps	Patel, H.K.; Dubey, G.K.	Sri Venkateswara Regional College of Engineering and	1983	Owing to discontinuous current in a thyristor-controlled reactor (TCR) of a static VAR compensator, harmonic currents are generated in the supply system. The paper presents a new method for reducing these harmonics. In the method used, the TCR is fed through the sequentially controlled transformer taps. Two alternative approaches of sequence control of transformer taps are described. The feasibility of the proposed method has been verified experimentally.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4643681

		Technology, Department of Electrical Engineering, Surat, India			
Study on Operational Tests for FACTS Thyristor Valves	Guangfu Tang; Kunpeng Zha; Zhiyuan He; Haitian Wang	State Grid Smart Grid Res. Inst., Beijing, China	2013	Developed synthetic test circuits for thyristor valves of flexible ac transmission systems (FACTS) are established in this paper. By controlling the thyristor valves of synthetic test circuits, it can reproduce test stresses, including, but not limited to, the forward high voltage before the thyristor valve withstanding overcurrent and reverse recovery voltage after thyristor valves withstanding overcurrent, on thyristor valves in FACTS equipment equal to or greater than those that appear in commercial projects. With corresponding test circuits and control strategies, the temperature-rise test, overcurrent test, and the synthetic test for thyristor valves can be performed, respectively. Then, a protection method of synthetic test circuits is presented. Finally, a temperature-rise test platform, overcurrent test platform, and synthetic test platform for thyristor valves have been set up, respectively. The test results show that the developed circuit and proposed control and protect strategies are available to test for thyristor valves used in FACTS.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6492158
Research on application of TCR+FC typed SVC in power quality integrated management for power traction system	Wang, Dan; Yang, Chaoying; Zhang, Xin; Wang, Jinhao; Li, Gengyin	State Key Laboratory of Alternate Electrical Power System with Renewable Energy Sources (North China Electric Power University), Changping District, Beijing 102206, P.R. China	2012	With characteristics such as impact, asymmetric and nonlinear, the electromotive in electrified railway is a typical kind of single-phase load. Electrified railway connected to power grid will bring a lot of power quality problems. To solve harmonic problems and three-phase voltage unbalance caused by the negative sequence, this paper proposes an integrated management of power quality problems based on the three-phase static var compensator (SVC). In this management, SVC is composed of fixed capacitors (FC) and thyristor controlled reactor (TCR). This SVC management is accessed to the high-voltage side of traction substation by a dedicated transformer, which focuses on compensating the negative sequence and the reactive power. Based on the analysis of this TCR+FC typed SVC, a composite control system is used in this paper, which consists of a open-loop control system and a closed-loop control system. By modelling and simulating the actual situation of a traction station in PSCAD/EMTDC software, the feasibility of the comprehensive power quality controlling device is verified and we conclude results that this TCR+FC typed SVC management can effectively control three-phase unbalance and harmonic power quality problems.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6493068
Improvement of Transmission Capacity by Thyristor Controlled Reactive Power	Olwegard, A.; Walve, K.; Waglund, G.; Frank,	Swedish State Power Board	1981	This paper shows that thyristor controlled reactive power can be used as an efficient tool to improve damping of large power systems. If thyristor switched capacitors are used there will also be positive contribution to transient stability. Examples of power systems where damping is the critical factor have been investigated. The use of supplementary control of generators and control of reactive power has been studied. Basic configurations of	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111084

	H.; Torseng, S.			thyristor switched capacitors and thyristor controlled reactors are presented.	
A New Generalized Concept for the Design of Thyristor Phase-Controleed VAr Compensators Part I: Steady State Performance	Hammad, A.E.; Mathur, R. M.	System Planning Manitoba Hydro	1979	The paper presents a new generalized concept for the design of thyristor phase-controlled reactors. The generalization brings out a whole new range of possible designs from which an optimum can be selected. The most attractive features of the new designs are that they produce less harmonics and appear cost effective due to savings possible in filtering and valve equipment. The paper develops a general analysis, and presents algebraic expressions for the harmonic magnitudes which can be readily used even for the known designs.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113467
Steady-State Analysis of a Self-Excited Single-Phase Reluctance Generator	Allam, S. M.; El-Khazendar, M. A.; Osheiba, A.M.	Tanta Univ., Tanta	2007	This paper presents an analytical method for predicting the steady-state performance of a self-excited single-phase reluctance generator (SESPRG), which supplies R-- L load. The proposed analysis is based on the d--q axis model and phasor diagram of such a generator in the steady-state condition. Excitation capacitors are connected across both the main and auxiliary windings. Magnetic saturation is taken into account and is assumed to be confined to the direct axis, and is accounted for a variable direct-axis magnetizing reactance. Conditions of self-excitation and the minimum value of the capacitance required to achieve self-excitation are also given. Special attention is focused on the machine performance when it operates as a pure single-phase reluctance generator (PSPRG). A fixed-capacitor (FC) thyristor-controlled reactor (TCR) scheme is used to regulate the generator terminal voltage by controlling the thyristor conduction angle. Further stability limits are investigated by developing the active-reactive (P-Q) power diagram. Reasonably close agreement between the measured and predicted results is observed confirming the validity of the proposed analysis.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4292177
ELF magnetic fields by close proximity to a large static VAr compensator: a case study	Pretorius, P. H.; Britten, A. C.	Technol. Res. & Investigations, Eskom, Cleveland, South Africa	1996	An investigation was conducted to determine the magnetic field levels in the vicinity of the static VAr compensator (SVC) at Eskom's Impala 275 kV substation. Of specific interest were the variation in magnetic field levels and harmonic content resulting from changes in the firing angle of the thyristor controlled reactor (TCR). Magnetic field levels were measured during three different settings of firing angle and with the SVC off. The results of this investigation are reported in this paper	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=563044
A novel type of thyristor converter with interphase reactors	Nakano, H.; Takahashi, I.	Technol. Univ. of Nagaoka, Japan	1988	A parallel-connected thyristor converter, having improved power factor and smoother output voltage waveforms, is presented. This is achieved by the use of interphase reactors with several taps changed by thyristors and two sets of asymmetrical controlled thyristor converters. To minimize the reactive power, a special asymmetrical triggering method is used. A method for finding the maximum power-factor switching mode is established. The triggering methods and experimental results are described.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=18172
Harmonic domain periodic steady state modeling of power electronics apparatus: SVC and TCSC	Lima, L. T G; Semlyen, A.; Iravani, M.R.	TEE/PGMEC, Univ. Fed. Fluminense, Rio de Janeiro,	2003	The paper presents a general model for the representation of a thyristor-controlled reactor (TCR) in the frequency domain. This model underlies the implementation of a Newton-Raphson procedure to determine the periodic steady state of the power system with fast convergence and high accuracy. The TCR model is used as a building block to represent more sophisticated power electronics apparatus such as the static VAr compensator (SVC) and the thyristor-controlled series capacitor (TCSC).	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1208384

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Status report on project Hercules	Loree, D.; Giesselmann, M.; Kristiansen, M.; Larson, D.	Texas Tech. Univ., Lubbock, TX, USA	1993	Project Hercules is a project to improve ignitron switches which will then be used on the upgrade of Lawrence Livermore's Nova Laser for its inertial confinement fusion program. The goals of Hercules are to lifetime-test (up to 10000 shots) prototype ignitrons or other switches with the required Nova current and Coulomb parameters (300 kA, 200 C), recommend design changes, and retest the second-generation switches. The design and construction of the test circuit and necessary diagnostics are described. The details of the design and construction of a 0.5 MJ electrolytic capacitor bank and a semiautomatic diagnostic/control system are described. The required test run data include peak current and corresponding tube voltage for every shot, entire current and voltage waveforms every few shots, and ignitor resistance values every few shots. In addition, the conversion of a 120 kW, 12 kV constant voltage supply to an 8 A constant current supply with the use of six SCRs and a commercial control board is described	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=195718
Implementation of Static VAR Compensator for Improvement of Power System Stability	Venkateswara Rao, B.; Kumar, G.V.N.; Ramya Priya, M.; Sobhan, P. V S	Thandrapaparayya Inst. of Sci. & Technol., Bobbili, India	2009	Static VAR compensator (SVC) is incorporated in Newton Raphson method in which Power Flow Solution is a solution of the network under steady state conditions subjected to certain constraints under which the system operates. The power flow solution gives the nodal voltages and phase angles given a set of power injections at buses and specified voltages at a few, both the models of SVC i.e.SVC Susceptance and Firing Angle Models are discussed. It is also shown that the power system losses are decreased after incorporating the SVC in this N-R method. The results are generated for 24-Bus system. The reactors are thyristor-controlled and the capacitors can be either fixed or controlled. Advanced load flow models for the SVC are presented in this paper. The models are incorporated into existing load flow (LF) Newton Raphson algorithm. The new models depart from the generator representation of the SVC and are based instead on the variable susceptance concept. The SVC state variables are combined with the nodal voltage magnitudes and angles of the network in a single frame of reference for a unified, iterative solution through Newton methods. The algorithm for Load Flow exhibit very strong convergence characteristics, regardless of the network size and the number of controllable devices. Results are presented which demonstrate the process of the new SVC models.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5376570
Seven-Level Shunt Active Power Filter for High-Power Drive Systems	Peng Xiao; Venayagamoorthy, G.K.; Corzine, K.A.	Thermal Dynamics Corp., West Lebanon, NH	2009	In high-power adjustable-speed motor drives, such as those used in electric ship propulsion systems, active filters provide a viable solution to mitigating harmonic related issues caused by diode or thyristor rectifier front-ends. To handle the large compensation currents and provide better thermal management, two or more paralleled semiconductor switching devices can be used. In this paper, a novel topology is proposed where two active filter inverters are connected with tapped reactors to share the compensation currents. The proposed active filter topology can also produce seven voltage levels, which significantly reduces the switching current ripple and the size of passive components. Based on the joint redundant state selection strategy, a current balancing algorithm is proposed to keep the reactor magnetizing current to a minimum. It is shown through simulation that the proposed active filter can achieve high overall system performance. The system is also implemented on a real-time digital simulator to further verify its effectiveness.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4752783
Dynamic performance analysis of a hybrid wind turbine	Tatsuta, F.; Nishikata, S.	Tokyo Denki Univ., Tokyo, Japan	2012	Dynamic performances of a hybrid wind turbine generating system consisting of series connected plural wind generators, a current-source thyristor inverter, a synchronous generator driven by a prime mover, and a duplex reactor are discussed. It is shown that tip speed ratios of the individual turbine and the system output power can	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6264

generating system with series connected wind generators using a current source thyristor inverter				be controlled almost constant with the proposed method, making an effective operation of the system possible.	534
Effective Application of Static Var Compensators to Damp Oscillations	Ohyama, Takeshi; Yamashita, Kiyoshi; Maeda, Takafumi; Suzuki, H.; Mine, Setsurou	Tokyo Electric Power Co. Inc.	1985	Static Var Compensator (SVC) is recognized to be effective to improve transient stability and to damp voltage fluctuation. The reason why power system planners hesitate to apply SVC to their systems is because of its expense. The authors have proposed a combination type SVC, which consists of both thyristor controlled capacitors and reactors and mechanically switched capacitors. This combination makes it economical to apply SVC to improve transient stability. In this paper another proposal is concerned with the conceivable installation of SVC to damp oscillations of power systems. The so-called "Reset Filters" is applied to the voltage detective circuit of SVC. Because of its leading characteristic, it produces a damping effect on the power system. The economy and effectiveness of the combination type SVC equipped with Reset Filter is illustrated to improve stability of the power system both analytically and quantitatively.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113243
A Field Test of Power Swing Damping by Static Var Compensator	Sawa, T.; Shirai, Y.; Michigami, T.; Sakanaka, Y.; Uemura, Y.	Tokyo Electric Power Company, Tokyo, Japan	1989	This paper presents the results of a field test conducted for a static var compensator installed at a 500 kV substation. The static var compensator with a damping control function improved power system damping performance significantly by increasing the synchronizing and damping torques. Frequency response analysis was employed for examining the synchronizing and damping torques. Simulations of the test cases were performed by time domain analysis and agreed well with the results of the field testing. Tokyo Electric Power Company (TEPCO) and Toshiba Corporation have jointly developed and installed a static var compensator (SVC) with multiple functions at the Shin-Shinano Substation of TEPCO [1][2]. The SVC entered operation in April, 1987. The SVC is connected to the tertiary winding of the main transformer (525/275/63 kV) at the Shin-Shinano Substation. It comprises a thyristor controlled reactor (TCR) and a fixed capacitor (FC). A 100 MVA TCR controls the reactive power from 80 Mvar capacitive to 20 MVar inductive with the 80 MVA FC. The TCR employs a directly light-triggered thyristor valves and a water cooling system for thyristor valve cooling. A triplicated direct digital control (DDC) system is applied to the control system of the SVC. The main functions of the SVC control system are voltage control, damping control and constant reactive power control, which are selective. As of August, 1988, the SVC has operated for approx. 4200 hours in the voltage control mode and approx. 6300 hours in the damping control mode with no system failures.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4310903
Novel plasma reactor using honeycomb ceramics driven by a fast Si-thyristor for environmental applications	Ibuka, S.; Nakamura, T.; Murakami, T.; Kondo, H.; Yasuoka, K.; Ishii, S.	Tokyo Inst. of Technol., Japan	2001	Summary form only given. Non-thermal plasma produced by a pulsed power generator has attracted the attention of researchers for air pollution control. Although many kinds of reactors have been proposed, no clear conclusion is obtained on the most suitable one for the pollution control. A key factor in the selection of the reactor is the energy efficiency for decomposing the pollutants. To achieve a breakthrough leading to high decomposition efficiency, we proposed to utilize a fast pulsed discharge in honeycomb ceramics. The honeycomb ceramics are one of the most common carrier materials to support various catalytic processes because of their large surface area that is highly active for chemical reactions. There is a possibility that the non-thermal plasma produced by the fast pulsed discharge enhances the chemical reactions on the ceramics	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=960980

				surface. To establish highly efficient decomposition of the pollutant gases, not only the volume reaction in the non-thermal plasma but also the surface reaction on the ceramics surface should be utilized simultaneously. To confirm feasibility of the proposed system, we applied it to a NO/sub x/ decomposing experiment. Two types of honeycomb ceramics were employed for the reactors, namely mesh-type cordierite ceramics and monolith-type alumina ceramics.	
Multimicrocomputer-based controller for 12 MW GTO power conditioning systems	Hirose, Syunichi; Seki, N.; Higa, O.; Miguchi, Y.; Takahashi, K.; Shibata, T.	Toshiba Corp., Japan	1988	A multimicrocomputer controller was fabricated for a 12 MW power conditioning system (PCS). The configuration of the PCS, which consists of a 12 MW GTO (gate-turn-off) inverter, series reactors, output transformers, AC circuit breakers, and a PCS controller, is described. The functions of the controller are outlined. Results of performance tests that were conducted on a 20 kW PCS model and on the 12 MW PCS are reported, reflecting the excellent performance of the controller.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=18187
Tools for supplying premium quality power	Baldwin, T.L.; Tison, K.	Transmission Technol. Inst., ABB Power T&D Co. Inc., USA	1995	The electric utility industry has done a good job of minimizing the long term outage, but for some industries, reliable power is not good enough. There is an increasing demand for premium quality power. The proliferation of sensitive electronic equipment at industrial and commercial sites has resulted in an increasing number of major power users who are sensitive to temporary voltage disturbances, momentary outages, and voltage fluctuations. An EPRI survey of distribution power quality reveals that that the average site experiences several voltage sags per month. Many sensitive critical processes are impacted by these events resulting in significant production losses and demands for better quality power that is free of voltage disturbances, fluctuations and momentary interruptions. A commercial framework for power quality is needed to support the implementation of these technical solutions within today's business environment. This paper discusses the concept of premium quality power, technical solutions, and applications. The authors discuss thyristor controlled reactors and thyristor switched capacitors which are two tools for static VAr compensators, and SSD, a micro-SMES system	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=485085
Evaluation of losses in thyristor valve for SVC application	Arunachalam, M.; Babu, R.R.; Bose, B.; Dutta, D.	TSC Dept., Bharat Heavy Electr. Ltd., Bangalore, India	1996	This paper describes methods to determine the operating losses of thyristor valves for SVC applications. Thyristor valves for thyristor controlled reactors (TCR), thyristor switched capacitors (TSC) and thyristor switched reactors (TSR) are considered. The procedure for loss evaluation requires some data which are to be estimated through factory measurements or type tests	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=539649
Bifurcations in a switching circuit with a thyristor controlled reactor	Dongyun Du; Yun Tang	Tsinghua University	2003	First Page of the Article <img class="img-abs-container" style="width: 95%; border: 1px solid #808080;" src="/xploreAssets/images/absImages/01351702.png" border="0">	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1351702
The Origin of Nonlinear Phenomena in TCR-SVC	Funaki, T.; Nakagawa, K.; Hikihara,	Tsuyoshi FunakiElectrical Eng.	2008	This paper focuses on anomalous nonlinear phenomena in a thyristor controlled reactor-static var compensator (TCR-SVC) system, called switching time bifurcation, and clarifies the relationship between the occurrence of nonlinear phenomenon and the intrinsic characteristics of the circuit equation with switching function. The	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4490

Associated With Parametric Excitation of Intrinsic Oscillation and External Excitation	T.	Dept., Kyoto Univ., Kyoto		occurrence of nonlinear phenomenon in a TCR-SVC system cannot be predicted when the dynamics of the circuit related to the switching action is neglected. Therefore, this paper considers the dynamics related to the switching operations in the analysis of nonlinear phenomena. The parametric excitation of circuit is discussed in relation to the homogeneous expression of the circuit equation. This paper indicates that the homogeneous equation of the TCR-SVC system results in Hill's equation, and it can be approximated as Mathieu's equation. The occurrence of nonlinear phenomena in the system is evaluated using the characteristics of Mathieu's equation. The anomalous nonlinear phenomena occur when the natural frequency of Mathieu's equation coincides with the frequency of the ac voltage in a TCR-SVC system. The parametric excitation is also confirmed through the characteristics of Hill's equation. This study clarified the interaction between the switching dynamics of the circuit and its external excitation, and clued the occurrence of nonlinear phenomena in the circuit. The proposed procedure can also be applied to the analysis for other switching converter circuits with periodic excitation source.	287
Operational experience of Tucson Electric Power's SVC	Meyer, A.; Mills, T.; Scott, B.; Larsson, D.	Tucson Electr. Power Co., Tucson, AZ, USA	2010	During the spring of 2008, Tucson Electric Power (TEP) and ABB successfully commissioned a Static Var Compensator (SVC) at a 138 kV substation located in central Tucson, Arizona. During system events, the SVC provides dynamic support that includes the ability of switching four mechanically switched capacitors (MSCs). The SVC also reacts to diurnal voltage changes and switches the MSCs for steady state voltage support to maintain adequate dynamic VAr margin. The following paper examines the configuration and topology of the 138 kV substation as well as the control strategy to ensure optimal reactive power compensation while still maintaining reactive reserves and SVC availability. Specific system events and switching instances are further discussed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5484421
Slope reactance effects in single-phase saturated reactors	Walshe, K.A.; Cooper, C.B.	UMIST, Department of Electrical Engineering and Electronics, Manchester, UK	1979	The paper presents an analysis of the single-phase saturated reactor using a mathematical model based on a 2-state switched linear circuit theory. It is shown that the observed incremental fundamental-frequency voltage/current characteristic is not an image of the B/H characteristic of the core, but when saturated corresponds to a reactance that is greater than the leakage reactance of the reactor. This increase is due to the inherent control action of the iron core and is influenced by the harmonic content of the terminal voltage of the saturated reactor. From the theory developed, the saturated reactor is seen to complete its full transient response in half a cycle. Experimental results using 100 VA models of both a saturated reactor and an equivalently controlled thyristor-switched reactor are given to confirm the theory.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5252869
Reactive power and harmonic distortion control in electric traction systems	Martinez, J.; Ramos, G.	Univ. de los Andes, Bogota, Colombia	2010	Electric traction systems generate various power quality problems that have an important impact on its distribution network. In this paper a DC electric traction system was modeled in order to generate the problems that its operation implicated. Once the power quality phenomena were replicated a compensation device, SVC, was added to de distribution network to improve voltage and also a filter was installed in the same node to reduce wave distortion. Finally the possible events that can appear if the original configuration of the compensator device is changed are evaluated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5762918
Identification of ferroresonance as the cause of SVC	Gagnon, R.; Viarouge, P.; Sybille, G.;	Univ. du Quebec a Rimouski,	2000	This paper identifies ferroresonance as the cause of an instability case of a static VAr compensator (SVC) used in a degraded configuration of the Hydro-Quebec series compensated network. An electric circuit, which has a sub-synchronous resonance and a hyper-synchronous one, is used as a model for the network. The SVC is	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8501

instability in a degraded series compensated network	Tourkhani, F.	Rimouski, Que., Canada		composed of a power transformer which supplies a thyristor-controlled reactor (TCR) and a bank of thyristor-switched capacitors (TSC). The analogical simulations, which were realized at the IREQ Transients Network Analyzer (TNA) in order to study the stability of the SVC, are presented. An instability is illustrated and analyzed. In this paper, it is shown that during the instability, the SVC transformer is magnetically saturated. A sub-synchronous voltage oscillation at the SVC terminal is identified as the cause of the magnetic saturation of the SVC transformer. It is proved that the cause of the instability is the ferroresonance of the SVC transformer. Finally it is shown that this ferroresonance is a quasi-periodic one	66
Improvement of EMC in railway power networks	Styczynski, Z.A.; Bacha, S.; Bachry, A.; Etxeberria, L.	Univ. of Magdeburg, Germany	2002	This paper presents the electromagnetic compatibility (EMC) study of a rail transportation power system, in which a thyristor controlled reactor (TCR) system was installed in order to improve voltage stability. Additionally, a passive filtering subsystem was configured to dampen the undesirable effects of the TCR. The whole railway network consisting of substation, lines (catenaries), signalizing transformer, trains and the mentioned above voltage conditioning system (voltage booster-VB) is modeled based both on parameters given by the railway companies and on measurement data. The harmonic state estimation before and after the installation of the VB is shown. The presented EMC analysis mainly considers 'worst case' conditions and comprises not only harmonic levels in the railway network and at the point of common coupling (PCC) but also contains the study of compatibility levels of electromagnetic field taking into consideration the signalizing equipment and the influence on the environment. Comments regarding the calculations concerning both the European norm guidelines and the requirements demanded by railway companies are presented.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1221529
Analysis of a Virtual Air Gap Variable Reactor	Dolan, D.S.L.; Lehn, P.W.	Univ. of Toronto, Toronto	2007	This paper presents the basic operation of a virtual air gap variable reactor (VAG-VR). Variable reactors have many applications in the power industry. Their use allows control of line power flow, as well as damping of power oscillations and subsynchronous resonances. A variable reactor is most commonly implemented as a thyristor controlled reactor (TCR) by switching in and out a constant reactance to achieve an averaged variable reactance. By using a virtual air gap, implementation of a continuously variable reactance is possible without introducing the harmonics created by the thyristor switching. A high speed of response is achieved by using a power electronics solution to drive the DC control windings. A full bridge dc-dc converter is used to provide the full range of negative and positive voltage required.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4342160
Power-Flow Model and Steady-State Analysis of the Hybrid Flow Controller	Nabavi Niaki, S.A.; Iravani, R.; Noroozian, M.	Univ. of Toronto, Toronto, ON	2008	This paper introduces a hybrid flow controller (HFC) as a new member of flexible ac transmission system (FACTS) controllers for steady-state and power-flow control of power transmission lines. HFC is a hybrid compensator (i.e., provides series and/or shunt compensation). Structurally, an HFC unit is composed of a mechanically switched phase-shifting transformer, a mechanically switched shunt capacitor, and multimodule, series-connected, thyristor-switched capacitors and inductors. This paper describes the steady-state operation, single-phase equivalent circuit, power-flow model, and V-I and P-Q characteristics of the HFC. This paper highlights the steady-state technical features of the HFC for power-flow control of a study system and also provides a quantitative comparison of the HFC, UPFC, and PST.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4529107
Design and Development of a Static VAR	Berge, J.; Varma, R.K.	Univ. of Western Ontario,	2007	A static VAr compensator (SVC) is designed for compensation of a midsized three-phase unbalanced industrial load. The control system is programmed in the National Instruments LabView programming environment and implemented in an Intel based platform using National Instruments digital to analog conversion and timing	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4437

Compensator for Load Compensation Using Real-Time Digital Simulator and Hardware Simulation		London		hardware. The hardware design is done for a fixed capacitor-thyristor controlled reactor (FC-TCR) configuration of a static VAr compensator (SVC). The SVC controller is tested on both a real-time digital simulator (RTDS) and a physical hardware model.	344
Effects of harmonic voltage distortion on the terminals of single phase thyristor controlled reactors	Eggleston, J.F.	Univ. of Western Ontario, London, Ont., Canada	1990	An expression for the harmonic current of a thyristor controlled reactor (TCR) as an explicit function of its terminal voltage and thyristor firing instants is formulated in the context of the increased interest in TCR harmonics. The expression is used to examine the effects of terminal voltage distortion and is incorporated into an iterative algorithm to assess the harmonic interactions in a TCR. The response of the TCR's controller to the effects of such harmonic interaction is included in the iterative algorithm to show its importance in the interaction process, without the need for a full harmonic load flow	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=151356
Reactive power and harmonic distortion control in electric traction systems	Martinez, J.; Ramos, G.	Universidad de los Andes, Bogotá, Colombia	2010	Electric traction systems generate various power quality problems that have an important impact on its distribution network. In this paper a DC electric traction system was modeled in order to generate the problems that its operation implicated. Once the power quality phenomena were replicated a compensation device, SVC, was added to de distribution network to improve voltage and also a filter was installed in the same node to reduce wave distortion. Finally the possible events that can appear if the original configuration of the compensator device is changed are evaluated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5762881
Load and Voltage Balancing in Harmonic Power Flows by Means of Static VAr Compensators	Mayordomo, J. G.; Izzeddine, M.; Asensi, R.	Universidad Politecnica de Madrid, Madrid, Spain	2002	In special applications, static VAr compensators (SVC) with thyristor controlled reactors (TCR) are used to balance unbalanced loads or to eliminate voltage unbalances at the terminals of the SVC. In both cases, load balancing and voltage balancing, the TCR can present a significant unbalanced behavior that produces important quantities of noncharacteristic harmonics. In this paper, the formulation and solution of the load and voltage balancing problems are developed for harmonic power flows obtained from a combination of two blocks: a conventional load flow (CLF) and an iterative harmonic analysis (IHA). In both blocks, the treatment of load and voltage balancing is described in detail. Load flow calculations and harmonic analysis show the presence of noncharacteristic harmonics in these two situations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4312159
Thyristor controlled reactors as harmonic sources in HVDC convertor stations and AC systems	Yacamini, R.; Resende, J.W.	University of Aberdeen, Department of Engineering, Marischal College, Aberdeen, UK	1986	Thyristor controlled reactors (TCRs) are a relatively new source of harmonic distortion in power systems. The steady-state balanced (or characteristic) harmonics are easily calculated and are well known. Other noncharacteristic harmonics can, however, be generated by TCRs. A detailed representation is therefore necessary which will consider all types of imbalance, be it in the TCR or in other parts of the total system to which they are connected. It is also important to consider the effect of connecting TCRs to systems which do not have a high fault level (weak AC systems) and to consider the effect of control feedback on harmonic generation. The methods by which these factors can be included in calculations of nonideal systems are the subject of this paper. The methods are illustrated by example.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4644197
Phase-controlled circulating current cycloconvertor-	Hamad, A. K S; Holmes, P.G.;	University of Leicester, Department	1977	The paper describes the use of an induction motor stator as an intergroup reactor in a circulating-current cyclo-convertor. A double-layer stator winding formed into electrically separate thyristor group circuits, magnetically coupled in the stator slots, provides a conventional rotating field in the airgap. This enables the double wound	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5252

induction-motor drive using rotating intergroup reactor	Stephens, R. G.	of Engineering, Leicester, UK		stator machine to act as a reactor maintaining circulating current operation in the cycloconvertor and as a torque producing motor. Standard induction motors may be additionally incorporated into the system as in a conventional cycloconvertor drive. A closed-loop speed control system is incorporated that maintains constant speed independent of load on the divided-winding reactor machine. Any additional induction motors then operate technically under open-loop conditions, but open-loop instability is avoided by the inclusion of the reactor machine in the loop.	826
Modelling of traction load distortion in electricity supply systems	Yacamini, R.; Hamoud, O. A R; Afacan, O.	University of Manchester Institute of Science and Technology, Department of Electrical Engineering & Electronics, Manchester, UK	1981	A modelling method is described which has been used to study the harmonic and fundamental problems associated with thyristor- and diode-controlled traction loads. The effect of changing system parameters, such as the number of overhead lines fed from a feeder transformer, is shown. Different bridge configurations are also demonstrated and, in particular, the use of a commutation reactor in an asymmetrical bridge.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4643348
Three Phase, Steady-State Static Var generator Filter Design for Power Systems	Kusic, G.L.; Whyte, I. A.	University of Pittsburgh Department of Electrical Engineering	1984	In power systems, the harmonics originating from thyristor switching are usually eliminated by filtering. Exact solutions of voltages and currents for Static VAR Generators (SVG) used in power systems are found using a state variable formulation with time-domain convolution. Each conduction period of delta-connected thyristor-controlled-reactors is a linear circuit. The initial conditions for each piece-wise linear circuit depend on the prior firing sequence of the thyristors. An additional condition is zero initial current through the thyristor when turning on. There are six possible thyristor conduction sequences for every half cycle of the periodic system voltage. An iterative method is used to determine the initial conditions for the first of the six conduction sequences in order to force the system response into periodic operation at the line frequency. State variable transition matrices and initial conditions are then used to calculate circuit, voltages and currents at any instant of time. It is thus possible to obtain peaks or determine harmonic distributions. Unbalanced three phase voltages and component unbalances may be introduced in the circuit using this analysis. Filters, which are capacitive compensation at the line frequency, are then sized to limit harmonic content in the voltage supply.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112590
Harmonic Domain Periodic Steady-State Modeling of Power Electronics Apparatus: SVC and TCSC	Lima, L.; Semlyen, A.; Iravani, R. M.	University of Toronto; Universidade Federal Fluminense	2002	This paper presents a general model for the representation of a thyristor-controlled reactor (TCR) in frequency domain. The model undelines the implementation of a Newton-Raphson procedure to determine the periodic steady state of the power system with fast convergence and high accuracy. The TCR model is used as a building block to represent more sophisticated power electronics apparatus, such as the static var compensator (SVC) and the thyristor-controlled series capacitor (TCSC).	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4311932
Developments in phase-variable	Derek Humpage,	University of Western	1986	Of the different control objectives of reactive-power compensators based on thyristor-controlled reactors, the advances in modelling methods and computer simulation of the paper relate specifically to the mode of voltage-	http://ieeexplore.ieee.org/stamp/stamp.j

modelling for thyristor-controlled reactive-power compensators	W.; Nguyen, T.T.	Australia, Department of Electrical & Electronic Engineering, Perth, Australia		magnitude control in which each phase is controlled individually. For this control objective, a comprehensive analysis formulation is developed in phase-variable notation in a form which can directly be incorporated into Newton-Raphson network analysis in which each phase retains its separate identity. The main context of the development is that of the supply from transmission networks of loads of substantial imbalance between the separate phases. The analysis and evaluation facilities to which the developments of the paper can lead, provide means by which the response of compensators with individual phase-voltage-magnitude control functions can be investigated for the conditions of pronounced imbalance in steady-state primary system operation. Following the analysis derivations and the developments in phase-variable modelling for thyristor-controlled compensators, a representative design investigation is given in the paper in which phase-to-phase loads are supplied from a section of a 220 kV network. In this particular application, the effectiveness of individual phase-voltage-magnitude control in lowering operating imbalance is quantified.	sp?arnumber=4646861
Nonlinear dynamics and switching time bifurcations of a thyristor controlled reactor	Rajaraman, R.; Dobson, I.; Jalali, S.	University of Wisconsin	1993	First Page of the Article <img class="img-abs-container" style="width: 95%; border: 1px solid #808080;" src="/xploreAssets/images/absImages/00693116.png" border="0">	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=693116
Harmonic Interactions in Thyristor Controlled Reactor Circuits	Bohmann, L.J.; Lasseter, R.H.	University of Wisconsin Madison	1989		http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4310836
â€œControl of an SVC for the load balancing and power factor correction with a new algorithm based on the power analysisâ€	Mokhtari, Maghsood	Urmia University/ Department Of Electrical Engineering, Iran	2010	A compact algorithm based on power analysis for reactive power compensation as well as load balancing through the static var compensator (SVC) in three-phase three-wire system is developed in this paper. The structure of the SVC is thyristor controlled reactors with fixed capacitors (TCR-FC). By the proposed algorithm the required compensation susceptances for each phase of the SVC is obtained from a very simple function of voltage and reactive power signals which are measured from the network. The salient feature associated with the proposed method is that the circuit representation of system load is not required and the load is recognized just by its active and reactive consumptions. The load's type and connection, hence, do not matter and this method is valid for the case of active loads too. The validity and performance of the new approach are analyzed via a numerical example and the obtained simulation results are thoroughly discussed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5624696
Adjustable speed drives in nuclear applications	Porter, Newell S.	Washington Public Supply System, Richland, WA, USA	1992	The application of adjustable speed drive technology at a nuclear plant is described. The 8900 hp reactor recirculating coolant pump motors will be driven by a GTO-PWM (gate turn-off pulse-width-modulated) drive rated at 11200 hp	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=301406
Dynamic compensation of AC	Gyugyi, Laszlo	Westinghouse Electr.	1994	This paper describes a novel approach in which solid-state synchronous voltage sources are employed for the dynamic compensation and real time control of power flow in transmission systems. The synchronous voltage	http://ieeexplore.ieee.org/stamp/stamp.j

transmission lines by solid-state synchronous voltage sources		Corp., Pittsburgh, PA, USA		source is implemented by a multi-pulse inverter using gate turn-off (GTO) thyristors. It is capable of generating internally the reactive power necessary for network compensation, and is also able to interface with an appropriate energy storage device to negotiate real power exchange with the AC system. The paper develops a comprehensive treatment of power flow control using solid-state synchronous voltage sources for shunt compensation, series and phase angle control. It also describes the unique unified power flow controller that is able to control concurrently or selectively all three network parameters (voltage, impedance, transmission angle) determining power transmission. Comparison of the synchronous voltage source approach with the more conventional compensation method of employing thyristor-switched capacitors and reactors shows its superior performance (including the unmatched capability of using both reactive and real power compensation to counteract dynamic disturbances), uniform applicability, smaller physical size, and potentially lower overall cost	sp?arnumber=296273
Static Kiln Drive Power Supplies: II--Reactor-Controlled Rectifier Drive Operation and Design Characteristics	Sabatt, John F.	Westinghouse Electric Corporation	1969	The operation and design characteristics of a reactor-controlled rectifier drive are described and it is compared with the eddy-current coupling and thyristor-controlled types.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4181010
Nonlinear reactors as protective elements for thyristor circuits	Paice, Derek A.; Wood, Peter	Westinghouse Electric Corporation, Pittsburgh, Pa	1967	Control of rate of change of current and voltage in thyristor power circuits is provided in diverse ways according to the special features of the particular problem and the ingenuity of the designer. It is shown that the use of a nonlinear reactor in series with the thyristor provides advantages in some surge suppression networks, and a design technique is presented for these reactors. Characteristics of a basic damping circuit are presented in the form of non-dimensional design curves, and a relationship is established between the losses of a surge suppression network and the thyristor<tex>partialt/partialt</tex>and<tex>partialV/partialt</tex>capabilities.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1066053
Power electronics in electric utilities: static VAR compensators	Gyugyi, Laszlo	Westinghouse Res. & Dev. Center, Pittsburgh, PA, USA	1988	The author deals with dynamic VAR compensation of electric power systems, applying power electronics for reactive power generation and control. After an overview of the emergence and status of modern, solid-state VAR compensators in utility and industrial applications, it is shown how dynamic VAR compensation increased transmittable power by providing voltage support, transient stability improvement, and power oscillation damping in electric power transmission systems. Methods of reactive power generation and control using thyristor-controlled reactors, with fixed and thyristor-switched capacitors or modern gate-turn-off (GTO) power converters that can function without AC capacitors or reactors, are described. A summary is included of the control structure and operation to provide the desired characteristics and performance in power systems applications	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4433
Stability and harmonics in thyristor controlled reactors	Bohmann, L.J.; Lasseter, R.H.	Wisconsin Univ., Madison, WI, USA	1990	Harmonics that arise from the interaction of thyristor controlled reactors (TCRs) and power systems can sometimes cause stability problems. The classical method for calculating harmonics is to calculate the harmonic current assuming an infinite bus at the high side of the TCR transformer. This current is then used as a harmonic current source on the AC system. The basic problem with this method is that many of the interactions between the AC system and the TCR are neglected. Two methods for studying the neglected interactions are described. The first uses state variables to analyze the circuit containing the TCR. The resulting equations are linear differential equations with periodic coefficients. This formulation allows the study of stability, periodic	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=53138

				operation, and resonance, which cannot be achieved by other methods. The second method uses a Fourier matrix description of the TCR. In this model the coupling between the different harmonics due to the switching is clearly shown	
Harmonic interactions in thyristor controlled reactor circuits	Bohmann, L.J.; Lasseter, R.H.	Wisconsin Univ., Madison, WI, USA	1989	Harmonics that arise from the interaction of thyristor-controlled reactors (TCRs) and power systems are difficult to analyze. Two methods are described. The first develops a Fourier matrix model for the TCR. The coupling between the harmonics through the system impedance is clearly shown. The second method uses state-variable analysis to write the system equations for a circuit containing TCR. The system of equations that result are linear with time-varying coefficients. Using linear system theory, statements on resonance conditions can be made	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=32691
Stability and harmonics in thyristor controlled reactors	Bohmann, L.J.; Lasseter, R.H.	Wisconsin Univ., Madison, WI, USA	1989	Two methods for studying the interactions between an AC power system and thyristor-controlled reactors (TCR) are described. The first uses state variables to analyze the circuit containing the TCR. The resulting equations are linear differential equations with periodic coefficients. This formulation allows the study of stability, periodic operation, and resonance, which cannot be achieved by other methods. The second method uses a Fourier matrix description of the TCR. In this model the coupling between the different harmonics due to the switching is clearly shown.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=39019
Thyristor controlled two-stage magnetic-valve reactor for dynamic VAr-compensation in electric railway power supply systems	Baichao Chen; Kokernak, J.M.	Wuhan Univ. of Hydraulic & Electr. Eng., China	2000	The electrification of railway systems is becoming more prevalent throughout the world. The implementation of adjustable speed drives in conjunction with the mobile nature of the trains presents a case where harmonic content varies with time and location along the power supply. Advanced systems implement power factor correction on the rail car system. Existing systems require expensive conversions to accomplish this. A variable saturable reactor is presented here that provides a more economical approach to add power factor correction to existing rail systems. The system includes structure modifications to limit hysteresis and skin effect losses. A 27.5 kV, 2400 kVA system is constructed and tested to confirm the operation of the system	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=822820
A new type controllable shunt reactor	Chen He; Chen Weixian; Tian Cuihua	Wuhan Univ., China	2001	A novel controllable reactor with extremely fast response is presented, which consists of parallel inductance branches connected in series with bipolar thyristors and has a compact structure. Formulae are provided for determination of reactor parameters. With an appropriate sequence control of the branch thyristors, harmonic currents can be maintained within the admissible level. For reactor construction, the architecture of the reactor is presented. Experimental tests have shown good performance of the developed reactor	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=970641
Controllable arc-extinguishing reactor with high speed response	Chen He; Chen Weixian	Wuhan Univ., China	2001	A novel autoregulated arc-extinguishing reactor with extremely short response time is presented. It consists of a high leakage transformer and controllable bipolar thyristors attached at the low voltage side winding of the transformer. Filter circuits are designed to suppress high harmonic currents and are connected to the third winding of the transformer. Methods are proposed to reduce iron loss and partial heat resulting from leakage flux. A technique is developed to measure the capacitive current of power distribution lines and put forward the mode of autoregulation for distinguishing between the permanent grounding fault and the series resonance occurring while the fault disappears. Experimental tests show excellent performance of the development equipment	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=970654
Static VAr compensator-based	Ahmed, T.; Nishida, K.;	Yamaguchi Univ., Japan	2004	In this paper, the steady-state operating performances of single-phase squirrel-cage self-excited induction generator (SEIG) are evaluated by using the per-unit frequency in addition to a simple steady-state analysis	http://ieeexplore.ieee.org/stamp/stamp.j

voltage regulation implementation of single-phase self-excited induction generator	Nakaoka, M.			based on the per-unit slip frequency. The single-phase SEIG operating performances, estimated by the per-unit slip frequency steady-state analysis at the prime move speed and the inductive load power variations, are discussed with those obtained by using the per-unit frequency. The results provide close agreements with a simple analysis and an efficient computation processing procedures. Moreover, the single-phase static VAr compensator (SVC) composed of the thyristor controlled reactor, the thyristor switched capacitor and the fixed excitation capacitor is applied to regulate smoothly the generated output voltage of the stand-alone single-phase induction generator with a variable inductive load. The fixed gain PI controller is employed to adjust the equivalent capacitance of the single-phase SVC. The experimental and simulation results are illustrated the practical effectiveness of the additional SVC with the PI controller-based feedback loop to regulate smoothly the output voltage of the single-phase SEIG.	sp?arnumber=1348752
Three-phase self-excited induction generator driven by variable-speed prime mover for clean renewable energy utilizations and its terminal voltage regulation characteristics by static VAr compensator	Ahmed, T.; Hiraki, E.; Nakaoka, M.; Noro, O.	Yamaguchi Univ., Japan	2003	In this paper, the practical impedance approach steady-state analysis in the frequency domain of the three-phase self-excited induction generator (SEIG) with squirrel cage rotor is presented along with its operating performance evaluations. The three-phase SEIG is driven by a variable-speed prime mover (VSPM) such as a wind turbine for the clean alternative renewable energy in rural areas. The basic steady-state characteristics of the VSPM are considered in the three-phase SEIG approximate electro-mechanical equivalent circuit and the operating performances of the three-phase SEIG coupled by a VSPM in the steady-state analysis are evaluated and discussed on line under the conditions related to the speed changes of the prime mover and the electrical inductive load power variations with simple computation processing procedures. A three-phase SEIG prototype setup with a VSPM is implemented for the small-scale clean renewable and alternative energy utilizations. The experimental performance results give good agreements with those ones obtained from the simulation results. Furthermore, a PI controlled feedback closed-loop voltage regulation of the three-phase SEIG driven by the VSPM on the basis of the static VAr compensator (SVC) composed of the thyristor phase controlled reactor (TCR) in parallel with the thyristor switched capacitor (TSC) and the fixed excitation capacitor bank (FC) is designed and considered for the wind generation as a renewable power conditioner. The simulation analysis and experimental results obtained from the three-phase SEIG with SVC for its voltage regulation prove the practical effectiveness of the additional SVC with the PI controller-based feedback loop in the steady-state operations in terms of the fast response and the high performances.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1257593
Minimum excitation capacitance requirements for wind turbine coupled stand-alone self-excited induction generator with voltage regulation based on SVC	Ahmed, T.; Noro, O.; Matzuo, K.; Shindo, Y.; Nakaoka, M.	Yamaguchi Univ., Japan	2003	In this paper, the nodal admittance approach steady-state frequency domain analysis of the minimum excitation capacitance required for the squirrel cage rotor type three-phase self-excited induction generator (SEIG) driven by variable-speed prime movers (VSPMs) such as a wind turbine and a micro gas turbine is presented. The steady-state analysis of this power conditioner designed for the renewable energy is based on the principle of equating the input mechanical power of the three-phase SEIG to the output mechanical power of the variable-speed prime mover with using the approximate frequency domain based equivalent circuit of the three-phase SEIG. Furthermore, a feedback closed-loop voltage regulation of the three-phase SEIG as a power conditioner which is driven by a variable-speed prime mover employing the static VAR compensator (SVC) composed of the fixed excitation capacitor bank FC in parallel with the thyristor phase controlled reactor (TCR) and the thyristor switched capacitor (TSC) is designed and considered herein for the wind turbine coupled the power conditioner.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1252144

				To validate the effectiveness of the SVC-based voltage regulator for the terminal voltage of the three-phase SEIG, the inductive load parameter disturbances in a stand-alone power generation are applied and characterized in this paper. In the stand-alone power utilization system, the terminal voltage response and the thyristor triggering angle response of the TCR are plotted graphically. The simulation and experimental results prove the effectiveness and validity of the proposed SVC controlled by the PI controller in terms of fast response and high performances of the three-phase SEIG driven directly by the rural renewable energy utilization like a variable-speed wind turbine.	
Study on SSR characteristics of power systems with static VAr compensator	Hongtao Liu; Zheng Xu; Zhi Gao	Zhejiang Univ., China	2001	Using the complex torque coefficient method realized by time domain simulation, the subsynchronous resonance (SSR) characteristics of power systems with static VAr compensators are studied in depth in this paper. The studied model is modified from the first IEEE Subsynchronous Resonance benchmark system added by a static VAr compensator (SVC), consisting of a thyristor-controlled reactor (TCR) and a thyristor-switched capacitor (TSC). A number of cases are studied by simulation through varying some key parameters of the model. By comparing the electric damping in different cases, the subsynchronous resonance characteristics of power systems with SVCs are identified.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=988408