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Title : *Simulation Studies Of SEL Box MOSFET And Lateral Bipolar Junction Transistor (LBJT) On SOI With Selective Or Modified Buried Oxide Structures*

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Abstract

The main objective of this work is to study MOSFET and lateral bipolar junction transistor (LBJT) on Silicon-On-Insulator (SOI) with selective or modified buried oxide for their possible applications in mixed signal technology, System-on-Chip and power electronics. An effort is made to address various issues involved in the efficient realization of selective buried oxide (SELBOX) MOSFET and LBJT on SOI. The main issues related to these devices such as, self-heating, short channel effects, breakdown voltage, and lower on-resistance have been thoroughly studied and addressed. A two-dimensional numerical simulation study of these devices has been carried out using MEDICI and ATLAS/ATHENA (Silvaco) simulation tools. Simulation studies indicate that the SELBOX structure can reduce the main problems of self-heating, low breakdown voltage and floating body effects in the SOI device. However, the magnitude of short channel effects (SCEs) can be higher in such a structure, preventing its use in the nanometer scale range. The problem of increased SCEs in the SELBOX MOSFET can be significantly reduced by the incorporation of partial ground planes (PGPs) in the SELBOX structure. The PGPs have significantly improved the SCE suppression in the SELBOX structure in comparison to a simple SELBOX structure. The PGP-SELBOX device being thermally efficient is now close to the thin film SOI device in SCE suppression. The leakage current analysis has revealed that the PGP-SELBOX device possesses lower leakage current in comparison to SOI and the SELBOX devices. Further, the cutoff frequency is not significantly different in the three structures. Recent rapid growth in the portable communication market provided a push to researchers and designers to develop mixed signal systems, such as, RF system on chip (SoC), where both analog and digital circuits are present on a single substrate. The SELBOX structure mentioned above can allow the implementation of both analog and digital circuits in the SELBOX substrates as the floating body effects that are detrimental for analog circuit implementation are mitigated in this approach. Besides the only MOSFET approach, another practical and popular way to realize SoCs, is the BiCMOS technology platform. This provides high speed bipolar and low power MOS domains together for RF/analog and digital circuit realizations respectively. However, there is a main problem of incompatibility in the integration of SOICMOS with the vertical bipolar transistor in BiCMOS technology realization. This problem has been reduced by replacing the vertical bipolar transistors by the lateral

bipolar transistors. The LBJT on SOI is compatible with BiCMOS processes on SOI. Further, it possesses many more advantages, such as low power consumption, low parasitic capacitances and share fabrication steps with CMOS. However, the lateral bipolar transistor on SOI suffers from the problems of reduced current gain, reduced cutoff frequency and lower breakdown voltage. To obtain high breakdown voltage and a low on-resistance in a thin film lateral bipolar junction transistor on SOI is a challenge for device researchers. These problems have been addressed in this work by proposing some novel structures of LBJTs on SOI with SELBOX and modified buried oxide (BOX). A significant improvement in the tradeoff between the breakdown voltage and on-resistance is obtained in such structures. Further, the high voltage thin film LBJT on SOI is expected to perform better than their MOSFET counterparts due to inherent conductivity modulation property. This work also introduces LBJT on SELBOX to remove the thermal problems of LBJT on SOI. At a specific length of SELBOX, called as the "just pass location" length, an interesting and unique values for cutoff frequency, current gain and breakdown voltage are obtained. It may be noted that the SELBOX and modified BOX approaches for implementing high breakdown voltage LBJT is particularly useful for SoCs integrating low-power and high-power circuits on the same substrate.

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Title : *Impact of Placement of Source and Drain Contact on Performance of Organic Thin Film Transistors*

Author(s) : *Nurul Islam Munshi*
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Abstract

Organic thin-film transistors (OTFTs) are being actively pursued because of their potential for low-cost fabrication of large area circuits for applications such as active matrix flat panel displays, smart cards, radio frequency identification tags on substrates such as glass, plastic, fiber and paper. OTFTs are commonly fabricated as an inverted structure with gate at the bottom and source/drain at the top. Depending on whether source and drain contacts are deposited on the gate insulator prior to deposition of organic semiconductor film or on top of organic semiconductor film, there can be either a bottom contact (BC) or a top contact (TC) device. The BC OTFT has the advantage that standard lithographic techniques can be used to obtain short channel length devices relatively easily. TC OTFTs on the other hand have been commonly fabricated using shadow mask techniques that result in relatively large channel length devices. However, contact resistance and mobility are generally better in top contact devices and alternative patterning techniques have been reported whereby TC OTFTs with channel lengths smaller than 1μm have been fabricated. Despite considerable work on both device structures, a systematic investigation of the differences in performance arising solely due to structural differences has not been carried out. The present thesis uses 2D numerical simulation and analytical models to show that performance of top and bottom contact devices with identical dimensions and material parameters can be quite different simply due to different position of source/drain contacts. It is shown that for very small injection barrier heights, a top contact device will have a significantly higher source resistance due to the physical separation of source metal from the channel. An investigation of current flow in top contact device shows that current crowding occurs near the contact edge and only a small fraction of source participates in current conduction. A modified transmission line model is developed to explain current crowding and obtain an analytical expression for source resistance. Although transconductance is lower in top contact structures due to larger source resistance, the gate-drain capacitance in top contact devices can be significantly smaller resulting in higher unity gain frequency. This advantage becomes more pronounced in amplifiers where importance of gate-drain capacitance becomes larger due to Miller's effect. An analysis of subthreshold conduction shows that off-state current can also be significantly lower in top contact device structure. The results of this thesis show that the superior unity gain frequency and lower off-state current of top contact devices resulting from structural differences together with higher experimentally measured mobility and new lithography techniques promising shorter channel devices makes this structure an attractive candidate for development of Organic TFT based Integrated circuits. To alleviate the higher source resistance problem in top contact structure while maintaining its advantage of a lower gate-drain capacitance, an asymmetric structure with source at the bottom and drain at the top is proposed. Analysis of this structure shows that its unity gain frequency can be significantly higher than top contact device, while off state leakage although higher than top contact structure, is still smaller than bottom contact device.

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Title : ***Performance Analysis Of MIMO Wireless Systems Using Delayed CSI At The Transmitter***

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Abstract

Multiple Input Multiple Output (MIMO) communications can enhance the performance of a wireless system significantly with Channel State Information at the Transmitter (CSIT). However the enhancement is largely dependent upon the quality of the available CSIT. Therefore in the scenario of time-varying channels and delayed feedback, performance analysis of a wireless system with imperfect or delayed CSIT is of interest. In this thesis, we consider a special case of a MIMO system with N transmit and two receive antennas. We consider five different system models which use either Transmit Beamforming (TB) or Alamouti transmit diversity. We assume spatially independent and flat fading Rayleigh channels. The five system models are (1) Nx2 system with TB (2) (N,2;2) system (two out of N transmit antennas are selected) with TB (3) (N,2;2,1) system (two out of N transmit antennas and one out of two receive antennas are selected) with TB (4)(N,2;2) system with Alamouti transmit diversity and (5) (N,2;2,1) system with Alamouti transmit diversity. For all the system models we assume perfect Channel State Information at the Receiver (CSIR) while beamforming and Antenna Selection (AS) are done by delayed CSIT. In the case of (N,2;2) systems we consider the optimum AS scheme, whereas in the case of (N,2;2,1) systems we consider two sub-optimum AS schemes in addition to the optimum AS scheme. Amongst the five system models considered, any two systems may be identical for some special case; however, in general, no system is a special case of any other system. For each system model, we determine the probability density function (pdf) of the received SNR in two steps. In the first step, we express the pdf conditioned on delayed CSIT by using two well-known techniques: a Gauss-Markov process model and an orthogonal transformation. In the second step, using this conditional pdf and the pdf of delayed CSIT, we derive the closed form expression for the pdf of SNR. Using this pdf, we derive the expressions of BER and outage probability and interpret them. All the expressions are obtained as a function of the correlation between perfect CSIR and delayed CSIT. We also discuss some special cases, for example no CSIT and perfect CSIT, and compare them with the results available in the literature.

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Title	***:***	***Synchrophasor Assisted State Estimation and Voltage Stability Monitoring Including Optimal PMU Placement***
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Abstract

Synchrophasor based Wide Area Monitoring Systems (WAMSs) are being increasingly deployed in power system networks due to their ability for fast detection of the dynamic changes in the system, required to prevent severe blackouts. The key element of the synchrophasor technology is the Phasor Measurement Unit (PMU), which computes the time synchronized voltage and current phasor values from the sampled data from the field, but is relatively a costly equipment. Hence, the first and the foremost task, towards implementing a WAMS, is to install optimal number of PMUs in the network. An Optimal PMU Placement (OPP) scheme is developed, to ensure the topological and the numerical observability of the power system, utilizing an Integer Linear Programming (ILP) based algorithm, and a Sequential Elimination Algorithm (SEA). Once the optimal number and location of the PMUs are determined, the utilities may like to install them in multiple stages. A Multi-Criteria Decision Making (MCDM) model is developed to prioritize these PMUs based on few practical criteria and plan their deployment in stages. The phasor measurements, so obtained, can be integrated with the conventional SCADA measurements to improve the accuracy of the state estimation results. Two variants of phasor-assisted State Estimators (SEs) are developed, referred as Hybrid SE and Sequential SE, without changing the existing state estimation model. The most commonly used phasor estimation method in PMUs, at present, is 1-cycle DFT method, which assumes the steady state signal model. However, under dynamic conditions of the power system, the steady state definition of a phasor is no more valid and becomes inaccurate. A fast and accurate dynamic phasor estimator and a Synchrophasor Transient Monitor (STM) are, therefore, developed utilizing the concept of Teager energy. Further, a synchrophasor-assisted voltage stability monitoring scheme is proposed to indicate the impending long-term voltage instability. A new index, referred as the Synchrophasor based Voltage Instability Monitoring Index (SVIMI) is proposed, utilizing the deviation of bus voltage magnitudes and rate of change of voltages. Unlike many available methods, the proposed scheme is free from any parameter identification, such as Thevenin equivalent, and is able to indicate impending voltage instability at an early stage.

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Title : ***Real Time Power System Stability Prediction Using Synchrophasor Based Wide Area Monitoring System***

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Abstract

In the present day large interconnected power systems, one of the major operating concerns is to monitor the stability of the system. The conventional methods of the stability analysis utilize the off line numerical integration as well as linearized eigenvalue based approaches. Synchrophasor technology based Wide Area Monitoring System (WAMS) comprises of geographically distributed Phasor Measurement Units (PMUs), which utilize time synchronized GPS clock signals to estimate the time stamped phasor values, i.e. the magnitude as well as the phase angle, of the voltages and currents. The fast refreshing rate of the PMUs enables them to capture the dynamic states of the power system. These unique advantages of the synchrophasor based WAMS open up the possibilities of real-time prediction of the power system stability. This work is mainly concerned with the synchrophasor based real time rotor angle stability monitoring, which includes the critical mode estimation of the low frequency oscillations and the transient stability prediction. The identification of the critical modes, under small signal oscillations, helps in designing the proper controllers to improve the system damping. Traditionally, for large power systems, these modes are identified through eigenvalue analysis, utilizing a linearized time-invariant model around a given operating point of the system. Since, in a practical power system, the oscillation characteristics always change with the variation of the system operating conditions and its topology, the identified modes, using the above off line methods, do not provide sufficient and meaningful information to the system operator. The measurements from the PMUs, which are collected at the Phasor Data Concentrator (PDC), can be used for online identification of the modes. The present thesis proposes some measurement based methods for the estimation of these low frequency oscillation modes, such as Modified Prony, Improved Prony along with Noise Space Decomposition and Modified TLS-ESPIRIT methods. Test results on the sample test signals with different SNR, two-area system and probing data of WSCC system reveal that the proposed methods are fast and more robust in the presence of the measurement noise. For transient angular stability prediction, the rotor angles of the generators are important state variables, required to be monitored. A fast and efficient method, based on the use of Divide-by-Difference filter, is proposed for estimation of the rotor angle of the synchronous generators, which performs better than an existing Direct Terminal Measurement based method. Utilizing the estimated rotor angles and other measurements from the PMUs, placed at the generator terminals, a fast and reliable algorithm for estimating a stability index, based on the on-line estimation of the potential energy of the system, has also been proposed. The effectiveness of the proposed method for the transient stability prediction is demonstrated on several test systems.

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Title : *Development of Adaptive Load Shedding and Distance Relaying Schemes utilizing Synchrophasor Technology*

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Abstract

Recent increase in wide-area disturbances in the power system has emphasized the need of effective protection and control measures based on real-time monitoring of system dynamic states. Conventional protective schemes are based on fixed and predefined design rules, which have been implemented to protect an individual or a group of power system elements. Recent advancements in Synchronized Measurement Technology (SMT) has paved the way to the development of a new class of Wide-Area Monitoring, Protection, and Control (WAMPAC) systems for the reliable operation of the power systems. A prerequisite for initiating the emergency controls, through a WAMPAC system, is that the protective relays, placed in the system, must be adaptive. In the absence of the same, the distance relays based on fixed characteristics may inadvertently respond on satisfying a set condition and it may lead to catastrophic failures in the power system. System events that cause the undesired operation of the distance relays are mainly power swings, voltage instability and also the presence of Flexible AC Transmission (FACTS) Controllers. In this thesis, an adaptive distance protection strategy has been developed, based on Support Vector Machine (SVM), for avoiding the undesirable operation of the distance relay during power swing. The scheme has been further enhanced for discerning the system dynamic events which lead to encroachments into distance relay characteristics at critical locations. These locations have been identified through a new index named RRI (Relay Ranking Index). Proposed scheme effectively classifies the system events into faults, power swings and voltage instability. An adaptive trip boundary prediction scheme has also been devised for the distance relay in the presence of Unified Power Flow Controller (UPFC) utilizing PMU measurements. A Generalized Regression Neural Network (GRNN) has been employed for this purpose. A WAMPAC scheme for the frequency stability has been proposed based on an adaptive load shedding scheme to alleviate both frequency and voltage instabilities associated with the major contingencies in the system. The proposed scheme is able to regain the system stability with minimal load shedding. The post disturbance operating states have been further optimized through generation redispatching, to minimize the load shedding amount through an Optimal Power Flow model, while maximizing the static voltage stability margin.

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Title : ***Modelling of Gaseous Discharges within Narrow Dielectric Channels***

Author(s) : ***Ashraf Ganjovi Alireza***
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Abstract

Gases within small channels encapsulated within solid dielectric materials are likely to undergo discharge on the application of a sufficiently large electric field. This applies to partial discharge (PD) activity within cavities of solid insulating materials. In this work, we develop a two dimensional kinetic model based on Particle-in-Cell methods with Monte Carlo Collision (PIC-MCC) techniques in order to study the dynamics of such discharges within dielectric cavities of sub-millimetre dimensions. The gas considered is the air at atmospheric pressure. Apart from micro-cavities found within dielectric materials due to manufacturing defects, other sites of sub-millimetre dimensions for PD activities are the electric tree channels. Tree progression is associated with PD activity within the tree channels. Spark-type PD pulses occurring within the micro-channels are responsible for causing degradation to the surrounding dielectric material, and therefore further growth of the tree structure. Thus, the model is further utilized to estimate the degradation of the dielectric material surrounding the tree channels due to charged particle interaction. Moreover, to study the effect of excited (radiative) states of air within the tree channel, a radiation transport (RT) model has been developed and integrated with the above mentioned PIC-MCC code. Finally, as a complementary work the PIC-MCC model is used to model gaseous discharges in the presence of E×B field and applied to the case of a discharge in the dielectric channels of a stationary plasma thruster (SPT).

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Title	***:***	***Automatic Fault Diagnosis Of Internal Combustion Engine Using Intelligent Techniques***
Author(s)	***:***	***Yadav Sandeep Kuma***
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Abstract

The automotive industry in the recent past has paid considerable attention to internal combustion (IC) engine condition monitoring since it helps to prevent serious damage by checking the engine status. Initially, the condition monitoring of the IC engine depended on the experience of skilled technicians, but the decision making process remained highly subjective. Hence the conventional method was both time consuming and somewhat unreliable. Accordingly, to monitor the quality of an IC engine, a robust technique was needed to detect its faults. In this Thesis various techniques for fault diagnosis of IC Engine has been proposed. Detailed analyses of all the proposed schemes are done.

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Title : ***Novel Neuron Models In Complex Domain And Their Applications***

Author(s) : ***Tripathi Bipin Kumar***

Roll No : ***Y3204062***

Supervisor(s) : ***Kalra Prem Kumar***

Abstract

The evolution of computational neuroscience has envisaged an advanced machinery world, where human life is made better by recent developments in biologically inspired techniques. It makes an important bridge to computer science and other discipline that study information processing. Complex-valued neural networks have presented the second generation of development in ANN. They are more efficient, and have better learning and generalization ability in 2-D. They are more significant in problems, where it is necessary to capture phase information in data and retain all through the problem. They have also presented improved performance even in the case of real-valued problems. ANN today is much more than just a simple MLP (network of conventional neurons). The computational power of a neuron lies in the spatial aggregation of synapses. Our study is focused on the design and assessment of non-linear aggregation functions for artificial neurons in a complex domain. The performance analysis in real and complex domain has been carried out on wide spectrum of problems viz. classification, function approximation, conformal mapping and pattern matching (face recognition). The computational power and approximation capabilities have been verified through different performance evaluation matrices. An improved resilient propagation algorithm in the complex domain (C-RPROP) has been proposed for efficient learning. It has given drastic reduction in learning cycles. The role of neural network is explored for reliable identification of facial features in the large data sets. The performance of CVNN has scored over RVNN on real-valued problems. It motivated us to design a face recognition system in complex domain and figure out its technical benefits over conventional methods. Its success depends heavily on the particular choice of feature extractor and classifier. The proposed technique aims at developing a face recognition system that is invariant to variations in facial features. We propose complex independent component analysis (CICA) based feature extraction algorithm for capturing of salient class-specific features in reduced dimension. Performance evaluation is carried out on three different standard face data sets. Proposed neurons provide efficient training with fewer numbers of learning parameters for storage and future testing. The robust recognition with CICA across variety of noises is particularly encouraging, because most applications of machine face recognition contain the noise inherent to identifying images collected on varied environmental conditions from the sample images.

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Title : *Hyper Elastic Image Registration : An Application To Mammograms*

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Supervisor(s) : *Kalra Prem Kumar*

Abstract

This thesis is the appraisal of a new registration technique that will align mammograms in a more comparable way. Currently, elastic transformations are the popularly used method to register mammograms. These transformations need control points extracted from the mammogram. Nipple is the only reliable control point presents in the mammogram. In most of the mammograms, nipple may not appear in profile, making extraction of location difficult. Besides elastic transformations, lots of physical model based techniques are present to register medical images and they don't require nipple location or landmarks to register. However, feeble amount of research has been devoted for physical model based registration applicable for mammograms which is far more challenging than many other medical images. This is due to the dynamic nature of breast. But, scientifically it leaves a big hollow between reality and proposed models. The same explanation can be extended to viscous models as well. So, the need of the hour is a model which makes no use of control points, yet robust and scientifically correct too. In this thesis, the properties of the human organ especially breast have been studied well and it is concluded that human body is highly nonlinear and possesses hyper-elastic property. By understanding the properties of the flesh, a new clinically meaningful hyper-elastic model has been proposed for registration of mammograms. Even though this algorithm has been tested only on mammograms, it is assumed that this algorithm can be extended as a universal algorithm to apply on any medical images. Further, the availability of raw medical data is a huge problem. Especially, the temporal mammograms are out of reach for ordinary researchers. So, it is often a common procedure to use simulated temporal mammograms for testing the efficacy of the algorithm. But, simulated mammograms do not reflect the real complicated mammogram which creates a huge bias in validating the performance of the algorithm. This problem has been rectified by a new novel idea, by the introduction of micro calcifications (Mcs) detection as an intermediate step. Existing entropy based Mcs detection techniques use Shannon entropy (SE) for obtaining the threshold before processing the mammogram to detect the Mcs. But, mammograms are highly complicated images, demanding a non-extensive techniqueTsallisentropy (TE) which possesses the above mentioned property has been a revolution in late in image processing field. TE has been introduced in this thesis for detecting Mcs. TE has one more parameter called 'q' which depends on the non-extensiveness of the

mammogram. There is no existing technique discussing the automation of ‘q’ selection. A new technique, based on density index of the mammograms to calculate ‘q’ is proposed. The success of this procedure much depends on the removal of pectoral muscles from mammogram. Further, one more technique based on type II fuzzy set is proposed for identifying the best threshold corresponding to the optimal ‘q’, which is considered as elegant as the former. Normalized Tsallis entropy (NTE), often considered as nephew of TE has also been tested for its capability in detecting Mcs. Thus, a complete evolution of techniques based on TE and NTE is shown. Global registration is an important step applied prior to any local registration technique to avoid the local minima. Traditionally, SE based mutual information (MI) technique is used to register mammograms globally. But, recently it is proved through experimental results that TE based MI algorithm outperforms the algorithms using SE based MI (MI/SE). However, existing techniques don’t discuss about automation of the ‘q’ parameter. In this part of research, a new automatic algorithm based on TE for registering mammograms is discussed. Here, the optimal parameters for registration corresponding to optimal Tsallis parameter ‘q’ are found out using simplex optimization. The proposed algorithm not only outperforms Shannon based IR works but also it is completely automatic.

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Title : ***Some Studies On The Performance Of A Dual Predetection Equal Gain Combining Receiver***

Author(s) : ***Patel Prabhat***

Roll No : ***Y5104081***

Supervisor(s) : ***ChaturvediAjit Kumar***

Abstract

The performance of an equal gain combining (EGC) receiver is known to be comparable to the best possible receiver while at the same time it is much simpler to implement. Hence it has been widely studied in the literature. Still there remain several scenarios for which its performance analysis is not available. In this thesis we have addressed some such issues. Using Gil-Pelaez lemma and Parseval's theorem based approach, we have analyzed the error performance of a dual-EGC receiver for several modulation schemes over correlated Nakagami-m fading channels with arbitrary and non-identical m and unequal branch SNRs. The derived expressions can be viewed as a generalization of many special cases reported in the literature. Further, we have presented a probability density function (PDF) based approach to obtain closed form expressions for average signal to interference plus noise ratio (SINR) and outage probability, in the presence of co-channel users and additive white Gaussian noise over independent Nakagami-m fading channels. For the same scenario, expressions for average level crossing rate (LCR) and average fade duration (AFD) have also been obtained. An expression for the PDF of the SNR at the output of a dual-EGC receiver over independent, non-identical Rayleigh channels has also been derived for the case when the branches have different noise levels. Using this PDF, closed-form expressions for average SNR, outage probability and bit error rate for coherent binary schemes have been derived. From the results obtained, we show the cases when the performance of a dual-EGC turns out to be inferior compared to selection combining and even single branch receivers.

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Title : ***Computationally Efficient Nonparametric Markov Random Field Based Texture Synthesis***

Author(s) : ***Sinha Arnab***

Roll No : ***Y3404061***

Supervisor(s) : ***Gupta Sumana***

Abstract

Nonparametric non-causal Markov random field (NNMRF) model is known to synthesize a broad range of natural textures. There are mainly two problems associated with texture synthesis using NNMRF model. They are, model order estimation (MOE) and huge computational complexity. We have developed a novel fast algorithm to estimate the model order for near-regular (NR) textures. Thereafter, we proposed a new neighborhood system (NeiSys) for NR textures. It has been shown that the proposed NeiSys is computationally efficient with respect to the existing NeiSys, with almost no degradation of results. The algorithms are tested with a number of natural textures. Finally, we developed another fast algorithm for the robust and accurate estimate of model order. This algorithm is based on nonparametric Pseudo-Likelihood measure. The computational complexity of the existing NNMRF based texture synthesis algorithm (TexSynAlg) is reduced with the incorporation of dimensionality reduction and fast kernel density estimation (FKDE) methodologies within the TexSynAlg. The proposed incorporation of dimensionality reduction approach worked well for only NR textures, though it is faster than the proposed FKDE; whereas the proposed FKDE algorithm can be applied to a broad range of natural textures. Given a large textured region we do not know how to extract a small exemplar such that the original textured region can be synthesized back faithfully. A multi objective framework is developed for this problem. We proposed three objective functions with an constraint, and analyzed them with a number of natural textures. The results established the efficacy of the proposed multi-objective framework.

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Title : Unsupervised Concept Acquisition From Surveillance Videos
Author(s) : Guha Prithwijit
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Supervisor(s) : Venkatesh K S&Mukerjee Amitabha(CSE)

Abstract

If one takes the grand goal of computer vision as that of enabling an artificial agent to respond appropriately to the widest possible range of situations, then it becomes clear that in the end, no system can be engineered to handle the vast diversity of inputs that may arise. In this thesis, we explore the possibility that computer vision systems may be "programmed" not so much directly by the engineers using code but that they may be "meta-programmed" so that they may discover the salient aspects of different visual contexts through repeated exposure, along with (minimal) inputs from supervisors or peers. In this view, the vision system is initially a mere observer, accumulating and identifying similarities between visual sequences leading to a set of incipient visual categories of objects, actions and relations. Occasionally, it may "reify" or consolidate some of these categories based on interactions with other agents where they may refer directly to some of the objects/actions, or may only discuss these in a broader context, as in linguistic descriptions of the scene. The objects of interest interact among themselves and the static scene structures exhibiting many visual occlusion configurations. Thus, occlusions form a key part of the visual signatures of many scene activities involving object interactions. Considerable research has looked into the problems of occlusion in two largely non-overlapping communities. In the computer vision community, the focus has been on practical problems, but the analysis here is often unsystematic - it is not "complete" in the sense of considering all possible distinctions based on an equivalence relation. On the other hand, the work in the Qualitative Spatial Reasoning (QSR) community is complete, but does not distinguish occlusions due to background objects (static occlusion) from that by other moving objects (dynamic occlusion). Also, most of the occlusion relations proposed in QSR are not of sufficient interest in computer vision. We formulate a complete set of fourteen occlusion states based on the nature of occlusion (static and/or dynamic) in 3D and object visibility (single part or fragmented) and object region overlaps (isolation/grouped) in 2D image plane. It is further shown that, the aforementioned states re-group into seven observable occlusion states when these objects are detected as foreground blobs and are tracked across the frames. To the best of our knowledge, this is the first attempt to characterize occlusions in a systematic way and use them in tracking and interaction modeling. In surveillance videos acquired from a static camera, the objects of interest are generally detected through foreground-background segmentation. We propose a pyramidal background modeling approach, which results in both performance improvement and reduced

computation in foreground extraction. The objects detected from the foreground blobs are tracked using single/multiple color patches hosting mean-shift trackers. The observable occlusion states of the objects are detected and also used as cues in the process of tracking. Based on object appearances, trajectories and occlusion states obtained by multiple object tracking, we use an unsupervised machine learning framework to discover the conceptual representations for object and activity categories. Object discovery is performed through a two stage clustering process. The well segmented object appearances recovered from their tracks (when isolated) are clustered first in the shape and Haar feature space to obtain the appearance modes. An object is modeled as a joint distribution of these appearance modes. These object models are clustered further using a Bhattacharya metric between the joint distributions to discover the object categories. Activities can be broadly classified as "single object actions" and "multiple object interactions". Single object actions are represented as sequences of the individual object occlusion states or the quantized motion directions (trajectories). Two objects are considered to interact if they satisfy a proximity criterion computed from their positions and dimensions in the image plane. The sequence of co-occurrent occlusion and quantized motion direction states of the two interacting objects for this entire period of proximity form the descriptor of the corresponding interaction. In most practical cases, the activity descriptor sequences contain a lot of self-transitions of object states. We propose to model the activities by a "transition sequence mining" (TSM) tree, which avoids learning self-transitions but preserves relative frequencies of the activity descriptors themselves and their transition subsequences. This has direct advantages in terms of memory usage, compared to the existing approaches like VLMM, SCFG or suffix tree which learn these self-transitions as well. A semi-metric derived from weighted Bhattacharya distance is used further to cluster the learned activity models (TSM trees). Finally, we proceed to discover the linguistic terms that correlate with the learned object and action concepts. We show that based on commentaries of two videos from twenty speakers, we are able to associate English phrases such as "Right to Left" for motion and "man", "Car", "tempo", "Bus" and "Truck" for object labels.

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Title : *Coordination And Navigation Of Multi-Robot Control Systems In An Unstructured Environment*

Author(s) : *Ray Anjan Kumar*
Roll No : *Y4104099*
Supervisor(s) : *Behera Laxmidhar & Jamshidi Mo*

Abstract

This thesis work is concerned with development of consensus based algorithms for coordination and navigation of multi-robot control systems in an unstructured environment. This work is built with the understanding that any complex task or work is the combination of some simple tasks. If we can identify those simple tasks, gradually the complexities of the problem will be reduced. While geometric projections and intersections of different curves are the technical backbone of the analysis to some extent, the main focus remains in the exploration of problems and its step-by-step formulation as per human understanding. Simulation results as well as real-time hardware implementations are presented to show the simplicity and applicability of these proposed methods. (i) A navigation algorithm consisting of Forward Safe Path (FSP) based on geometric modeling and Target Switching Approach (TSA) has been proposed. In this scheme, physical placement of sonars, their ranging limits and beam opening angles are considered. FSP simplifies the environment conditions as well as removes the so called 'oscillation' problem. It has been shown that TSA method along with FSP can avoid the 'dead cycle' during the navigation. These schemes are successfully implemented in Pioneer batch of mobile robots. (ii) A decentralized formation control has been proposed for multi-robot systems which enables mobile robots to collaborate and navigate in different unstructured environment. The scheme guarantees no self-collision, obstacle avoidance and minimum inter-agent communication. In this approach, the agents are divided into front agents and follower agents. A simple method based on geometry of the configuration space has been proposed to define the formation of multi-agents and identity of agents. In depth understanding is presented related to interaction of the robots in the formation depending on possible formation and environmental conditions. The agents decide their own behaviour onboard knowing the motion initiative of the master agent of the formation. The algorithmic flow is presented in such a way that any agent can estimate the behaviour of other agents in the formation. The proposed scheme thus reduces the dependency of the agents on other agents while taking decision. (iii) Another decentralized formation control scheme has been proposed which allows a formation to regain and maintain its shape in case of avoiding obstacles in addition to all the features mentioned in part (ii). The proposed approach reduces the communication burden on the formation where only the master agent broadcasts its motion status per sampled time. In both the approaches, any front agent can act as a master agent

without affecting the formation in case of fault in initial master agent. It has been shown that proposed schemes presented in (ii) and (iii) can also be used for velocity as well as orientation alignment problems for multi-agent rover network. These schemes have been tested through extensive simulations for different environmental conditions. (iv) A consensus based multi-robot traffic scheduling using FSP has been proposed where agents not in formation can collaborate to avoid self-collision during navigation in an unstructured environment. While sonar/laser range finder based approaches have severe cross-talk problems and vision based approach has complexities in terms of computation and feature extraction in unknown environment, the proposed approach provides a simplified solution which is suitable for real-time implementation. Different situations are discussed to explore the unexplored possibilities of interaction among the agents. This work is specifically important as it will allow automatic traffic scheduling for unmanned vehicles. (v) A consensus based orientation alignment during the initial formation of multi-robot systems has been proposed. The methods presented in (i) are clubbed together with consensus building process to show how different robots located at random initial positions can come together to form the desired shape of formation in an unknown environment. In this approach, different robots with random orientations can build a formation with orientation alignment with the reference to the master agent.

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Title : ***Linear Transform Approaches To Vocal Tract Length Normalization For Automatic Speech Recognition***

Author(s) : ***Doddipatla Rama Sanand***

Roll No : ***Y4104102***

Supervisor(s) : ***Umesh Srinivasan***

Abstract

This thesis is concerned with the development of computationally efficient approaches to perform speaker normalization for automatic speech recognition (ASR) using vocal tract length normalization (VTLN). Though VTLN requires a single parameter for normalization and hence can be robustly estimated with very less amount of data, but it requires all the warped features in the search range to be generated in advance before the optimal warp factor is estimated. In this thesis, we present an approach based on the idea of spectral Center of Gravity (CG) to perform speaker normalization. In speaker-normalization, it has been shown that speaker variations manifest as shift in the Mel frequency domain. Therefore, speaker normalization is achieved by shifting the Mel warped spectrum based on the difference in CG's. The thesis shows that this method performs comparably with conventional VTLN and reduces the computational complexity by more than 80%. The thesis also presents two novel linear transform approaches to VTLN using the ideas of dynamic frequency warping (DFW) and band limited (Sinc) interpolation. The idea of these approaches is to generate VTLN warped cepstral features by applying a matrix transformation on the conventional Mel frequency cepstral coefficients (MFCC). Such an approach eliminates the need to change the signal processing (i.e. change the filter bank structure) required for each warping factor to obtain the warped cepstral features in conventional VTLN. The results indicate that proposed approaches perform comparably with conventional VTLN. Obtaining a linear transformation also helps in accounting for the Jacobian of the transformation in warp factor estimation during VTLN. This term is usually ignored in practice as the transformation across the unwrapped and warped cepstral features is complex. In the present frame work of linear transformation for VTLN, the Jacobian will be simply the determinant of the transformation matrix. The thesis proposed covariance adaptation on top of VTLN to cope with the variations in the mismatch between the train and test speakers and showed that it improves the recognition performance when accounted properly.

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Title	***:***	***Forecasting Of Short-Term Load, Operating Reserves And Price & Optimal Generation Portfolio Management In Electricity Markets***
Author(s)	***:***	***Pindoriya Naran Manji***
Roll No	***:***	***Y5204063***
Supervisor(s)	***:***	***Singh Sri Niwas&Singh Sanjay Kumar***

Abstract

The work carried out in this thesis comprises of two major parts. First part concentrates on short-term forecasting of electric load, operating reserves and price in competitive electricity markets using the artificial intelligence techniques (Viz., artificial Neural Network (NN), Adaptive Wavelet Neural Network (AWNN), etc.). The AWNN is a new class of feed-forward NN having continuous wavelet function as activation functions of the hidden layer nodes. Therefore, it combines the time-frequency localization characteristic of wavelet and learning ability of feed-forward NN into a single unit. Whereas second part involves the application of heuristic optimization algorithm, particularly Particle Swarm Optimization (PSO), for optimal generation allocation for Generation Companies (GenCos) in short-term and medium-term operations planning horizon in the competitive environment. The California, Pennsylvania-New Jersey-Maryland Interconnection (PJM) and Spain electricity markets are selected as the case markets and the brief overviews of these markets are presented. The main contributions of this thesis include: Development of more accurate, efficient, and robust short-term forecasting method based on AWNN that can capture the volatility and non-stationarity in electric load, operating reserves and price time series. Formulation of the multi-objective self-scheduling problem and address the optimal generations scheduling in day-ahead market using the meta-heuristics optimization algorithms like Hybrid PSO (HPSO) and Multi-Objective PSO (MOPSO).Development of multi-objective Mean-Variance-Skewness (MVS) model, to tackle the problem of skewed distribution, for electrical portfolio management and study the MOPSO algorithm based optimal generation allocations in the spot energy market and the bilateral contracts.

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Title : ***Reactive Power Capability And Performance Analysis Of Grid Connected Unified DFIG For Wind Power Application***

Author(s) : ***Rajpurohit Bharat Singh***

Roll No : ***Y5204061***

Supervisor(s) : ***Singh Sri Niwas***

Abstract

Electric power generation from wind has emerged as one of the most successful programs in renewable energy sector, and has started making meaningful contributions to the overall power requirements in India and worldwide. In comparison to conventional synchronous generator, wind power is developed in relatively small units. Typically, the wind power generator rating varies from kWs to MWs with wind farms ranging from few megawatts to hundreds of megawatts. The penetration of wind turbines in the electrical power systems is increasing continuously and is influencing the overall power system operation. It is, therefore, important to analyze the impact of wind power generation in the existing system and to lay down the technical grid connection requirements. The doubly-fed induction generator (DFIG) system is the most popular wind energy conversion scheme (WECS) among its counterparts for wind power applications due to its several distinguished advantages. The stator windings of the DFIG are directly connected to the grid, but it is one of the problems in regards to tolerating connection point voltage disturbances. In this work, a novel architecture of DFIG, i.e. unified architecture (UA) has been proposed, to address fault ride-through capability of DFIG to meet specifically advanced grid codes issued by several transmission system operators (TSO). In this work, a detail analysis of DFIG & UA has been performed by developing suitable model for transient and small signal stability analysis including development of models of power-electronic converters and the complete capability curve of DFIG & UA including various limitations and reactive power capability of converters associated with DFIG system. Computational intelligence (CI) based advanced control of power-electronics converters of DFIG and UA has been developed for more accurate and efficient control.

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Title : *Studies On Advanced Filters In Planar Environment Using Generalized Multi-Band Filter Theory In Conjunction With Genetic Algorithm And Further Using EBG/DGS Structures*

Author(s) : *Mohan Akhilesh*
Roll No : *Y4404061*
Supervisor(s) : *Biswas Animesh*

Abstract

A filter is a frequency selective network that allows or stops a certain band of frequency. Microwave filters that comprise a network of usually highly selective cascaded resonators, are an indispensable building block in RF/Microwave wireless communication systems. This thesis concentrates basically on the synthesis of generalized multiband filters. The frequency transformation has been used for the transformation from low-pass prototype to multiband filters. A simpler and efficient procedure for synthesizing both symmetric and asymmetric multi-band frequency responses including any number of pass bands is presented. A synthesis method using hybrid genetic algorithm (HGA) for multiband filters is presented. The HGA is used here in order to overcome the drawbacks of conventional optimization techniques and simple genetic algorithm (SGA). A variety of symmetrical and asymmetrical filters have been synthesized using the proposed HGA. The advantage of using HGA is that different coupling matrices for the same frequency response can be achieved. It provides flexibility in achieving the practical coupling coefficients. A novel planar micro strip filters with EBG structures in the form of rectangular slots and circular pattern etched on the ground plane are presented. This novel planar EBG filter provides a way of minimization of the pass band ripples which arises due to periodicity of band gap structure. Conventional tapering techniques based on low-side lobe array theory and tapering techniques are used for further reduction in the ripple level in the pass band of the EBG structure. A novel defected ground structure (DGS) unit cell has been proposed. This novel DGS cell has high quality factor, compact size and better spurious performance than the other DGS cells reported in the literature. A more accurate equivalent circuit of this novel DGS cell is proposed in order to incorporate the next higher order mode. This novel DGS cell has been applied to a variety of filters such as stop bandfilter, low-pass, band pass and dual band pass filters.

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Title : *Kinematic Control Of Redundant Manipulators Using Neural Networks*

Author(s) : *Kumar Swagat*
Roll No : *Y4104111*
Supervisor(s) : *Behera Laxmidhar*

Abstract

This thesis is concerned with the development of learning algorithms for kinematic control of a 7 DOF redundant manipulator using neural networks. The inverse kinematic map for a redundant manipulator is a one-to-many relation problem, i.e., for each Cartesian position, multiple joint angle vectors are associated. When this inverse kinematic relation is learnt using existing learning schemes, a single inverse kinematic solution is achieved although the manipulator is redundant. Two different neural architectures, Kohonen Self-organizing map (KSOM) and feed forward neural networks have been used for solving the inverse kinematic problem comprehensively. (i) Least-square based estimation methods have been proposed to learn the parameters of a KSOM network which, in turn, is used to learn the inverse kinematic model in an open-loop framework. The prime objective is that the end-effector should reach the target position in the task space in a single step movement from any arbitrary initial configuration of the robot manipulator. Novel concepts such as function decomposition and sub-clustering in joint angle space have been introduced to make the convergence faster and the model more accurate. (ii) Least-square based scheme in part (i) can provide accuracy of not more than 1 cm positioning error as there exist no error-corrector loop in the learning algorithm. An error corrector-loop has been introduced in the learning scheme. Then a Self-organized map (SOM) based redundancy preserving network has been proposed to learn the one-to-many relation using sub-clustering in joint angle space. The proposed scheme has been implemented on a 7 DOF Power- Cube robot manipulator successfully with visual position feedback only. The vii positioning accuracy of the redundant manipulator using the proposed scheme outperforms existing SOM-based algorithms. (iii) A control theoretic approach using Lyapunov function has been developed to train feed-forward networks such as multi-layered network and radial basis function network. It is shown that the weight update rule in this new approach replaces the fixed learning rate in back-propagation algorithm with an adaptive learning rate. Convergence analysis of weight update rules have been done for two different cost functions associated with the network parameter optimization. Through simulation on various benchmark problems, it is established that the proposed algorithm outperforms both Back Propagation (BP) and Extended Kalman Filter (EKF) algorithms in terms of convergence speed. (iv) The proposed algorithm in part (iii) has been used in learning the forward kinematic map of a 7 DOF manipulator. An inverse-forward adaptive scheme with a Kohonen self-organizing map (KSOM) based hint generator has been proposed to find out inverse kinematic solution. This scheme overcomes some of the limitations of conventional network inversion based schemes thereby increasing the applicability of network inversion to kinematic control of redundant manipulators. The proposed scheme has been effectively used to manipulate the workspace in the presence of obstacles. Real-time experiment has been performed on 7 DOF PowerCube robot manipulator to validate simulation results.

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Title : *Study Of Electric Tree Growth In Polymeric Dielectrics With And Without Voids*

Author(s) : *Kasinathan Elanseralathan*
Roll No : *Y4104103*
Supervisor(s) : *Gupta Nandini*

Abstract

Electrical treeing is one of the most important long-term failure mechanisms in polymeric insulating materials in service. The electric tree channels grow through repeated discharges, eventually initiating a breakdown process. Electrical treeing is a complex process, and though we have a reasonable understanding of the many factors that influence tree growth, we still lack a clear understanding of the physical processes by which they determine the characteristics of the ensuing tree structure, making it almost impossible to predict failure. The current work aims at investigating a number of factors that play crucial roles in determining and detecting tree growth. Partial discharge (pd) activity within the tree channels is inextricably linked to tree growth. The amount of charge deployed in the discharge depends on several factors, including channel size, shape, material, electric field applied, etc. Tree branching and its ensuing shape is largely determined not only by the applied field, but also by the amount of space charge accumulation at different points of the dielectric. In this work, the effect of space charge accumulation on tree growth is studied. It is clearly shown that the space charge modified field has a large role to play. In the absence of accurate measurements of the space charge distribution within the dielectric, the simulations give meaningful insights into the kinds of charge distributions that encourage tree growth in axial or horizontal directions, and produce bushy, bush-branch or tree-like trees. Further, with the insights gained from the simulation, it is possible to predict approximately the nature of tree growth under high-field and low-field conditions. With the aim of relating observed pd patterns to the stage of tree growth, laboratory experiments are undertaken wherein simultaneous pd measurements and visual observation of treeing are performed. It was found that the pd pattern does change substantially over the various stages of tree growth. Trees are known to initiate from voids in the insulation. Since considerable discharge activity occurs within the void, it is to be expected that any tree growth in its vicinity would be affected by the presence of the void. In this work, we examine the presence of voids on already growing trees, through simulation as well as phase-resolved pd measurements. Experiments on tree growth in the presence of voids indicates that the void affects tree progression only in its immediate vicinity, and this is made possible only when a tree branch reaches close to the void under the influence of the other controlling factors. The effect of various parameters like the location and size of the void, as well as the charge density accumulated on its walls through repeated discharges, are studied through numerical simulations. The presence of small voids in a treed sample is found not to be discernible from the pd patterns. When the tree branch reaches the void, high intensity discharges ensue that cause rapid degradation of the channel walls and consequent widening of the tree tubules. A detailed observation of the process of channel widening by such processes is presented through visual images and pd pattern analysis.

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Title : ***Detection and Localization of Power Quality Events in Noisy Environment and Classification using Support Vector Machines***

Author(s) : ***Dwivedi Umakant Dhar***

Roll No : ***Y3104124***

Supervisor(s) : ***Singh Sri Niwas***

Abstract

An electrical power system is expected to deliver undistorted sinusoidal voltage and current continuously. The problem of power quality (PQ) occurs when there are deviations in voltage, current or frequency form the defined values which cause failure or mal-operation of the customers' equipments. With increased use of sensitive power electronics based equipments and more automation, there is a growing concern about PQ and its automatic monitoring and analysis has become an important challenging issue for power engineers. Detection and classification of PQ disturbances based on the visual inspection of waveforms by human operators are laborious and time consuming. Moreover, it is not always possible to extract important PQ information from simple visual inspection. Highly automated monitoring software and hardware are needed in order to provide adequate coverage of the entire system, to understand the causes of these disturbances, to resolve the existing problems, and to predict the future problems. PQ analysis is based on the large amount of data recorded by the measuring devices. But, the raw data gathered by continuous monitoring directly provide very little information on power quality. Automatic processing of data is therefore necessary for fast and effective use of the measured data. The traditional methods based on root-mean-square (rms) measurements, though very simple, are constrained by its accuracy. The fundamental signal processing techniques used in practical PQ monitoring have been based on discrete Fourier transform. Extracting frequency contains of the PQ waveform using Fourier analysis can help in detecting some of the PQ problems but, time information is missing in Fourier representations and also it is not suitable for nonstaionary waveforms. The recent developments in the digital signal processing (DSP) and pattern recognition areas have shown the potential of designing more accurate and intelligent PQ monitoring algorithms using these techniques. Several works have been reported proposing methods based on DSP techniques (like short time Fourier transform (STFT), discrete wavelet transform (DWT) etc.) for detection and features extraction, and artificial intelligence based tools for PQ event classification. In most of these studies, the pr-event waveform is assumed to be pure sinusoidal free from noise and harmonics which is not always possible. In practical situations, signals captured by the measuring devices are often corrupted by the noise and harmonics. The presence of noise not only degrades the detection capability of the wavelet and other DSP based techniques but also hinders the extraction of important information from the signal for its analysis. These issues (e.g. effect of noise, case of multi-event disturbances, dynamic changes in load configuration etc.) have not been addressed properly in the existing

literature. To improve the performance of existing techniques in the practical conditions of noise, harmonics, and dynamic load changes, more reliable and accurate waveform processing algorithms capable of analyzing a broader range of PQ events have been proposed in the thesis. The state of the art DSP techniques used for assessment and analysis of PQ in this thesis include nonparametric decomposition based methods namely DWT, orthogonal polynomial approximation (OPA), and adaptive filtering. Three different techniques have been devised to effectively denoise PQ waveform data for enhancing detection and localization outcomes of wavelet based algorithms, and for robust feature extraction. The developed noise suppression algorithms use statistical properties of wavelet transform and exploit the local structure of wavelet coefficients as well as the high correlation of adjacent wavelet scales. Effectiveness of these approaches has been tested with both simulated and measured power line disturbance data, and the results show that the proposed schemes significantly outperform existing methods used for denoising of PQ waveform data. Also, a new and effective power system transient detection and analysis method that uses combination of adaptive filter for event detection and wavelet transform for feature extraction has been proposed. Least mean square (LMS) adaptation based adaptive filtering has been proposed to accommodate dynamic changes in systems' load configuration. Finally, a classification system is designed using wavelet and support vector machine (SVM). Three approaches of SVM for multiclass classification problem using binary classifiers, one against all, one against one and Dendogram-based SVM (DSVM) are proposed and compared to classify various power quality events. The training of all SVMs has been done on MATLAB tool box. For testing purpose C codes were written, and testing was performed on TMS320C6713 DSK Device Cycle Accurate Simulator to test its suitability for real-time applications. The developed techniques are easily extendable for condition monitoring of electrical motors, generators, transformers, condition monitoring of insulation of power cables, etc.

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Title : ***Frequency Regulation Service And Reactive Power Management In Electricity Markets***

Author(s) : ***Parida Sanjoy Kumar***

Roll No : ***Y4104108***

Supervisor(s) : ***Srivastava SC&Singh Sri Niwas***

Abstract

The system support services, called as ancillary services in the electricity market environment, were generally provided as an obligatory service and their charges were embedded with the energy price. With the introduction of competition, the market participants are no more obliged to provide these services without proper incentives. Therefore, various approaches are being devised in for the procurement and remuneration of different types of ancillary services depending on the structural and operational practices in different countries. In this work, different approaches have been developed for frequency control and voltage control ancillary services management. A capacity linked incentive mechanism for promoting frequency regulation service provision in India has been proposed. The proposed method takes care of the demerits of the prevailing norms and incorporates the lost opportunity cost and usage cost. An integrated approach for optimal frequency regulation service procurement in India using an interactive method has been suggested. The approach simulates a simultaneous market clearing for energy and frequency regulation service procurement. The clearing price for up regulation and the UI price have been considered for the benefit analysis and to determine the optimal frequency regulation requirement. A hybrid approach for security constrained reactive power planning, in electricity markets, has been devised, considering the security along with the minimization of cost and loss simultaneously. A method for reactive power cost allocation that uses the valuation of reactive power utilization by the system users has been developed. The design and operation of a voltage security constrained localized reactive power market and an approach for reactive concentration analysis considering the effective availability of the reactive power from the generators have been proposed. The effectiveness of the proposed methods has been tested on Northern Regional Grid data of India, IEEE 24-bus Reliability Test System and 75-bus Indian system. The simulation results obtained on these systems revealed that the proposed methods for Indian scenario are simple and can be implemented in practice. The methods proposed for reactive power planning, reactive power cost allocation and reactive power concentration analysis can enhance the security of the system considering equitable allocation of incurred cost components.

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Title : ***Adaptation Of Fractal Structures For Wideband And Multiband Planar Antennas***

Author(s) : ***Joshi Ravi Kumar***

Roll No : ***Y3104120***

Supervisor(s) : ***HarishA R***

Abstract

In this work, three novel antenna structures based on the combination of conventional and fractal shaped elements are presented. It is shown with three case studies that the input bandwidth of these antennas can be enhanced by a judicious choice of fractal geometries. For each case, two approaches for bandwidth enhancement and dual band/multi-band operation have been proposed and discussed with the help of parametric study and its experimental validation. In the first approach, the dimensions of the antenna geometry are changed in such a way that the bandwidth is maximized while in the second approach, fractal shaped elements are incorporated with the antenna to maximize the bandwidth as well to convert the antenna into a dual band antenna with a wide range of tuning capability. The conventional part of the structure can be in the form of V antenna, bow-tie antenna or a printed strip loop antenna that is usually connected directly to the balanced feed line. The fractal structures in the antennas can be either directly coupled by attaching them with the radiating elements of the antenna or can be parasitically coupled with the directly fed radiating part of the structure.

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Title : ***WDM Fiber Delay Line Based Optical Packet Switch Architectures***

Author(s) : ***Srivastava Rajiv***

Roll No : ***Y3104116***

Supervisor(s) : ***SinghYatindra Nath***

Abstract

The demand for higher bandwidth is increasing day by day due to the data centric application like, Internet TV, video on demand etc.. The optical packet switching is considered as next generation data transfer technology because of its high throughput, low latency, fine granularity and ultimate bandwidth utilization. The optical network implementations can have electronic or all-optical switches. One of the key issues involved in optical networking is the design of switch/router architecture which can perform the switching operation efficiently at higher data rates. The switching aims to route the packets to the destined output ports. The important aspects of photonic packet switching are control, packet synchronization, clock recovery, packet routing, contention resolution and packet header replacement. Contention is one of the key issue, which occurs when two or more than two packets try to leave the switch from the same output port. To avoid the contention, one of the contending packets, is directed to the intended output port and rest of them are either stored or dropped. All-optical memory suitable for optical storage is not currently possible due to the technological limitations. Therefore, as an alternative defection routing or optical fiber delay lines (in traveling or re-circulating type configuration) can be used. Different solutions for optical buffering by using fiber delay lines have evolved in past few years and still researcher are trying to obtain better solutions. Optical buffering can be introduced in three ways: input buffering, output buffering and in shared manner. In this thesis, different aspects of optical buffering are investigated in various optical packet switch architectures. New architectures have also been proposed along with the novel buffering structure. The main objective of the thesis is to identify the limitations of the loop buffer based architectures and to solve them by proposing new architectures which have simpler buffer structure such that large number of packets can be stored in the buffer with very few components.

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Title : *Wavelet Kernel Machines For Image & Video Compression And Content Based Image Classification*

Author(s) : *Tolambiya Arvind*
Roll No : *Y5104077*
Supervisor(s) : *Kalra Prem Kumar*

Abstract

Recent interest in kernel machines motivated a large number of applications covering awide range of research fields. The ability of learning in kernel machines provides an interesting alternative to other conventional research methods. In this thesis, two applicationsof wavelet kernel machines are investigated. The first one is image and video compressionand second one is content based image classification. The two applications demonstrate theeffectiveness of wavelet kernel machines for image/video coding as well as image classification.Visual communication is a rapidly evolving field for telecommunications, computer andmedia industries. Recent progress in electronics technology and broadband communicationnetworks are leading to an increasing interest in a variety of applications such as video telephone, medical imaging, high - definition television (HDTV), remote surveillance, education,video mail, and entertainment. Due to limitation of storage and transmission capacity, datacompression has become inevitable for a wide class of applications. Therefore compressionof digital images and video sequences is necessary for efficient storage and transmission. Fortunately an image (a video stream contains both spatial and temporal redundancy) contains spatial redundancy. These redundancies, together with the way the human eye perceivesimages are exploited in image compression algorithms. The rapid growth of the internet hascreated demand for faster and more efficient data compression algorithms. The main research objective is to investigate the sparse properties of wavelet kernel machines with application to image and video compression. Algorithms exploiting sparseproperties of support vector machine (SVM) and relevance vector machine (RVM) learningare used to compress the images. Compression is achieved in the frequency domain by combining machine learning with the discrete wavelet transform (DWT). Four novel algorithmsare developed applying SVM and RVM learning to model transform coefficients after thesurface has been transformed into the frequency domain. In first approach SVM is used tomodel wavelet coefficients using constant Vapnik error ( ).This error is known as an insensitivity zone in SVMs terminology. The human vision is more sensitive to the loss of edgeinformation in the horizontal and vertical orientations and less sensitive to that in the diagonal orientation hence the sensitivities of the human visual system (HVS) are incorporated inthe second approach, termed as `Contrast Sensitive -SVR'. We tailored the insensitivityzone in the SVR model to obtain a good subjective performance in image coding. The RVMis a sparse learning algorithm, similar to the SVM in many respects but capable to delivera fully probabilistic output and allows avoiding the set of free parameters that the SVMhave. These free parameters usually require cross-validation based post optimizations. RVMhas a comparable

generalization performance to the SVM but requires dramatically fewerkernel functions than the SVM. In this correspondence, we applied the RVM learning inthird approach. In fourth approach, termed as `Adaptive Wavelet Kernel RVM', we use wavelet basisfunctions with adaptive free parameter (i.e. dilation of the basis functions). Since the distribution is typically different for different wavelet sub-bands, the constant dilation parameterfor estimating wavelet coefficients of all sub-bands may not give optimum results. So a moreefficient coding can be performed if we modify RVM training by adapting automatically thedilation parameter of the wavelet basis functions to the optimal for each wavelet sub-bands.The kernel function in kernel machines plays the central role of implicitly mapping the inputvector (through an inner product) into a high-dimensional feature space. The performanceof kernel machines greatly depends on the choice of kernels and its parameters. A comparative study among different wavelet kernel is presented for image compression applications. A performance comparison of proposed algorithms with JPEG, Rki-1, SPIHT, JPEG2000compression systems is done. It is found that Adaptive Wavelet Kernel RVM algorithm givesbetter image quality for a given compression ratio in comparison to JPEG, Rki-1, SPIHTand comparable to JPEG2000.Having a still image compression technique based on kernel machines compression, thereis a basis for designing a kernel machines based video compression scheme. There are manymode decisions in the video coding process that are used to optimize the performance interms of the bit rate, the speed and the quality of the decoded video. In this chapter, we describe a RVM classification based scheme for making macroblock mode decisions in theH.264 video coding process. The performance of proposed scheme is measured in terms ofboth the bit rate as well as the computation complexity, across different kinds of sequences,and the results are very encouraging.Recently, there has been considerable amount of interest in using machine learning methods to classify images by object they contain. The release of challenging data set with everincreasing number of object categories is forcing the development of image representationsthat can cope with multiple classes and of algorithms that are efficient in training and testing. This thesis explores the problem of classifying images by object they contain in thecase of large number of categories. It is proposed in this thesis to utilize the wavelet kernelRVM (WK-RVM) for content based classification of images. Comparative study has beencarried out among different wavelet kernels with both SVM and RVM. It is shown that theRVM based classification approach can provide similar classification accuracy (AC) as theSVM-based classification, with a significantly reduced number of relevance vectors (RVs).This feature makes the RVM based classification approach more suitable for applicationsthat require low complexity and real time classification.

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Title : ***A Utility Friendly High Performance Multilevel Inverter Fed Induction Motor Drive System For Traction And Industrial Applications***

Author(s) : ***Behera Ranjan Kumar***

Roll No : ***Y3104119***

Supervisor(s) : ***Das Shyama Prasad***

Abstract

A utility friendly high performance Three-Level Neutral Point Clamped (TLNPC) converter-inverter system is developed for induction motor drive. The front-end utility friendly bi-directional converter feeds a three-level NPC converter that drives an induction motor. The induction motor is operating under direct torque control (DTC) scheme. Front end converter is operating under hysteresis current control mode. A frequency domain switching characterization is presented for TLNPC ac-dc converter having rectification and regeneration capability. The main objective of the front end converter control is to keep total dc-link voltage constant and balanced across each electrolytic capacitor. The input power factor is maintained unity during all operating conditions. Nonlinear system is analyzed based on describing function and Tsypkin's method. This analysis gives prediction of maximum operating switching frequency and stability study of the converter system. Analysis has been carried out for nonlinear hysteresis based methods for stabilizing nonlinear switching phenomena. A triangular carrier is compared for constant switching frequency operation. The method of obtaining the minimum amplitude of carrier signal for a relay type nonlinear system also analyzed for proper switching of the power converters. The load side TLNPC converter, initially classical DTC methods are analyzed and reported. A DTC with modified look-up table method is proposed to overcome the flux demagnetization problem in the classical DTC techniques. This algorithm also improves the torque performances under free running and full load condition. An improved control technique to minimize torque and flux ripple of the DTC drive is developed using dither injection. The optimal value of dither frequency and magnitude is found out under free running and loaded condition. This approach reduces current, flux and torque ripple. However, it retains same dynamic response of torque and speed. Finally, Design methodologies and fabrication of a PWM based high power medium voltage three-level NPC converter are developed systematically. Conventional power circuit wiring is replaced with planar bus bar structure. This ensures low loop stray inductance and gives snubberless operation. Forced cooling is incorporated to eliminate bulky cooling fins of the heat sinks. Simulation study has been carried out using C++ and MATLAB/Simulink based programming language. Vital stress is given on the Hardware realization of three-level back-to-back NPC converters to test the feasibility of the proposed scheme. The overall induction motor drive system comprising the TLNPC ac-dc converter and load end TLNPC converter is simulated and experimentally implemented in the laboratory. The simulation results are obtained using MATLAB/Simulink. A Pentium PC having LabVIEW with

National Instruments (NI) data acquisition system (PCI-MIO16-E-4) has been used for the control of front-end ac-dc converter. The control platform for three-level inverter fed induction motor drive is built around the dSPACE (DS1104 DSP Controller Board) system, which has Matlab-Simulink GUI for the DSP processor. To validate the proposed control scheme, the simulation results are compared with the experimental results.

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Title : ***Fast Available Transfer Capability Determination And Its Enhancement In Electricity Markets***

Author(s) : ***Jain Trapti***

Roll No : ***Y4104112***

Supervisor(s) : ***Srivastava SC&Singh Sri Niwas***

Abstract

In electricity markets, all generating companies and power purchasing companiesbid for the most profitable transactions, which may lead to congestion of certaincorridors of the transmission network. The transmission congestion may be caused byviolation of line flow, voltage and stability limits and, thus, undermines the systemsecurity. Therefore, it is important to determine the "Available Transfer Capability (ATC)" of the transmission system. The ATC information is required to becontinuously computed, updated and made available to the market participantsthrough the web based systems. This thesis has mainly addressed the issue of fast andaccurate calculation of static as well as dynamic ATC and its enhancement throughuse of Flexible AC Transmission System (FACTS) controllers.A Radial Basis Function Neural Network (RBFNN) model has been developed todetermine static ATC in presence of bilateral as well as multilateral transactions inelectricity markets. To identify the severe contingencies, required to be considered fordetermining the ATC, a new contingency severity index, considering the impact oftransaction on relative severity of contingencies, has been proposed. Oscillatorystability constrained ATC has been determined by developing an optimization basedformulation, utilizing the bifurcation approach. Dynamic ATC considering transientstability limit, has been determined by developing a hybrid approach, based on thedirect structure preserving as well as the time domain simulation methods. The impactof the Static Synchronous Compensator (STATCOM) and the Unified Power FlowController (UPFC) on dynamic ATC has been analyzed. The optimal locations of these controllers have been obtained by computing the sensitivity of the structurepreserving energy margin with respect to their control parameters. An AdaptiveWavelet Neural Network (AWNN) based method has been proposed for fastdetermination of the dynamic ATC.The effectiveness of the new proposed methods have been tested on 39-bus NewEngland, 75-bus and 246-bus Indian systems. The simulation results obtained on thesesystems revealed that the proposed RBFNN based method is fast and accurate todetermine static ATC. The AWNN based method, to determine dynamic ATC, isfound to be the most suitable for on-line implementation.

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Title : ***Modulation And Control Of Diode-Clamped And Flying Capacitor Multilevel Converters For Power System Compensation Applications***

Author(s) : ***Shukla Anshuman***

Roll No : ***Y3104109***

Supervisor(s) : ***Joshi Avinash&Ghosh Arindam***

Abstract

To implement the flexible ac transmission system (FACTS) devices and medium to high voltage custom power (CP) devices, high power inverters are needed. In this thesis, two multilevel inverters, namely; diode-clamped multilevel inverter (DCMLI) and flying capacitor multilevel inverter (FCMLI) have been considered for applications in the two FACTS devices; STATCOM and UPFC and one CP device; DSTATCOM. For the modulation of multilevel inverters in FACTS applications, multicarrier PWM scheme has been considered. The various multicarrier PWM schemes have been studied and comparatively analyzed. In the DSTATCOM application of multilevel inverters, the hysteresis modulation scheme has been chosen. The various multilevel hysteresis control techniques have been presented and analyzed comparatively. The proposed time-based hysteresis modulation scheme has been used in the DSTATCOM applications. To counteract the dc capacitor voltages unbalancing in DCMLI, four different schemes are presented to control the additional chopper circuit at the dc bus. A flying capacitor based chopper circuit has been proposed for the capacitor voltages equalization in DCMLI which in addition to reducing the voltage stress across the chopper devices, can also provide ride-through enhancement during system disturbances. In FCMLI to achieve natural balancing of flying capacitor voltages balancing, various implementation schemes have been proposed. The preferential switch state selection based approaches have been proposed to achieve robust and reliable control over the flying capacitor voltages. A time-based approach of flying capacitor voltage balancing is proposed under hysteresis current control mode of operation, which offers reliable and robust performance with fast transient response and is not affected by the loading conditions. DCMLI and FCMLI based STATCOMs and UPFCs, with the proposed schemes applied, are investigated and compared in terms of their various functions such as voltage regulation, power flow control and power oscillation damping. With the proposed modulation and control schemes applied, DCMLI and FCMLI are investigated for their application as a DSTATCOM. Both the stiff and non-stiff sources are considered and corresponding approaches for controlling of DSTATCOM are derived to result in balanced and distortion free source currents and terminal voltages. To counteract the neutral point unbalance when the load currents contain dc components, two new equalizing chopper circuits are proposed for the multilevel inverters based DSTATCOM. The feasibilities of the proposed modulation and control schemes for the considered multilevel inverters have also been verified through simulation and experimentation.

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Title : ***Loading Sensitivity And Price Based Indices For Optimal Placement Of Facts Controllers To Enhance Power System Performance***

Author(s) : ***Singh Jai Govind***

Roll No : ***Y3104113***

Supervisor(s) : ***Srivastava S C&Singh Sri Niwas***

Abstract

Secure, stable and reliable operation of the power system has become a serious challenge,specifically in the emerging electricity market scenario. Continuous growth in power demandand supply pattern, along with limited expansion of transmission network, changes the powerflow patterns in the power system in such a way that some of the transmission corridors get overloaded. The Flexible AC Transmission Systems (FACTS) controllers are being increasingly usedin the network to address some of these challenges. The FACTS controllers have been used forpower flow control, voltage control and stability enhancement. However, these controllers are every expensive and, hence, their optimal locations in the network must be properly ascertained.A new set of AC sensitivity factors, termed as change in system loading factor with respectto UPFC series parameters, has been proposed for optimal placement of the UPFC and itseffectiveness has been established two test systems in terms of system loading enhancement. Forthe power system security enhancement, a new set of indices, referred as change in real powerflow performance index (PI) with respect to change in UPFC series parameters has beenproposed, based on AC power flow approximation, and utilized to determine the optimal PI,which measured the system security, and also compared with DC power flow approximationbased method. A new set of System Loading Distribution Factors (SLDF) termed as change inline real power flow with respect to change in system loading factor for the optimal placement ofseries controller of the UPFC. The effectiveness of SLDF has been studied in terms ofimprovement in power system performance and compared with two existing methods. Theeffects of line contingencies have been included in the determination of above sensitivity factors.A new set of Real Power Transmission Congestion Distribution Factors (PTCDFUs), inpresence of optimally placed UPFC based on SLDF, has been defined for identification of theclusters/zones for single and multi-line congestion cases. Generators from the most sensitivezones have been selected for rescheduling their real power outputs to alleviate congestion. Thecongestion management problem has been formulated as an optimization problem minimizingthe congestion cost and compared with existing method. In addition, a new set of Reactive PowerSpot Price Index (QSPI) has been suggested for optimal location of Static VAr Compensator (SVC) and its impact on the improvement of power system performance has been studied.

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Title : Intelligent Control Schemes For Nonlinear Systems
Author(s) : Kar Indrani
Roll No : Y3104112
Supervisor(s) : Behera Laxmidhar

Abstract

This work is concerned with modeling and control of nonlinear systems using intelligent controltechniques. Changes in environment and performance criteria, un-modeled dynamics and disturbances,unavailability of generalized controller design tools are some of the characteristicsof nonlinear systems which necessitate intelligent control. The present work has mainly beenfocused on developing new control schemes which use intelligent control paradigm to addressthe control issues of nonlinear systems in a better way.Learning and function approximation capabilities of neural networks and fuzzy systemsmake them suitable to be incorporated in an intelligent control system. A nonlinear systemcan be accurately approximated using a fuzzy cluster of local linear models which is popularlyknown as a Takagi-Sugeno (T-S) fuzzy model. In the proposed controller design scheme, theterms in the T-S fuzzy model are expressed in such a way that a single nominal plant is separatedfrom the rest. Two variable gain state feedback controllers are proposed to stabilize the nominallinear plant while considering the effect of rest of the plants as a disturbance term. As the systemtraverses from one operating point to another, the upper bound of this disturbance can be seenas a variable quantity which leads to a variable gain controller. This is in contrast with the fixedgain controller proposed by S. H. Zak where the upper bound was computed considering theworst case scenario. In the second control scheme, the nominal plant also varies along with theoperating point. This relaxes the condition of applicability for the controller. The efficacy ofthe proposed controllers is established through simulation results.Another popular method of designing controller for a T-S fuzzy model is using a linear matrixinequality (LMI) technique. But this design technique depends on the fact that all linearmodels of the T-S fuzzy system must have a common Lyapunov function. Thus the LMI techniqueor the above described control technique cannot be applied for all systems. A controllerdesign scheme is proposed, for more general cases, based on the inversion of the T-S fuzzy model of a nonlinear system. The control input is iteratively updated between two successivesampling instants to match the T-S fuzzy model output to the desired output of the system. Aparametric form of the controller is also assumed and the parameters are updated online throughnetwork inversion. The proposed control scheme simplifies the design process and can be usedboth for regulation as well as tracking problems. The inversion based controller is implementedon the cart pole system and it is observed that the proposed scheme works for a wider operatingregion compared to standard linear quadratic regulator (LQR) design.Feedback linearization is another useful control design technique where a large class ofnonlinear systems can be made linear as well as stable by nonlinear state feedback. Exactknowledge of system nonlinearities is required for successful implementation of the controllerwhich is not the case

always. A neural network based adaptive control scheme is proposedfor a class of input-output linearizable affine nonlinear systems using the concept of feedbacklinearization. The affine systems are assumed to be in strict feedback form. The nonlinearfunctions involved in the dynamics of the systems are approximated by radial basis function (RBF) networks. The weight update laws of the RBF networks are derived in such a way thatthe closed loop system is Lyapunov stable and the output tracking error converges to zero withtime. The proposed scheme has been extended for discrete time systems where it removes theneed for any projection algorithm or additional control action presented in the literature.The applicability of a fuzzy learning paradigm has been studied for the inverse kinematiccontrol of a 6 DOF (degree of freedom) robot manipulator using visual feedback. The basic taskis to derive the mapping from manipulator task space to joint angle space. Two fuzzy learningschemes have been proposed for the very purpose. In case of a 6 DOF robot manipulatorwithout orientation feedback, there are redundant solutions for joint angle. In the first scheme,the inverse kinematics is represented by a T-S fuzzy model. The fuzzy centers are fixed a priorito span the entire workspace. The Jacobian matrices associated with each center are learned using gradient descent algorithm. Once the inverse kinematics is learned, the model computesthe required joint angle for a desired target position in one step. In the second scheme, theinverse mapping is learnt using a fuzzy cluster where c-mean clustering algorithm is used tocompute the cluster centers. The concept of sub-clustering is introduced in the joint anglespace to increase the dexterity of the manipulator. An incremental learning is also adoptedwhich greatly reduces the position tracking error. The proposed learning paradigm has beensuccessfully implemented on a 6 DOF PowerCube manipulator from Amtec robotics.Towards a novel paradigm of intelligent computing, an alternative neural architecture namely,Recurrent Quantum Neural Network (RQNN) is proposed in this thesis. The model is based onthe assumption that the individual neuronal response does not play a significant role when thecollective behavior of a neural lattice is observed. The collective response model proposed inthis work entails that there exists a quantum process that mediates the average behavior of aneural lattice. This collective response is described here as the output of a Schrodinger waveequation. In any classical approach to system identification, an a priori generic model is assumed.For example, in stochastic filtering the signal type is assumed as, for example, DC,sinusoid or modulated. Besides, the embedded noise in the signal is assumed as either Gaussianor Non-Gaussian. Similarly in classical control systems, it is assumed a priori if the system islinear or nonlinear. It is also assumed if the parameters are constant or time varying and theuncertainties in parameters are always upper and lower bounded. The basic motivation of thiswork is to develop models using minimal assumptions. The application of the proposed RQNNmodel is studied for stochastic filtering and adaptive control problems.

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Title	***:***	***Studies On InhomogeneoUs Dielectric Resonators For Improved Mode Separation In MIC Environment Using Efficient FDTD Algorithm And Its Application To Bandpass Filter***
Author(s)	***:***	***Srivastava Kumar Vaibhav***
Roll No	***:***	***Y4104106***
Supervisor(s)	***:***	***Biswas Animesh***

Abstract

The microwave resonators are the key element for designing the filters and oscillators at microwave frequency. The main considerations for designing of microwave resonators are its size, unloaded quality factor, spurious performance, power handling capability and temperature stability. Some of the popular microwave resonators are coaxial resonators, waveguide resonators, strip line resonators and dielectric resonators. The dielectric resonators (DR) are advantageous over the coaxial, stripline and waveguide resonators in terms of its size and unloaded quality factors but its spurious response limits its application in filters and oscillators. Several attempts with partial success are made in past for improving the spurious free frequency band response of dielectric resonator. The ring shape of dielectric resonator is known to be the best available shape of dielectric resonator for improved mode separation and frequently used in recent day's filters and oscillators.This thesis presents some possible novel DR structures and its analysis for determination of mode spectrum to improve its frequency band response in microwave integrated circuit (MIC) environment. One of the suggested novel structures, named here as a modified ring dielectric resonator, provides the better mode separation over the state of the art ring dielectric resonator without any deterioration in quality factor. Another novel DR structure is multi-layer multi-permittivity (MLMP) ring DR which comprises several ring cross sectioned layers (n) of varying dielectric constant (εri; i = 1 to n) and thickness (hi) stacked together. The MLMP ring DR also shows the better mode separation over conventional ring DR in MIC environment.To determine the DR characteristics, the finite-difference time-domain (FDTD) method is used here. The FDTD code is made efficient by implementing 2.5-D Cylindrical FDTD in cylindrical coordinate system and 3-D Conventional ADI FDTD in Cartesian coordinate system. The further improvement in ADI FDTD is suggested by developing first time 3-D Artificial Anisotropic ADI FDTD in Cartesian coordinate system which reduces the numerical dispersion error as created due to large time step in conventional ADI FDTD.

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Title : ***Development Of Market Monitoring System And Swarm Intelligence Based Bidding Strategies In Electricity Markets***

Author(s) : ***Bajpai Prabodh***

Roll No : ***Y220464***

Supervisor(s) : ***Singh Sri Niwas***

Abstract

A number of countries around the world have been engaged in reform initiativesincluding liberalization, privatization and/or restructuring of electricity industry since mid-1980sto make it more efficient through competition. Competitive market provides the driving force forthe generators to operate in most efficient and economic manner in order to remain in businessand recover reasonable profits including other benefits like customer choice, better investmentsignals, encourage innovations, rewards to risk takers etc. However, operation and control ofrestructured Electricity Markets (EMs) pose more complex and technical challenges than theconventional monopolistic markets. Indian power industry restructuring process begins withopening up of power generation for private investment in 1991 and later through regulatory reforms; this process has entered a new phase with the recent enactment of Electricity Act 2003.However there is need of organized market mechanism to address major concerns of present EM.Gaming behavior by the market participants, especially generators, may lead to marketpower abuses, which cause inefficient dispatch, high consumer costs and inefficient signals fornew investment, etc. Thus, it is necessary for the system regulators and policy makers to identifythe potential market power and find ways to mitigate them to improve the market efficiency.Very few works on bidding strategies are available using latest evolutionarycomputation technique, Particle Swarm Optimization (PSO), which has several advantages oversimilar population based heuristic methods. Moreover, fuzzy adaptive PSO approach is betterthan all other approaches for strategic bidding problem in a dynamically varying environment (multi-hourly market clearings).In this work, a suitable market model for Indian system along with the market monitoringsystems has been suggested. Optimal bidding strategies for successive market clearings in a dayaheadmarket have been developed taking into account inter-temporal constraints and precisemodel of cost functions using PSO. Both block-bid and linear-bid models of an EM have beendeveloped using PSO with inertia weight approach. Uncertain behavior of competitors isestimated using two different probability distribution functions. The bidding decision of asupplier in a transmission constrained EM using FAPSO has been optimized in a bi-leveloptimization model. In the lower level, system operator clears the market by solving a securityconstrained economic dispatch problem, while upper level problem maximizes the payoff of agenerator using economic withholding bidding strategy. Multiple cases have been simulatedtaking into account network and ramp up/down rate constraints in multi-hourly market clearing.

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Title : ***Study Of P-Cycle Based Protection In Optical Networks And Removal Of ITS Shortcomings***

Author(s) : ***Asthana Rachna***

Roll No : ***Y110492***

Supervisor(s) : ***Singh Yatindra Nath***

Abstract

P-Cycle (preconfigured cycle) based protection is one of the most promisingtechniques of span protection in optical networks because of mesh like efficiency andring like speed. Distributed cycle pre-configuration protocol is used for deployment of pcyclesin real networks. This protocol has been studied extensively. A modifieddistributed cycle pre-configuration protocol (MDCPC) which reduces the computationalcomplexities, by finding all the copies of the same p-cycle in single iteration, has beenproposed. All the copies of the same p-cycle are aggregated together to reduce thenumber of switching fabrics and the amount of signalingtraffic. The restoration paths provided by the p-cycles are usually many hops long, aslonger p-cycles provide better efficiency. With longer p-cycles, there will be loop backsin the restored path. If these loop backs can be removed, the restored path length will bereduced significantly, and redundant capacity will also be released. To remove these loopbacks, an algorithm, removal of loop back (RLB), is developed to reconfigure therestored path without compromising on any features of the p-cycles. This aspect of the pcyclehas not been discussed so far in the literature. The average lengths of the restoredpaths with and without RLB for the networks with 2.0 average nodal degrees have alsobeen derived. Further, a distributed protocol has been developed for the implementationof removal of loop back (RLB) algorithm to reconfigure the restored path. The reductionin the restored path length also depends on the fact that which p-cycle is being used toprotect a particular path. The problem has been formulated as optimum p-cycle allocation (OPA) problem and solved with Hungarian Algorithm. Finally, some specializedprotection techniques have been proposed to resolve the issues related with lowavailability spans and for protection of critical traffic which may have stringentrequirements for protection.

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Title : ***Studies On Multiple Transmitter Indoor Optical Wireless Systems***

Author(s) : ***Sivabalan A***

Roll No : ***Y120461***

Supervisor(s) : ***John Joseph***

Abstract

There has been considerable interest in the use of infrared frequencies for indoor wireless LAN applications. A typical indoor optical wireless system uses a single transmitter located at the center of the ceiling to transmit data to the receivers located anywhere on the room floor. This arrangement results in substantial variations in the received optical power at various points in the room, which can exceed the dynamic range of typical receivers. The degree of uniformity in power levels and the channel bandwidth are two important performance factors for effective communication. The thesis studies existing channel models and proposes two models, viz. the modified recursive and the extended ceiling bounce models, for computing the channel impulse response in multiple transmitter environments. Computed impulse responses using the above models are used to estimate the degree of uniformity and the channel bandwidth of the proposed multiple transmitter configurations which substantially improve the degree of uniformity compared to others. Further, the effects of room size, number of transmitters, and their placements on the performance parameters are studied, which are useful for designing high performance indoor optical wireless systems.

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Title : ***Optical Packet Switching Architectures Incorporating Various Buffering Techniques Using Fiber Delay Lines***

Author(s) : ***Singh Rajat Kumar***

Roll No : ***Y120463***

Supervisor(s) : ***Singh Yatindra Nath***

Abstract

The bandwidth demand due to more and more data intensive application and growth inuser-base is increasing day by day. The optical networks are the most suitable option forthis increased bandwidth requirements due to the availability of large bandwidth in thefiber. The optical network implementations can have electronic or all-optical switches. Inoptical transport networks, the current approach is to use optical circuit switches to set uplight paths. These all-optical switches are transparent to information carried over the lightpath, and provides for creation and management of virtual topologies. The possibility ofpacket switching using photonic technologies, allows all-optical packet switched networkswhere packets remain in optical form without undergoing optoelectronic conversionat intermediate nodes. Thus, photonic packet switching offers high speed (data rate),format transparency, efficiency and flexibility in configuration due to switching operationin physical layer.One of the major issues involved in optical networking is the switch/router architecturewhich can perform the switching operation efficiently at such high data rates. In last decade,several research efforts have been reported on the design of switches/routers. These switches are of various types: electronic, all-optical or optical. The purpose of switchingis to route the packet to the destined output port. The important aspects of photonicpacket switching are control, packet synchronization, clock recovery, packet routing, contentionresolution and packet header replacement. These are used for successful operationof a packet switch. Contention is one of these problems, which occurs when two or morepackets arrive at same time for same destination. To avoid this contention, one packet isdirected to the output and other packets have to be stored in optical memory. All-opticalmemory suitable for above purpose in photonic packet switches has not yet been developed.Different techniques for optical buffering by using fiber delay lines have evolved inlast decade and still research is going on to explore better solutions.In the thesis, different aspects of optical buffering have been investigated for variousarchitectures of optical packet switching. Some new architectures have also been proposedalongwith the buffering techniques and their analysis. The main objective is to utilizethe optimal buffering parameters to provide least packet loss probability and reasonableaverage delay with given resources.

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Title : *Transient Stability Assessment Of Power Systems Containing FACTS Controllers Through Trajectory Sensitivity*

Author(s) : *Chatterjee Dheeman*
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Abstract

The demand of electricity is growing fast across the globe. But due to environmental and economic constraints, building of new generating stations and transmission lines are often restricted. Hence the maximum possible utilization of the existing infrastructure becomes an absolute necessity. The ongoing restructuring and deregulation of the power sector is also pushing the system in the same direction in the pursuit of a more efficient electricity market by introducing larger competition. However, this search for growth of competition and increase of operational efficiency has eroded spare infrastructure capacity that used to serve as a shock absorber. One way of making power system operation more efficient is through the introduction of Flexible Alternating Current Transmission System (FACTS) controllers. Series FACTS controller like TCSC and shunt FACTS controller like STATCOM can help to operate the systems near their thermal limits. However, as the systems are being pushed to their limits, maintaining stability gains larger importance and the need for efficient tools of dynamic security assessment becomes pronounced. In this thesis, the effectiveness of the Trajectory Sensitivity Analysis (TSA) method in successful assessment of power system transient stability condition compensated by FACTS controllers has been studied. Transient energy function (TEF) method is the standard tool used for this purpose. However, this method may become too complex when detailed model including FACTS device is considered and a number of parameters have to be taken into account. The TSA method being independent of model complexities can help to overcome this problem. It has been used in this thesis to find out suitable location and control parameters for different types of FACTS controllers. It is found that numerical calculation of sensitivities is faster than analytical sensitivity without any appreciable difference in the results. The effects of individual and simultaneous application of the FACTS controllers have been compared. The stability condition of a stressed system has been studied using trajectory sensitivity. On-line security monitoring methods must be carried out fast enough so that the power system operators have sufficient time to take suitable measures as and when necessary. One possible way of increasing the computation speed is the system reduction, with the constraint that the compromise in accuracy of assessment is not considerable. Therefore, the effectiveness of TSA to produce sufficiently accurate results when a part of the power system network is replaced by equivalents has been studied. The computation time decreases considerably and is found to be dependent on the ratio of the number of buses of the reduced system to the total number of system buses.

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Title : *Design And Implementation Of An Optimum Unified Power Quality Conditioner With Minimum VA Loading*

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Abstract

The thesis investigates the functionality of the conventional UPQC further by proposing a novel control of the DVR, leading to 'minimum VA loading of the overall UPQC'. This includes the mathematical modeling for VA loading of individual series and shunt inverter followed by reducing the VA loading calculation to a minimization problem. It is shown that the angle at which the voltage is injected by the DVR affects the VA loading directly and an optimum angle of injection can be employed to minimize the VA loading of the overall UPQC. A numerical case study is carried out to show the effectiveness of the scheme through comparison with UPQC-Q and UPQC-P. Besides, the 'minimum VA loading' sensitivity is investigated for the experimental error in the angle of voltage injection by the DVR.Single-phase software phase-lock loop, based upon Park's transformation theory, is implemented with the help of a PC interfaced with a Data Acquisition Card. The variable size 'Circular Buffer' is implemented to generate the quadrature components needed for the Park's Transformation. A 120 V, 5 A prototype single-phase UPQC is developed in the laboratory with a DSP controller (dSPACE R&D 1104).The same concept is further experimentally verified for three-phase UPQC as well. The DVR control strategy based on Synchronously Rotating Frame (SRF) method is used directly to control magnitude and angle of the voltage injected by the DVR. Scalar control technique is implemented for the closed-loop control of the STATCOM. Less number of feedbacks, simplicity of implementation and no need for phase transformation make this scalar control suitable for 3-phase UPQC, to reduce the overall complexity. Subsequently, an experimental prototype model in laboratory for the single-phase 'Optimum UPQC with minimum VA loading' is developed. A 50 kVA, IGBT IPM (Mitsubishi Make PM50CSD120) is chosen to experimentally verify the analytical model. The control platform is built around the dSPACE (DS1104 R&D Controller Board), which has Matlab-Simulink GUI for DSP processor. A supplementary PC based Dynalog make Data Acquisition card is used for sensing % sag (x) and 'd.p.f.' (Φ1). Hardware circuit for calculating volt-second area per half cycle is explained in detailed. Selected experimental results at 120 V, 5 A, 20% sag are reported to corroborate the proposed theory.

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Title : *Characterization And Design of Inverter Switching Control For Distribution System Compensation*

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Abstract

A significant growth in the usage of power electronics based compensators fordistribution system power quality enhancement has occurred in the recent times [1]. Thepower quality problems that these compensators address include harmonic distortions due tononlinear loads, poor load power factor, voltage sag/swell, supply voltage distortions etc.Each of these compensators is made of a voltage source inverter (VSI) along withtransformer and passive elements that are used for interfacing and switching harmonicssuppression. The modulation of VSIs at a specified switching frequency is desired due todevice limitations, filter design, electromagnetic interference (EMI) and switching lossestimation.There are various VSI configurations available for both single-phase and three-phaseapplications [2]. The most fundamental of all these are single-phase half bridge and fullbridge (H-bridge) VSIs. The latter is more popular for single-phase applications. Thistopology of VSI can be used to obtain either two-level or three-level output and it can beused for low and medium voltage distribution system compensation.For higher voltage and power applications, the switching frequency and device ratingsare limited. Therefore it is desirable to distribute the stress among the number of devicesusing multilevel inverters. There are three important multilevel topologies. These are diodeclampedmultilevel inverter (DCMLI), flying-capacitor multilevel inverter (FCMLI) andcascaded H-bridge multilevel inverter (CHBMLI) [3]. The cascaded H-bridge multilevel inverter topology is gaining importance for medium to high voltage distribution systemcompensation, due to the modularity of basic H-bridge. The modular nature of cascadedmultilevel inverter reduces the cost of realization. Since these inverters are composed ofseries connections of multiple H-bridge units, the voltage and power stress are distributedamongst them. With a suitable modulation technique, the frequency spectrum of themultilevel output voltage can be appropriately shifted to the high frequency region and themagnitude of the switching harmonics in the output voltage can be reduced [2]. These twofactors considerably reduce the inverter switching components in the output voltage deliveredby the multilevel inverter. Each H-bridge unit in this topology requires a separate dc voltagesource for the purpose of isolation. In order to avoid the use of separate dc source, a cascadedtransformer topology is used [4]. In this a common dc voltage source can be used for all theunits.There is a variety of VSI based compensators for distribution system compensation [1]. In this thesis, two basic compensators, i.e., distribution static compensator(DSTATCOM) and dynamic voltage restorer (DVR), utilizing various VSI topologies areinvestigated for the verification of various inverter switching control schemes.A DSTATCOM is a versatile device

and can operate both in voltage and currentcontrol modes [1], [5]. When operated in a voltage control mode, it can control the voltage atthe point of common coupling (PCC), irrespective of the distortion in the source or load side.In current control mode, it can improve the quality of power by eliminating the effect ofharmonic contents in the load. It can simultaneously reduce the effect of poor load powerfactor and balance source currents even when the load is unbalanced. A DVR is mainly usedto protect sensitive loads from sags/swells or disturbances in the supply voltage [1], [4].The instantaneous method of control has been very popular due to its fast dynamiccharacteristics and robustness properties [1], [5]-[7]. This method involves comparison ofinstantaneous values of the state vector with its corresponding references. The resultant errorvector, when multiplied by a suitable gain matrix, forms a switching function. Based on theinstantaneous value of the switching function, the inverter switching is controlled. In thesimplest form of implementation, an ideal relay can be used for the generation of theswitching signals. However this ideal implementation leads to infinite switching frequencyfor the inverter. In order to limit the switching frequency for practical devices such as insulated-gate bipolar transistor (IGBT), the switching control follows the commonmodulation techniques. These include hysteresis based modulation and triangular carrierbased modulation (or ramp-comparison control) [7]. These two closed loop modulationmethods have wide popularity due to their ease of implementation through both analog anddigital devices. For a two-level inverter, the hysteresis based modulation [5]-[7] compares theswitching function with either fixed or variable hysteresis band for the determination of theinverter switching signals. The method of fixed hysteresis band has excellent dynamic andsteady state performance. However the major disadvantage of the method is that it has avariable switching frequency over a fundamental period. In order to maintain a constant switching frequency, an adaptive hysteresis band can be used [8]. In a triangular carrier based modulation [7], [9], the switching function is compared with a fixed frequency triangular carrier to generate the switching signals for the inverter. This method yields a fixed switching frequency operation over wide operating conditions. However this method leads to a steady state tracking error in the output variables. Conventionally, a time domain method is used for the characterization of inverter switching control for both hysteresis based [8] and triangular carrier based [9] modulations. The characterization implies finding out the relation the inverter switching frequency has with various system and design parameters, which include distribution system parameters, passive filters, dc link voltage, load, controller gains and hysteresis band or carrier amplitude. In order to ensure a smooth modulation at a constant switching frequency, a suitable design of hysteresis band or carrier amplitude is required. It is shown in [8] that the hysteresis band can be made variable as a function of source voltage, slope of reference, dc link voltage etc.,in order to keep the switching frequency constant. Similarly in [9] a controller gain is designed as a function of these variables for fixed switching frequency operation. The switching characterization based on time-domain approach is difficult for compensators like DVR and DSTATCOM connected with output LC filter, especially when controllers such as state feedback control are used and the compensator is connected at the remote end of a radial feeder in a weak ac system. The problem becomes more complicated

when multilevel inverters are used as VSI and the control and modulation schemes are implemented digitally. Therefore there is a need of a generalized framework to address the variety of compensators with their implementation strategies. Based on the above discussion, following are the main objectives of the thesis. To develop a common framework for the characterization and design of switching control for both the two-level and multilevel VSIs, suitable for both analog and digital implementations. To extend the application of above framework for commonly used compensating devices,i.e. DSTATCOM and DVR. To identify the various systems and design parameters affecting the switching characteristic.To obtain a general methodology for modeling and analysis of aforesaid compensating devices and to propose the appropriate control methods. Following are the specific contributions of this thesis to fulfill the above objectives.1. Simple and effective controllers are proposed for both DSTATCOM and DVR. A state space method of modeling is used for all the compensators. The models are converted in the s-domain for the purpose of analysis and design.2. A frequency domain method is proposed for the characterization and design of the switching control of VSIs for both analog and digital implementations of the control and modulation schemes.3. The switching transition concept of Tsypkin's method [10] has been used to characterize the two-level hysteresis modulation [7]. Basic expressions are obtained for different compensators showing dependency of switching frequency with different system and design parameters. A novel adaptive/variable band hysteresis modulation is proposed to overcome the disadvantage of variable switching frequency with fixed hysteresis band.4. Carrier-based closed loop modulation of two-level inverter is analyzed with the help of sinusoidal carrier waveforms using the concept of forced switching [7], [10]. The analytical method is proposed for the characterization of the commonly used PW triangular carrier modulation.5. Both hysteresis-based and carrier-based modulation methods are extended to the modulation of the cascaded multilevel inverters. The frequency domain switching characterizations are also correspondingly extended for multilevel modulations.6. All the proposed control and modulation methods are validated through simulation and experimental implementations of DSTATCOM and DVR. The Simulations results given in this thesis are performed using the PSCAD/EMTDC simulation package (version3.0.7). The experimental verifications are obtained using FPGA based control of a singlephaselaboratory model utilizing both the two-level and the multilevel VSIs. The threephaseapplication of the various compensators is shown through simulation studies.The thesis is organized in seven chapters and starts with the introduction inChapter 1. Various VSI topologies are introduced in this chapter. The two basic custom power devices, i.e., DSTATCOM and DVR are discussed. The commonly used switching control schemes are reviewed and the popular time-domain analysis for switching characterization is discussed. The two compensating devices, DSTATCOM and DVR are modeled and their corresponding controllers are designed in Chapter 2. In particular, a sliding mode control is proposed for the DSTATCOM operating in the voltage control mode. In current control mode both state feedback and current feedback control are analyzed. Output feedback implementation of the sliding mode control as proportional plus derivative control is used for the operation of DVR for load voltage control. Various system characteristics are studied for the compensators in association with their

controllers. These include stability, tracking and disturbance attenuation characteristics. The commonly used two-level hysteresis based modulations have been analyzed in Chapter 3. The inherent property of variable switching frequency of fixed band hysteresis modulation has been characterized. An algorithm is proposed to adapt the hysteresis band in order to maintain a constant switching frequency. The concept of parameter sensitivity is introduced to highlight the dependency of switching frequency on various system parameters. The continuous-time analysis has been used for DSTATCOM switching characterization due to state feedback type of controllers. However discrete-time analysis is needed in case ofDVR, due to the additional dynamics of the controller and low pass filter. Commonly used sampled error modulation is analyzed as an extension of the discrete-time analysis by using an ideal relay. All of the proposed theoretical results are verified by the operation of singlephaseDSTATCOM and DVR as voltage compensating devices both through the simulationsand experiments.Chapter 4 begins with the concept of forced switching for carrier based closed loopmodulation of the two-level VSIs using sinusoidal carrier. The analytical expressions have been derived for the determination of the minimum carrier amplitude for smooth modulationat fixed switching frequency, for PWM switching using triangular carrier. The methods areextended to the discrete-time characterization of the carrier-based modulations. The proposedtheoretical results are verified for the operation of single-phase DSTATCOM and theextended results for digital implementation are verified for the single-phase DVR operationboth through simulations and experimentations.The two modulation methods proposed in the previous two chapters are extended fora cascaded multilevel inverter in Chapter 5. The hysteresis modulation of the two-levelinverter is extended to multi-band hysteresis modulation of the multilevel inverter. Thecarrier-based closed loop PWM of the two-level inverter is extended to the multi-carrierclosed loop PWM of the multilevel inverter. Theswitching conditions for the two methodsare determined based on the results of the two-level modulations. Smooth modulation of boththe methods leads to a lower modulator gain and this deteriorates the tracking characteristics.The use of an additional resonant controller improves the tracking characteristics albeit at theexpense of the dynamic performance. In this chapter simulation and experimental verificationare obtained for the operation of DSTATCOM and DVR as voltage compensating deviceusing three and five-level inverters. In addition the multilevel modulation is also verified forthe DSTATCOM in current control mode using a simple current feedback throughexperimentation with a five-level inverter. In Chapter 6, the various single-phase control and modulation techniques presented in the previous chapters are extended to the compensation of a three-phase four-wire distribution system. The chapter begins with the VSI classification for the application with the different compensators depending upon the voltage and power ratings of the distribution system. The voltage control applications are illustrated through DSTATCOM and DVR as voltage compensating devices. The current control applications are described usingDSTATCOM in the current control mode. All the results given in this chapter are verified through simulation studies. The general conclusions of the thesis are summarized in Chapter 7 along with the suggestions for the future scope of work. Some theoretical results are given in Appendix Aand details of the experimental setup used in the laboratory are given in Appendix B.

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Title : ***Methods Based On Fourier-Bessel Representation For Analysis Of Non-stationary Signals***

Author(s) : ***Pachori Ram Bilas***

Roll No : ***Y3104117***

Supervisor(s) : ***Sircar Pradip***

Abstract

In this thesis, we address the problem of decomposing a signal containing multiple non-stationarysinusoids into its components. A non-stationary sinusoid is one whose envelopeand frequency are functions of time. We assume that these variations are slow enoughso that the components occupy distinct regions in the spectrum at each instant of time.We propose to separate the components by using the Fourier-Bessel (FB) expansion. Therelation between the frequency and the order of the FB expansion coefficients has been developed.The components which are disjoint in the frequency domain can be separatedusing the FB coefficients. If the components are disjoint in the time-frequency domain, thetime-order representation based on the FB expansion is used to separate the components. Some of the real-time applications of the FB decomposition like speech formant separation, Bat echolocation signal components separation, AM-FM signal separation and segmentation of electroencephalogram (EEG) signal are studied, and the comparison with the existing methods is presented in this thesis. The details of the above applications are as follows: In the AM-FM signal model of speech, the instantaneous frequency (IF) and the amplitude envelope (AE) of an individual speech resonance are estimated by the discrete energy separation algorithm (DESA). But first, we need to isolate a single resonance from the speech signal. The FB decomposition allows us to separate speech resonances without introducing any distortion in the amplitude or the phase of a single resonance. The FB decomposition along with DESA technique gives accurate tracking of the IF and the AE of the formants.• The separated component signal is modeled using the second-order time-varying autoregressive(TVAR) process. The TVAR modeling of a multicomponent signal requires inversion of large correlation matrix, whereas the modeling after component separation requires the inversion of a number of relatively small correlation matrices with better numerical stability properties. In presence of noise, the method based on the FB expansion and the TVAR process improves the estimation of the time-varying poles also. The FB coefficients have been used as a feature vector for the segmentation of the EEGsignal. The segmented EEG signal is modeled by the second-order TVAR process. Inthis way, the analysis of EEG signal will require less computational complexity. The Wigner-Ville distribution (WVD) technique is applied on each separated components of the composite signal to determine its time-frequency distribution (TFD) without cross terms. The TFD without cross terms of the Bat echolocation signal is obtained by using the combination of the time-order representation and the WVD.

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Title	***:***	***Upper SNR Threshold And BER Characteristic Estimation And ANew Stopping Criterion For Turbo Codes***
Author(s)	***:***	***Rajesh A***
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Supervisor(s)	***:***	***Chaturvedi Ajit Kumar***

Abstract

In this thesis we have used the information theoretic measure - mutual information, to estimate the upper signal to noise ratio (SNR) threshold and the bit error rate (BER) characteristic of turbo codes. Both the estimates have been found to be close to the true values for different encoder and inter-leaver size combinations. Subsequently, we have used another information theoretic measure - equivocation, to derive a stopping criterion for turbo decoding iterations. This criterion is combined with the short Cyclic Redundancy Check (CRC) technique to arrive at the new stopping rule. Simulations show that in terms ofBER and Frame Error Rate (FER) performance the proposed criterion almost equals the hypothetical Genie receiver. Furthermore the average number of iterations required is also less than that required by the existing stopping criteria.

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Title : *Development Of Nonlinear Adaptive Damping Controllers For Improving Power System Stability*

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Abstract

Maintaining stability of the interconnected system has been one of the major operating concerns of the power system engineers. A recent report of IEEE-CIGRE working group has broadly classified power system stability into three types viz. rotor angle stability, frequency stability and voltage stability. This thesis has mainly dealt with design of damping controllers to improve the rotor angle stability. The rotor angle stability can be further classified into small signal stability and transient stability. Use of high gain exciters of the generators and contingencies have been found to deteriorate the power system damping and cause small signal oscillations in the system. Power System Stabilizers (PSS) have been widely used, as a supplementary controller to the exciter for improving the power system damping. PSS can effectively damp out local as well as inter area modes of oscillations. Conventionally, the PSS parameters are determined at a given operating point, around which the nonlinear power system is linearized. Since, the PSS parameters are found at a specific operating point, its performance is not guaranteed at other system operating conditions. Many researchers have proposed different methodologies to tune the PSS parameters, so that it performs well in a wide range of operating conditions. Some of these methods utilize robust control techniques, linear matrix inequalities, optimization techniques etc. In order to make the PSS robust, these methods should consider several operating conditions to tune its parameters. Thus, the nonlinear power system has to be linearized at every operating condition, which increases the computational complexity and time. Due to the linearization of the power system, those methods fail to capture some of the essential characteristics of the nonlinear power system, such as response of the system to the severe faults. Many research works are available in literature, which have utilized fuzzy logic or neural networks or a combination of both to design PSS. These methods adaptively tune the PSS parameters for a change in the operating condition. The fuzzy logic based controllers need expert knowledge, that restrict their application to comparatively small systems. Use of neural networks for PSS design, even though efficient, faces problems of choosing the appropriate parameters such as learning rate, scaling factors etc., for which no precise method exists. Recently, the nonlinear control techniques like direct feedback linearization (DFL) is gaining attention. Using DFL the open loop nonlinear power system can be transformed into decentralized closed systems whose characteristics are linear over wide range of operating conditions without actually linearizing the system. The advantage with the DFL is that it effectively transforms a nonlinear

power system into linear decentralized sub systems, so that the damping controllers can be designed for each sub system independently. Most of the researchers have only utilized DFL to design PSS, for a single machine infinite bus system (SMIB). Also, most of these methods have considered simplified models of generators. The Flexible AC Transmission Systems (FACTS) controllers like Static Var Compensator (SVC), Static Synchronous Compensator (STATCOM), Thyristor Controlled Series Compensator (TCSC), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC) are primarily used either for providing reactive power support or controlling the real and reactive power flows in a line. Besides their primary task, FACTS controllers can also be used for improving power system damping, when provided with additional supplementary feedback controllers. The extent to which a FACTS controller can provide damping depends on its location in the system. Most of the works available in the literature for placement of FACTS have considered only static criterion like improving loadability, available transfer capability (ATC) etc. Very few works are available, considering dynamic criterion for the placement of the FACTS controller to improve power system damping. The existing methods, however, are not computationally efficient for large systems. The FACTS supplementary controllers have structure similar to the PSS. The conventional FACTS supplementary controllers do not guarantee good performance at different operating conditions, as their parameters are tuned at a specific operating point. The fuzzy logic or neural network based FACTS supplementary feedback controllers face the same problems as the fuzzy logic or neural network based PSS. Although many researchers have utilized DFL techniques for designing FACTS supplementary controllers, most of them have utilized SMIB system and their performance on multi-machine systems have not been established. In view of the certain limitations of the existing methods discussed above, relevant to the design of power system damping controllers such as PSS and FACTS supplementary controllers, the main objectives behind the research work carried out in this thesis have been the following. To utilize nonlinear feedback control techniques along with linear quadratic regulator with prescribed degree of stability to design power system stabilizers. To utilize adaptive techniques like Sugeno-type Adaptive Neuro-Fuzzy Inference Systems (ANFIS), in order to make the nonlinear power system stabilizers suitable for on line applications. To suggest a methodology to optimally place the FACTS controllers in order to improve the damping of the power system. Shunt, series and series-shunt type FACTS controllers have been considered in this work. To design supplementary damping controllers to the FACTS using nonlinear techniques and to make them suitable for online application, utilizing adaptive techniques such as ANFIS. This thesis has been organized in following seven chapters: Chapter 1 discusses few basic aspects of power system stability and damping controllers. It presents the relevant state-of-the-art survey on the subject and sets the motivation behind the present work. Chapter 2 proposes a direct feedback linearization control law to convert the nonlinear power system into closed loop decentralized linear systems. The linear quadratic regulator with prescribed degree of stability has, then, been utilized to stabilize the decentralized linear system. The application of the proposed nonlinear PSS to few practical multi-machine power system has been studied. The performance of the

proposed nonlinear PSS (NPSS) has been compared with the conventional PSS on New England 10-machine, 39-bus system and New England-New York interconnected 16-machine, 68-bus system. In Chapter 3, the nonlinear PSS design procedure suggested in chapter 2 has been modified to achieve relatively higher degree of stability. The modified nonlinear PSS has, then, been replaced with first order Sugeno-type Adaptive Neuro-Fuzzy Inference Systems (ANFIS) so as to eliminate the need to solve the algebraic Riccati equation at every sampling interval. The procedure for selection and training the ANFIS has been discussed. The performance of the modified nonlinear adaptive neuro-fuzzy PSS has been compared with that of the nonlinear PSS (NPSS) and conventional PSS on two area 4-machine, 11-bus system and New England-New York interconnected 16-machine, 68-bus system. Chapter 4 proposes an index, named as Controllability Index (CI), to place FACTS controllers in a multi-machine system for improving system damping. The CI has been computed for shunt and series FACTS controllers for the base case as well as for few critical single line contingency cases. The placement of FACTS controller have been decided based on the average values of the CI. The performance of the FACTS controllers, placed at the optimal locations as found out by CI, have been evaluated through step response. The efficiency of the proposed method has been tested on New England 10-machine, 39-bus system and New England-New York interconnected 16-machine, 68-bus system. In Chapter 5, two types of nonlinear supplementary feedback controllers have been proposed, depending on the type of feedback signal used, i.e. local or global signal, for SVC using DFL control law along with linear quadratic regulator with prescribed degree of stability. The second type of nonlinear supplementary feedback controller for SVC, utilizing global signals, has been proposed in a SMIB system and then its applicability has been tested on multi-machine systems. In order to facilitate the online implementation of the proposed controller, the nonlinear supplementary feedback controller has, then, been replaced with ANFIS. The second type of supplementary feedback controller proposed for the SVC has also been extended to STATCOM. The effectiveness of the proposed supplementary feedback controllers to SVC and STATCOM have been tested on New England-New York interconnected 16-machine, 68-bus system. In chapter 6, nonlinear supplementary feedback controllers for TCSC, SSSC and UPFC have been proposed for a SMIB system using DFL control law and linear quadratic regulator with prescribed degree of stability. Their applicability has then been extended to multi-machine systems. In order to facilitate the online implementation of the proposed controllers, the nonlinear supplementary feedback controllers of the TCSC, SSSC and UPFC have been replaced with ANFIS. To establish the effectiveness of the proposed supplementary feedback controllers to TCSC, SSSC and UPFC, studies have been carried out on New England-New York interconnected 16-machine, 68-bus system. Chapter 7 concludes the main findings of the work presented in this thesis and suggests few areas for future research.

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Title : *Biologically Inspired Novel Artificial Neural Networks*
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Abstract

Philosophy of the artificial neural network (ANN) is derived from the functioning of biological neurons and their interconnections. It has been pointed out that brain and artificial neural networks share certain common structural features, such as, massive parallelism. However, biological networks can solve various complex problems easily, but existing artificial neural networks do not. To bridge this gap and to improve the performances of ANNs more and more biological facts have to be included in the neural networks models. It has been established that there are nonlinear interactions among different neuronal components. This thesis is an attempt to incorporate the presence of nonlinear interactions among different neuronal components in the artificial neural network models. In this work, the nonlinear interactions are represented mathematically by introducing higher order and multiplicative terms in the calculation of net aggregation at each neuron. The main contributions of this thesis can be viewed as fourfold. The first prominent contribution is the dynamical analysis of various neuron models. Specifically, it deals with the nonlinear dynamical system theory which is a core of the computational neuroscience research. Study of the nonlinear dynamics of a single neuron is the first step toward the study of brain dynamics as neuron is the basic building block of the brain. FitzHugh-Nagumoand FitzHugh-Rinzel neuron models are considered for the dynamical analysis. The effect of parameter variation on the dynamical behaviors of these models is studied in order to investigate chaos and Hopf bifurcations. It is observed that the neuronal activities exhibit a variety of attractors such as fixed-point, limit-cycle, and chaotic attractors at different values of stimulus, synaptic strengths, and other parameters. The second significant contribution is the development of three biologically inspired new neuron models for solving various benchmark and real-life problems. Function approximation, regression, and classification are some difficult problems, which conventional neural networks can solve but they require significantly large number of neurons and take long training time. In order to achieve faster training and better generalization, three new neural network models are proposed and discussed. These models are motivated from three different models of biological neurons, i.e. integrate–and–fire, quadratic integrate–and–fire and spiking neuron models. The proposed models consider modified aggregation methodologies at different network units. These modifications account for nonlinear aggregation operations at dendrites. We observed that with such modifications, the learning performances are significantly improved. Artificial neural networks based on integrate–and–fire and quadratic integrate–and–fire neuron models are inspired from the relationship between injected current and inter-spike interval, whereas the spiking neuron based ANN is inspired from the fact that the actual shape of action potential does not contain any neuronal information; it is

the timings of spike sequences that contains the neuronal information. Spiking neuron baseband also incorporate threshold variability in the formulation of the activation function. Our extensive experimentations on these neuron models show that the proposed models exhibit improved convergence with significantly less number of connections as compared with the existing neural networks. Performance of these models is analyzed on the basis of various benchmark problems of classification and function approximation. We observed that the proposed models are significantly better in solving the classification, function approximation, and regression problems. The third substantial contribution is the development of a modified Hopfield neural network for solving difficult optimization problems. The application of conventional Hopfield neural network was limited to optimization problems with quadratic cost functions only. To overcome this limitation, modified Hopfield neural network is proposed. The functioning of this network is inspired from nonlinear dendritic aggregation. In the present work, this feature is incorporated by considering both linear as well as nonlinear terms in calculation of the net aggregation at each neuron of the network. Stability analysis for the proposed networks is carried out, and it is shown that the energy of the system decreases and the networks hold the stable dynamics. We have used this network to solve the set of nonlinear algebraic equations and then to calculate non-repeated roots of a characteristic equation. The fourth contribution is the development of a modified forward-only counterpropagationneural network (MFO-CPN). We have used phenomenon of nonlinear dendritic interaction to propose a modified forward-only counter propagation neural network (MFO-CPN).This modification lies in application of higher order distance and other distance functions to determine the winning neuron in Kohonen layer. A novel approach to alter the Kohonen'sand Grossberg's layer learning rates is suggested. This is inspired from the biological fact that learning and forgetting is a nonlinear phenomenon. These modifications lead to the faster convergence of network. The proposed network is tested for color image compression. Improvements in the quality of image and quick convergence have been achieved by using different higher order distance measures. Results with these distance functions are presented and compared. One of the limitations of the proposed method of image compression is that the compression ratio depends on the number of hidden layer or Kohonen layer neurons. A combination of wavelet transform and MFO-CPN is proposed to overcome this limitation. It is observed that this combination results in better compression and quality. Several experiments on benchmark images have been carried out.

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Title : *Distribution Bus Voltage Regulation Using Power Compensating Devices*

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Abstract

Power quality has attracted intense research and development recently. Increased use of complex power electronic equipment's leads to higher pollution of power distribution systems. This pollution appears in the form of harmonic contamination, unbalance and distortion in the system voltages. Therefore, maintaining quality of power has emerged as one of the most prominent challenges for the utilities. Custom power is the technology of the application of power electronics to power distribution systems. The custom power provides an integrated solution to many power quality problems encountered by the utilities and power distributors. Power compensating devices are power electronic based controllers used in custom power solutions. In this thesis, the attention is focused on distribution bus voltage regulation using various power compensating devices (DVR, DSTATCOM, UPQC and interline devices). DVR is a series compensator, which protects critical loads from most common supply side disturbances other than outages. A generalized algorithm is proposed to maintain balanced sinusoidal load voltage using DVR when both the source and the load are unbalanced and distorted with harmonics or inter-harmonics. DSTATCOM is a shunt compensator, which controls the distribution bus voltage (PCC voltage) against any unbalance or distortion in the utility side or load side. The operation of a DSTATCOM in voltage control mode is discussed in which it regulates the PCC voltages in a distribution system containing loads that draw inter-harmonic currents from the feeder. UPQC performs series and shunt compensation simultaneously. The UPQC operation is demonstrated where it tightly regulates the bus voltage of critical loads against unbalance and other disturbances occurring in a distribution system. The performance of a DVR is analyzed in case of a mismatch between the source frequency and the frequency at which the DVR is operated. It is illustrated that under a mismatch, the total real power requirement of the critical load has to be supplied by the DVR. A simple frequency estimation technique is proposed which uses a moving average process along with zero-crossing detector. The concept of interline compensating devices is explored. The performances of two new interline devices i.e., interline UPQC (IUPQC) and interline DSTATCOMs in voltage control modes (IVOLCON) are evaluated considering various disturbance conditions. It is shown that the power flow from shunt to series VSI takes place in case of an IUPQC and bi-directional power flow is achievable in the case of an IVOLCON. The feasibilities of the inverter switching controllers have also been verified through simulation and experimentation.

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Title : ***Automatic Generation Control And Reactive Power Management In Restructured Electricity Markets***

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Abstract

In electricity markets, system operation and market management is carried out by an independent agency known as System Operator (SO). In order to facilitate transportation of contracted power at acceptable quality and reliability level, the SO arranges certain ancillary services. This thesis has mainly addressed the issues of Automatic Generation Control (AGC) and Reactive Power Management in electricity markets. A modest attempt has also been made to develop the mathematical framework for frequency regulation, based on Availability Based Tariff (ABT) mechanism, in India. A general model for multi-area AGC, considering various possible transactions has been developed. For each area, a PID controller, utilizing the least square minimization principle, and a general-purpose fuzzy logic controller have been proposed. A centralized Linear Quadratic Gaussian (LQG) regulator, for multi-area AGC has been designed that minimizes overshoots and transient frequency deviations. For ease of implementation on large systems a decentralized multi-area AGC scheme, based on the Eigen structure assignment technique, has also been proposed. A general-purpose model for frequency control scheme provided by the Availability Based Tariff (ABT) mechanism in Indian power system has been proposed and tested on NREB system along with a fuzzy logic based scheme to maximize the profit of generators. Further, an approach has been evolved to select the optimal location and size of the reactive power sources (other than generators). The reactive power source connected at the selected location satisfies the economical as well as the technical criteria. A modified reactive bid structure for the synchronous generators to remunerate them for lost opportunity cost has been developed. A new scheme for procurement of reactive power from independent reactive power providers has been proposed based on an optimal reactive power dispatch (ORPD) algorithm. The effectiveness of the new proposed algorithms have been tested on IEEE 14-bus, 39-bus New England, 75-bus Indian and the IEEE 118-bus test systems

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Title : *Adaptive Echo Cancellation Based On A Multipath Model Of Acoustic Channel*

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Supervisor(s) : *Sharma Govind&ChaturvediAjit Kumar*

Abstract

All conversations, whether face to face or over a communication network, generate echoes [1], [3], [5]. However, echo is not noticed if the delay associated with the acoustic feedback loops is small or the magnitude of the echo is below perception threshold. The problem is more pronounced in the case of digital wireless applications where long processing time is needed for signal compression, channel coding etc. Acoustic echo is generally modeled as the response of a linear system, the impulse response of which is of the order of a few tens to hundreds of milliseconds. Hence, in general, acoustic echo cancellers (AEC) are realized by adaptive Finite Impulse Response (FIR) filters having thousands of coefficients [8]. These filters use the LeastMean Square (LMS) algorithm for adaptation. Due to the long length of the filter and the usage of the LMS algorithm, the convergence speed of these adaptive filters is considerably slow. Moreover, the acoustic channel is time varying which leads to further degradation in performance. Several methods have been reported in the literature to improve the convergence speed of adaptive filters [40], [47], [48]. But these methods do not try to exploit the multipath nature of acoustic echo. In this thesis we model acoustic echo as a sum of signals propagating via different paths with a delay and filter associated with each path. Based on this model we propose a multiple sub-filter structure for the AEC [49].The idea is that each branch of the multiple sub-filter can cancel the signal in the corresponding path of the echo signal. To be able to realize the proposed multiple sub-filter structure we need to deter-mine whether multipath is present and also the delay and filter order associated with the path(s). We detect the presence of multipath in the received signal by modeling as a binary hypothesis testing problem [22]. Derivation, analysis and simulation have been carried out for three different cases. It is observed from the Receiver Operating Characteristics (ROC) of the detector that there is a trade-of between the Signal to Noise Ratio (SNR) and the a priori information available about the channel and the transmittedsignal. The next step is the estimation of delays in each path. A number of methods are available in the literature to estimate delay [30], [29], [25]. In [29], [25] the received signal is considered as a sum of delayed and attenuated versions of the transmitted signal without taking into consideration the effect of filtering in each path. Hence, the existing algorithm [25] is modified to suit our situation. To reduce the effect of noise, the squared autocorrelation function is passed through a window [50]. The resultingcorrelogram has peaks corresponding to the actual delays and their differences. The locations of these peaks can be used to estimate the delays. The algorithm is furthermodified by eliminating some of the peaks which appear at the deference of the actual delays. Among the rest of the peaks every combination of M peaks, where M denotes the number of multipath, is examined on an objective function. The set of M peaks whichmaximizes this objective function corresponds to the estimate of delays associated with each path. This way the delays are estimated with higher accuracy and at reduced computational cost. Different performance measures have been introduced to characterize the performance of

the delay estimator. The estimator performance has been compared with the Cramer Rao Lower Bound (CRLB). In the high SNR range the performance of the estimator has been found to be close to CRLB. Furthermore, it is observed from simulations that when the SNR increases or the number of paths decrease, the performance of the algorithm improves. We also need the order of the sub-filter in each branch of the multiple sub-filter. We have used the Power Spectral Density (PSD) method [34] to estimate these orders. Using the estimated time delays and sub-filter orders, the multiple sub-filter structure is constructed. The convergence and tracking performances of the conventional, long adaptive filter and the proposed multiple sub-filter are compared using the LMS algorithm for adaptation. The convergence time of the multiple sub-filter has been found to be noticeably less than that of the conventional filter. In a tracking situation, in the case of the proposed multiple sub-filter, we need to estimate the delays periodically while there is no such requirement in the case of the conventional filter. This leads to additional complexity. But interestingly, despite the additional time required by this additional complexity, the multiple sub-filter has been found to have better tracking capability. We have studied the tracking behaviour for two cases: first case is when the change in delay is small and the second case is when the change in delay is allowed to be large. In both the cases, the multiple sub-filter performs better than the long adaptive filter. As expected, the performance of both the filters degrades when the changes in delays are large. Furthermore, when there are frequent changes in delay, the tracking performance of multiple sub-filter is better since its convergence time is less.

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Title : *Performance Analysis Of A Predetection Equal Gain Combining Receiver For Correlated Nakagami-M And Independent Weibull Fading Channels*

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Abstract

Application of diversity combining at the receiver improves average bit error rate (ABER) performance in fading channels [1]. Maximal ratio combining (MRC), equal gain combing (EGC) and selection combining (SC) are known basic diversity combining techniques. Although the performance of MRC receiver is known to be optimum, its implementation complexity is high while the EGC receiver is known to have a performance close to that of a MRC receiver with less implementation complexity. Hence, it is of interest to analyze the performance of an EGC receiver in fading channels. An EGC receiver can be of two types, predetection or post detection depending on whether the combining operation is performed before or after the detection operation. In this thesis we focus on the ABER performance analysis of a predetection EGC receiver for fading channels for which results are not known. In the sequel, by an EGC receiver we mean a predetection EGC receiver. Performance analysis of an EGC receiver is relatively difficult in comparison to MRC and SC receivers. The usual approach for this requires a closed-form expression for the probability density function (PDF) of a sum of random variables (RVs) corresponding to the fading envelopes of each of the diversity branches. A closed-form expression for the PDF of this sum is not known for available fading channel models except for the case of Rayleigh, for which it is known for two independent RVs only [2].Two alternative methods, which do not need the PDF of the above sum, are the Gil-Palaez lemma based approach [6] and the Parseval's theorem based approach [2]. Instead, these methods require the characteristic function (CHF) of this sum. For analyzing the performance in Nakagami-rn channel we have used Gil-Palaez lemma based approach for coherent modulations and Parseval's theorem based approach for non-coherent modulations. We have analyzed an EGC receiver with three antennas in which the signal received by a pair of antennas experience correlated fading whereas the fading of the signal received by the third antenna is independent [8]. A closed-form ABER expression for this receiver has been obtained for binary, coherent and noncoherent modulations for Nakagami-m. channels. Numerical and simulation results for ABER vs. average branch SNR have been plotted as a function of the channel parameters. Results have been compared with the published results which are special cases of the antenna structure considered here and found to be a close match. A study on the effect of the third independent antenna on the ABER performance of a dual diversity system shows that the percentage difference in ABER is more for higher SNRs [8].Subsequently, we have analyzed an EGC receiver with multiple pairwise correlated antennas wherein the received signals are pairwise correlated while the pairs experience independent fading. For this receiver an analytical method to obtain a closed-form ABER expression for binary coherent phase shift keying modulation for an arbitrary number of antenna pairs has been presented. For illustration, a closed-form ABER expression for two pairs of antennas has been derived. The derivation of ABER requires an expression for the imaginary part of the product of an arbitrary number of complex numbers. We have obtained the expression

required for this. Numerical and simulation results for ABER vs. average branch SNR have been plotted for identical and nonidentical correlation coefficients between antennas of each pair. We have derived a closed-form ABER expression for an EGC receiver for coherent binary phase shift keying and noncoherent modulations for exponentially correlated, Nakagami-m distributed arbitrary number of branches [10, 11]. The CHF required for this was derived using the closed-form expression of the joint PDF given by Karagian-nidis [9]. Derivation of ABER for noncoherent modulations requires the real part of a product of an arbitrary number of complex numbers, in addition to the expression for its imaginary part mentioned before. An expression for this has been obtained. Numerical and simulation results for ABER vs. average branch SNR have been plotted as a function of number of diversity branches, correlation coefficient and fading parameter. The Weibull fading channel model exhibits an excellent fit to fading channel measurements, for indoor as well as outdoor environments [12, 26]. Performance analysis of MRC and SC receivers in independent fading channels has been reported in the literature using the moment generating function (MGF) of Weibull distribution [13]. In [14] analysis of an EGC receiver for nonidentical Weibull fading channels has been given using Pade approximation technique. For Weibull distribution the CHF can be obtained from its MGF given in [13]. However, this expression for CHF involves Mei-jer's G function. When this expression is used for the evaluation of ABER either in the Gil-Palaez lemma or Parseval's theorem based approaches it does not result in a closed-form expression. So, a numerical integration is required. For higher values of the fading parameter the available softwares give erroneous result in the numerical integration involving Meijer's G function. Further, the CHF is limited to integer values of fading parameter. For these reasons Gil-Palaez lemma and Parseval's theorem based approaches cannot be used for the performance evaluation of EGC receiver in Weibull fading channels.The PDF of a sum of independent RVs has been expressed by Beaulieu in the form of a convergent infinite series [3]. Using this expression the authors in [4, 5] studied performance of an EGC receiver for binary, coherent and noncoherent modulations in Nakagami-m and Rician fading channels. We have analyzed the ABER performance of an EGC receiver in independent Weibull fading channels for binary, coherent and noncoherent modulations for arbitrary number of branches. To be able to apply the PDF of sum of RVs approach we require closed-form expressions for the mean values of cosine and sine of a function of Weibull RV. This mean value has been obtained by expressing sinusoidal functions in their infinite series forms [15]. Numerical results for ABER vs. average SNR have been plotted for different values of the fading parameter.

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Title : Novel Neuron Models And Their Applications
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Abstract

he McCulloch and Pitts (MP) neuron model is a combination of linear aggregation and an activation function. The most popular and standard form of aggregation function is linear weighted summation and the most common type of activation functions are log sigmoid or tan sigmoid functions. This type of neuron models, when used to solve the real life problems, require significantly large number of neurons in the standard artificial neural networks (ANN) and also take longer training time. Since the number of adaptive parameters required to solve any problem depends on the number of neurons used in the ANN, the applicability of the ANN becomes computationally intensive. The computational burden can be minimized either by reducing the number of neurons or by improving the learning algorithm. It is well known that the number of neurons required to solve any problem depends on the mathematical structure of the neuron model itself. A neuron having higher order statistics can produce superior ANN with comparatively less number of neurons. Some higher order neurons have been previously presented in the literature to reduce the number of total connections and training time while mapping nonlinear relationships. These neuron models fail to provide an accurate solution if the input-output relationship is purely linear because these models do not preserve the linear features of MP model. Similarly, MP model takes more neurons in hidden layer to provide the accurate solution if the input-output relationship is highly nonlinear, as it does not contain the features of higher order neurons. Therefore, we need to develop some new neurons having both linear and nonlinear statistics of MP model and existing higher order neurons, respectively. Here, we propose two new neuron models named as "multiplicative neuron model" (MNM) which incorporate higher order statistics and "generalized mean neuron model" (GMN). The function approximation capabilities of these proposed neuron models have been theoretically analyzed. Our wide experimentation on these neuron models show that the MNM which generates higher order statistics improves the convergence speed to a large extent with same or significantly less number of connections as compared to the existing standard neural networks. Similarly, the GMN improves the convergence speed to a significant level with the same or less number of connections and hidden neurons as the standard neural networks. We found that with these proposed neuron models the computational burden can be reduced up to 30 — 50%. The performance of these models is analyzed on the basis of various benchmark problems pertaining to classification and function approximation problems. One of the important aspects in modeling of the ANN is the selection of the activation function. For many problems the rate of convergence and number of neurons required depend on the activation function being used. We

used the log sigmoid as the activation function in all of our simulations. The X-OR and parity problems have been frequently utilized for testing and comparing the performance of different ANN. The N-bit parity problem is defined on 2N distinct binary vectors that indicate whether the sum of the N components of the binary vector is odd or even. Here, our effort is to show how the proposed models work efficiently for classification problems using less number of neurons with better classification accuracy than the standard neuron. Besides the X-OR and parity problems, we have also used iris classification, synthetic two class problem, pima Indian problems, Mackey-Glass time series prediction problem, Box-Jenkis gas furnace data, Wolfer sun spot data, stress-strain hysteresis loop data estimation and other functional mapping problems like, highly oscillatory function, multiplicative function, harmonic function, radial function and simple interaction function to examine the classification and function approximation capabilities of the proposed neuron models. We used standard gradient descent based back propagation learning algorithm to compare the performance of the proposed neuron models with the existing perceptron model. Different performance evaluation criterion, such as network topology, training and testing error for a given data set, number of epochs to achieve a given accuracy level, correlation coefficient of actual and desired output values, error variance and Akaike's information criterion, have been used to provide a comparative study of the proposed neuron models with the existing MLP. By extensive experimentation and considering the above maintained performance evaluation criterion, we found that the proposed models are significantly better in solving the classification and function approximation problems. Like the any other newly developed models, the neural network models also have to be applied to some engineering applications. We apply the different neural networks for the dynamically tuned gyroscopes usability classification, channel equalization, internet incoming and outgoing traffic prediction, flight dynamics estimation, aero elastic aircraft stability estimation, EEG data estimation and CPU usage prediction problems. Simulation results show that the proposed neuron models perform interestingly well within the given evaluation criterion as compared to the existing standard neural network models.

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Title : *Voltage Stability Constrained Power System Security Assessment and its Enhancement using Facts Controllers*

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Abstract

Voltage stability is the ability of a power system to maintain voltage magnitudes at all the buses in the system within acceptable range after being subjected to a disturbance from a given initial operating condition. Due to increase in power demand, modem, power system networks are being operated under highly stressed conditions. This has resulted into the difficulty in meeting reactive power requirement, especially under contingencies, and hence maintaining the bus voltages within acceptable limits. A power system may undergo voltage collapse if the post-disturbance equilibrium voltages near loads are below acceptable limits. Voltage collapse in the system may be either total (blackout) or partial. Security of a power system is its ability to remain in normal state under contingencies without any interruption of power supply to consumers. Security assessment of a system involves contingency analysis. Due to several incidences of voltage collapse in different parts of the world during last two decades, assessment of voltage security and its enhancement has been considered as one of the main concerns by the researchers and power utilities. Apart from ensuring bus voltage magnitude to remain within limit, voltage security assessment also requires to check system voltage stability condition. A voltage secure system should be voltage stable not only for the system intact case, but also under contingencies. Due to long list of contingencies, which may occur in the power system, the full security analysis becomes time extensive. Hence, a set of critical contingencies is required to be identified based on voltage stability criterion. The preventive and corrective measures for these critical contingencies may be planned to enhance the voltage security of the system. Most of the researchers have considered voltage stability as static phenomenon, and several indices / methods have been proposed for contingency ranking based on static voltage stability criterion. Static voltage instability has been also linked to the saddle node bifurcation in the system. Voltage instability is mainly triggered by reactive power deficit at some of the load buses. The deficit of reactive power may be due to limitations on generation and transmission of reactive power. Limitations on the generation of reactive power are due to limits on armature and field current of generators. Hence, additional reactive power support may prove to be helpful in enhancing the static voltage stability (maximum loadability) of the system. The reactive support requirement under various contingencies may, in general, be different. A contingency that needs higher reactive support may be considered as more severe. Few indices based on reactive support requirement exist in the literature. However, these indices have certain drawbacks, which may result into misranking of contingencies. Voltage security of the system may be enhanced by

installing new reactive power sources. Flexible A.C. Transmission Systems (FACTS) controllers have been established as an effective means in improving the system stability including the voltage stability. However, due to high cost of these controllers, and for effective control of voltage stability margins, these should be optimally placed in the system. The placement of FACTS controllers should enhance maximum loadability for the system intact case, and also under critical contingency cases. Very little effort seems to have been made for optimal placement of FACTS controllers to enhance voltage stability margin under contingencies. With change in system parameters, Hopf bifurcation may occur in the system before saddle node bifurcation point (maximum loadability point). Hopf bifurcation in the system takes place when one pair of complex eigen values of the system state matrix crosses imaginary axis. This may result into emergence of periodic orbits, causing oscillatory instability in the system. If participation factor of voltage states corresponding to the critical eigen values at the Hopf bifurcation point are maximum, it may causeoscillatory voltage instability. The contingency ranking based on the oscillatory voltage stability criterion may, in general, be different from the ranking based on static voltage stability criterion. Very few indices / methods are available in the literature to estimate post-contingency oscillatory voltage stability margin (the distance between the base case operating point and the Hopf bifurcation point) suitable for fast contingency ranking.In most of the work existing in the literature, the placement of FACTS controllers has been considered mainly for enhancement of static voltage stability margins. Some of the researchers have also studied the impact of FACTS controllers for enhancement of oscillatory voltage stability margins. Very little effort has been made to evolve a hybrid criterion for placement of FACTS controllers for simultaneous enhancement of static and oscillatory voltage stability margins for the system intact case. However, no method seems to have been proposed to place these controllers for simultaneous enhancement of static and oscillatory voltage stability margins under contingencies.The structural weakness of the power system, due to weak transmission boundaries between different groups of buses, has also been considered a reason of voltage instability. These groups of buses, located in geographically compact region, have similar voltage changes for any outside disturbance. The bus clusters so formed are called as Voltage Control Areas. Voltage control areas have been mainly formed for the system intact case. Very little attempt has been made to form voltage control areas considering the impact of contingencies.Therefore, the motivations behind the work presented in this thesis have been:(i) To develop a new index / method for effective ranking of contingencies based on static voltage stability, considering post-contingency reactive power support requirement of the system.(ii) To decide optimal location of FACTS controllers for enhancement of static voltage stability margin for the system intact case and under critical contingencies.(iii) To develop a new index for efficient ranking of contingencies based on oscillatory voltage stability. (iv) To develop a hybrid criterion for the placement of FACTS controllers for simultaneous enhancement of static and oscillatory voltage stability margins for the system intact case and also under critical contingency cases.(v) To develop an approach for formation of voltage control areas considering the impact of contingencies, and study the effectiveness of the reduced system, so formed, on the voltage

stability margin assessment.The thesis is organized in following seven chapters:Chapter 1 introduces various aspects of voltage stability and power system security, presents a brief survey of the relevant literature on the subject, and sets the motivation behind the work carried out in this thesis.In Chapter 2, two modified methods based on the reactive power support requirement in the system, have been proposed for static voltage stability based contingency ranking. Method-1 uses a Modified Reactive Support Index (MRSI), which computes the weighted sum of the difference between reactive power output of sources at the maximum loadability point and the base case operating point, with generators' open reactive power limits. Method-2 uses a binary search procedure for estimation of nose point (maximum loadability point) of different groups of contingencies. The contingencies within each group have been ranked using an existing Reactive Violation Index (RVI).Chapter 3 presents a method based on the sensitivity of loading factor to reactive power source outputs for placement of Static VAR Compensator (SVC), and the sensitivity of loading factor to line reactance for placement of Thyristor Controlled Series Compensator (TCSC). The placement of Unified Power Flow Controller (UPFC) has been considered in a line having high priority for TCSC placement towards a bus having high priority for SVC placement. In Chapter 4, a new index based on change in the damping ratio associated with the most critical complex eigen values as a percentage of initial damping ratio, has been proposed. The proposed index, termed as Critical Damping Index, has been utilized for oscillatory voltage stability based contingency ranking. Chapter 5 presents a combined static and oscillatory voltage stability based criterion for optimal placement of SVC and TCSC to enhance voltage stability margin for the system intact case and under critical contingency cases. In Chapter <5, a modified approach based on the sensitivities of Newton Raphson Load Flow Jacobian, together with, the bus voltage variations under contingencies, has been proposed for the formation of voltage control areas. The voltage control areas so formed have been reduced to equivalent nodes by Radial Equivalent Independent (REI) reduction technique, and the impact of FACTS placement on voltage stability margin has been investigated in the reduced system. Chapter 7 presents the main findings in this thesis and suggests few points for further research in this area.

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Title	***:***	***Network Reduction, Congestion Management and Transaction Allocation Algorithms for Electricity Markets***
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Abstract

. Electricity supply industries are undergoing a phase of restructuring, across the globe, with the aim of bringing competition at wholesale and retail levels and creating a market condition to possibly bring down the electricity prices and increase the customer focus. The new electricity market structure results in large number of independent players, such as Generating Companies (GENCOs), Transmission Companies (TRANSCOs), Distribution Companies (DISCOs) and customers. The system operation and market management is carried out by an independent agency, having no business interests, known as System Operator (SO). As competition is introduced amongst the market players, each gives priority to its own economic incentives, tending to undermine technical constraints which are necessary for secure and reliable operation of the power system. The main technical issue manifests itself in the form of limitations of the transmission systems. While the suppliers and customers have full freedom to interact and make power transaction deals, this may lead to occasional overloading or congestion in the transmission system. This, in turn, brings in market inefficiencies apart from posing potential danger to the power system components at stress. Although preventive actions may help avoiding a situation of congestion up to a certain extent, network congestion is an inevitable phenomenon and must be handled promptly and efficiently. Various congestion management schemes, such as price area based, transaction based, and optimal power flow based congestion management methods, have been suggested in the past. Amongst these, the optimal power flow (OPF) based congestion management utilizing rescheduling bids from generating companies has been popularly adopted. Most of the literature on congestion management has utilized the bids for real power rescheduling of generators, while a few have proposed the use of bids from interruptible loads. The system operators must utilize the bids of the generators and loads, which are most sensitive in relieving the congestion. Although the congestion management has been primarily handled by real power rescheduling, the reactive power flow becomes quite significant under the system stressed condition. Only a limited work has been reported, which consider the role of reactive power rescheduling in congestion management. Sufficient reactive power support maintains the bus voltages within acceptable range that helps in maintaining the power flow on transmission lines within limits. Hence, there is a need to evolve an efficient and fast congestion management scheme, which considers the reactive power rescheduling bids along with the real power rescheduling bids from generators as well as interruptible loads. The bid based congestion

management upsets some of the transactions already settled in the market and requires additional cost to be paid to the generators and loads rescheduling their output for this purpose. This cost is referred as the congestion cost, which has to be paid by the parties responsible for causing the congestion. While congestion cost required to be paid to the generators and loads can be easily computed based on the amount of rescheduling and corresponding bid values, there has been considerable debate about apportioning this cost amongst the parties responsible for causing the congestion. It has not been possible with the existing laws to uniquely identify the transacting parties with the amount of usage of transmission resources. Several methods have been suggested in the past for the congestion cost allocation. Some of the methods rely on line power flow sensitivities to apportion the cost, while others utilize the power flow tracing. The existing methods have considered the sensitivities / tracing of only real power flow, whereas the reactive power also has a significant impact under the congested condition. Hence, the allocation scheme should consider the apportioning of the congestion cost, in some rational manner, based on both the real power ami the reactive power flow sharing. In the competitive electricity markets, the primary settlement of the bids of generators takes place in advance, generally a day ahead, to meet the projected demand of the customers, without accounting for the transmission losses. However, when actual transactions occur, a surplus power must be arranged to make up the transmission losses. The system operator either procures this extra power from the ancillary services market or asks the suppliers to make up the losses themselves according to the amount of the transaction committed during that period. Although losses form a small proportion of the actual power being transacted, the revenues associated with them are significant and must be allocated properly. Several loss allocation schemes are available in the literature. The most popular ones are the pro rata based, incremental transmission loss sensitivity based and power flow tracing based schemes. All these methods have been found to produce vastly different results and no technique can be clearly said to be technically superior to the other. Most of these have considered the loss allocation based on real power transactions and little effort has been made to incorporate the effect of reactive power transaction in the loss allocation, despite the fact that the reactive power also has significant effect on losses. A loss allocation scheme must be logical, transparent, simple to understand and implement. Losses must be allocated considering the size of transacting parties and their sensitivity to the losses. Besides addressing these issues, the loss allocation should also be based on both real and reactive power transactions. A restructured electricity market involves a large number of power transactions amongst various participants. Several techniques have been reported in the literature to evaluate the condition and power handling capability of the network. As size of modern power systems have increased tremendously, these techniques often become impractical for online applications, even with the fastest state-of-the-art computing facilities. Thus, there is a need to reduce the problem size and computational time by possibly using a reduced representation of the system. Traditional static network equivalencing methods partition the full network into internal and external networks. The internal network is represented in full detail while the external network is reduced to its equivalent. Conventionally, the external networks are fully eliminated to the boundary buses of

the internal network. However, in a restructured electricity environment, the transmission networks are going to be affected more and more by external causes. Thus, a network model is envisaged which is able to preserve certain amount of details of external network and thus being able to appropriately model the changes occurring in the external system. Economic theory suggests that the most logical and reasonable way to charge a customer is at its bus marginal price. Transactions in the network keep on changing continuously and hence customers must be informed about the nodal prices as fast as possible in order to allow them to respond to any price change. However, it is practically not possible to calculate the marginal price at each and every node in a short span of time required for online updating. Due to these reasons, few markets post zonal prices rather than individual nodal prices. A systematic method is required to form the groups of nodes to derive the price zones. A practical approach will be to form the group of geographically close nodes that have similar marginal price and respond similarly to any changes occurring in the network and then reduce them to equivalent nodes and, thereby, achieving a reduced representation of the system. Looking at some of the technical challenges discussed above, relevant to the satisfactory operation of the electricity markets in the restructured environment, the main objectives behind the research work carried out in this thesis have been the following:• To develop a sensitivity based bus clustering and external network equivalencing method suitable for fast power transfer calculation and to study the impact of change in power transactions in the external area on the internal area network.• To develop a nodal pricing, based approach for clustering of buses to achieve a reduced representation, suitable for fast pricing calculations.• To develop an OPF based congestion management approach considering bids of both real and reactive power rescheduling from generators and interruptible loads.• To develop new set of distribution factors based on proportional sharing principle for MVA flow tracing, suitable for congestion cost allocation.• To develop a new method for allocating transmission loss amongst customers considering their load value and MVA injection sensitivity to line losses.

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Title : ***Front-End Signal Processing For Speaker Normalization In Automatic Speech Recognition***

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Abstract

There is considerable variability in the acoustics of speakers in a population enunciating the same sound. One of the dominant factors responsible for this variability is the difference in the average vocal tract length between speakers. This source of variability results in significant degradation in performance for a speaker-independent speech recognition system when compared to a speaker-dependent speech recognition system. In the past, a number of approaches has been proposed to address this problem. The majorities of them employs some kind of frequency warping in feature-space to compensate for speaker differences and are referred to as speaker normalization (which includes the popular vocal tract length normalization). Recently another class of approaches have emerged which address this problem by applying a transformation in model-space and are referred to as speaker adaptation. In this work, we have addressed three major issues related to the feature-space approach to reduce speaker differences. We now give a brief overview of the three issues that are discussed in the thesis. The first idea is based on the observation that for the commonly assumed linear scaling model to describe the relationship between speakers, speaker differences would appear as fixed translations in the log-warped spectral domain; and the differences can therefore be removed by appropriate corrective shifts in the warped domain. In our proposed approach, he required shift factor is estimated using maximum likelihood (ML) grid search. We refer to this as ML shift-based speaker normalization approach. Although our proposed shift-based approach appears to be a simple reformulation of the widely used ML warp-based normalization approach, there axe some very important differences. First, we show that our shift-based approach uses a more appropriate scaling model than the usual assumption of the entire spectra (including pitch harmonics) being scaled. Secondly, it is comparatively simpler to implement shifts than warping, and finally we show that it provides better recognition performance than the conventional warp-based normalization methods. The second idea is motivated by a recent study that argues that Mel-warping is a more appropriate warping function for separating speaker-dependent differences as fixed translation factors in the warped domain than the earlier used log-warping. We show that a linear shift in Mel-warped domain can be interpreted as speaker normalization using a non-linear scaling model to describe the relationship between speakers enunciating the same sound. Our proposed nonlinear scaling model provides better recognition performance compared to linear scaling model both in shift-based and warp-based normalization frameworks on telephone based connected digit recognition task. Finally, we have shown that in the shift-based approach, the normalization can also be performed through a linear transformation in the cepstral domain instead of the conventional spectral domain. Using these calculated linear transformations, we show that speaker compensation can also be done in the model-space. Further, the fact that normalization can be done through linear transformations provides us with a tool to study the influence of the often neglected Jacobian in ML feature transformation based speaker normalization methods. Thus our proposed shift-based speaker normalization approach provides us with a unifying framework that relates existing perceptually motivated shift-based normalization approaches with the frequency warping-based normalization approaches, enables us to study the influence of Jacobian in ML speaker normalization approach and also demonstrates a connection between ML speaker normalization and model transformation based speaker adaptation approaches.

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Title : *Available Transfer Capability Determination And Congestion Management In Competitive Electricity Markets*

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Abstract

Month and Year of thesis submission: July, 2003. During last two decades, many electric power utilities, worldwide, have been forced to change their way of operation and business, from vertically integrated to unbundled open market structure. The main aim of the restructuring is to bring some form of deregulation or re-regulation in certain part of electricity business sectors in order to allow competition at wholesale and retail levels. In addition, it is expected to provide choice and economic benefits to the customers. The former vertically integrated utilities, which performed all the functions involved in power generation, transmission, distribution, and electricity sales, are disintegrated into separate entities devoted to each function. In a deregulated market environment, many technical challenges are required to be addressed which are far more complex than those in a monopolistic market structure. This thesis has mainly addressed the issues of ATC determination and transmission congestion management. A modest attempt has also been made in addressing the issue of transaction allocation. Available Transfer Capability (ATC), between a given interfaces in the transmission system, is a measure of its unutilized capacity available for further commercial activity over and above the existing transfer commitments. The ATC determined with only static constraints, such as line flow limits, voltage limits, and maximum loadibility limit, is referred as ' Static ATC\ whereas that determined with dynamic constraints also, is referred as 'Dynamic ATC. Various methods for static ATC determination have been reported in the literature utilizing repeated load flow and continuation power flow based approach [1], optimal power flow based approaches satisfying all static constraints [2-3], and network sensitivity based methods [4]. The continuation power flow based approach is accurate. However, the power flow based and the optimization-based methods are, in general, time consuming. ATC in an electricity market is required to be posted by system operator (SO) along with day ahead market settlement and also is required to be updated dynamically based on the actual operating conditions. Hence, for market operation, the ATC needs to be calculated very fast and accurately. For fast determination of static ATC, network sensitivity based methods utilizing DC power transfer distribution factors are being widely used [4]. However, these factors provide quite inaccurate results as these are based on DC load flow assumptions. The literature survey reveals that most of the works on determination of Available Transfer Capability (ATC) have considered only the static limits. The dynamics of the system subjected to small and large disturbances has to be studied and analyzed for stability. Few papers have appeared in literature to determine dynamic ATC [5-6]. Hiskens et al. [5] proposed an iterative approach for computing the trajectory sensitivities and a set of differential-algebraic-

discrete equations for the power system model. The application of the method is, however, limited to the evaluation of a single free parameter that can be used to yield marginally stable trajectories. The method is computationally complex for application to large systems. Tuglie et al. [6] proposed static optimization based approach including the dynamic security constraints for the assessment of the dynamic ATC, which is also computationally involved. Bifurcation analysis has been applied to voltage stability studies by several researchers. Hopf bifurcation has been associated with dynamic voltage instability while saddle node bifurcation has been related to the steady state stability limit. However, v bifurcation analysis has, probably, been not applied to the assessment of ATC in restructured electricity market. Reactive power flow over the transmission lines poses another limit on transactions. Load compensation and additional reactive power support is expected to improve the total transfer capability of the system and hence the ATC of the system. Flexible AC Transmission Systems (FACTS), based compensating devices provide reactive power compensation to the system, and thus may improve the system ATC. In a competitive electricity market, congestion occurs, when the transmission network is unable to accommodate all the desired transactions due to violation of system operating limits. Various congestion management schemes such as the price area based congestion management methods, transaction based congestion management methods, and the optimal power flow based congestion management methods have been primarily used. In optimal power flow based methods, congestion has been managed by either rescheduling the generation or through minimum curtailment of the loads [7]. An effective congestion management scheme should utilize the bids from the most sensitive set of sources or load entities in relieving the congestion. A congestion clusters based method utilizing DC load flow approach has been reported for this purpose in ref. [8]. This work considers real power flow in the lines for assessing congestion and the real power bids from sources in the most sensitive zone/cluster for managing the congestion. From literature review, it is observed that very few papers have addressed the role of reactive power in congestion management [7], Due to change in power transactions, the reactive power requirement also changes simultaneously. Sufficient reactive power support maintains the bus voltages and also the power flow on transmission lines within limits. Therefore, procurement of reactive power support services is becoming important in the competitive electricity markets and has been identified as one of the important ancillary services. The reactive power support in the system can help in managing the congestion more effectively. The reactive power management schemes assume that the generators have sufficient reactive power reserve for contingency conditions. Thus, the Var support vi requirement from generators and capacitors to manage congestion, along with real power re-scheduling poses great challenge to the SO in an open electricity market. Various approaches have been reported in literature for transaction and loss allocation, which are based on power flow based method, tracing based methods and network sensitivity based methods. The power tracing based methods, which are based on proportionality sharing principle consider only the nodal injections. A sensitivity based method has been utilized for the loss allocation in ref. [9]. However, this method involves DC load flow assumptions. Hence, the main objectives behind the present work have been the following: • To propose a new

set of AC sensitivity factors, referred as AC Power Transfer Distribution Factors (ACPTDFs), to determine the allocation of transactions to the line flow and transmission losses. • To determine static ATC utilizing the ACPTDFs and also new sets of voltage distribution factors as well as outage distribution factors. • To determine static and dynamic ATC considering Saddle Node Bifurcation (SNB) and Hopf Bifurcation (HB) limits, respectively and to study the impact of some of the FACTS controllers in the improvement of the ATC. • To develop a new set of congestion distribution factors, in terms of real as well as reactive powers, to form congestion clusters. • To study the impact of real power rescheduling and also rescheduling of both real and reactive power outputs of sources including optimally placed capacitors for congestion management. • To suggest a method for optimal location of Thyristor Controlled Phase Angle Regulator (TCPAR) and to study its impact on the congestion management. The thesis is organized in the following seven chapters: Chapter 1 introduces the restructured electricity market and discusses some of the technical challenges. It presents the relevant literature survey and sets the motivation behind the research work carried out in this thesis. vii In Chapter 2, a new set of AC sensitivity based factors called as AC Power Transfer Distribution Factors (ACPTDFs) has been proposed. These factors have been utilized for allocating the impact of transactions to the line flows and line losses. The proposed sensitivity based factors, have also been utilized for determination of area wise loss allocation. In Chapter 3, the static Available Transfer Capability (ATC) has been determined using the ACPTDFs suggested in Chapter 2 and new sets of voltage sensitivity factors have also been defined. The effects of line contingencies have also been included for ATC determination by defining new sets of line outage distribution factors. In Chapter 4, bifurcation approach has been used for static and dynamic ATC determination. Hopf bifurcation limit has been used to determine dynamic ATC and the saddle node bifurcation limit to determine static ATC in presence of static as well as dynamic load. Voltage limit has also been considered for the static ATC determination. Studies have also been carried out to determine the impact of SVC in the enhancement of the static and dynamic ATC. In Chapter 5, a sensitivity based approach has been proposed to form congestion clusters/zones. Generators from the most sensitive congestion zones have been selected for rescheduling their real power outputs to alleviate congestion. Two different AC methods have been suggested for determination of the sensitivity factors. The congestion management problem has been formulated as an optimization problem minimizing the congestion cost. In Chapter 6, the approach developed in Chapter 5 has been extended to define real and reactive line power flow sensitivity factors, which have been utilized to form the congestion clusters/zones. The optimal location of the capacitor banks has been determined based on reactive line flow sensitivity factors at each bus. The optimal real and reactive power rescheduling of generators and capacitor outputs has been obtained solving an optimization problem for the congestion management. In addition, a method for optimal location of Thyristor Controlled Phase Angle Regulator (TCPAR) has been suggested and its impact on the congestion management has also been studied. viiiChapter 7 presents the main findings of the thesis and makes few suggestions for further research in this area.

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Title : *Articulatory Phonetic Feature Based Neural Network For Continuous Speech Phoneme Recognition*

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Abstract

The objective of the thesis is to develop a system for general phonetic recognizer for speaker independent continuous speech recognition. Our aim is phonetic recognition of speech without incorporating language modeling into consideration, in this way the recognizer can be used for any language once language model for the given language is taken into consideration. Research activity in speech recognition started as early as 1950s, and it is still an exciting and growing field of scientific enquiry. In this long period of research activity people have attempted different approaches to solve the speech recognition problem. S. Furui [29], proposed speaker independent word recognition system using instantaneous and dynamic features of speech spectrum. Zhao [71], proposed a speaker adaptation technique for improving speaker independent continuous speech recognition. Bengio et al. [10], combined multilayered and recurrent artificial neural networks (ANNs) with hidden Markov model (HMM). Bamberg and Mandel [7], presented a model for adaptable large vocabulary speech recognition. They used "phoneme-in-context" (PICs), which are triphone supplemented by a code to describe prepausal lengthening. The Time-Delay Neural Networks (TDNN) proposed by Waibel et al. [59], represents one of the earliest demonstrations that excellent performance can be achieved for phoneme-discrimination tasks. R. L. Wa- trous [63], studied the adequacy of connectionist network for the problem of phonetic speech recognition. E. Wan [61], proposed temporal back propagationalgorithms, that can train a TDNN without spatial expansion or weight constraints, assuming fixed time delays and discrete time presentation of input patterns. A continuous time generalisation of these algorithms with adaptable delays was presented by Day and Devenport [15].The major problems in speech recognition is to find suitable front end features. Although it is not known which type of parametric representation is most suited for the task of speech recognition, there are few studies which compare different type of representations. These studies show that in general, features derived from frequency domain representation perform better than the features derived from time domain representations, but which type of feature extraction is best, is still unknown. Harvey Fletcher et at. [1,28] studied human perception of speech in detail, and their results indicate that humans perceive speech sound more or less independent of each other. Speech can be represented by a continuous acoustic signal. Speech recognition can be viewed as a mapping operation. The result of speech recognition process is a discrete description in the form of a linguistic code {phone, diphone, syllable, word etc.) which conveys the semantic content of the message. Hence, speech recognition requires the mapping of the physical continuous speech signal from the acoustical domain into discrete linguistic descriptors of a linguistic code domain. This discrete description is only the transcription, of the utterance, not its semantic decoding. However, this transcription is sufficient to decode the semantic content of information by mapping it into semantic domain in a second mapping operation. We can think of speech recognition as the first part of a two-step mapping process. In the first step - the speech recognition process - the signal is translated into a sequence of linguistic code domain. In the

second step - the semantic interpretation process -this linguistic transcription of the speech is interpreted within the framework of the semantics of the communication situation. There are various factors involved in speech recognition, what are the feature to be used, which set of features is most suited for speech recognition, how these sets of features are obtained, which linguistic code to be used in the recognizer, how the co-articulation is taken care of, how the speech is segmented etc. There are various experiments, which suggest that in the normal listening process a feature analysis (by ear) precedes a phonetic analysis. We use articulatory-phonetic features as a set of features in our recognizer. These features are extracted using the Articulatory Phonetic Feature Extraction Network (APFEN). The APFEN is described in the third chapter of the thesis. The APFEN network is a four layered neural network, the aim of which is to extract articulatory phonetic features from the speech waveform. This network is first trained to learn the mapping between speech spectrum and articulatory-phonetic features using training dataset. Once this network is trained, it is used later for extracting the articulatory-phonetic features from speech signal. The other major problem in continuous speech recognition is that of co-articulation effect. We have borrowed the idea of equalization in the communication system [49] to model the coarticulation in the continuous speech. In the fourth chapter we present the coarticulation network. We have used feedback equalizer, which is implemented using neural network concept. This network takes output of preprocessing network (APFEN), as its input and gives modified articulatory-phonetic feature as outputs. In the fifth chapter we present an algorithm for segmentation of the frames into phoneme segments. The algorithm uses Euclidean distance between frames for segmentation. These phoneme segments are then identified using identification network, which is initially trained to learn mapping between articulatory-phonetic feature and phonemes. We have used articulatory-phonetic features for the identification of phonemes in the continuous speech. These features were extracted from power spectrum of speech signal using a neural network. The effect of co-articulation in the speech was modeled as a equalization problem. Finally sequence of frames was segmented, and identification of phonemes was done. We trained the APFEN with data taken from different dialect regions of TIMIT corpus. Frame-by-frame recognition rate for a configuration of APFEN network is given in Table 1. We used only "SA" sentences from TIMIT corpus for our simulation work. Wu and Chan [68] reported frame-by-frame recognition rate of 35.41% in close set and 35.26% on open set (for 43 phonetic class). For the 36 phonetic class probabilistic mapping network offers recognition of 44.1% and 44.2% for the close and open set, respectively. Bengio and De Mori [9], reported best frame-by-frame error 41.8% on the test set. Lee and Hon [42], obtained 41.3% error with HMMs and no language model, and 26.2% using a context dependent bigram model. Robinson and Fallside [52] obtained 24.9% error with a recurrent network plus a dynamic programming postprocessor using a bigram and duration model (the error is about twice that amount without the postprocessor). The error using APFEN is lower but it is still high in comparison to others. Frame-by-frame accuracy further improved by 14.46-18.95% after co-articulation effect taken care of by the co-articulation network. Finally we get error in phoneme recognition 28.55% on "SA" sentences of the TIMIT corpus.

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Title : ***Investigation On Complex Variable Based Back Propagation Algorithm And Applications***

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Abstract

Complex-valued Neural Networks have been studied in the thesis from the viewpoint of Error functions (EF). Practical data are prone to outliers that offset an optimization scheme by contributing greater cost to the standard Quadratic EF. Statistics literature pointed out other EFS that can effectively circumvent this problem and afford a better solution thereby. Seventeen such EFS have been gathered from different sources and Back-Propagation algorithm developed over them. The functions have been generalized to complex variables and Complex-valued Back-Propagation Algorithm (CVBP)developed over them. To validate the EF based networks, the following Benchmark Problems have been employed: Exc

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Title : ***Development And Integration Strategy For Power Distribution Automation***

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Supervisor(s) : ***Sachchidanand&Varma Rajiv K***

Abstract

It present a new modular of software element like Master DA Software and Engineering Analysis Software and develops integration to facilitate independent & modular development of application software Component. It also designs develops and influents of fewer distribution Automation system in the real life situation to lest the efficiency of proposed software structure and integration strategies. The application based structural framework of master DA softer ware and the engineering analysis software has been conveniently applied in realization of various DA functions. An interface called Massage flow process-process across applications & another interface called data access interface to enable a forces to access the database of there applications were introduced. Reference is compared with actual & expected values to check the data measurement accuracy and demonstrate the efficiency of developed strategies.

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Title : *Quasi-Resonant Soft-Switching Inverters For Power Supplies And Induction Motor Drives*

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Abstract

Soft-switched dc-ac inverters are attractive for power supply and motor drive applications due to distinct advantages such as high efficiency, high frequency operation, compact structure, and low EMI etc. compared to hard-switched converters. The present thesis deals with design, simulation and laboratory implementation of various quasi-resonant dc link inverters for different loads. Initially, a novel quasi-resonant dc link (QRDCL) inverter comprising of two switches and three resonant components is proposed for high power factor loads. Simulation of the inverter under modified space vector modulation (MSVM) for an R-L load at 400 Hz is carried out. The MSVM is developed incorporating soft-switching technique. It differs from the conventional space vector modulation (SVM) in implementing zero vectors. The resonant components are designed and a laboratory-sized model is fabricated and tested. Test results agree with simulation results showing soft-switching of devices in the resonant link and the inverter. The inverter proposed earlier has the limitation that it can operate only with high power factor loads. Another novel QRDCL inverter suitable for high as well as low power factor loads is proposed. The quasi-resonant link comprises of four switches and three resonant components. The inverter operates satisfactorily with positive and negative dc link current. The simulation is carried out with the help of SABER incorporating MSVM control technique. Experiment is conducted with both R-L and induction motor loads. Simulation and experimental results reveal soft-switching with low and high power factor loads. A high performance induction motor drive is operated using QRDCL inverter incorporating direct torque control (DTC) scheme. The DTC scheme along with QRDCL inverter is analyzed by SABER Simulator. The soft-switching of inverter devices, independent control of torque and flux are verified from simulation. Further, the simulation is extended to include a reduced-order stator flux observer robust to speed variation. From the SABER simulation of the observer-based DTC scheme, it is found that the stator flux from the observer follows closely the flux obtained from the mathematical model of the induction machine. The experiment is conducted on a laboratory-sized induction machine for both with and without observer. The results obtained X Abstract from the experiment compare well with those obtained from simulation. The detailed study of QRDCL inverter reveals that it can be used not only for power supplies but also to high performance induction motor drives. Because of soft-switching and high performance of the inverter, it can find application in airborne power supplies where size, and weight due to paucity of space are of paramount importance. Key words: Dc-ac converters (inverters), quasi-resonant dc link (QRDCL) inverter, High and low power factor loads, Modified space vector modulation, high performance induction motor drive, and robust reduced order stator flux observer.

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Title : ***A Study Of QOS Based Managment Of Congestion Using Backpressure Mechanism And Call Admission Control In ATM Networks***

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Supervisor(s) : ***Srivathsan K R&Bose Sanjay Kumar***

Abstract

It gives a closer look at presenting congestion by blocking a newly arriving call using call admission control and by regulating the source traffic using appropriate back pressure feedback. It modeled the sojourn terms of the network element into observed & Underwood states fluid flow approach is used to model the statistical multilevel & sources are modeled as On-off type fluid sources. The matrix partial differential equations governing the probability density of first passage time is obtained using backward Chapman-Kolmogrov equations. Phase of modulating process and the content of fluid buffer are obtained by defining the embedded Markov Chain using the equilibrium probability of Markov Chain the explicit expressions for probability density function of sojourn times into over load & under load provides are obtained. The feedback model with delayed feedback and ON-OFF type fluid sources with sources buffer are used to study the impact of feedback in terms of impact in mean overload periods the discussion suggest approaches to use the information obtained from measurement of mean over load under load duration of a network element to supplement call central procedures based on proposed effective band width.

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Title : Some Investigations On Unified Power Quality Conditioner
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Abstract

Thesis Title: Some Investigations on Unified Power Quality Conditioner (UPQC) Name of student: Malabika Basu Roll Number: 9710462 Department: Electrical Engineering Thesis Supervisors: Dr. G. K. Dubey and Dr. S. P. Das Degree for which submitted: Ph. D. SYNOPSIS Power Quality (PQ) has been identified as a major concern for improving system efficiency, minimizing various losses and ensuring production quality. Electric power quality can be broadly classified as a measure of how well electric power is available to customers. When wave shapes deviate from ideal sinusoid, the magnitude of voltage does not pertain to the specified value and the reliability of power supplied is under question, power quality degrades from its desirable standard. The advent and wide spread use of high power high frequency semiconductor switches over past two decades have given PQ problem a new dimension [1-5]. Because these switches are capable of power conversion with high speed, good control flexibility and high efficiency, they have secured an indispensable position in the processing and utilization of power starting from transmission, distribution to application at very small level. As their non-linear switching actions give rise to consumption of large VAR and current harmonics, non-sinusoidal currents in utility have increased alarmingly, which pollute the supply current and the voltage at the Point of Common Coupling (PCC). Similar to clean environment, clean utility is also the demand of current engineering practices because of several electrical system and equipment hazards like over-heating, increased loss, underutilization of installed capacity, saturation of transformers, mal-triggering of control signal interfaced with utility etc. [4-6]. To protect the interest of utility, international agencies like IEC, IEEE [6] have been developing various standards for harmonic specifications for PCC as well as individual equipment. PQ surveys [1,2] have been conducted to find out various effects of power xii disturbances on industrial production. Voltage sag has been found out to be a major PQ disturbance for which industries suffer huge production losses in terms of material, manpower and money. No specific mandatory standards have come up yet to protect consumer interest from such utility voltage disturbance, though voltage distortion limits have been specified by standards. Worldwide research on custom power equipment for various Power Quality Control (PQC) measures [7-9] is trying to develop suitable utility interface, which can protect both utility and interest of consumers. The present dissertation investigates the function of a multi-purpose PQ compensating equipment, Unified Power Quality Conditioner (UPQC), for non-linear and voltage sensitive loads. For eliminating harmonic current pollution, shunt Active Power Filters (APF) [10,11] have proved to be the widely accepted solution while

to mitigate voltage sag, series injection of voltage with supply is absolutely essential [12, 13]. UPQC being a combination of shunt and series compensators bears advantages of both. UPQC, unlike Dynamic Voltage Restorer (DVR), does not need any external storage device or additional converter (typically diode bridge rectifier) to supply and maintain the dc link voltage. The common dc link voltage is used by both the series and shunt converters, and shunt converter maintains the dc link voltage through a closed-loop control. Both single phase [14] and three phase topology [15, 16] of the UPQC have been simulated in SABER and implemented in the laboratory. The developed UPQC has the following features: > UPQC eliminates the harmonics in the supply current, thus improves utility current quality for nonlinear loads. > It provides the VAR requirement of the load, so that the supply voltage and current are always in phase, therefore, no additional power factor correction equipment is necessary. The shunt compensator, which is a Synchronous Link Converter VAR Compensator (SLCVC), is a current controlled VSI that keeps the supply current within a sinusoidal hysteresis band. Therefore, it keeps the THD of supply current low, within the specified standard limit, and the utility has to supply only the fundamental active component of load current. > UPQC maintains load end voltage at the rated value even in the presence of balanced supply voltage sag. Xill > The voltage injected by UPQC to maintain the load end voltage at the desired value is taken from the same dc link, thus no additional dc link voltage support is required for the series compensator. > The injected voltage maintains quadrature advance relationship with the supply current, so no real power is consumed by the series compensator in steady state. This is a big advantage when UPQC mitigates under-voltage conditions. Because of self-sustaining dc bus voltage, duration of sag or under-voltage is not a constraint of operation for UPQC. The series compensator of the UPQC also shares the VAR of the load along with the shunt compensator, so the VA loading of the shunt compensator reduces. To highlight this aspect of quadrature voltage injection, the equipment has been termed as UPQC-Q in the dissertation. A detailed VA loading calculation is performed for a wide range of power factor and sag conditions which brings out the mutual VAR sharing conditions of the two compensators. In the available literature on UPQC, applications for three phase systems are reported. The present dissertation has reported a control scheme suitable for single phase as well as three phase applications. A new PC - based closed-loop hybrid controller has been proposed, combining analog and digital controllers, having good accuracy, speed, flexibility and ease of implementation. A dynamic sag controller, through a closed loop PI controller, has been proposed which ensures the phase quadrature relationship in case of variable voltage sag and variable load. Detailed design simulations in SABER simulator and experimental implementation on a laboratory prototype have been performed for single phase and three phase UPQC-Q to verify the theory. Another control scheme for unbalanced sag mitigation with the help of UPQC has been designed and simulated in SABER, d-q-o component based synchronously rotating frame analysis has been adopted in this case for dynamic sag controller, with a closed loop control to ensure that voltage injected during sag is appropriate. During balanced voltage sag, the injected voltage is found to be in phase with the supply current, therefore the series compensator is only active power consuming device and acts as a dc load to the dc link capacitor. To highlight this aspect, the system is termed as UPQC-P in the thesis. A detailed

VA loading analysis has been carried out for different load power factor and sag conditions. Results confirm the effectiveness of the proposed control technique. The dissertation also envisages a possibility of efficient utilization of parallel converters as VAR compensators and Active Power Filters (APF) for large power loads, by sharing suitable responsibility, which is according to the nature and capacity of the semiconductor switches [17]. Due to limited power handling capacity of individual devices, paralleling is the choice to increase rating of equipment while keeping the THD of the current at PCC within the agency specified standards. It has been reported in literature that paralleling several converters rather than switches is more reliable in sharing of load largely due to thermal coupling problem. In this perspective, multilevel converters carry lot of weight, as their typical power circuit configuration limits the stress on individual devices to an appreciable extent. Also they bear the advantage of low switching frequency and full utilization of switching devices, which is very essential in high power applications. These favorable advantages have been utilized in parallel combination with a low power high frequency current controlled APF, such that the higher order harmonics can be eliminated. A new parallel converter topology with a three-level Neutral" Point Clamped (NPC) converter and an auxiliary current controlled VSI has been proposed and control techniques have been developed. Extensive simulation study has been carried out in SABER simulator for linear and non-linear loads, and performance has been compared with a combination of standard six-step main converter and the auxiliary APF. This study is useful in the design of UPQC for high power application. The work presented in this thesis is organized as follows. Chapter 1 introduces the necessity of Power Quality Conditioners from the perspective of different PQ issues and problems. A review on Power Quality Conditioners has been reported in Chapter 2. The three major custom power equipment namely, Shunt (APF), Series (DVR) and Unified compensators (UPQC) are discussed with their different power circuit topology and control philosophy. The detection algorithms for control are discussed. The important observations on Power Quality problems and solutions are summarized. A single phase UPQC-Q has been proposed in Chapter 3 with a new closed-loop control strategy. VA loading for different load power factor condition and supply voltage sag has been carried out. Detailed simulation studies have been made. Hardware realizations of the experimental setup followed by experimental results obtained from a laboratory prototype are also presented. XV The detailed design, simulation and implementation of UPQC-Q for three phase three wire systems has been reported in Chapter 4 The PC based hybrid controller implementation has been described. Simulation and experimental results are presented. In the second part of Chapter 4, a novel control strategy with UPQC-P to mitigate unbalanced supply voltage sag has been proposed. The control theory has been verified through SABER simulation. A parallel converter scheme suitable for high power load compensation has been reported in Chapter 5. A new combination of power circuit topology has been investigated along with suitable control technique. The effectiveness of a three level Neutral Point Clamped (NPC) inverter (high power, low switching frequency, main converter), with a dedicated task of VAR compensation of load at fundamental power frequency is presented. The main converter harmonics and load harmonic currents are compensated by a parallel connected low power high frequency APF. The NPC converter is then replaced by a six-step converter and the performance has been compared. Chapter 6 summarizes the contributions of the dissertation and gives suggestions for further research in this field.

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Title : *Torsional Interaction Studies On An SSSC Compensated Power System*

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Abstract

In recent times there is a steady growth in the demand for electric power, much of which has to be transmitted over long distances. Environmental and right of way concerns somewhat prohibit the construction of new power plants and erection of new transmission lines. Therefore the existing lines are required to evacuate increasing amount of power. Static capacitor banks can be used in series with long transmission lines in order to compensate for their large inductive reactance, which would otherwise limit the maximum amount of power that can be transferred down the line. Series capacitor compensation also improves the transient stability and voltage regulation of the system. However, the extent to which a transmission line can be compensated with series capacitance is often severely restricted by concerns for the destructive effects of sub synchronous resonance (SSR). Two shaft failures at the Mo have Generating station in Southern Nevada [1] led to the understanding of SSR phenomenon and since then extensive research and development efforts have been devoted to the development of SSR mitigation methods. Sub synchronous resonance is an electric power system condition where the electric network exchange significant energy with a turbine generator shaft system at one or more frequencies below the synchronous frequency of the system [2]. The synchronous frequency is defined as the frequency corresponding to the rotor average speed. The terms sub synchronous and super synchronous denotes frequencies below and above the synchronous frequency. Sub synchronous resonance encompasses the oscillatory attributes of electrical and mechanical variables associated with turbine generators when coupled to a series capacitor compensated transmission system, where the oscillator y energy interchange between the electric system and the turbine generator shaft system is lightly damped, undamped, or even negatively damped and growing. As energies are exchanged, their frequencies of oscillations are the natural frequencies of their respective systems. Three distinct aspects of SSR analysis have been identified and are referred to as induction generator effect, torsional interaction, and transient torque amplification [2]. Induction generator effects result form the apparent negative resistance characteristic of generators at sub synchronous frequencies. At a resonant electrical frequency defined by the combined inductance and capacitance characteristics of the system, this apparent negative resistance may exceed the network resistance. Such a condition will result in self-excitation of oscillatory currents at the natural frequency. Torsional interaction problems may occur when the electrical natural frequency is near the complement of a turbine generator natural frequency. The turbine generator shaft system responds to disturbances with oscillations at its torsional natural frequencies. Oscillations of the generator at these frequencies result in the modulation of the

generator voltage. The sub synchronous frequencies voltage component is at a frequency that is the complement of the natural frequency of the turbine generator shaft system. When this frequency is close to electrical natural frequency, the resulting armature current produces an oscillatory component of rotor torque which enhances the generator rotor oscillations. When this torque is larger than that resulting from mechanical damping, the coupled electro mechanical system will experience growing oscillations. The Mohave accidents were due to transient torque amplification. When the transmission system constraints series capacitors, the transient electrical torque may contain large amplitude frequency components close to resonant frequencies of the shaft system. This can result in high shaft torques which may seriously damage the turbine generator unit especially when the system is subjected to a large disturbance e.g. a fault. Besides the interaction between turbine generator and series capacitor compensated networks, sub synchronous oscillations in turbine generator have also resulted from interaction with other power system components. Other potential sources include power system stabilizers, high voltage DC converters, high speed governor controls variable speed drive converters, and control loop of FACTS devices. In genera l any device that controls of responds rapidly to power or speed variations in the sub synchronous frequency range is a potential source for the excitation of sub synchronous oscillations. Growing demand of power and environment concerns necessitated are view of the traditional power system concepts and practices to achieve greater operating flexibility and better utilization of existing power systems. The development of semiconductor technology has also made significant impact on AC transmission. Hingoran i [3] proposed the concept of flexible AC transmission systems or FACTS which provides the needed corrections of transmission functionality in order to fully utilize existing transmission systems. FACTS technology is based on the use of reliable high speed power electronics, advanced control technology advanced micro computers, and powerful analytical tools. This technology has been demonstrated successfully and continues to be implemented at transmission locations in various parts of the world. The installed FACTS controllers have provided new possibilities and unprecedented flexibility aiming at maximizing the utilization of transmission assets efficiently and reliably. Controllable series line compensation is a cornerstone of FACTS technology. It can be applied to achieve full utilization of transmission assets by controlling the power flow in the lines, preventing loop flows and with the use of fast controls, minimizing the effect of system disturbances, thereby reducing traditional stability margin requirements. There are two basic approaches to FACTS series compensators, one, which employs thyristor switched capacitors and thyristor controlled reactors to realize a variable reactive admittance, and the other, which employs a switching power converter to realize a controllable synchronous voltage source. Most of the work in advanced series compensation has focused on the study of thyristor controlled series compensator (TCSC)< which is parallel combination of a fixed capacitor and thyristor controlled rea ctor. However, TCSC suffers from some disadvantages [4]. It injects low order harmonic components (typically 3rd , 5th , 7th and 9th) into the power system because of thyristor phase control. Since the thyristor firing pulse is available only once in each ha lf cycle, transient response of the circuit is rather slow. Deriving a closed loop model of TCSC is

complicated [5]. Other disadvantages include higher per MVA cost and susceptibility to parallel resonances due to the presence of inductors and capacitors i n parallel paths. Static synchronous series compensator (SSSC), proposed by Gyugyi [6], is a relatively newer FACTS device. It injects synchronous ac voltages in series with a transmission lien to allow fast continuous control of the flow of power in the lien. It is implemented by a GTO based voltage source inverter and can provide controllable compensating voltage over an identical capacitive and inductive range, independently of the magnitude of the line current. Unlike other series compensators, an idea l SSSC is essentially a pure sinusoidal ac voltage source at the system fundamental frequency. Its output impedance at other frequencies is theoretically zero. Thus, SSSC is unable to form a classical resonant circuit with the inductive lien impedance to initiate sub synchronous system oscillations. The non capacitor like behaviour, the superior operating characteristics and hitherto unattainable application flexibility that the SSSC offers, may provide a sufficient basis to reconsider the general applicability of series compensation for power flow control and system stability improvements [7]. However, unlike other FACTS devices SSSC has received very little attention. The question of sub synchronous resonance will arise in all FACTS applications, for the basic reason that all high speed high power controllers have potential of enhancing or degrading sub synchronous phenomenon. In a practical SSSC, the dc side of voltage source converter is terminated by a finite energy storage capacitor to maintain the desired dc operating voltage. Thus the dc capacitor in effect interacts with the ac system via the converter switches. This interaction may conceivably influence the sub synchronous behaviour of a practical SSSC [8]. There is considerable opportunity for original research to explore the torsional character tics of SSSC. It is also very likely that he SSSC can be controlled to be highly effective in the active damping of prevailing sub synchronous oscillations brought about by conventional series compensation [7]. Based on the above considerations, this thesis focuses attention on the torsional characteristics of SSSC compensated power system. Therefore, the objectives and scope of the thesis are: 1. Design a reactance controller to control the power flow in an S SSC compensated power system and to design controllers to regulate the dc link capacitor voltage of the SSSC. Also to investigate torsional characteristics of the compensated system with the designed controllers. 2. To study the control interaction between the SSSC and a Power System Stabilizer (PSS) in the SSSC compensated power system and to propose modification in the PSS design to improve the damping of the torsional modes. 3. To design robust controllers for SSSC to provide satisfactory performance under wide variations in the operating point. 4. To study the potential of the SSSC to damp out SSR oscillations brought about by a fixed capacitor when both the SSSC and the capacitor are connected in series with the transmission system. Also to investigate the advantage of such a compensation scheme vis a vis the damping of swing mode, synchronizing torque and size of SSSC. To achieve the above objectives we use the IEEE First Benchmark Model) IEEE - FBM) for SSR analysis [9] as our study system. We shall also use the tools like eigenvalue analysis and EMTDC/PSCAD simulation package [10] for digital simulation. An outline of the work reported in the thesis is given below. Chapter 1 gives an introduction to the various aspects of the problem presented in the thesis an d reviews briefly the

previously published works. In Chapter 2, fundamental principles and characteristics of SSSC are presented. In this a 48 step SSSC is considered [11]. A brief review of this SSSC and its equivalent circuit models are presented. A power flow controller is designed for the SSSC compensated power system. Some simulation results outlining the operation of the power flow controller are also presented. In chapter 3, a linear zed models of a power system, with SSSC as a compensator, is presented. Eigenvalue analysis is carried out with linear zed overall system model to study the torsional characteristics of SSSC compensated power system. The effect of dc link capacitor of the SSSC on torsional performance is studied. An integral state feedback controller is proposed to improve the torisional characteristics of the system. Torsional characteristics of SSSC compensated system and that of fixed capacitor compensated system are compared nonlinear time domain simulations are used to validate the results of the eigenvalue analysis. The effect of excitation system that includes power system stabilizer (PSS) on torsional performance of SSSC compensated power system is studied in Chapter 4. The control interaction study is carried out through eigen value analysis and time domain simulations. A torisional filter with speed and acceleration as input signals is designed to reduce the destabilizing effects that the PSS has on the torsional modes. In Chapter 5, the H ∞ optimal control theory has been used to design a robust controller for regulating dc link voltage of the SSSC. Eigen value analysis and nonlinear simulation using PSCAD/EMTDC have shown that the controller can provide satisfactory torsional performance under wide variations in operating conditions. It has been shown that a robust auxiliary controller with a fixed proportional plus integral (PI) control for dc voltage regulation gives better performance compared to a robust dc voltage controller with a conventional auxiliary damping controller. In Chapter 6, a torisional characteristics of the system when compensated by a combination of a fixed capacitor and SSSC is studied. The stability of the system is analyzed through eigen value analysis and the results are validated with time domain simulations. An auxiliary damping controller is proposed to improve the damping of the torsional modes. With auxiliary control, it has been shown that SSSC can mitigate the SSR oscillations brought about by conventional fixed series capacitors. This thesis concludes in Chapter 7 outlining the oscillations drawn form the thesis and suggests some future scope of work.

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Title : Switch Mode Rectifiers And Applications
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Abstract

Switch mode rectifiers (SMR) are being widely used for ac to dc conversion to reduce the input current harmonics and to improve the power factor in order to meet the harmonic standards laid down by IEEE and other international agencies like IEC 1000-3-2. The main advantages of SMR using active current wave shaping techniques over its passive counterparts are I) considerable reduction in the passive element count and thereby reducing size, losses and cost, ii) inherent output voltage regulation and fast transients response. Reduction in the input current harmonics also improves the input power factor, therefore these converters are also called power factor correction (PFC) converters or resistance emulator. Active current wave shaping techniques using variable switching frequency [1. 2] have drawbacks like- (i) Non-optimal use of switching device. (ii) Variations should be known apriori for a given range of load current. (iii) EMI filter design is complex. (iv) Energy storing elements are to be designed for lowest operating frequency, giving larger size. Further, they often need the precision current sensing and a fast and accurate current sensor is costly. These problems are overcome by constant switching frequency current control schemes. There predictive current control schemes for boost converter are proposed and investigated in the first part of the dissertation. Control scheme-I is for continuous conduction mode (CCM) and control scheme-II is for discontinuous conduction mode (DCM). Unlike the scheme in [3, 4] the switching frequency remains constant throughout the variation of the load. In the control scheme-III a mixed mode operation of SMR with two different but constant switching frequencies is proposed and implemented. In this scheme the SMR is made to operate in purely CCM for highervalues of load and in purely DCM for lower values of load, for a given range of load variation. This method selecting CCM and DCM with load eliminates the possibility of a DUAL mode, where the total harmonic distortion is the highest. Furthermore, the boost inductor size is considerably reduced as compared to the size required for purely CCM operation at minimum expected load. In all these control schemes the input current is maintained at unity power factor by predicting the switching instants of SMR power switch with the proposed control laws. This avoids he need of fast and accurate input current sensor. However the average load currents used as the impute to the controller and this does not requires a fast current sensor. The design of input inductor and the choice of switching frequency are made in such a way as to keep the input current harmonic within the limits specified by IEC 1000-3-2 harmonic standards. The validity of the control harmonic within the verified through extensive simulations and experimental studies. Unlike [5, 6] the hybrid kind of hardware implementations using partly digital and partly analog circuitry give the freedom of choice of control parameters, take source frequency variations and make the implementation

easy. In order to satisfy harmonic standards presently switch mode rectifiers operate at a high switching frequency. Therefore their applications are limited only to low power. Due to the low switching frequency limitations and increased switching losses of high power devices these techniques have not been exploited at high power levels. The second part of the thesis deals with the development of new approach for higher power SMRs. A novel suggestion for high power application area is to use a parallel combination of a high power main converter operating at low switching frequency with an auxiliary converter using low power high switching frequency device [7, 8]. The purpose of the main converter is to supply the total active power needed by the load whereas the auxiliary converter is to supply only the harmonic power of the main converter. But the above approach needs an additional transformer, sometimes with multiple secondary windings, adding to the extra cost of system. In [9] separate dc links supplying two different load are considered. Here again the VA rating of the auxiliary converter depends on its active load, which is at times comparable to the main converter resulting in power limitations. Other proposals of the parallel scheme make use of forward converter [10] or buck converter [11] as the main converter along with fly back topology as the auxiliary converter with the aim to satisfy merely class D harmonic requirements for input current but only at low power levels. Based on above approach a parallel converter topology using a single switch boost SMR as main converter and two-switch converter as auxiliary converter is proposed for high power applications. The total active power demand of the load is met by the main converter, which is operated at low switching frequency so that it can be used for high power applications. High power low switching frequency device of main converter is controlled by a constant switching frequency current control scheme to avoid the variable switching HCC, as its purpose is to supply only harmonic power requirement of main converter. The auxiliary converter topology which is derived from half bridge synchronous link converter configuration does not require two identical center tapped capacitors at the output, and therefore the problem of unbalanced voltage across the two capacitors does not arise. Additionally the chosen auxiliary converter topology and it novel connection scheme results in low overall component count and cost of the system by avoiding the need for an interface transformer. The proposed SMR draws sinusoidal input current with high power factor and low current harmonics. Using two independent current control scheme simplicity of the system is maintained. A prototype model of the proposed SMR is implemented in the laboratory to measure the experimental waveforms and to verify the simulated behavior. Hybrid implementation of the proposed control scheme having partly digital and partly analog circuitry is done in order to reduce the effect of EMI and to keep the ease of control parameters selection. Experimentally the power handled by the auxiliary converter is only 11% to that of the main converter which supplies the total active power requirement of the load. The simulation and experimental results show satisfactory performance of the proposed SMR. Novel topology and low cost implementation are merits of the proposed scheme. Third part of the dissertation is the development of a magnet power supply with sinusoidal input current and unity power factor. For magnet power supplies, very low current ripple and fast dynamic response at the output are of primary convert. Stability and ripple requirements for

these power supplies vary from 1000 ppm (0.1%) to 10 ppm (0.001%) for various applications [12-13]. The typical cycle of operation for load current of magnet power supply is trapezoidal in nature with repetitions rate of around 1 Hz. It consists of two steady state levels a ramp-up and a ramp-down period [12-18]. Diode bridge and phase controlled rectifiers using passive filters have been used since long for such kind of power supplies. These converts have poor power factor and draw the source current rich in lower order harmonics. Passive filter components used to attenuate the current/voltage harmonics generated from input/output terminals of these rectifiers tend to become bulky and expensive when used to filter the low order harmonics [14]. Additionally the transient response with such passive filters is poor. PWM converters have also been used for magnet load power supplies using the passive filters but they raise many other problem such as the limitation of operation range of converters and resonance with the converter switching frequency. Multilevel converters have inherent voltage balancing problem [18]. Various combinations of active filters have been used in the recent past to eliminate the output current ripple. But heavy power loss occurs in case of series active filters [15-16] while dynamic performance suffers for the shunt active filter [17]. The hybrid approach-using phase controlled rectifier in parallel or in series with a high frequency PWM converters [15-17] also end up with low power factor and high harmonic injection into utility supply. Switch mode power supply using the FET chopper [19] gives better performance about has the limited energy handling capacity. With the upcoming standards for limiting the input current harmonics ac to dc converters for magnet load power supplies need special attention. A single phase cascade topology of two state switch mode rectifier (SMR) for booster kind of magnet loads (correction and adjustment coils) at low and medium power applications is proposed and implemented in the final part of the dissertation. The first stages is a switch mode rectifier (SMR) to shape the input current in phase with the supply voltage. It takes care of utility constraints and maintains near unity power factor at the input. The second stages is a buck converter operating with constant frequency PWM control to satisfy the low ripple and first dynamics requirement at the output. The chosen converter topologies and their connection scheme resisting low overall component count and hence lower cost of the system. Use of two independent current controlled schemes namely hysteresis current control for the first stage SMR and constant frequency current controlled PWM for the second stage ensures simplicity of the system. Judicious choice of the feedback loop maintains the steady state accuracy and low current ripple requirement whereas the feed forward loops enhance the transient response and maintain high accuracy during current ramping. Extensive simulations are done to predict the behavior of the proposed systems and a prototype model is developed in the laboratory to validate the theoretical predictions.

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Title : *Studies On Some New Classes Of Optical Orthogonal Codes*
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Abstract

The objective of the thesis is to design some new classes of Optical Orthogonal Codes. More specifically we look at those classes of codes, which have smaller have smaller code length s and better correlation properties. The codes discussed here are suitable for use in fiber optic codes division multiple access (FO - CDMA) systems. Though our discussion has been centered around applications of these codes in the FO - CDMA systems the codes can be used for any optical CDMA systems. The rapid development s in optical processing and the advantages of fiber optic communications have provided the necessary impetus towards development of all optical networks. CDMA systems allow multiple users to simultaneous share a command channel asynchronously with little control amongst users by assigning minimally interface unique code sequence to different users. The vast bandwidth available in optical fiber channel makes it a natural medium for applications off Adam specialist in fiber optic local area networks. The need to have a large number of users in the FO - CDMA system requires a large number of minimally interfering code sequence assigned to different users. The optical orthogonal for truly (0,1) systems. Such codes have been referred to as Optical Orthogonal Codes (OOCs) and have many more 0's than 1's in them to approach orthogonality. An OOC, represented by (n,w, lambda) has n as the length of each of its codewords w is the number of 1's in each codeword (also called weight of the codeword); any codeword has a maximum off - peak autocorrelation of lambda. We denote the number of code wards in the OOC by M. Thought the thesis we have represented the codewords of the OOCs in the form of w - sets where elements of the w - sets are integers modulo n and represent the locations of 1's in the code sequence. Several classes of Optical orthogonal Codes have been proposed in the last two decades. These include OOCs based on the Prime Sequences Quadratic Congruences Projective Geometry and algebraic error correcting codes. In most of these codes the length required to generate even a moderate number of codewords is quite large. The study reported here is im potent for two reasons. First the smaller length of codewords generated for a relative large number of codewords allows higher data rates to be supported for a given minimum laser pulse width. Secondly the correlation values have been kept small which result in lower multiple user interfaces. . Given the present trend of growth of optical networking the requirement to have a large number of users in the system can only grow .We summarize some contributions of the thesis in the following. Main Results: The thesis has been organized in seven chapters. In Chapters 1 we give an intro education of FO - CDMA systems and introduction the Optical Orthogonal Codes. Chapter2 contains a review of OOC proposed earlier in the literature .We discuss the c odes on the basis of their construction procedure s and the code parameters .The OOCs discussed in this chapter include the Projective Geometry two dimensional codes 2n Prime Sequence codes and OOC s based on the error correcting codes .We include a few examples to illustrate the constriction procedure and the characteristics of these codes .We briefly compare these existing codes on the basis of their parameters . In Chapter 3 we propose a new class of OOCs based on the well - known Hadamard matrices First we generate the difference sets by a truncation of the Hadamard matrices. These difference sates are then converted to w - sets with each w - set representing a codeword .We illustrate the construction procedure with the help of suitable

examples and show the parameters of the OOCs constructed using this method. Later we present a generalized construction procedure for generation of the codewords for this class of OOCs .The OOCs constructed using this approach are of the form (4t - 1, 2t - 1,t - 1, t) where t is a positive integer. This class of OOCs can be constructed for any length n = 4t - 1, if a Handmaid matrix exists for an order (n+1). Chapter 4 is concerned with the development of another new class of Optical Orthogonal Codes using the Sequences .The basic idea in this chapter is to put integers in the w - sets in such a way that the off - peak autocorrelation and crosscorrelation constraints are satisfied .A translated version of Skolem sequence is proposed to put distinct integers as the distance between 1's in a w - set for a code of weight w = 3. The correlation constraints never exceed a value of 1 for this class of codes as all the distance between 1's are distinct .We explain the generation of code words with the help of a few examples. This class of codes gives us code words having minimum lengths for a few examples. This class of codes gives us code words having minimum length for a given number of code words. This class of OOCs has M codewords each of which has a length of 6m+1 weight 3 and the correlation parameters lambda=1. The requirement for generation of codewords for this class of OOFCs is th at the number of codewords M should be congruent to either 0 (modulo 4) or 1 (modulo 4). We present methods to construct three more classes of OOCs in Chapter 5.Each class has a different set of code parameters. First we suggest a method to generate codewords of an Optical Orthogonal Code Using The Table of Primes. These are variants of the Prime Sequence Codes and give us codewords with better off - peak autocorrelation value lambda while trading of the cross correlation constant. These codes are of the form (p2 - p, p - 1, 1,p - 2), where p is prime number. Next we suggest a method to construct OOCs by partitioning the Galois Field GF (n) where n is a prime number of the type n= 3t+2 .The constraint here is that 3 must be a primitive root of n. The GF (n) is partitioned into t number of 3 - sets. We illustrate the construction procedure using an example .The off - peak autocorrelation and cross correlation values of the resultant codeword never exceed a value of 2.The code are of th e form (3t+2,3,2,2,), and the number of codewords is t. The OOCs based on the Quadratic Residues are then proposed as the third method. These codes are constructed using the quadratic residue of a prime number and the construction procedure is explained using an example. This code can be constructed for any prime number and the resultant codeword have the maximum off - peak autocorrelation and cross correlation value of 2. The code suggested here is better than the OOCs based on the Quadratic Congrue nce's since the maximum cross correlation value is reduced from 4to 2, while keeping all other parameters the same. These codes have the form (p2, p, 2,2,), where p is a prime number. A comparison of the codes proposed in this thesis with the cod e suggested earlier is presented in Chapter 6. We make this comparison on the basis of number of codeword generated for the given code parameters and their ability to tolerate multiple access interface .We discuss the superiority of the OOCs proposed in this thesis and their relevance to Fiber Optic CDMA systems. We observe that the OOCs constructed using a prime number as their basis as prime Sequence Quadratic Congruence's Quadratic Residues etc., are not optimal from then point of view of the number of codeword generated for given code parameters against the Johnson bound. In Chapter 7 we summarize conclusions of the thesis and give suggestions for future work.

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Title : *A Study Into The Applicability Of P+ N+ Universal Contact To Power Semiconductor Diodes And Transistors For Faster Reverse Recovery*

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Abstract

PN junction diodes and Bipolar junction transistors (BJTs) are used in a wide variety of switching applications, such as, TV deflection circuits, motor drives, switched mode power supplies and others. In most of these applications, the diodes and transistors are used for operation at frequencies less than 100 kHz. The limiting mechanism for the speed of operation is the presence of stored minority charge during the ON state and the reverse recovery time required for removing these stored charges. The uni-polar devices like Schottky and MOS are inherently fast because of absence of minority charge storage but also have the disadvantage of lower reverse breakdown voltage and higher heat dissipation in comparison to bipolar devices. The Insulated Gate Bipolar Transistor (IGBT) has low on-state losses but due to its relatively involved technology, it is restricted to higher end devices. Even with the limitations as compared to Schottky, MOSFET and IGBT, the PIN rectifiers and BIT are still used in various applications. There have been developments to enhance the switching performance of diodes and transistor, such as, through Au doping and through use of Schottky clamp transistor. In 1982, Amemiya [1] introduced a concept known as universal contact to improve reverse recovery performance of diodes and transistors. The present work is concerned with the various aspects of the application of the "universal contact" (UC) to diodes and transistors. Amemiya et al showed that the incorporation of n+p+ UC m a p^nn+ diode at the n4" end resulted in significant improvement in reverse recovery and decrease in the forward ON voltage. In addition, the application of UC had an advantage when compared to the technique of Au doping to control the reverse recovery, that it did not lead to increase of leakage current or a soft breakdown. The incorporation of universal contact in the n+ region such that it adjoins the lightly doped n region, works well with diodes of low or moderate breakdown voltage, but degrades the reverse blocking capability of high voltage diodes due to the onset of reach-through. Kitagawa [2] proposed the incorporation of p+n+ universal contact inside the diffused region of the p+nn+ diode away from the lightly doped region; this avoided the reach-through and still improved the reverse recovery time. Besides diodes, the universal contact has also been applied to low voltage BJTs to obtain significant reduction in storage time, Naram [3]. In the work [1-3], although the usefulness of the universal contact has been demonstrated, its application however has been in a limited range of current, voltage and devices. It will be further desirable to explore the effects of incorporation of UC over a 2 wider range of current and voltage in diodes and transistors and other devices. The application of UC in a diode or transistor involves creating new diffused

regions in an otherwise conventional device. The presence of these new regions alters the distribution of minority carriers and the currents flowing within the device. It is necessary to have a suitable analysis and model, which can account for the various phenomenon taking place inside the device and their influence on various parameters of the device. Keeping in view the above considerations, we define the following objectives of the thesis -(1) To study the reduction in reverse recovery due to incorporation of universal contact and its effects on other device characteristics using a combination of analytical modeling, numerical simulation, fabrication and characterization of low and high voltage PIN diodes with and without incorporating of universal contact. (2) To suggest changes in the design of PIN diode to achieve better characteristics. (3) 3To study and model the reduction in reverse recovery due to incorporation of UC and its effects on other device characteristics using a combination of analytical modeling, numerical simulation, fabrication and characterization of low and high voltage BJT with and without incorporating universal contact. (4) To suggest changes in design of BJT to achieve better characteristics. The major contributions of this thesis are* 1. A theoretical framework is developed which shows that effective minority earner lifetime (xeff) , defined as the ratio of total minority charge stored to the total current flowing through the diode, can be viewed as a function of three time constants: r^r^+r^+r"1, where TL/TM = WIL> ?M IS the recombination lifetime m the lightly doped middle region and xR /xM = IM/IR. IL , IR and IM are the mmonty carrier currents injected into the left p+, right n+ and middle v regions Using this viewpoint, it is shown that effective minority earner lifetime and therefore reverse recovery time which is closely related to it, can be reduced by redistributing current away from lightly doped v-region to n+ and p+ regions where effective minority carrier lifetime can be reduced by incorporating universal contact. 2. The analytical model developed in this work shows that the effective lifetime decreases with increase in current density and that the advantages of incorporating a universal contact decrease as the breakdown voltage of the diode increases. It is also shown that the incorporation of universal contact allows a new tradeoff between the switching speed and the reverse blocking voltage determined by the proximity of universal contact to the lightly doped region of the diode. The predictions of the model are verified through extensive 2-D [4] numerical simulation and fabrication and characterization of low (-150 V) and high (>1000 V) voltage diodes. [5] 4 3. A new diode structure incorporating universal contacts inside both n+ and p+ diffused regions is proposed. It is shown through analytical calculations and 2D numerical simulations that this diode structure results in large reduction in reverse recovery. The improvements in reverse recovery are 60% and 66% at 0.3 A/cm and 50 A/cm2 respectively with respect to the conventional diode structure. 4. The analytical model developed for PIN diodes is extended to model the effects of incorporating universal contact within the extrinsic base of B JTs. It is shown that the use of universal contact allows redistribution of base current in saturation from collector region where recombination lifetime is high to extrinsic base region where effective recombination lifetime is low. As for the diode case, the model predicts improvement in switching speed with increase in collector current density but degradation of switching characteristics with increase in transistor's reverse blocking voltage. These results are verified

through 2-D numerical simulation 5. The improvement in switching characteristics as a result of incorporation of universal contact is accompanied with an increase in the ON state voltage, VcE(sat) of transistors. The increase in VCE(Sat) in transistors with UC is attributed to decrease of pR, the reverse current gam and early onset of quasi-saturation effects 5 6. The usefulness of the universal contact in high voltage (BVCBo >1000 V) transistors has been experimentally demonstrated for the first time. An improvement of 23% in reverse recovery has been obtained in experimental high voltage BJT [6] OUTLINE OF THE THESIS The study is divided into five chapters. The first chapter gives an introduction to the need for faster switching power devices and the position of PIN diode and BJT amongst other competing devices. The conventional methods of improving reverse recovery are discussed followed by a description of advantages of UC with respect to these methods and the review of the work already done in this area. In the second chapter, a theoretical framework for investigating the switching characteristics of PIN diodes is developed through modeling of effective minority carrier lifetime in the device. The dependence of effective lifetime on important device parameters and its relationship with other device specifications such as reverse blocking voltage are discussed in detail. The results obtained from the analytical model are validated and elaborated through extensive 2D numerical simulations and fabrication and characterization of diodes of different breakdown voltages. Based on this study a new improved structure for PIN diode is suggested, In chapter three, the model developed for PIN diode is extended to discuss the switching characteristics of B JTs and the impact of insertion of universal contact within the extrinsic base region The relationship between effective minority carrier lifetime in the transistor and parameters such as collector current density and breakdown voltage are discussed in detail. The effect of universal contact on the ON state voltage VCE(sat) of the transistor is analyzed in detail. The results from the analytical model are validated and elaborated using 2D numerical simulations of the device and fabrication and characterization of low and high voltage transistors. In chapter four, the process flow developed for the fabrication of low and high voltage diodes and transistors and the incorporation of universal contact within device is described in detail. In chapter five, the important results obtained in the thesis are summarized and further extensions of the work are discussed.

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Title : *Voltage Stability Margin Enhancement Using Facts Controllers*

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Abstract

Most of the early developments of major power system networks faced the classical machine angle stability problem/. However innovations in types of controlling devices and stabilizing measures have made possible the full utilization of transmission capacities of modern power system networks. Specifically in the last two decades many power systems have been operated under highly stressed conditions due to various economic and environmental constraints. Under the stressed conditions and following some disturbances like load variation or contingencies a power system can exhibit a new type of unstable behavior called as voltage instability characterized by slow (or sudden) voltage drops sometimes leading to the voltage collapse or voltage oscillations .As a con sequence voltage stability has become a major concern in power system planning and operation Significant efforts have been made for developing new analysis tools and controlling this types of instability [1] . Voltage stability has been studied both from the static as well as dynamic point of view. Most of the researchers considered it as a static phenomenon due to slow variation of voltage over a long time until it researches near the maximum load ability (or collapse) point .The system model i s based on load - flow equations and the static voltage stability phenomena [2]. While some of them used minimum singular value and condition number [3] of the load flow Jacobian others utilized optimization techniques [4] Continuation power flow method [5] and multiple load flow solutions [6] to predict the proximity to static voltage instability. Voltage instability is basically triggered by the reactive power defect at some of the system load buses due to the limitations on generations and transmission of reactive power Limitations on the generation of reactive power are to the limits on armature and field current of generators whereas the primary limitations on the transmission of reactive power are due to the high reactive power loss in heavily loads lines becoming more severe in case of lime outages. Therefore efforts should be made to minimize the total reactive power transmission loss in the system either by the existing means of corrective action like generation re - scheduling and /or using external reactive power compensating devices like Flexible AC Transmission Systems (FACTS) controllers [7]. However due to high cost of FACTS controllers and for effective control of stability margins these controllers should be optimally placed in the system. Traditionally the FACTS controllers have been planned in the system based upon the dynamic criterion to improve the transient and small - single stability margins. Some of the recent work in the static voltage stability area have evolved criteria for the placement of those controllers only the static point of view. However no effort has been made for the optimal placement of FACTS controllers with the aim of reactive power transmission, which

in turn should be helpful in improving the static vintage stability margin. For secure and stable operation of a power system adequate stability margins should be ensured not only for the normal loading conditions but for contingency conditions also .It requires that the ranking of all the credible contingencies be based upon some voltage stability criterion. Control actions can then be taken to increase the stability margin so as to avoid voltage instability and collapse due to likely contingencies. Limited efforts have been made in the literature [8,9] on condensing voltage stability criteria for contingency ranking and enhancement of voltage stability margin under contingencies. Some power systems are highly stability margin under contingencies. Since power systems are highly non - linear dynamical systems the popular analytical tool of non - linear dynamics i.e. Bifurcation theory has been widely used to study both static as well as dynamic voltage stability phenomenon. Saddle - node and Hopf bifurcations [10] have been recognized as main reasons although not the only ones behind the voltage instability problems. Saddle - node bifurcation is a static bifurcation resulting into a slow (but gradual) voltage drop whereas Hopf bifurcation is a generic case of dynamic bifurcation leading to oscillatory voltage instability .The proximity of a system model to the voltage stability boundary (with respect to saddle - node or Hopf bifunction) can be quantified in terms of the distance between the operating point and the cloest point on the bifurcation surface. Both interactive as well as direct methods of computing the cloest bifurcations in load parameter space have been demonstrated [11]. Further it has also been shown that some simplified power bifurcation occurs [12]. Therefore for the margin available with respect to the Hopf bifurcation. However to know the magnitude of margin available with respect to the Hopf bifurcation However very little efforts [13] have been made in predicting stability margin with respect to Hopf bifurcation. The exciter dynamics was considered with static loads ignoring the load dynamics. Voltage instability is load driven i.e. larger determined by load characteristics and available means of voltage control. But no effort has been made to include load dynamics into system modeling while calculating stability margin with respect to Hopf bifurcation. FACTS controllers have not only been found to increase the static voltage stability margins but have also been demonstrated to improve dynamic stability margin with control of bifurcation and chaos [12]. In practice it will not be viable to have two separate FACTS controllers one for improving static margin and other for improving dynamic margin and therefore a utility will like to use the same controller for controller both static and dynamic voltage stability margins. However no efforts seems to have been made in the literature to evolve a mixed static – cum - dynamic criterion for achieving the two goals simultaneously. Therefore the motivation behind the work presented in this thesis is: (i) To develop a method for the optimal placement of FACTS controllers in the system for minimization of total reactive power loss in the system network and to study their effectiveness in the enhancement of static voltage stability margin along with re - scheduling of reactive power sources. (ii) To develop a fast method for voltage stability based contingency remarking. (iii) To develop a method for determining the rating and optimal placement of shunt compensating devices and to investigate the effectiveness of such devices in improving static voltage stability margin under contingency conditions. (iv) To develop a new method based on optimization

technique to determine the closest distance to Hopf bifurcation taking into accounts both exciter and load dynamics. (v) To develop a method for optimal placement of FACTS controllers UN the system to improve both static and dynamic voltage stability margins simultaneously. A brief description of the reported in the thesis is given below: Chapter 1 introduces various aspects of voltage in this stability presents a survey of the relevant literature on the subject and sets the motivation behind the present work. In Chapter 2 sensitivity based method have been proposed for the optimal placement of FACTS controllers in the system. An Optimal Reactive Power Dispatch (ORPD) problem with an objective to minimize the total reactive loss in the system has been solved for determining the optimal setting of various reactive power sources transformer tapes and FACTS controllers which in enhancing the static voltage stability margin. Chapter 3 present an approach for the voltage stability based contingency ranking based on a new severity index termed as Reactive Violation Index (RVI) which utilizes a modified set of distribution factors for computing the reactive power outputs of sources during contingency. In Chapter 4 a simple approach has been suggested for determining the rating and optimal placement of shunt compensating devices for enhancement of static voltage stability under the contingency conditions. This utilizes the proposed reactive violation index (RVI) and a new set of sensitivity factors. Chapter 5 demonstrates a method of computing the closet distance to Hopf bifurcation in load parameter space formulated as an optimization problem - incorporating load dynamic in the system model apart from the generator and exciter dynamics. In Chapter 6, a static - cum - dynamic criterion has been proposed for the placement of SVC to maximize both static and dynamic voltage stability margins. The methods makes use combined participation factors obtained from the loss sensitivity factors computed in Chapter – 2 and dynamic state participation factors. System studies in Chapter 2 to 6 have been carried out on IEEE 30 - BUS system and an Indian system representing 75 - bus UP State Electricity Board Network respectively. Chapter 7 presents the main finding in this thesis and suggests few points for future research work.

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Title : *Load Compensation And Voltage Regulation Of Distribution System Using Dstatcom*

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Abstract

There has been a significant increase in the use of consumer electronics requiring switched mode power supplies and power electronic devices such as adjustable speed drive in the last couple of decades. These have caused a serious problem of harmonic pollution in power distribution system. The excessive harmonic current in the network causes voltage distortion, excessive neutral current flow heating of electrical machines and transformer and poor power factor. Therefore cleaning up the supply power is a challenging proposition. This has led to the evolution of various and compensation techniques. In the most primitive form of load compensation, passive LC filters were used. But passive LC filters have certain problems. They may create new series or parallel resonance. The number of passive filters required is same as the number of harmonics in the load currents to be eliminated. To overcome these problems associated with passive filters, active power filters were evolved by eminent researchers in 1970s. with the improvement in switching characteristics of power semiconductor devices, e.g. IGBTs, GTOs and their voltage and current rating, active power filter technology grew consistently. Filters are currently regarded as the most efficient option to solve problems created by non-linear loads. The sophisticated PWM inverter technology and the recently developed control algorithms helped the acid power filters to reach the sage of commercial installations. In 1978s, sampling and averaging techniques of load compensation were proposed by Gyugyi et al. [1]. These methods of loads compensation can only supply the fundamental reactive power of the load. However they are not suitable for time varying and/or non-linear loads. Out of many methods for generating the compensator reference current, the pq theory has gained considerable attention and is well established [2]. The compensation scheme based on the pq theory can eliminate all unbalances and harmonics caused by non-linear time varying load provided source voltage are balanced and sinusoidal and power converter has sufficient bandwidth track the reference compensator currents. However when the source voltages are unbalanced, the scheme does not provide satisfactory results. Furthermore, a reference current generation scheme is computations intensive due to αβ0 and inverse αβ0 transformations. On the other hand load compensation based on theory of instantaneous symmetrical components [3] is much simpler than pq theory. It does not require complex transformations of currents and can effectively control the phase angle of the source currents. The compensation based on generalized instantaneous reactive power theory [4is much more general. In this the instantaneous compensator current induces both the active and reactive power components. Nevertheless formulating reference current vector in terms of compensator powers makes the choice for

compensator powers more difficult and indirect. To realize the active shunt power filters, various distribution static compensators (DSTATCOM) topologies are used. A DSTATCOM consistsa three-phase voltage source inverter (VSI) that is driven by dc storage capacitor(s). The output of the VSI is connected to the ac system through three interface inductors or transformers. The point at which his connection is made is called the point of common cuppling (PCC). For instance in [3] a single dc storage capacitor and three single phase inverter with isolation transformers are used to realize actishunt power filters. In cases where the load contains dc current, the compensator must cancel it such that the current drawn form the source is a pure sinusoid. In this case topology presented in [3] will fail. Neutral clamped inverter topology [6] in which two dc capacitors supply the voltage source inverter (VSI) is not very effective for loads containing ac and dc components. The dc components of the current has a tendency of charge one capacitor and discharge the other. A threephase four-leg inverter with single dc storage capacitor topology [7] can be used for ac and dc load compensation but it passes inverter-switching components to the system neutral. The algorithms used for generating reference current usually assumed that voltage at PCC is stiff. However distribution loads are generally supplied through feeder. Thus if these algorithms are used for the generation of reference filter currents it results into erroneous compensation as switching frequencies of the inverter are passed to the voltages at PCC. Since these shunt algorithms assume balanced voltage, taking the distorted PCC voltage as an input to these algorithms results in distortion of source current too. The use of a DSTATCOM for load compensation is very common. In this the DSTATCOM compensates for the unbalance and distortion in the load current by injecting current to cancel these effects. In this thesis this is termed as the operation of DSTATCOM in current control mode. The DSTATCOM is however is much more flexible device the can also be used for controlling the voltage of a distribution bus against any distortion. This is termed as the operation of DSTATCOM in voltage control mode. Keeping in view the above considerations, we define the following objective of the thesis:1. To evolve a general algorithms for various kinds of shunt compensation schemes. 2. To find a suitable topology which words for compensations of load current with ac and dc components under balanced and unbalanced voltages. 3. To provide a control algorithms for load compensation when the source is not stiff. 4. To provide DSTATCOM control to regulate the bus voltage at a nominal value. Research has been carried out to achieve the above mentioned objectives and the major contributions of the thesis are: 1. A shunt algorithm is proposed based on generalized instantaneous reactive power theory [4]. This is called the generalized theory as all other theories e.g. pq theory [2], theory of instantaneous symmetrical components [3] can be derived from it. By appropriate selection of source power terms, we can obtain different kinds of compensation [8]. The general algorithms is then modified for load compensation under unplaced source voltages. The feasibility of shunt algorithms is demonstrated by realizing DSTATCOM using neutral clamped inverter. Its performance is studied both is steady sate and transient conditions. It is shown that the compensator exhibits the fast dynamic performance. 2. It is illustrated that when the load current contain dc components in additions to ac components. Voltages imbalance occurs with natural

clamped inverter that leads to erroneous compensation. To overcome this problems a new DSTATCOM topology is proposed [9] in which a chopper circuit is connected to the neural point of the dc capacitors. Various control schemes of chopper are proposed to regulate the voltage of the dc capacitors around a reference value. This ensures the correct performance of the compensator for load current containing dc components. 3. To overcome the voltage distortion problem when the source voltage is not stiff, fundamental of the PCC voltage is extracted and fed to the shunt algorithms. In addition a state feedback hysterics band controller is used for tracking control signal. An interesting feature of this control is than the inverter switching frequency components are highly attenuated in source current and the PCC voltage. It is demonstrated that for balanced and sinusoidal upstream source voltage, the proposed control gives excellent performance. The control scheme also produces satisfactory performance when the upstream source voltage is distorted. 4. An algorithms to operate DSTATCOM in voltage control mode is suggested which regulates the bus voltages nominal value. A dead beat control for switching of the inverter is used. The DSTATCOM is this mode is able to maintain the PCC voltage balanced and distortion free irrespective of distortion either in the source or the load side. OUTINE OF THE THESIS Chapter 1 introduces the concept of load compensation and voltage regulation using DSTACOM. A detail literature review is also presented. Chapter 2 begins with the discussion on general theory of shunt compensation. Various shunt compensation theories e.g., sampling and averaging techniques source current synthesis using capacitor voltage feedback pq theory load compensation using instantaneous symmetrical components theory and generalized instantaneous reactive power theory are described. It is shown that different compensation requirements can be satisfied with the generalized instantaneous reactive power theory. The general shunt algorithm is then modified for systems with unbalanced source voltages. All the above algorithms are verified through detailed simulation and experimentation with an ideal inverter. In chapter 3, various DSTATCOM topologies are described to realize shunt compensator for ac load compensation. Neutral clamped inverter topology is chosen for ac load compensation in the three phases, four wire distribution systems. The control loop for dc capacitors voltages is described. The state space model of the compensator is developed. The voltage source inverter is operated in a hysteresis band current control mode. Based on the state space model the simulation results for the steady state and the transient performance of the compensator are presented. The balanced as well as unbalanced source voltages are considered. The simulation results are also verified through experiments. A new DSTATCOM topology called neutral clamped inverter chopper topology is proposed for compensation of loads with ac and dc components in chapter 4. It is compared with other existing topologies. Due to presence a dc component in the load current he dc capacitors face voltage imbalance problem i.e., one capacitor discharges while the other charges uncontrollably. To solve this imbalance problem a chopper circuit is used. Various chopper control schemes are presented and they are verified through simulation. Some of the selected schemes are also verified through experiments. In chapter 5, load compensation with non-stiff source is considered. It is demonstrated that if any of the shunt algorithms for stiff voltage source is applied o a system with non-stiff voltage source

the PCC voltage gets distorted. To eliminate these distortions, a positive sequence voltage extraction algorithm is used and reference compensator current is calculated using the shunt algorithms described in chapter 2. These are used to form the reference state vector. A state feedback switching controller is then designed for tracking the reference state vector. This guarantees that the PCC voltages as well as the source perfectly balanced and sinusoidal. All the above points are demonstrated through digital simulation and experimental results. DSTATCOM that operates in voltage control mode to regulate the voltage of PCC is designed in chapter 6. The magnitude of the PCC voltage can be arbitrarily chosen while its phase angle is obtained by the dc capacitor voltage control loop. This control loop ensures that source supplies the active power to the load and losses in the inverter. It is demonstrated that under unbalanced and distorted source voltages and load currents, the PCC voltage is regulated at the nominal value. Detailed simulation and experimental results are also presented. The thesis ends in chapter 7 where the general conclusions derived from the thesis are presented and some scope for future work is suggested. The experimental set up used in the laboratory is given in the appendices.

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Title : *Soft Computing Application To Real-Time Navigation Of Mobile Robots In Stationary And Dynamic Environments*

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Abstract

Mobile robot navigation has been studied extensively for more than two decades. Initially recast into a problem of commotional geometry that was attempted by computer scientists and combinatorial mathematicians robotic navigation has developed into a v ery broad interdisciplinary field a chasm that ranges from systems and control engineering on one hand to pattern recognition machine vision and AI on the other. Mobile robots find divers applications today such as in automatic freeway driving of hallo ways terrain exploration and as aids for rehabilitating patients in hospitals .New frontiers include what are being called as cooperative robotics where a team of mobile robots cooperates to accomplish a set tasks human robot interaction and personal robotics where the primary objective is one of developing interacting personal and user - friendly mobile robots. For the various divers and ambitious applications listed above the essential components of a navigating system remain more or less the same .I t draw upon a sensing system through which the features of the local environment get stored a internal representations in suitable from such as maps or simply assuring data a planer module that figure out a collision free path based on these representation s and a well - level controller that translate the decisions output by the parameter to suitable voltage that actuate the transactional and rotational movements of the robot .A suitable feedback for estimating robot's own ego motion and its localization in an environment typically through sensors is also generally employed . This thesis is concerned principally with the path planning and the environment perception features of the navigation system (mobile robot). The phrase real - time navigation has been analogously used with the term path planning throughout the remaining contents of the report .By this we imply the ability of the mobile robot to trace a collision free path in the absence of prior information about is environment based on the features of the environment experienced through its sensory system (sonar or laser finders). Tradinationaslly three have been two approaches to the problem of finding a collisions free path. One is termed the global approach where the knowledge of the contents of the environment in terms of the location s of the objects present is available to the planner prior. This knowledge gets transformed into a model of the environment represented in terms of geometric structures such as the visibility gr aphvornoi diagrams and cellular grids. Atypical graph search on these structures levels the collision free path. The planning here is offline. The other local approach involves real - time obstacle avoidance based on online experiences of the environment. Since real - time navigation

is commonly encountered in day to day life where the ability of human intuitive reasoning figures prominently, soft computing approaches with their propensity for capturing figures prominently soft computing approaches with their propensity for capturing such intuitive/linguistic resonance have been found apt for navigation in unknown and uncertain environments. The main contribution of this dissertation can be viewed three fold. The first prominent contribution has been th e development of network architecture for incorporating cognition and remembrance properties during real time navigation of mobile robots. Specifically it deals with implementing a memory bade navigation strategy where previous experience of the environment play a significant role in deciding the future decisions of the navigation algorithm. In general most of the real time navigation algorithm typically decide the subsequent direction of robot motion based on the environment experienced at that instant and a few prior instances alone and hence lack a memory - based reasoning scheme .The specific features of such memory p - based reasoning include apart from real - time collision avoidance (I) spatial understanding of robots immediate environment or scaniro, (ii) memorizing of such scenario and their classification into attention (iii) an ability to focus on a primitive or a particular aspect of it through selective attention (iv) correlating a current experience of the world with a similar previous experience by recall from memory .These features enhance the robot's navigation capability through intelligent decisions due to spatial understanding scope recognition abilities by remembrance and detection of local minimum traps through place minimum barrier through paths shorter than those furnished by other methods that tackle the local minimum problem. The second significant contribution has been in the areas of receiving multiple dynamic objects moving amidst static ones. Motion planning in dynamic environment entails tracking the moving objects and predicting their further positions. However this requires as a first step classification of objects and predicting their further positions. However this requires as a step classification of objects present in the environment as static or dynamic objects a step that somehow seems to have been overlooked in literature dealing with navigation in dynamic environments. Presented in this thesis four approaches for perceiving the presence of dynamic objects and an explicate classification of the objects in the robot's neighborhood as static of dynamic .The first these approaches extends the network architecture used for memory based an experience of static or a dynamic object. The second method detects motion in the environment by observing changes stagy for representing the objects in the environment by observing change s in the map of the environment it bulbils and updates. The other two methods use a clustering a clustering strategy for representing the o objects in the environment through clusters. Inspecting the characteristics of the cluster reveals the dynamic objects. It is to be noted that for a sensor based moving robot the problem of accurately classifying an object as static or dynamic is an involved one .The non - triviality of the situation stems from the reason that apparent changes in the robot's perception of the environment may not only be due to the actual motion of the objects but also to a change in point of view of sensor. Distinguishing between actual moving actual moving objects and unclassified stationary objects seen from different viewpoints is not a simple one. The third contribution has been in the development of a distributed fuzzy logic based collision avoidance

system for avoidance of multiple dynamic objects .The classified objects from the strategies mentioned above is tracked in the subsequent instances. While an integrated fuzzy controller avoids the static objects the dynamic objects are tackled through the distributed approach where the fuzzy rules base distributes itself to act on each of the dynamic objects perceived and tracked. Several interesting cases that arise when dynamic objects are encountered in succession have also been investigated. Other explorations of the thesis includes an extension of the fuzzy clustering algorithms (FCM) over norms measures incorporated from robust statistics and learning navigation behaviour through an Adaptive Network Based Fuzzy Interface System (ANFIS). The traditional Education norm is known to be vulnerable in the presence of outliers when parameters are estimated through the lest squares method. M - estimators have been popular in robust statistics to improve the estimation of parameters under noisy data with outliers. Similarly the FCM uses the Education metric in its objective function and hence found susceptible to noisy data.A suggestion for robudstifying its performance by modifying its objective function through the M - estimators is another minor contribution of this work. Also investigated herein the feasibility of learning primary navigation behaviour through environment feedback modeled via ANFIS.

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Title : *Modelling And Control Of Conventional And Modified Buck Boost DC-DC Converter*

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Abstract

A good regulated DC power supply is needed for general purpose electronic products like microwave ovens, laser printers, medical instruments, stereos, televisions, electronic lighting, and personal computers to sophisticated equipment to be used in aerospace applications or satellite control equipment. A regulated power supply should be able to produce a constant output voltage without losing stability against load and supply voltage changes [1]. It is also desired that the regulated power supply is capable of tracking a change in reference command. Besides these, there are other considerations for a DC power supply. Miniaturization of the power supply is a growing requirement for space saving and cost effectiveness of utilities. Electromagnetic Interference (E MI) compatibility, loss minimizations, etc. are some of the other factors. A regulated power supply must be able to cater to widely varying loads and power supply conditions. This requires a closed loop control design of the converter that gives a stable operation for maximum possible loads conditions and supply disturbances at a reasonable high - speed. To design a closed loop controller for the converter and to study the stability of closed loop system, a mathematical model which describes the dynamics of the open loop system is required. The DC - DC converter is a switched piece wise linear circuit. Its input is duty ratio and output is the output voltage. In the solution of piecewise linear model, the duty ratio appears in exponential form. Therefore the input - output relation is nonlinear and not suitable for closed loop control design. Hence a suitable model must be obtained that can be used for control design. A model for the converter must be able to address following issues: • The equations describing the dynamics should be consistent with the actual behavior. • The mathematical equation must be in closed form that is suitable for closed loop controller design. • The model must be able to describe the converter operation for all possible operating points A number of models of converter operating in closed loop and open loop are proposed in literature. These models either converges to State Space Average (SSA) model proposed by Middle brook [2] or can be derived from the SSA. The SSA models, though simple, but have limited validity for perturbation around an operating point. This restricts the controller operation limits, i.e. the controller works only for a very small zone around the operating point. To handle larger perturbations, a better model is required. A n improvement in model prediction was reported in [3]. The average output voltage equation has been derived without averaging any circuit states and thus has a better performance than SSA. Using this linear model, a controller can handle larger perturbation compared to

controller designed on the basis of the SSA model of the converter. It is however desirable to increase the perturbation zone even further from the point of view of the robustness of operation. A closed loop controller has its parameters designed for a given parameter set of the system. If the system parameters are valid for a wider range, then the closed loop system will have large area of operation. The modeling error therefore must be as small as possible over a wide range. This requires a new model suitable for better control design. The closed loops system may have a number of performance indexes for achieving desired dynamic response, but the stability is of paramount importance. Normally, the nonlinear systems are linear zed using Taylor's series expansion. The linear model thus derived has a limited validity. To widen the validity zone, affined terms of Taylor's series expansion are taken in model. This makes the system nonlinear. Therefore nonlinear controller design techniques are applied to guaranty stability. The design philosophy of these systems can be based on Lyapunov's method [4]. The fast dynamics response is another important criterion for a regulated power supply. A number of research works are reported in literature for improving the speed of the closed loop response. There are two ways to improve the dynamic response – first by designing a better - closed loop control strategy as in [5] or by improving the topology itself [6]. In the view of the above discussions, the objectives of the thesis are as follows: • To derive a perturbation model of a given DC - DC converters, which has larger validity zone compared to the existing models. • To design a closed loop controller for the proposed converter - using model derived. • To explore the possibility of finding a new converter topology that can improve the dynamic response. • To design a closed loop controller for the proposed new converter topology. To achieve the above mentioned objective research work is carried out in this thesis. The major contributions of the thesis are (!) A new discrete time model has been derived. It has b been given the name of Bilinear Corner Point (BCP) prediction model. Let the end point refers to a point in time at which the switch is closed. The model is derived by expanding the equation of an end point in terms of the previous end point and duty ratio by Taylor's series. The bilinear terms are retained while the second and higher order terms are neglected, as the bilinear term's contribution is more significant. Based on the BCP model, a model for obtaining average of the voltage and the current is also proposed. A generalized converter model has been derived. This model has been called generalized as it is shown that the linear corner point model [3], the BCP prediction model and SSA models can be derived form the proposed model. All the models proposed have been verified by extensive simulation and experiments on a Buck Boost converter. The same modeling approach can however be extended to other DC - DC converters. (2) Closed loop operation of converter based on the bilinear model has been done and verified by extensive simulation and experimentation. The controller is designed based on feedback linearization using Lyapunov's direct method. A supplementary linear controller is also used. The linear controller can be designed using either pole placement technique or minimizing a linear quadratic performance index. (3) A multi zonal fuzzy controller based on bilinear model of the converter has been derived. The fuzzy controller has been verified by simulation studies. The fuzzy based controller has a larger zone of closed loop operation compared to feedback linear zed controller. (4) A new topology called modified

buck boost converter [7] has been proposed. This converter allows simultaneous opening of inductor charging switch and load capacitor charging switch. To do so, energy recovery winding with an uncontrolled diode or a switch is required. The steady state characterization of converter has been done at constant frequency operation by circuit averaging theorem and has been verified experimentally. The converter can be operated in buck or boost modes depending on the duty ratio of main and load switches. A small signal perturbation model of the converter has been developed. (5) A variable frequency closed loop control strategy for the modified buck - boost converter has been proposed. In this scheme, the inductor current and the output voltage are forced to operate within a pre - decided hysterics band. The load and supply changes are rejected at the cost of the energy recovery interval. The closed loop controller takes in account of cold starting and overloads conditions. (6) The proposed two switch modified buck boost converter has been extended for multiple output s. The steady state characterization of multiple output converters at variable frequency has been done. The closed loop operation of converter using hysterias controller at variable frequency has been performed. The feasibility and operation are established through simulation and experimentation.

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Abstract

Discrete Cosine Transform (DCT) based compression with its well-known advantages is being used in various applications. Especially, most of the international standards for image and video compression such as JPEG, H.261, H.263 and MPEG have recommended the use of the block DCT as a main compression technique. The DCT scheme has potential to be used as a compression scheme because of its desirable energy compactness property and relative ease of implementation. The performance of such a system at high compression ratio is limited by blocking artifacts. In DCT based compression schemes, the high compression ratios are obtained by discarding information about coefficients that are considered to be less important. This results in visible discontinuities along the block boundaries, commonly known as blocking artifacts. These artifacts often limit the maximum compression ratios that could be achieved. One main reason of blocking artifacts is that the blocks are encoded and quantized independently without considering the correlation between adjacent blocks. These blocking artifacts cause three types of noise in monotone area, staircase noise near the edges and corner outliers at the cross point of M X M blocks. Noise in block coding is correlated with the local characteristics of signal. Grid noise in monotone area, causing visually annoying artifacts, manifests itself as an artificial boundary among the pixels of adjacent blocks. An edge usually partitions an image into two monotone regions. Block coder can maintain continuity of edges within the blocks but cannot assure this across them. Furthermore, if the coder is not able to adequately represent the part of an edge within a block, then the degradation of an entire edge is increased. Therefore, edges tend to unsmooth in block boundaries and each side of an edge is no longer a monotone region. This is known as staircase noise. The ringing further increases the problem in edge area. Ringing is well known Gibbs phenomenon due to the truncation of high frequency components by quantization. Post processing of the DCT coded the images can reduce the coding artifacts and therefore it is a very promising research area. The main objective of post processing is to remove the coding artifacts with lowest computational complexity. As discussed above, the noise in block-coded images is correlated with the local characteristics of the signal; so space invariant filters are unable to exploit the correlation to reduce the noise. These filters are not suitable because they will blur the edge and degrade the visual quality of image. This is because most of the grid noise is out-of-band, while staircase noise is in the direction parallel to the edge. Signal bandwidth in monotone area is much lower than the bandwidth of the average spectrum of the edge blocks. Thus, this filter cannot remove the locally out-of-band noise in monotone area without blurring the edges. It is also found that the Human Visual System (HVS) is more sensitive to blocking artifacts in monotone regions than the edge region tends to introduce undesirable blur. For edge regions, smoothing of a few pixels around block boundaries by directional low pass filter is sufficient. Hence, space-variant or adaptive filtering depending on local image characteristics is preferable. The information about local image characteristics can be obtained from the image by edge detection or measuring the flatness of the region. Thus, one of the best approach for post processing is to classify the image blocks into various categories

and then each is processed by one or two-dimensional (2D) filter. Several post processing algorithms based on space-variant/adaptive filtering have been proposed to reduce the blocking effect of block coding system [1 - 4]. As discussed, linear space-invariant filtering is inadequate to remove these artifacts. Iterative methods such as Projection Onto Convex Set (POCS) and Constrained Least Square (CLS) are not suitable for real-time applications because of their greater computational complexity. Space variant adaptive filtering schemes requires the edge information extracted from the received blocky images which contain false edges due to the blocking artifacts. Recovery of loss of accuracy of DCT coefficient by discontinuity criterion is another method [5] to reduce the artifacts. But this method provides good results only in the monotone area. Thus, the algorithms proposed in the literature are not able to reduce the coding artifacts in various regions of image simultaneously with low computational complexity. Therefore, they are not suitable for real time applications. The performance of DCT based image compression scheme degrades at high compression ratios and most of the existing post processing algorithms are not able to give good results in this situation. Therefore, post processing algorithms with good performance at high compression ratios are much needed. This thesis addresses various post processing issues that may arise in practice: (i) reduction of coding artifacts; and (ii) computationally efficient methods to make it suitable for real time applications such as video and still image decoding. The coding artifacts are more visible at higher compression ratios but they can be reduced more efficiently than the existing post processing techniques. Various aspects of DCT based image compression and post processing methods are studied with a state-of-art survey on the subject. A number of post processing algorithms for reducing the coding artifacts are being proposed in this work. The first contribution of the thesis is the development of a hybrid scheme for post processing by clubbing the merits of several existing algorithms. Smoothing of artificial discontinuities due to blocking artifacts improves the image quality whereas smoothing of actual image edges degrades it. Thus, there is a need to satisfy these two conflicting requirements are simply as possible. The proposed algorithm includes advantage of adaptive filtering in edge area and block-boundary discontinuity minimization in monotone area along with the corner outliers reduction. The second contribution of the thesis is the design of a 2D multiple-notch (Both FIR and IIR) filter and its applications in reducing the blocking artifacts. These filters are designed with the goal of reducing blocking artifacts from DCT coded images. The third contribution of the thesis is to provide four computationally efficient algorithms for post processing of DCT coded images. In literature several powerful post processing algorithms have been developed to reduce blocking artifacts. However, from applications point of view, these are complex for real time applications such as video and still image decoding. These proposed algorithms can improve visual quality with improvement in peak signal-to-noise ratio (PSNR) with a very low computational complexity. The performance analysis and the simulation results show that the proposed algorithms are very competitive compared with those available in the literature. Summary of algorithms proposed in this work In the present work a number of algorithms for post processing of DCT coded images have been proposed. These algorithms can be summarized as: A hybrid scheme for the post processing of DCT coded images is proposed. The scheme is named as hybrid as the processing is done is both DCT as well as in spatial domain by two different algorithms. The scheme makes use of adaptive filtering in edge are and block boundary discontinuity minimization in monotone area. The use of a lower order signal adaptive filter and the block-boundary discontinuity minimization algorithm reduces the processing time. Corner outliers reduction schemes further improves the performance. In this scheme the compensating DCT coefficients for monotone

block are calculated and added to corresponding DCT coefficients to achieve minimum block boundary discontinuity. These compensating DCT coefficients for monotone blocks are calculated from the DCT of the block boundary pixel differences. In this calculation, some of the block boundary pixel difference are made zero if the neighboring block is an edge block. In the proposed scheme the edge information is extracted and used for the classification of image blocks. For edge blocks a signal adaptive filters performs the filtering along the edge to reduce the staircase noise. This filters also uses the same edge information (edge-map). It has been observed that the performance of this algorithms is better than the space variant filtering as well as the two individual algorithms used in the hybrid scheme. We have developed the design methods for 2D IIR multiple notch filter and some of its application are being proposed here. A simple algebraic method [6] is used for the design of this filters. In this design approach, firs two 1D multiple tone filters are designed as per the specifications of 2D multiple notch filter and then these two filters are used to obtain 2D multiple vertical line filters and 2D multiple horizontal line filter. Finally cascade of these two filters gives the desired 2D multiple notch filter. The design of 1D multiple tone filter is based on the design of all pass filters as discussed in [7]. Then two new applications of 2D multiple notch filters is being suggested. The possibility of using 2D multiple notch filter for reducing blocking artifacts fully examined. It has been shown that 2D multiple notch filter can eliminate the square grid. It can also reduce the blocking artifacts from DCT coded images. The concept of reducing blocking artifacts by 2D multiple notch filter is based on the fact that the discontinuities due to block artifacts in block decoded image have periodic structure which ultimately results is some peaks in the DCT domain. These discontinuities are highlighted in the gradient of the image and thus dominant peaks can be observed in the DCT of this gradient image. A 2D multiple notch filters can kill these peaks to remove the false edges from the edge map of blocky image. In additions to this as the discontinuities due to blocking artifacts are more visible in the monotone area, the tilter can be applied directly in these area's thus improvement in the performances of space variant/adaptive filter by the removal of false edges from the edge map and the reduction of blocking artifacts directly in the monotone area are the new possible applications of 2D multiple notch filter. We have extended the design approach of 2D multiple notch filter to FIR type. FIR filter are suitable for image processing applications as they cause less distortion due to their linear phase property. The drawback of FIR filter is that they cause more delay. The design procedure for the 2D FIR multiple tone filter is similar to IIR type of this filter but the desired 2D multiple notch filter is obtained as a complementary filter [9] of the 2D multiple tone filter. In this case two 1D FIR multiple tone filter are designed by windowed Fourier series method with Kaiser window. Various plots show that all 1D and 2D filter are obtained as per the design approach. This filter is also applied for the reduction of blocking artifacts and removal of false from edge of blocky decompressed image. The results obtained in case FIR filter are better than FIR filter, as expected. At the end of this work, four simple and effective algorithms for the post processing of DCT coded images are being proposed. Although these algorithms look simple but they are all to reduce blocking artifacts significantly without much computational complexity. The performance of these computationally efficient algorithms is better at high compressions ratios therefore these are suitable for low bit rate video and image decoding applications. First algorithms proposed in this part of the work reduces the blocking artifacts by exploiting the residual inter block correlation that exists in the received blocky image. For this purpose a signal adaptive filter is used to smoothen out a sub image of DC coefficient of all the blocks. The algorithms reduces the blocking artifacts with a very low computational complexity. The second algorithms reduces the blocking artifacts significantly by capturing the discontinuities due to blocking artifacts in the new blocks

(made by the re-division of the image) and removing them in the DCT domain by selective attenuation of AC components corresponding to these discontinuities. These two algorithms together reduce the blocking artifacts considerably with slight improvement in PSNR. It has been verified by calculating the various discontinuity measures. In the third algorithms the discontinuities are captured in the same way but the singular value decomposition (SVD) based filtering scheme is sued for their reduction. This algorithms is very effective for reducing blocking artifacts but its computational complexity is slightly more because SVD algorithms is applied to each monotone block. Fourth algorithm proposed here is again a DCT domain algorithm. It reduces the blocking artifacts by eliminating some selected DCT coefficients of concatenated block of two adjacent blocks. The algorithm has low computational complexity, because no filtering is required. The availability of fast algorithm for DCT computation makes this algorithm suitable for low bit rate video and image decoding applications. In this algorithm only the first row and fist column of concatenated block are selected for elimination, which further reduces the computation time. The result show that this algorithms provides very good performance with minimum computational complexity. Motivations Therefore the motivations behind the work presented in this thesis are: • Uncompressed video and audio data are huge and there is a big problem for their storage and network communication. Therefore data compression is required. As the compression ratio of loss less methods (e.g., Huffman, Arithmetic) is not high enough for image and video compression a lossy compression scheme that can provide higher compression ratio is needed. • Very good energy compaction and decor relation properties of DCT motivated to work on the DCT based image compression scheme. The performance of DCT based compression scheme is limited by blocking artifacts. So the main objective was to find a DCT based scheme that can minimize these blocking artifacts. • Most of the existing popular standards for image compression also use DCT based image compression schemes. This was also one of the main reasons for taking up this problem. Although at the beginning a number of possibilities of modified coding schemes are studied but looking at these existing standards the work is centered around the post processing of DCT images. • DCT-based image compression is very popular and finds various applications. Improvement in quantization, encoding and post processing scheme over other schemes in many applications. • Low bit rate coding applications motivate to find computationally efficient algorithms for post processing of such images. Organization of Thesis Chapter 1 introduces various aspects of data compression with an overview of DCT based image compression scheme. Various methods of post processing of DCT coded images are discussed and a state-of-the-art survey on the subject is presented. In chapter 2, a hybrid scheme is presented which takes advantages of adaptive filtering in edge area and block boundary discontinuity algorithms in monotone area. Chapter 3 presents an approach based on space-variant/adaptive filtering. In this approach a 2D IIR multiple notch filter is designed from 1D multiple notch filter. This filter is applied to reduce the blocking artifacts from DCT coded images either by improving the classification scheme or by directly filtering the blocking artifacts in monotone areas. In chapter 4, the design approach presented in chapter 3 to 2d multiple notch filter is extended to FIR type filter. This filter is also applied to reduce the blocking artifacts from DCT coded images as in chapter 3. Chapter 5 is devoted to some new computationally efficient algorithms. Four algorithms to reduce the artifacts in DCT domain are presented. Chapter 6 concludes the major contributions of this thesis and suggests the scope for future research work in this area.

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