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NSERC CRSNG

ASPIRE | *Applied Science in Photonics and Innovative Research in Engineering*

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ABSTRACTS

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Optimal Filter Placement and Sizing Using Ant Colony Optimization in Electrical Distribution System

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Abstract **-** Renewable energy is growing fast these days. One of the most challenging problem deals with the renewable energy is the harmonics produced by their power electronic converters. This presentation presents an application of the Ant Colony algorithm for optimizing filter placement and sizing on a radial distribution system in order to reduce power losses and keep the rms voltages and the corresponding total harmonic distortion (THD) to lie within prescribed limits. First, a harmonic load flow (HLF) algorithm is performed to demonstrate the effect of harmonic sources on total power loss. Then the Ant colony algorithm is used in conjunction with HLF to place a selection of filter sizes available at each possible location so that both power loss and THD are minimized. As a result the optimal adjustment of location and size of the filter are determined. Results demonstrate improvement and effectiveness of using the filters at optimal location.

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Real Time System To Process Digital Images

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Abstract – Real time image processing has gained lot of attention lately because of the wide usage in new commutation such as video conference, video calls, media, digital cameras and mobile cameras. Because of this, image identification has become popular topic recently. The goal of our work is to develop a real time digital image processing system, which aimed at feature identification and classification.

Our work contains a toolbox that includes a number of different filters, including classical high and low pass filters as well as a number of novel morphological filtering tools. In subsequence work we will add edges and feature detection algorithms.

In this work we present the first phase of the work of noise removal from noisy images (signal to noise ration of 10% or more). Noisy images are created and then a variety of filters including mean, median, erosion, dilation, open and close filters are applied. These filters are then used to denoise the original images. Erosion and Dilation filters are the two basic filters in the area of mathematical morphology. However we have used them in gray scale level, although they are usually used in binary pixels level. The Mean and Median filters do similar job, except the median filter preserve more important details in a processed image than mean filter does.

We have developed and structured our work in C# as a second phase of the work. That provides our real working application/framework. Now, processing variety medical images can be done easily. This frameworks brings to light the main goal of our work. We are aiming to help radiology trainees or radiologists to detect abnormal tissue such as tumor or cancer.

The initial work was done in Matlab and then ported to C#. In the final phase of the project, the core image processing library itself.

Index Terms – Real-time; morphology; Segmentation; Mean and Median filters; Erosion and Dilation filters; Matlab, Median and Mean filters; Image processing; CUDA; C#; C++.

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Multi-Resolution Transmissions in Multicast OFDMA Wireless Networks

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Abstract – With more advanced signal processing at the base stations (BSs) and mobile stations, cellular systems operators better utilize spectral resources and can offer more advanced services including multimedia streaming. Of great interest in this area are multicast services that deliver content to multiple users simultaneously with a fraction of the resources required by unicast data services. Video streaming over wireless channels has been a great challenge for many years in the context of point-to-point communications and is even more complex in point-to-multipoint transmissions. Some of the issues in the latter area have been addressed when developing the cellular standard for Multimedia Services over Long Term Evolution (LTE). However, because multicast provides great value to both customers and service providers, even more spectrally and power efficient algorithms are required to support never ending demand for bandwidth and higher quality-of-experience, e.g., higher resolution video streams.

For these reasons, our research is focused on designing resource allocation algorithms for wireless multicasting with Orthogonal Frequency Division Multiple Access (OFDMA) which will balance fairness among users and maximize the throughput within limited spectrum and power resources in the cellular systems. One of our objectives is to exploit unequal nature of bit importance that characterize compressed multimedia streams and use different techniques for Unequal Error Protection (UEP). Specifically, in our research we will develop adaptive multi-resolution coding for the multimedia data. Our scheduling algorithm will be comprised of two phases: In phase one: *Frequency Allocation*; based on multicast group members channel conditions, best frequency blocks will be assigned for each multicast group of users. In phase two: *Bit allocation*; using multiresolution coding and multicast group channel state information, bits will be allocated to different frequency blocks to represent data for users in different zones depending on their distances from the BS.

Index Terms – Orthogonal Frequency Division Multiple Access (OFDMA), Relay Node (RN), Frequency Allocation, Bit Allocation.

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Uplink Medium Access Control and Power Allocation in MU-MIMO Systems

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Abstract – Wireless communication has evolved over the last decade and various standards for different systems have been released. The enhanced performance of these new systems is based on multiple-input multiple-output (MIMO) techniques which deploy multiple antennas and, with advanced signal processing, provide single user capacity increases. In recent years, research into MIMO systems is focused on improving multiple access with the use of spatial division multiplexing (SDM). Specifically, multiple parallel spatial streams between base stations (BSs) and multiple mobile stations (MS) are taken advantage of in this multi-user MIMO (MU-MIMO) model to maximize the system capacity. However, MU-MIMO is currently utilized only in downlink transmissions, from BS to MS, because of limitations in utilizing the channel state information (CSI). Henceforth, uplink transmissions with the corresponding medium access control (MAC) and resource allocation are considered as an open problem and are the focus in this research.

The multi user decoding process in the uplink MU-MIMO communications is performed at the BS after receiving the mixed signals that originated from multiple MSs simultaneously transmitting within a common spectrum. Performing zero-forcing (ZF) type of post-processing in uplink MU-MIMO enhances the noise and multiple access interference (MAI) and this problem has not been addressed in conventional (single user or rather single spatial stream oriented) MAC systems. Even though practical implementations of similar MU systems, such as Orthogonal Frequency-Division Multiple Access (OFDMA), have heavily investigated MAC and resource allocation problems, the resulting algorithms cannot be directly applied in SDM due to the fact that the channel gains are dependent on the selected/enabled antennas and this is the area of our investigations.

This research addresses the cross-layer SDM scheduling problem for a MU-MIMO system by proposing a centralized user/antenna/power selection algorithm with a low complexity, while maintaining acceptable performance. This is done by dividing the algorithm into stages, where every stage is assigned a certain limit on the number of spatial streams that could be occupied by a single user. Moreover, the MSs' buffer state information is feedback to the centralized scheduler to provide better fairness and less buffer overflow.

Index Terms – Multiuser multiple-input multiple-output, resource allocation, medium access control, cross layer protocol, zero forcing, and multiple access interference.

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Dielectric Micro-spheres/cylinders Based Super-resolution Optical Microscope

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Abstract – We study the photonic nanojet effect of a micro-scale dielectric cylinder or sphere in this work. Photonic nanojets was first studied in 2004 [1]. Theoretical study predicted that photonic nanojets could be observed when a plane wave propagates through a micro-scale circular dielectric sphere or cylinder. Since then, various numerical and experimental studies were conducted in the past decade. In 2011, researchers [2] designed a super-resolution nanoscope which is capable of resolving 50 nm features using the photonic nanojet effect.

However, all these studies only focused on regular micro-spheres or micro-cylinders with a smooth surface. In this paper, we study the optical resonances in surface-nanostructured dielectric micro- cylinders and the characteristics of the generated photonic nanojets. Numerical solutions were obtained for two types of dielectric surface-nanostructured micro-cylinders. A detailed analysis was carried out to characterize the performance of the nanostructured micro-cylinders. We also consider the impact of surrounding mediums on the generated photonic nanojets.

In conclusion, we found that the surface profile of a micro-cylinder has a significant impact on the obtained photonic nanojet. No photonic nanojets can be observed in some cases. This result enables one to obtain a better understanding of the photonic nanojet effect in practical applications. It also provides guidance when using photonic nanojets for probing or super-resolution imaging etc.

Index Terms –Super-resolution, Photonic Nanojet, Dielectric micro-sphere/cylinder, Optical resonance

[1] Z. G. Chen, A. Taflove, and V. Backman. “Photonic nanojet enhancement of backscattering of light by nanoparticles: a potential novel visible-light ultra-microscopy technique,” Opt. Express 2004; 12, 1214 – 1220.

[2] Z. B. Wang, et al. “Optical virtual imaging at 50 nm lateral resolution with a white light nanoscope,” Nat. Commun. 2, 218 (2011).

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Grating assisted surface plasmon waveguides

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Abstract – The field of plasmonics, studying the behaviour and use of surface plasmon polaritons – collective oscillation of electrons; has been getting more attention recently with the incessant push for smaller and faster devices. Plasmonics can serve as an extension of both photonics and electronics; keeping the operating speed in the phonic GHz to THz range while still retaining the submicron dimensions of electronics. It is therefore necessary to explore possible plasmonic components materials and configurations.

One of the key components is the plasmonic waveguide. Generally, a slab of conductor (metal) between two dielectrics or slab of dielectric between two conductors is used to couple two surface plasmon polaritons. This work explores the properties of such waveguides with the option of having a grating on top of the waveguide. The grating can either serve as a coupler, guiding incident light in and out of the structure by wavevector matching or can be used to alter the guided modes by increasing/decreasing resonance.

The principle is illustrated by analytical derivation of the modes for the grating-less waveguide and numerically calculated for the gratings. The method used is the RCWA – Rigorous Coupled Wave Analysis; a method where the grating profile is represented as Fourier series.

Index Terms –Plasmonics, Surface plasmon polariton, Waveguides, Gratings

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Exciting Surface Plasmon Polaritons with Partially Coherent Light Sources

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Abstract – Surface plasmon polaritons (SPPs) are surface electromagnetic waves generated by the incident light at a metal-air interface. If excited, the SPPs can enhance the electromagnetic field in a small area. Using coherent laser beams, different tools have been utilized to focus SPPs such as plasmonic lenses, dielectric gratings and interface embedded nanoparticles, fabricated by etching geometric patterns and structures on the interface.

To mitigate the high power requirements and low efficiencies often associated with various coherent sources, partially coherent light sources are commonly used. Such sources include white light sources, thermal light sources, light-emitting diodes (LEDs) and superluminescent diodes (SLDs) among others.

In this work, we propose to explore the SPP focusing by using partially coherent light sources, both spatial and temporal. Polarization effects will be taken into account, especially for radially and linearly polarized cases. Polarization controlled focusing and manipulation of SPPs generated by partially coherent light sources has the potential to enable a designer to realize more efficient SPP enhanced optical modalities than are available to date with coherent sources.

Index Terms – Surface Plasmon Polaritons, LED, SLD

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Improving Joint Random Access Satellite Communications via Iterative Demodulation and Channel Estimation

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Abstract – With the expanding prevalence of mobile communications and interactive services, satellites are gaining more attention as competitive infrastructure for wireless data services. In such situations it is typical for a large number of un-coordinated, mobile, low-cost, earth-based transmitters scattered over a large geographic area to connect intermittently to a single receiver over the satellite channel. This configuration fundamentally results in a random access scenario, where a large number of potential users contend for access to limited channel resources. Complexity is increased due to the geographic spread and localized weather effects which make it possible for each user have its own independent channel that must be estimated to ensure a high level of system performance.

This scenario is investigated with emphasis on employing joint detection and multiple packet reception techniques at the receiver to surpass the capacity of the single user channel in high density multiple user satellite communications. These techniques are utilized in conjunction with iterative estimation and advanced interference cancellation to develop an iterative receiver that jointly demodulates the received data and estimates channel state information for each active user. Estimates of the transmitted data are used as soft pilots to provide more accurate estimates of the channel state information; allowing for more complete interference cancellation in the multi user environment. This improved interference cancellation allows the system to support a higher number of concurrent users compared to conventional receiver structures.

Index Terms – Multiple Access, Random Access, Satellite Communications, Joint Detection, Iterative Processing

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Higher Precision Clock-Less ADC Using Wavelet Neural Network

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Abstract – A continuous-time system is studied that converts analog input to a continuous-time (CT) digital representation without sampling, and then processes the information digitally without the aid of a clock. As the conventional digital signal processing (DSP) suffers from aliasing and quantization noise, in this research we develop higher precision Clock-less ADC using Wavelet Neural Network (WNN). The input signal will be encoded by a delta modulator without clock into a series of non-uniformly spaced (Quanta) when a quantization level is crossed, which are processed by the digital signal processing in CT and converted to an analog output using a custom DAC that guarantees there are no glitches in the output waveform. ADC quantizer resolution and number of Quanta based on the rate change of the input signal constitute great challenge in CT. The CT systems suited for burst-like signals and low power applications such as those in hearing aids, ECG for monitoring and pacemakers, and neuron sensing for implantable prosthesis processing, as with an inactive input, the CT-ADC waits for a change in the signal while dissipating no dynamic power. Also CT-DSP offers the advantages of noise immunity and programmability as in conventional digital systems but without the use of a clock. Furthermore, no sampling is used; thus, no aliasing occurs.

In this dissertation, we propose a new method to realize a high precision ADC-CT converter with the same circuit design of the low precision ADC-CT with computation WNN technique for calibration, based on two stages. In the first stage, the input signal is converted to CT digital codes. In the second stage, the quantization error or residual signal of the CT-ADC and resample DAC are calibrated by WNN to get higher precision CT-DAC. Because of the quantization error, the CT-ADC possesses strong nonlinearity. Therefore, WNN has been employed to remove errors from ADC converter. Also, WNN incorporates the good and fast learning ability and generalization of NN and the good property of localization of wavelet transform.

The system has been design on 4 bits continuous-time ADC, which is simulated in Matlab by 16-level crossing with an ideal comparator using $(1\ V_{pp})$ and a clock resolution ($R=10^{7.18}$). The modulator has sampling clock of 28.5 Mhz. It achieves a dynamic range (DR) of 183.1 dB with Effective number of bits (ENOB) of 13.2 bits, Signal-to-Quantization-Noise Ratio (SQNR) of 81.3 dB, and a signal to-noise-and-distortion ratio (SNDR) of 132.6 dB over a 1.5 MHz input signal bandwidth (single sinusoidal).

Index Terms – Analog-to-digital converter (ADC), continuous time digital signal processing (CT-DSP), Wavelet Neural Network (WNN), Digital-to-analog converter (DAC), Neural Networks (NN)

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The Resistive Superconducting Fault Current Limiters Application and Effect on the Power Protection System

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Abstract – Due to the natural growth in demand for the electrical systems, the added network and generators to the electrical network systems will increase the occurrence of the expected fault current rate.

Power systems with high power-dense are often safety-critical. Power system protection is an obvious challenge in these systems. A smart solution to many of the problems faced is proposed by resistive superconducting fault current limiters (SFCLs).

The objective of this thesis is to use and implement the technology of resistive SFCLs. The focus related to the application of resistive SFCLs will be studied including the resistance rating, recovery period, location, and interaction with the protection systems.

The effects of the resistive SFCL technology on the protection system will also be analyzed to express the benefits of the resistive SFCLs including; the instantaneous response to network faults, the enablement of renewable generation connection, the cutting of capital and operating costs of the grid, the prolonging useful life of network plant, the enablement of capacity increase and lastly, minimizing the costs of upgrading electricity distribution and transmission networks over the next twenty to thirty years.

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Analysis of DFIG Tidal Turbine Fault Ride Using Superconducting Fault Current Limiter

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Abstract – Global awareness is being shifted towards renewable energy, as it is a safer, cleaner and a more efficient way of power generation and sustainable to the planet. Tidal and wind energies are relatively new sources of energy that have been gaining popularity due to their huge potential. Therefore, it is very important to make sure that they maintain connectivity to the grid during faults to avoid possible blackouts.

The doubly fed induction generator (DFIG) is one of the main types of generators that are widely used for tidal turbines. This is why it is used as the main generator type in this study as it would be most useful. Different system components are in use for safety and limiting fault current, such as circuit breakers and fuses. The Superconducting Fault Current Limiter (SFCL) resistance type is a method of limiting the fault current level, hence increasing safety and protecting other systems component, as well as improves the Fault Ride-Through (FRT) ability of the generating source.

The aim of this thesis is to show using research and simulations that the SFCL can indeed improve the FRT of the tidal turbine DFIG. The tests and simulations are done using MATLAB. The simulations will be done in fault conditions to observe the stator and rotor currents, with and without the SFCL. Moreover, the voltage shape and dips at the DFIG terminals will be measured and observed. Also, the SFCL resistance value will be changed and its effect will be analyzed. The expected results are that the SFCL will decrease fault current, the voltage dip at the DFIG terminals and the reactive power consumed by the grid.

Index Terms –SFCL, DFIG, FRT

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A Wave Equation Based Unconditionally Stable Explicit FDTD Method

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Abstract – Many numerical methods have been developed and are used in solving Maxwell's equations for electromagnetic structures. Among them are the explicit march-in-time numerical methods such as the finite difference time domain (FDTD). The explicit methods are normally free of matrix solutions and can provide a wideband solution with a single run of simulation. In additions, field behaviors can be observed in the time domain, a natural dimension in which a physical event occurs. As a result, both linear and nonlinear phenomena can be modeled naturally and easily.

However, time steps of these explicit numerical methods are restricted by the well-known Courant-Friedrichs-Lewy (CFL) condition. It places an upper bound or limit for the time steps. If a time step chosen larger than the CFL limit, numerical solutions will become unstable and divergent as they march in time. The limit depends on sizes of numerical spatial discretization and properties of the medium to be modeled. The smaller the spatial discretization (or finer the numerical grids), the smaller the limit. As a result, the CFL condition may cause long, sometimes prohibitively long, simulation time due to the small time step that has to be taken.

To address the issue, extensive research efforts have been made recently in circumventing the CFL condition by developing implicit FDTD methods or removing the CFL-caused instability. Take the well-known finite-difference time-domain (FDTD method) as an example, the root cause of numerical instability is investigated based on the eigen-matrix theory and Z transformation. It turns out that numerical field solutions of the FDTD method are linear combination of spatial eigen-vectors (or eigen-modes) of the FDTD system matrix. Whether a mode is stable or unstable depends on its corresponding eigen-value. As a result, we can discard the unstable modes and keep the stable modes to make a stable FDTD solution. In this presentation, we apply this theory to formulate the wave-equation based FDTD solution where electric and magnetic fields are solved in a decoupled and recursive manner without numerical instability.

Index Terms –Finite Difference Time Domain (FDTD), CFL condition, Numerical Stability, Eigen-Decomposition

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Fuzzy Model Based Control of Nonlinear Systems

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Abstract– Takagi-Sugeno (TS) fuzzy modeling framework supported by a parallel distributed compensation (PDC) approach is well suited for the control of nonlinear systems with guaranteed global system stability. The control scheme uses the sector nonlinearity method to represent the nonlinear terms in the physical plant model as fuzzy membership functions thereby decomposing the plant into various subsystems defined by the fuzzy rules. For each fuzzy model rule, a corresponding control rule is defined that has the same premise part but uses a linear state feedback control law in the consequent part. The local control gains for all model rules are found by solving a set of Lyapunov conditions sharing the same common positive definite matrix to ensure the global stability. A weighted combination of these local control gains based on the TS fuzzy inference mechanism yields the net gain for the plant.

This work is concerned with the application of aforementioned control scheme for balancing task of rotary inverted pendulum. TS fuzzy model of the simplified plant is first constructed using sector nonlinearity approach. A guaranteed cost TS fuzzy PDC optimal controller is then designed using LMI toolbox of MATLAB. The designed controller is experimentally evaluated on a 'Quanser Qube Servo' platform where it is compared with linear optimal controller which is also designed using LMI toolbox of MATLAB under the same design conditions. It is shown that TS fuzzy optimal controller shows better performance even though it is designed based on a simplified plant model.

Index Terms–Nonlinear systems, TS fuzzy modeling, Parallel distributed compensation, Optimal control, Rotary inverted pendulum

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Low-voltage and low-power Continuous-Time Current-Mode Multiple Loop Feedback Filters

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Abstract- Emerging technologies such as ultra wide band wireless access technology that operate at ultra-low power present several challenges due to their inherent design that limits the use of voltage-mode filters. Therefore, Continuous-time current-mode (CTCM) filters become very popular in recent times due to the fact they have wider dynamic range, improved linearity and extended bandwidth compared to their voltage-mode counterpart making them more suitable for low-voltage/low-power applications.

Several approaches such as the use of operational transconductance amplifiers and capacitors, utilization of grounded capacitor at the gate of a transistor to approximate an integrator were being used to realize CT filters. Both of these approaches have several problems in achieving a filter that would work at a wide range of frequencies. To address this issue, this work introduces a CTCM differentiator using the TSMC 65 nm CMOS technology as an alternative to existing integrator circuits. This CM differentiator exhibits higher stability and lower flicker noise than the voltage-mode integrator. Bilinear as well as biquadratic building blocks based on the differentiator have been introduced. These basic building blocks are then used to implement higher order filters using the cascade and multiple-loop-feedback (MLF) structures such as the follow-the-leader feedback (FLF), inverse-follow-the-leader (IFLF) and combination of both. MLF methods improve the performance and also the sensitivity of the filters.

A 6th order CTCM Chebyshev bandpass filter has been designed using the cascade and the MLF structures. Monte Carlo analysis will be used to compare the sensitivity performances of the resulting realizations.

Index Terms – Continuous-time current-mode filters (CTCM), Multiple loop feedback (MLF), Follow the leader (FLF), Inverse follow the leader (IFLF), Current mode filters (CM).

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Medical Nano Robots: Solution to Human Health

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Abstract – Medical field is the one of the most challenging and demanding are of research now days as there are lots of diseases, which are not curable. Even though scientists have treatments for them then many of the medical treatments are painful and/or open gates for another problems in a human body as the time passes. Nano robots are expected to enable new methodologies in diagnosis, medical therapies and minimally invasive surgeries. Nano robots can be useful to prevent damage to body during treatment of incurable diseases like cancer, Alzheimer.

Chemotherapy, Surgery and Radiation therapy are being used to cure cancer. All the techniques have their disadvantages. Chemicals are used to destroy unregulated DNA, which can cause other cancer and can damage bone marrow. Surgery is not ideal situation for in vivo cell growth and in radiation therapy radio waves are used, which are one main cause of cancer.

Nano robots can provide efficient early diagnosis of cancer and useful in drug delivery and reduce the side effects of chemotherapeutic process. As cells and DNA are the reasons for cancers, Nano robots can be injected into human body through injection to destroy unwanted cells and DNA. Chemicals, thermal and fiber sensors can be used to identify the effected areas. And all effective cells can be treated or destroyed using advanced drug delivery.

Nano robots can also be used in Advanced drug delivery, in which specific drug will be loaded on to Nano robots and they will drive through the blood streams and will reach to the specific target. We may control these tiny creatures from outside and able to drive them in blood streams with preloaded path following algorithms. Blood pressure is the main factor we need to consider while driving Nano robots in the blood streams.

Index Terms: Nano Robots, Nano Medicines, Advanced drug delivery

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Computationally Efficient Super-Resolution Algorithm of Microscopic Images

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Abstract – Super resolution image can be obtained from combining several low resolution noisy and blurred images. We propose an efficient algorithm to produce super resolution microscopic image through which Complete Blood Count can be obtained. The low quality input images are acquired from a prototype lens-less microscope with sub-pixel shifts. In the proposed algorithm, accurate sub-pixel motion between images is essential for reconstructing the image. Mean shift and add approach is applied to enhance the resolution of image and optical flow method is used for registration of images. The proposed method is applied to each color channel separately. The results show less time cost and memory consumption than those of existing methods and experimental results with real-life images shows significant improvement in quality of images, which are comparable to those from a compound microscope. Segmentation of red blood cells, white blood cells and platelets can be analyzed through the results obtained from our method in our future research.

Index Terms –Image resolution, Image motion analysis, Image reconstruction, Image registration

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To Extract Cole-Cole Impedance Model Parameters Using Fractional Order Switched Capacitors

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Abstract– This research focuses on Extracting Cole-Cole impedance parameters for biomedical applications using switched-capacitor (SC) realizations of fractional order (FO) differentiator and integrator. There are many s-z transformations available in the literature. An optimized s-z transformation technique that yields discrete-time differentiator and integrator with zero phase and magnitude errors has been proposed in the literature. This optimized s-to-z transformation will be expanded for fractional powers [1] using continued fraction expansion (CFE). The stabilized models thus obtained for FO differentiator and integrator are then realized using SC circuits.

These fractional order differ-integral circuits will be arranged in a ladder fashion to realize a FO capacitor. A FO circuit to measure the Cole-Cole impedance of biological tissues (impedance of FO) has been proposed in [2]. This circuit consists of a constant phase element (CPE) is also known as FO capacitor that is designed using approximation of passive RC ladder circuits. This (CPE) is replaced with the proposed FO capacitor that is realized using SC circuits described earlier. The simulations of these mathematical results, obtained by MATLAB, are then compared with their continuous-time counterparts. The performance of both designs involving active and passive components will also be evaluated in this thesis.

These mixed-mode realizations of FO differentiator and integrator using SC technique have potential applications in the development of FO circuits that can be used in biochemical and medical applications.This research could also be extended to the production of highly robust control applications.

Keywords*:* Fractional order circuits, Fractional capacitor, switched capacitor circuits, Biomedical applications

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A Novel Asymmetrical SRAM Cell Tolerant to Soft Error

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Abstract – As technology advances and the size of Static Random-Access Memory (SRAM) chip decreases, Single Event Upset (SEU) has become a severe problem that affects the reliability of the circuit. For SRAM design, traditional 6T memory cell is very vulnerable to radiation strikes or single node upset. With the decreasing size of transistors and circuits, the charge deposited by a radiation strike can be simultaneously shared by multiple circuit nodes. The direction of a particle strike can influence the amount of charge deposited and the value of Linear Energy Transfer (LET).

Different approaches have been proposed to address the SEU problem. For RHBD storage cells design, different cells structures have been proposed, among which Dual Interlock Storage Cell (DICE) is most favorable. Many previously proposed hardened structure are based on DICE. But in advanced technology, DICE cell is very sensitive to SEMNU and become less effective to mitigate SEU and Quatro cell becomes more favorable. It is reported that Quatro cell exhibits better soft error rate than DICE cell in 40nm technology. Another RHBD technique named Layout design through Error-Aware transistor Positioning (LEAP) is proposed, and reportedly it has got significantly better soft error rate.

In this work, we propose a novel asymmetrical 11T SRAM cell design that has fault correction capability. In addition, the Layout design through Error-Aware transistor Positioning (LEAP) technique is adopted in designing the layout of this proposed 11T cell. The area of the proposed 11T cell without using LEAP technique (regular 11T) is 76% larger than that of traditional 6T cell and 16% larger than that of the Quatro cell. The area of 11T cell with LEAP technique (LEAP-11T) is 15% larger than that of regular 11T cell and 103% larger than that of 6T cell. Simulation results show that the error cross section of regular 11T is 17X lower and 2.8X lower than that of traditional 6T at LET = 10 and 30 MeV-cm2/mg respectively in normal strikes; and it is 2.2X lower than Quatro cell when LET = 30 MeV-cm2/mg in normal strikes. With LEAP technique implemented, the LEAP-11T cell's error cross section is 6.5X lower than the Quatro cell when LET = 10 MeV-cm2/mg in angled strikes.

Index Terms –Single Event Upset (SEU), soft error, SRAM cell, LEAP

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Predictive Grid Control based on the Economics Modeling

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Abstract – The electrical grid has grown to cover the entire continent, providing almost everyone with a reliable source of electricity. The demand and consumption for electricity have substantially increased annually over the last 20 years. However, the electrical infrastructure has remained unchanged for about 100 years. Meanwhile, energy crisis worldwide and environmental deterioration increasingly challenge the current power system. A main trend has started what may become a paradigm shift in the way that power systems are designed and operated: the addition and rapid growth in renewable energy systems as sources of supply.

As an important source of renewable energy, solar energy is utilized directly to be converted into electricity by photovoltaics (PV). With decreasing prices, solar electricity continues to grow its share of the global electricity mix. While it becomes increasingly important to understand the technical challenges facing high penetrations of solar electricity, especially the effects of its variability with respect to the reliability and stability of electric power systems. Meanwhile, the need for an optimal forecasting of electricity production is becoming to prepare the integration of PV systems in the electricity markets.

Our ultimate goal in this project is to analyze the economic value of predictive analytics and predictive PV control solutions developed by Green Power Labs on power distribution grid operations. The solar prediction information will be effectively used without changing existing hardware. Specially, three different cases are considered: 1) better management and control of existing grid assets (on load tap changers, capacitor and reactor banks) in a distribution grid with high penetration of conventional (non-controllable) PV power generation assets based on predictive data; 2) better management and control of existing grid assets in a distribution grid with high penetration of fully-controllable ("smart") PV power generation assets utilizing supervisory predictive control solutions proposed by Green Power Labs; 3) better management and control of diesel generators in a stand-alone grid with PV power plant where the diesel generators and the PV power plant together provide power supply to a dedicated load (e.g., a remote mine). The control objective is to increase the economic efficiency, achieve the high penetration, and guarantee the reliability and stability of power distribution grids. The different system dynamics and the corresponding solar prediction information will be modeled properly.

Index Terms –PV, Smart Grid, Optimization, Solar Prediction

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The optical coherence gratings and lattices and their propagation properties

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Abstract – Partially coherent sources have been widely used in speckle-free imaging, distortionless information transfer and optical communications in free space. In this poster, we introduce a novel class of partially coherent sources, the so-called optical coherence gratings/lattices and study their propagation properties in free space [1][2]. The novel sources are constructed using the recently developed complex Gaussian representation of statistical pulses and beams. All novel sources generate either pulses with statistically stationary or beams with statistically homogeneous coherence properties in the source plane. Furthermore, the new class of sources shows periodic temporal or spatial coherence properties. We explore paraxial propagation of the beams generated by novel sources in free space. We give evidence of a novel phenomenon of periodicity reciprocity between the source intensity and coherence properties. We expect the new phenomenon to find applications to free-space optical communications.

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Index Terms – Partially coherent, Complex Gaussian Representation, Periodicity reciprocity

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DALHOUSIE UNIVERSITY

Underwater Power Transmission

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Abstract- Offshore power systems have been successfully incorporated in the European power grid. In North America, various forms of offshore power are still in the development phases. These various forms of offshore generation include wind or tidal power to name a few.

Means of interconnecting these various forms of offshore power as well as connecting said power sources to the modern power grid depends on many factors. The most significant factor is the decision to transmit AC or DC power. There are many consequences associated with the choice of AC or DC power transmission.

Determining which medium of transmission should be used for a given offshore power installation is a difficult problem to solve. There are many factors that must be considered in decision making. The economics of the physical installation, the power transmission capabilities, and application specific overhead costs, reactive power requirements, power quality impacts are all things that must be taken into consideration.

Having determined which medium of power transmission will be used for a given application; the consequences of this must be determined. The effects that an offshore cluster of generation sources will have on an onshore power grid must be analyzed. The steady power flow must be determined as well as the bounds of stability for this offshore/onshore system. Underwater power generation, under certain conditions, cannot be shed from the power system without a risk of damaging the underwater transmission lines.

Analysis of these can lead to a better understanding of how offshore power systems will interact with onshore power systems, and provide insights for future design applications.

Index Terms –Offshore Power, Underwater Cables, AC vs DC

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Low Power Beamforming for Underwater Acoustic Sensing Using a 5-Element Circular Hydrophone Array

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Background

The use of passive underwater acoustic sensing in order to detect and track mammals presents some unique problems. In high-flow environments turbulent flow around hydrophones couples to acoustic measurements as noise and can increase the noise floor by upwards of 40 dB when compared to the ambient acoustic noise floor [1]. Multipath propagation causes multiple instances of the same vocalization over a large delay spread, which can result in multiple detections and poor estimates on the location of an animal and on the number of animals present. Lastly, many of the vocalizations that researchers make use of are impulsive in nature and so the devices used to record these vocalizations need to be broadband.

These same problems that make acoustic monitoring so difficult also make wideband underwater acoustic communication less reliable. By reducing the effects of these issues, both marine monitoring and underwater communication can be made more robust. One method that can be used to address these problems is wideband beamforming. However, this is not readily implemented in small underwater sensors due to the complexity and power consumption that generally accompanies broadband spatial filtering.

The purpose of this paper is to introduce a low-power, low complexity real-time beamforming technique that makes use of a 5-element circular hydrophone array. This technique helps to reduce the flow noise present in the acoustic recordings as well as provide directionality to the recorded signal in order to help increase the signal to interference ratio and decrease the number of multipath recordings.

Ambisonics Based Wideband Acoustic Beamforming

The hydrophone array studied in this research is shown in Figure 1. The main objective of this work was to create a wideband beamformer that had 360 degrees of unambiguous coverage and that could reduce the flow noise present on the beamformed signal. It was determined early on through simulation that most current wideband beamforming techniques could not be applied successfully to this array, mainly because of the small number of spatial elements. A novel approach that was instead pursued was the use of Ambisonics recording.

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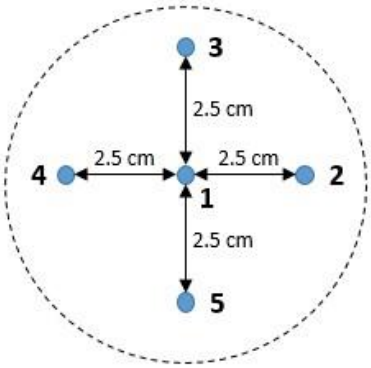

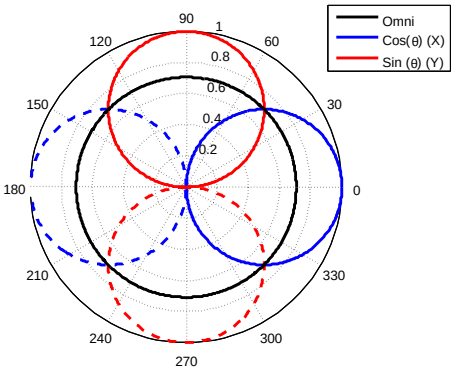

Plot of First 3 Circular Harmonics

Figure 1: 5-element array geometry. Figure 2: First 3 circular harmonics. Dashed line indicates phase shift of π.

Ambisonics is a method of recording and recreating surround sound, or a soundfield, such that the encoding is independent of the decoding [2]. Encoding in this sense refers to the recording of the soundfield and decoding refers to determining what signals are sent to the speakers in order to recreate the recorded soundfield. This means that the same recording can be used for almost any speaker layout in order to recreate the recorded surround sound.

To do this, the 2 or 3-dimensional soundfield of an environment is recorded by breaking it up into its spatial components, or spatial harmonics, for each sample in time. In 2-dimensional space this is done using circular harmonics, where the basis functions are the Fourier series, and in 3-dimensional space this is done using spherical harmonics. Practically, these series must be finite and so they are usually truncated. The first 3 circular harmonics are shown in Figure 2. Once the soundfield is recorded, decoding can be done for a specific speaker layout in order to recreate the recorded surround sound audio.

The input to each speaker is created as a linear combination of the recorded harmonics, where the weighting on each harmonic is determined by the speakers position in space. The linear combination of the harmonics is often called a ‘virtual microphone’. This is because the combination produces a beam pattern that points toward the speaker, as if a microphone with the same pattern was pointed in the direction of the speaker during the initial recording. For this decoding to work however, the number of speakers needs to be greater than, or equal to the number of harmonics recorded. If not, the solution will be underdetermined and lead to no, or infinitely many solutions.

Continued on next the next page

This research focuses on the use of a first order Ambisonics underwater recording system with recorded omni, cosine and sine channels, as shown in Figure 2, to beamform the recorded data. A single beam can be thought of as creating, or decoding, a single 'virtual hydrophone'. However, because the system only creates one output, one 'virtual hydrophone', it is equivalent to not having enough speakers to accurately reproduce the soundfield. The solution is therefore underdetermined for a first order recording with 3-channels and needs to be further constrained. To do this, the desired steering angle, θ, and beam pattern, p, of the 'virtual hydrophone'are also defined. The linear combination of the omni, cosine and sine channels that follows as a result of these constraints is then

$$Y(\theta,p) = pY_{omni} + (1-p)(\cos(\theta)Y_{cos} + \sin(\theta)Y_{sin}) \quad (1)$$

Equation 1 allows for real-time, wideband beamforming to be done using 4 multiply and 2 addition operations. Due to this simplicity, a number of wideband beams can be created simultaneously using only the three first order Ambisonics channels without drastically increasing the time, hardware or power requirements. This is in stark contrast to most techniques that would require a separate space-time filter for each desired steering angle. While this equation itself is quite simple, the challenge lies in creating the wideband cosine and sine channels.

Poster Contributions

The poster will introduce Ambisonics theory focusing on the signal processing required in order to produce the coincident omni, cosine and sine channels using the discrete 5-element array. Simulations of the beamformer will then be presented that analyse both the spatial discrimination and noise performance under simulated conditions in high flow environments. The poster will also highlight experimental results for both the noise reduction and spatial discrimination of the physical beamformer in an underwater environment.

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Mid-Term Electricity Price Forecasting Using Support Vector Machine

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Abstract – Having accurate predictions on market price variations in the future is of great importance to participants in today's electricity market. Few studies can be found focusing on predictions of electricity price in medium term horizon. Medium Term Price Forecasting has many applications such as plan forward/future contracts, and Risk management and derivative market pricing.

To forecast the electricity price, some factors are very important, such as chosen of the most useful price features that influence the market price, and chosen of the proper prediction model that is able of predicting the price behavior using the historical data.

In this work, we have developed and employed a model of forecasting daily electricity price; the model uses the system fuels prices, system demand data and weather data to predict the future behavior of the electricity price. The model employs input features preprocessing technique to select the most important predictors to electricity price behavior. SVM algorithm is used to model the forecaster, and in this study the SVM parameters are learned using Sequential Minimal Optimization (SMO) algorithm. Some other forecasting methods like radial basis function (RBF), regression tree, neural network and least median squared method are employed for the same data to compare the performance of the SVM method. NE-ISO data is used to test the proposed models. Different performance measures are used for models comparison. The proposed SVM regression method benefits in modeling efficiency and accuracy improvement, it has the lowest mean absolute percentage error (MAPE) in comparison to other forecasting methods. Graphical and numerical results are provided to verify the claims.

Index Terms – Forecasting, Features preprocessing, SVM, RBF, Neural Networks, Performance measures.

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State Estimation in Electric Power Grid using Multilayers Neural Networks

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Abstract – The composition of an electric power system grid is complicated because it contains many internal and external components such as generators, transmission lines, transformers, circuit breakers, and loads. The networks undergo different states such as normal, emergency, and restorative states as well as being subject to missing certain data or having corrupted data which can make it difficult for the control center operator to determine the exact state of the network more complicated. The process of state estimation offers help to obtain the missing or corrupted data by estimating the missing data. Recently, several researchers investigated alternative types of algorithms to enhance their performance to provide an accurate estimator for the network variables. The major purpose of this research is to focus and compare the analytical performance of several state estimation algorithms and implement these algorithms on IEE14, 30, and 118 bus networks to evaluate their performance and to distinguish the best estimate obtained by these algorithms.

To solve the above problems, the deterministic and heuristic algorithms have been reformulated in order to filter the residual of equivalent node measurements and estimate the state variables including phase angles and voltage magnitude at all the nodes which is useful for security assessments to give the operator in control room an accurate decision. When the new set of real time available measurements is taking into account, the predicted state variables can be forecasted.

In this work, a new computational technique in state estimation by using three multilayers neural networks interconnected in diverse ways and finalize the interconnection of four different topologies in total Cascade and Parallel interconnected topology. The primary intent of this work is to address the conduct of assorted topologies and then, implement these topologies with three separate nets to compare the best performance indices exhibited in maximum relative error, mean absolute percentage error (MAPE) and mean square error (MSE). Also every topology is contrasted with characterize the best connection architecture.

Index Terms — State Estimation, Artificial Neural Network, Multilayers neural networks, nodal power system estimation.

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PARTCILE SWARM OPTIMIZATION FOR STOCHASTIC PROCESSES

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Abstract – Particle Swarm Optimization (PSO) is one of the evolutionary computational methods that's been widely used in the recent years in various fields. PSO is inspired by the swarming or collaborative behavior of biological populations. Biological evolution has been the source of motivation for addressing the various complex computational problems. Scientific research involves random processes which are complex and unpredictable in nature. Higher the understanding of the randomness in the research field the better understanding of the process and more accurate the results. Optical electronics has its fair share of random process that remain unexplained till date. The stochastic nature in process such as spontaneous emission, polarization effects, Phase noises, non-linearity in losses are still unexplained. These processes contribute to the degradation of optical devices which could be avoided with a better knowledge of the unpredictable nature involved in these processes.

The randomness in optical electronics could be related to various random parameters that are incorporated in various evolutionary computational algorithms like Particle swarm optimization. This research is an attempt to study the interaction of random parameters incorporated within Particle Swarm Optimization (PSO) algorithm by using it as a standalone algorithm for prediction and estimation. PSO has been used in almost all possible fields of research due to its versatility, superior accuracy over other optimization algorithms and high convergence ratio with optimal initiation parameters.

There has been a commendable contribution in this field by previous researchers from my group. This research aims to understand and use the versatility of particle swarm optimization by enhancing its random optimization pattern with statistically optimized parameters and optimized error minimisation. The current stage of this research uses FOREX market with its highly stochastic nature as the test bed to understand the randomness that is included in the PSO algorithm. This involves using the various parameters that determine the currency exchange rates of different currency pairs as particles in PSO. These parameters would be used to predict and estimate the currency exchange rates in FOREX trading which would be the stochastic process. By enhancing the efficiency of PSO algorithm in the test bed to predict the currency rates, we would be able to use this algorithm for our primary objective which is to understand the chaotic processes in Optical electronics.

Index Terms – Particle Swarm Optimization; FOREX.

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Nanoparticles as Optical Lumped Nanocircuit Elements

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Abstract-The interaction of optical waves with nanoparticles is an intriguing problem in the field of nano-optics and nanophotonics. Both metallic nanoparticles with negative permittivity and nonmetallic nanoparticles with positive permittivity play an important role in these interactions. Noble metals such as gold and silver are mostly used as plasmonic materials. These nanoparticles are much smaller than the operating wavelength of the optical wave. Hence, because they are in the subwavelength dimension, we may use the lumped circuit theory in the optical range, as it can be successfully applied in low-frequency and RF ranges.

Circuit theory is one of the most useful paradigms for designing a complex functional circuit in the field of electronics. The development success of electronics can, in large part, be traced to the modularization of functional circuits to build more complex functional units. If we use the circuit theory in optical frequencies, it will simplify the design of photonics devices at the nanoscale. Our goal is to apply the lumped circuit model in the range of infrared and visible frequencies of optical waves to design nanophotonics devices such as nanofilters, nanoswitches, and nanomixers.

Index Terms –Nanoparticles, Lumped elements, Circuit theory

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Visible Light Communication Systems

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Abstract – The demand for wireless data and therefore the Radio Frequency (RF) bandwidth continues to increase as more consumer-level computing is being performed on mobile platforms. At the same time, light emitting diode (LED) based illumination sources are replacing traditional illumination sources for their superior watt-per-watt efficiency and longevity. However, LEDs also possess modulation speeds that vastly exceed other conventional illuminators, forming the basis of Visible Light Communication (VLC).

A solution to the problem of increasing demand for bands in the RF spectrum is to offload the demand to the Optical, or in this case Visible, spectrum. Appropriate uses include: short-range/high-density systems such as home/commercial wireless networks; high-security systems such as industrial/government/military networks, and systems with tight electromagnetic interference (EMI) regulations such as medical/aerospace electronics. The visible spectrum is safe to living tissue, is easily confined/distributed; and with pre-existing LED lighting can be readily modulated to transmit data wirelessly while performing as a source of illumination.

In this work, a three part research project is outlined with the goal of designing an optimal and practically implementable VLC system that can compete with or outperform the current state-of-the-art consumer wireless technologies (i.e.: *WiFi*) by taking a holistic approach, rather than treating the transmitting system, the receiving system, and the human observer individually.

The first part is the development of a model that adequately describes and predicts the perception of a rapidly pulsing light source (in both deterministic and nondeterministic patterns) to the human observer, in the form of a generalized nonlinear - or if possible, a conventional linear - impulse response that will be used to evaluate whether a particular modulation scheme will allow the modulated device to maintain satisfactory performance as a source of illumination.

The second part is the development of a source-coding/modulation scheme that obtains an acceptable evaluation from the model in part one as well as multiuser performance competitive with current wireless solutions, provisionally using a modified form of Code-Division Multiple-Access (CDMA) and conventional On-Off Keying (OOK). Protocols, such as using proper VLC for downlink communication from modem/router to client device and *invisible* (infrared) light communication for upstream, reservation of CDMA channels for up/downlink, or a hybrid VLC-downlink-RF-uplink, will also be considered.

The third part considers the physical-layer implementation of such a system designed in part two; the circuit level designs and performance requirements needed to compete with the state-of-the-art, culminating in a working prototype of the system as a whole.

Index Terms – CDMA, Impulse Response, Medical Devices, Nonlinear Impulse Response, OOK, Visible Light Communication, VLC

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Ultra Low Power Wireless Body Area Network for Health Care Monitoring

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Abstract – The continuous scaling in CMOS technology in the last decade helped to reduce the integration cost and led to new era of portable and miniature devices. Also, the progressive development in wireless technology and the improvement of the sensors integration had contributed in evolving the concept of wireless Body area network (WBAN). These network consist of autonomous sensor with radio, microcontroller and power source. A WBAN can provide a cost effective remote, mobile, invasive and non-invasive medical and health care monitoring. In order to enable a successful wireless biological sensor platforms that can be used in our daily life and can be applied to different applications starting from real time health care, elderly people monitoring, safety and military application, there are some necessary requirements at the design and architecture level should be applied.

Ultra low voltage and low power are essential requirement to enhance the WBAN performance to provide continuous health monitoring. Unavoidable trade-off between some factors should be done at physical level (size, weight, antenna size) and at the resource level (energy source, transmission range, data rate). Wearable sensors network should not interrupt the patient daily activity. This should be done without degrading the continuous data acquisition and without the need for human intervention by using a smart phone as a receiver to overcome the problem of short transmission range or multi node communications.

The main focus in this research, is to design a smart platform that collect physiological signals from multi bio-sensors in which they are remotely connected. The platform and the sensors will need no battery owing to the continuous RF to DC harvesting system. This platform will allocates the sensors, controls the data acquisition and transmission to a base station.

Index Terms –WBAN, RBF, continuous health care monitoring, body sensor network

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DALHOUSIE UNIVERSITY

Design Optimization & Performance Improvements of DCSR UWB Transmitter

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Abstract – This paper presents the design improvements of Differential Code Shifted Reference (DCSR) scheme of Ultra Wide Band (UWB) transmitter to achieve optimal performance. DCSR is an impulse radio UWB signaling scheme proposed by our research group. DCSR transceiver uses ultra-short 4ns impulses which are generated according to DCSR algorithms using FPGA to carry the data. At the receiver data bits are extracted from data modulated pulses according to DCSR demodulation algorithms in FPGA. Using DCSR impulse radio makes the system low power consuming, less complex and also more immune to interference compared to conventional narrowband radio schemes. The transmitted DCSR signal has the pulse repetition rate of 20 MHz and the bandwidth of 500 MHz centered at 4.44 GHz, meeting the FCC bandwidth requirement for UWB signal transmissions.

In spite of simplicity, the implemented DCSR system faces several performance challenges. The required amplitude ratio of the DCSR pulses between the baseband stage and RF stage reduces nonlinearly due to nonlinearity of the RF mixer circuit. Power spectrum of DCSR transmitter needs to be tuned to follow FCC spectral emission regulations. Also the digital signal combining with analog circuit elements results in significant noise at transmitter which couldn't be modeled or simulated.

In this paper, we present the methods and techniques used to solve or mitigate the above issues. We also implement a better DCSR data extraction algorithm than the current one at the DCSR receiver and then carry out the bit error rate testing of the DCSR system.

Index Terms – Ultra Wide Band (UWB), Differential Code Shifted Reference (DCSR), Impulse Radio, Bit Error Rate Testing.

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Silicon Kerr Effect Electro-Optic Switch

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Abstract – The design of an ultrafast silicon-based electro-optic switch for integrated-optic applications is investigated. We live in an information age with exponential growth of digital data which is expected to increase ten times every five years and is estimated to be of the order of 10^{22} bytes in the year 2020. In order to move this huge amount of digital data over the internet, within data centres, between desktop computers or between chips of high performance computers, optical interconnects are desired. This is because optical interconnects can operate at a higher bandwidth and consume lower energy compared to their electrical counterparts. Silicon with its low cost and mature manufacturing processes offers the possibility of silicon photonics for optical interconnects and thereby provide solutions for the problem of achieving low cost, high data rate optical communication. Silicon photonics for optical interconnects in communication networks requires opto-electronic integration in silicon. This would mean the development of a silicon-based integrated–optic transmitter and receiver connected through a fiber-optic channel. A switch or a modulator is one of the building blocks of an integrated-optic transmitter and this research focuses on the design of an ultrafast (< 1ps) silicon-based electro-optic switch at the telecom wavelength of 1.55 micrometers.

The proposed design uses silicon nanocrystals in silica as the optical medium and the quadratic electro-optic effect or the Kerr effect. The structure used is a slot waveguide ring resonator. The key performance indicators for the switch with the chosen ring resonator structure are analysed. The maximum modulation bandwidth for the electro-optic switch is calculated to be 137.4 GHz.

Index Terms – Silicon Photonics, Electro-Optic Switch, Silicon Nanocrystals in Silica, Kerr Effect, Slot Waveguide, Ring Resonator

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The design and implementation of a low-cost tool for measuring and recording household-appliance power-consumption

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Abstract –Electricity, regarded as a source of electrical energy to deliver power, meets 41% of residential demand and home appliances account for 42% of total electricity throughout the entire world. Almost everything from lighting, heating, cooling, and electronic equipment uses electricity. Studies have shown that when consumers are aware of the electricity consumption of their appliances, up to 15% energy reduction can be achieved. In order to improve people's awareness of their electricity usage, this poster describes a low-cost tool for measuring and recording the power consumption of most 110VAC household appliances by creating a time-series dataset. The time-series can be reviewed later and compared with other appliances using graphs generated using Excel. The device offers features that are not supported by commercial products such as the Kill-a-Watt energy monitor, which displays electrical parameters such as real power, apparent power, RMS voltage, RMS current and apparent power.

The device contains a socket into which the plug of an appliance is inserted, a voltage sensor circuit for recording the instantaneous voltage (V), and a current sensor circuit for sensing the current flow (I). The collected information from the two sensors is then transferred to the data acquisition module where it is processed and filtered to obtain the active power (P), apparent power (S), voltage (V_{rms}), current (I_{rms}), and the power factor (P.F) which are written to an SD card for future examination.

A prototype has been developed and tested on several home appliances including a washing machine, microwave oven, room-heater, toaster, and refrigerator. For example, when the refrigerator was turned on, the results obtained from the prototype device showed that the compressor draws around 100 W during the refrigeration cycle and starts every five minutes, while the microwave's defrost cycle required nearly 950 W every ten minutes and the power factor was found to be stable and less than 1 with nearly six times occurrence of the transient current impulse.

The poster also briefly describes how the time-series data collected by the device can be used with a smart-home controller to allow the scheduling of legacy appliances.

Index Terms – Appliance Power Consumption, Appliance Signature, Appliance Profiling, Smart Home

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Polarization Dynamics of Optical Coherence Gratings in Birefringent Fibers

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Abstract –The degree of polarization is an important measurable quantity in the realm of statistical optical physics. In this work, we explore the degree of polarization evolution of a recently discovered class of statistical pulses, optical coherence gratings in birefringent optical fibers. We elucidate the roles the group velocity mismatch and group velocity dispersion play in shaping up the pulse polarization properties. In particular, the walk off magnitude, determined by the strength of the group velocity mismatch, will be shown to play a crucial role in determining the final polarization state of the pulse. All our findings are supported by numerical simulations.

Index Terms –Birefringent optical fiber, walk off parameter, group velocity mismatch, optical coherence

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A Robust Meshless Method with QR-Decomposed Radial Basis Functions

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Abstract – Recently, meshless methods have attracted attention for solving electromagnetic problems due to their intrinsic properties such as conformal and multi-scale modelling capability. For most of these meshless methods, only spatial node information is needed to formulate electromagnetic problems. No connection information among nodes is required. Consequently, the method is no re-arrangements of grid lines are required when a structure is modified partially.

In general, meshless methods are based on the point interpolation process. Inversion of the associated interpolation matrix is then required. When the shape parameter becomes very small, the matrix become seriously ill-conditioned, which leads to failure of practical simulations. On the other hand, the smaller the shape parameter is, the more accurate results can be obtained. Therefore, tradeoff between the accuracy and the matrix condition needs to be made for the meshless methods. Special care needs to be taken to choose reasonable values of the shape parameters. Several strategies have been proposed to search for the optimal shape parameters. Unfortunately, these so-called optimal values are often problem-dependent and we have to perform the search for every different problem or for every partial change of a structure. Even worse, it is quite possible that such an optimal value does not exist in a problem.

To resolve the issue of the ill matrix condition associated with expansion basis functions, a method to modify radial basis function is proposed in computational mathematical community for non-electrical applications; in it, Gaussian radial basis function (RBF) is expanded with the QR decomposition and the shape parameter can theoretically be factored out from the original basis functions. In this work, we propose to extend the same technique to the meshless method for solving electromagnetic problems; as a result, a robust meshless method without the ill-condition issue is developed for solving Maxwell's equations.

Index Terms –Meshless, QR-Decomposition, Radial basis function (RBF)

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Enhancing the Performance of Asynchronous Traffic in Y Channel with Opportunistic Coding

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Abstract – Y channel is the very efficient network coding method to conduct the packet flow and it allows a throughput of six packets in two time slots. The scheme includes a relay node and three users who can only communicate with each other through the relay node, hence forming Y-shape traffic flows. This process applies a coding technique that requires all three users sending their packets simultaneously, which means that the traffic is thought to be synchronous.

However, in reality the packets are coming randomly and it results in asynchronous traffic. Because the users cannot know if each other have packets to send, a time-slotted sending performance is applied in the system, so the users would not mind others' situation and all system is controlled by time slot. If at one time slot, some users do not have packets to send, then they sent zeros instead in order to perform the Y channel coding. We first examined the influence of asynchronous traffic in Y channel. Different parameters such as transmitting period, buffer size and the rate of packet coming are inspected with simulations. The result shows that the system would become unstable after enough long time with increasing number of packets in the buffers. Then we present the method to decrease the probability of unstable situation occurring. This method contains two stages: one is the normal asynchronous transmission; the other is the clearing phase with employment of a possible faster sending rate to reduce the packets in the queues.

Furthermore, we found that when the users send zeros instead of information about the messages power would be wasted. Hence, a more efficient way was developed by transmitting the packets that are obtained by coding the message packets when there are no other packets in the queues. These opportunistic packets are used by receivers for reducing bit error rate. This arrangement would increase the reliability and stability of the system.

Index Terms – network coding, asynchronous traffic, Y channel, queuing, scheduling

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Body-Reflection 3D Tracking

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In the recent years, there are a lot of motion tracking and localization systems being designed, such as radio frequency localization, Kinect and imaging systems. Even though RF localization system uses WIFI and some other connecting tools to identify people's location through the wall and non-line sight of scenarios,the user has to carry a device. On the contrary, despite the user does not carry a device, Kinect and imaging systems require the user to stay within the device's line of sight, so these tracking and localization systems still includes their own limitations. Utilizing advantages of these technologies to find a new way to track people's motion, it is shown the radio reflection to track user's position and motion, such as 3D tracking, fall detection and pointing at directions. Specifically, the system transmits the waveform and then bounces off user's body, comparing change of these pictures to identify user's movement. Consequently, a user who does not require to carry a device is able to be detected in the other room and non-line of sight scenarios. To conclude, this system could bring a lot of benefits to people's life.

Index Terms: 3D Tracking, RF Localization, Kinect, Body Reflection

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STBC Based MIMO Y Channel

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Abstract – We consider a 3-users multiple-input multiple-output (MIMO) relay channel, where each user is intended to exchange their message with other users via a relay station. Traditionally, this model is studied in order to reach a high system capacity but there is few research focus on reception reliability. In my research, a scheme based on space-time block code is studied and a fusion of STBC and MIMO Y channel is proposed to improve the bit error performance of the system in environment of Rayleigh fading channel.

So far, the only works that focus on reception reliability is iterative optimization of precoding vector. The main idea is by adding redundant antennas to achieve more than one available space signal dimension, which is the realization of the beamforming and it leads to more possible precoding vectors. The author generate beamforming vectors iteratively with the expanded signal dimension and then the best performing set is chosen as the final optimal beamforming vector to improve the system bit error performance.

In my work, assuming not adding the redundant antennas, we consider the same setup as before and the communication still is divided into two phases. However during the MAC phase, four sets of new precoding vectors are carefully designed and a STBC based complex versions of signals are transmitted to relay node within four time slots, instead of one time slot traditionally. For the BC phase, the relay broadcasts signal to user nodes in the original way but increasing the transmission power to improve the BER performance. This is due to the fact that relay station is normally not power-limited while user nodes are usually working in wireless mode so power is constrained. Monte Carlo simulation is provided to demonstrate that the proposed scheme achieves BER improvement.

Index Terms –MIMO Y Channel, STBC, signal alignment, under-determinant equations