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Dead-Zone Controller for the Value Function Learning with Chaotic Dynamics

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Abstract
As Reinforcement Learning (RL) does not require any knowledge about the dynamics of the systems, it is not possible to know the finite horizon value and choose appropriate initial state. Thus the optimal duration of the applied control signal is not known in advance; hence infinite horizon RL is considered. Moreover, systems might have chaotic nature which yields unpredictable future dynamics; so that it might be interesting to examine the value function learning with these chaotic dynamics. In this part of the report, infinite horizon value function learning will be analyzed in the case of having a plant exhibiting chaotic dynamics. Since the system has chaotic behavior, the value function shows roughness around the chaotic region. Furthermore, as the dynamics move around the equilibrium point due to applied time optimal control signal, the chaotic behaviour is inside a bounded region. Having chaotic dynamics does not allow obtaining explicit closed form solution for the value function consisting of polynomial basis and parameter vector due to unpredictability of chaotic behavior. Therefore, parameter convergence and rate of convergence cannot be explicitly analyzed.

Generalized Discrete-time Multivariable Popov Criterion for Optimizing Controllers

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***Abstract* –** In control theory, feedback is used to stabilize systems whose open-loop behaviour is uncertain. Many systems of practical interest can be represented by two blocks consisting of linear and nonlinear subsystems in feedback with each other. We consider the case where a discrete-time multivariable LTI plant is stabilized by a quadratic-programme-based optimizing controller which can be represented as a generalized (unstructured) sector- and slope-bounded nonlinearity. We derive a generalized discrete-time multivariable Popov criterion in the linear matrix inequality (LMI) form which is applicable to the absolute stability of such a system.

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Blending a Ray of Sunshine with a Breath of Fresh Air – SMART GRID, A Controlled Power System.

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Abstract

The largest power generator around provides more clean energy per hour than is consumed in a year by the world population, The Sun. The UK is exposed to about a third of the EU's wind total, meaning it one of the windiest places in Western Europe. Engineers in the UK are developing Smart Grids to better capture, distribute and control the flow of this unique blend of clean energy to address global warming, the depletion of fossil fuels and a growing global population.

The challenge is to develop; a sustainable and secure power system by intelligently integrating everything connected to it, a Smart Grid. Our research brings together advances in efficient renewable energy generation with ingenious methods of Control and Communication engineering.

We are currently investigating the impact of a large sustained increase in the generation of electrical energy from homes fitted with solar panels and wind turbines. We will combine this with projections of increased power consumption in homes brought about by an increase in the use of electric; vehicles and heating. New system wide communication will be developed to allow influence and control to be implemented on real time power use. By simulating these forecasts, and, monitoring real systems, we will develop a cost effective strategy to control power flow in order to safeguard existing infrastructure and negate the need for reinforcement.

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Search procedures for SISO Zames-Falb multipliers

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Although Zames–Falb multipliers were proposed more than 40 years ago, the search for an optimal multiplier remains an open problem, mainly because the L1-norm condition is expressed in time domain, rather than frequency domain. For this reason, the efforts to find a multiplier in the literature have focused on specific structures that are advantageous for mathematical analysis. In order to capitalize on these structures, the designer has to trade off computational effort and mathematical simplicity, leading to two approaches for the multiplier search: a multiplier can be mathematically simple but requires a big computational effort for its synthesis, or it can be mathematically complex and restricted to conservative conditions, but be computationally simple to calculate. In this paper, a comparison between these two approaches is explored. Delta distributions offer a simple way to calculate the L1-norm of the multiplier, but they are a computationally intensive process and require some user tuning. On the other hand, an approach that is computationally simple, such as a summation of exponential functions or limited order rational transfer functions, will not require any setup, but will be restricted by additional conditions that are not present in the general set of Zames–Falb multipliers. These restrictions will produce accurate results, but can sometimes be fundamentally conservative because of the exclusion of large sections of the general set of multipliers. Examples of these restrictions are causality and inexact estimation of the L1-norm of candidate multipliers.

Robust Flatness Control

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ABSTRACT

Vibration describes the mechanical/physical movement/displacement about the equilibrium position. Vibration motions of electric motors, engines, or any other mechanical device can be due to uneven friction, imbalances of rotating parts, gear teeth meshing, etc. leading to an undesirable, wastage of energy, creation of unwanted (thermal) noise and lower operating efficiency.

In this project, the modelling and control of the flatness of a transportation engine board (such as ship, train and etc) when subjected to current depicted as random disturbances is considered. The modelling of the board is done in a 2D framework using two actuators (mass-spring-damper system). A simple physical model that characterizes the relationship between the actuators and the flatness of the engine board is developed from first principles of mechanics and then linear controllers using state feedback and robust control methods are designed to be applied to the nonlinear system. The performances of the various controllers designed are measured using the rise time, settling time and amount of control action. Based on these performance measures, it is determined that with the angle to reference axis as the output ($\theta_{x,y,z}$), different controllers are designed using PID, integrator-augmented LQR and LQG.

Design and control of a novel unmanned ground vehicle

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Abstract –

This work presents a novel design of a full-degree-of-freedom, tri-rotor-actuated single-wheeled system. The model of the wheel mimics an inverted pendulum system, which is a typical representative of highly nonlinear systems with non-minimum phase, characterized by an unstable equilibrium point. With an appropriate choice of output variables, classical feedback linearization is invoked on the coupled nonlinear states equations of the single-wheeled vehicle for subsequent controller synthesis. Here, we use efficient weight optimization algorithm, formulated using the well-known H_∞ loop-shaping design procedure to synthesize a robust controller. This efficient framework was also developed on the PhD program in such a way to simultaneously synthesize loop-shaping weights and controller that give the best robust performance in a feedback interconnection while ensuring a certain level of robust stability margin that gives sufficient gain and phase margins of the feedback interconnection. The designer chooses the robust stability margin 'a priori' while using this algorithm, which is an added incentive. The controller is verified by means of computer simulations, and the time-domain simulations show that the design objective of robustly stabilizing the wheel in its unstable equilibrium (upright) position is satisfied. The choice of controller is further justified as it adequately gives satisfactory input and output disturbance rejection characterizations.

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Tuning the Electrical Properties of ZnO Thin-Film Transistors by Thermal Annealing in Different Gases

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There is a growing interest in zinc-oxide (ZnO) thin-films due to a range of desirable properties.[1, 2] It has been reported that the electrical properties of ZnO films are strongly affected by the oxygen adsorption and desorption.[3, 4] We have developed a method to tune the electronic property of ZnO thin-film transistors (TFTs) by annealing in different gases. In our experiments, we annealed the top-contact bottom-gate TFTs in either air or nitrogen atmosphere. The ZnO films were grown by atomic-layer deposition at 200°C with diethylzinc and H_2O. The air annealing was performed at temperatures ranging from 180 to 280°C for 1 hour. The sample annealed in air 280°C, was subsequently annealed in nitrogen at 180°C, 200°C, 220°C, 260°C and 280°C for 1 hour.

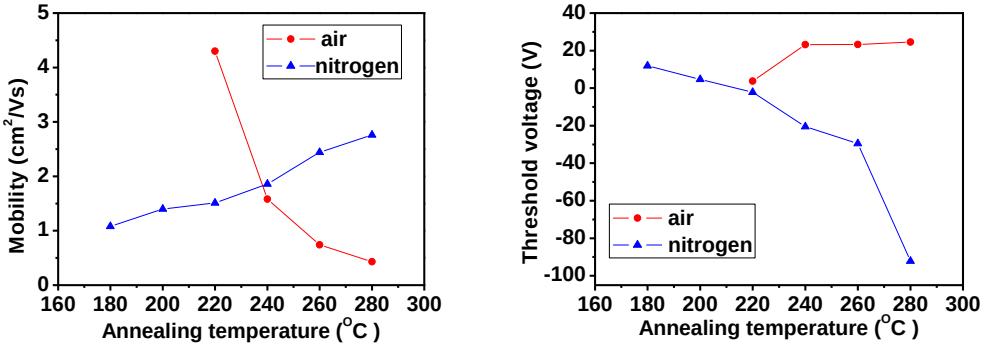

Fig. 1. (a) Mobility versus annealing temperature. (b) Threshold voltage versus annealing temperature

The changes in the mobility and threshold voltage as a function of annealing temperature in air and nitrogen ambient are displayed in Fig. 1 (a) and (b), respectively. These results demonstrate that the threshold voltage and the channel carrier concentration can be shifted in both directions by annealing in different gases. After annealing in air, we observed reduced mobility and increased threshold voltage. We hypothesize that this was due to the enhanced adsorption and interaction of oxygen in the ZnO films when it was annealed in air at high temperatures. Annealing introduced oxygen atoms may capture electrons from conduction band, and hence reduce the carrier concentration and increase the threshold voltage. The reduced mobility at higher annealing temperatures might be explained by a reduced ability for carriers to screen scatters in the ZnO film at lower carrier concentrations. In contrast to air annealing, when annealing the previously air annealed sample in nitrogen the electron mobility increased and threshold voltage shifted to more negative value. The reduced threshold voltages indicated higher carrier concentrations, which was most likely due to increased oxygen vacancies when annealing in pure nitrogen at high temperatures. Our studies demonstrate that using a combined air and nitrogen annealing may provide a practical way to tune the threshold voltage of ZnO TFTs to suitable values for different circuit applications.

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Modelling and Design of MMIC Low Noise Amplifier using an in-house InP-based Process.

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InP-based HEMTs have previously demonstrated superior noise performances at millimetre-wave frequencies using short-gate length and are indeed commonly used in high performance LNAs, though at cryogenic temperatures. The work presented here demonstrates a series of room temperature operating MMIC LNAs that were designed based on a novel high breakdown InGaAs/InAlAs/InP pHEMTs with all designs optimised for the frequency range of 0.3GHz to 2GHz. A fully integrated MMIC single-ended single stage LNAs was successfully designed and measured for low noise performance. The noise figure of single stage design is less than 0.56dB with a gain of 15dB to 9dB across the full band. A single-ended double stage MMIC LNA was then proposed as a gain booster resulting in gains of ~ 26dB across the frequency band of interest. The noise figure for double stage LNA is comparable with the single stage LNA as the noise is only govern by the first stage. Finally, an InP pHEMTs based double stage, differential to single-ended MMIC LNA design was also studied. The first stage is fully differential, optimised for noise performance and with good gain, while the second stage is a differential input single-ended output for gain boosting and stability performance. The noise performance of the second stage has minimal effect on the amplifier's noise characteristics due to the considerable high gain of the first stage (~12-15 dB) and the effect of the Friis's effect. All designs are unconditional stability for the entire frequency band of interest with power dissipation of < 300mW.

Thermal stability study of InGaAs-InAlAs pHEMT using Palladium gate metallisation

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Abstract

III-V compound semiconductors have been recognised for a while now as possible contenders for the ITRS post 22nm node due to their intrinsic high electron mobilities and high carrier densities. The excellent DC and RF performance of III-V materials attracts many interests in such various applications as low noise amplifier (LNA), power amplifier (PA) and high speed logic circuits.

Traditionally, Titanium and Gold (Ti/Au) has been used for the gate metallisation of pHEMT devices. The high adhesion property of Ti provide a good interface for the between the Au and the underlay semiconductor materials. Also, Ti is a very good diffusion barrier which stops the inter-diffusion between gold and the epi-layers. However, the thermal stability of Ti/Au will become worse in the succeeding pHEMT fabrication processes which involve heat treatment at varies temperature and duration. The Au metal will diffuse into the epi-layers and it would degrade the Schottky barrier and also the device performances.

Different refractory metals such as Platinum (Pt) or palladium (Pd) have been studied for the gate metallisation on AlGaAs-InGaAs interface [1].The introduction of Pt or Pd gate metallisation can improve the Schottky barrier height and also thermal stability. In this study, we are going to report the thermal stability of delta-doped (□-doped) InGaAs-InAlAs pHEMT using Pd/Ti/Au gate metallisation. Comparing to the AlGaAs-InGaAs pHEMT, the InP-based system has much higher mobility and results in an impressive improvement in terms of DC and RF performance. Investigations on different Pd thickness and annealing temperatures were carried out to analysis their impact on the device performances.

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Non-Linear Piezoelectric Effect in Wurtzite III-N semiconductors

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Abstract

First-and second-order piezoelectric coefficients for all binary group-III nitride (III-N) wurtzite semiconductors are calculated using *ab initio* density functional theory. The method used allows the simultaneous determination of spontaneous and strain-induced polarization within the same framework. Although the linear coefficients are similar to all existing values reported in the literature, all spontaneous polarization terms are substantially smaller than the currently proposed values. Second-order coefficients also change the total strain-induced polarization significantly. We compare the predictions obtained using these coefficients with data in superlattice structures comprising binary nitride semiconductors and by including composition dependence with all available experimental data on III-N ternary alloys. We show that, unlike existing models, our calculated piezoelectric coefficients and nonlinear model provide a close match to the internal piezoelectric fields of quantum well and superlattice structures.

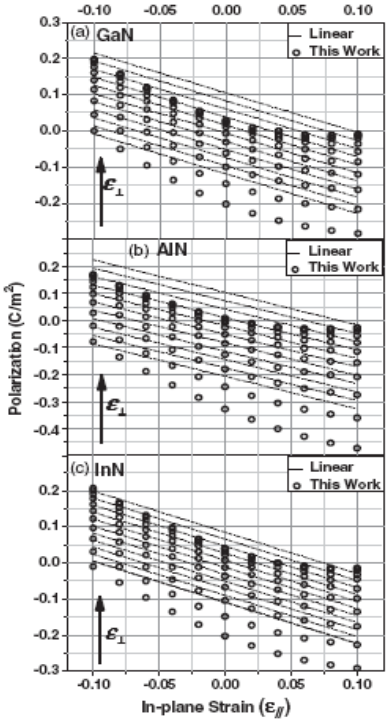

Fig1: Comparison of the total polarization as a function of perpendicular and parallel strain calculated in this work (circles) and using the linear model with parameters from Ref. [i] (dashed lines). The perpendicular strain varies from −0.1 to 0.1 in steps of 0.02.

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Novel Unipolar Nanodiodes in InAs/AlGaSb Heterostructure Fabricated by Wet Chemical Etching

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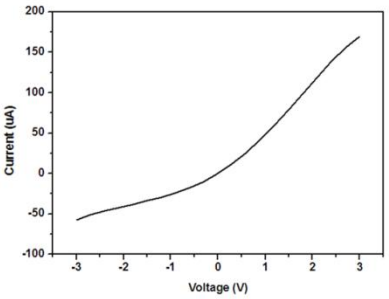
A novel semiconductor nanodevice, the self-switching diode (SSD), has been fabricated into an AlGaSb/InAs/AlGaSb heterostructure by electron-beam lithography (EBL) and wet chemical etching. The SSD is defined by breaking the geometric symmetry of a narrow semiconductor channel, which results in a strong nonlinear *I-V* characteristic.[1,2] The threshold voltage is determined by the geometrical width of the channel, rather than by the material utilised as in conventional diodes. A linear arrays of SSDs connected in parallel can be fabricated by simply placing SSDs next to each other. The planar layout of the device reduces the parasitic capacitance and ultimately improves the operating speed and room-temperature operation has been demonstrated up to THz frequencies. [3]

The AlGaSb/InAs/AlGaSb heterostructure, shown in Fig.1(a), was grown by molecular beam epitaxy (MBE) on InP substrate. Free electrons were confined to a two-dimensional electron gas (2DEG) in the quantum well located 18 nm below the surface. The carrier density and the electron mobility at T = 300 K were 1.82×10^{12} cm^{-2} and 16500 cm^{-2}/Vs, respectively. Although the AlSb metamorphic buffer layer can provide the high electrical resistivity required for device isolation,[4] it leads to a strong oxidation in air, which affects the SSDs' electrical properties. 10% Ga was added to the AlSb layer in order to reduce the oxidation rate, although the electron mobility was slightly decreased.

InAs	$1.0x10^{19}$ cm^{-3}	20 å
In0.5AlAs		40 å
Schottky layer	Al0.9GaSb	70 å
Doping layer	2 mono-layers	InAs
Doping plane	$2x10^{12}$ cm^{-2}	
Doping layer	2 mono-layers	InAs
Spacer	Al0.9GaSb	
Channel	InAs	150 å
HEMT buffer	Al0.9GaSb	
Metamorphic buffer	Al0.8GaSb	2500 å
Metamorphic buffer	AlSb	7500 å
Growth on 2'' InP (001) SI Wafer		

(a)



(b)

room temperature.

When the etching stopped at the metamorphic buffer layer, $Al_{0.8}Ga_{0.2}Sb$, a good insulation could be achieved between adjacent devices. Ohmic contacts were formed by alloying Au/Ge/Ni at 360 °C. Arrays of 14 SSDs were defined by EBL and etched into the heterostructure to a depth of 85 nm (enough to insulate the 2DEG) by a $Br_2/HBr/HNO_3/H_2O$ wet etching. Immediately after the etching the devices were coated by PMMA to prevent the formation of native oxide. The *I-V* characteristics on SSD arrays were measured at room temperature and showed the expected diode-like behaviour as plotted in Fig.1(b). Due to the high electron mobility of the 2DEG, we expect that AlGaSb/InAs/AlGaSb SSDs can be efficiently used as sensitive THz detector.

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THz Emissions from Planar Nanodiodes

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A pressing concern in the deployment of terahertz technology is the lack of efficient and portable terahertz radiators (emitters). Recently, self-switching devices (SSDs) have offered a neat and robust two-dimensional planar technology that demonstrated detection of microwave radiation up to 2.5 THz for temperatures up to 150 K.[1] The planar architecture of the SSD favours high speed and low parasitic capacitances. Furthermore, frequency multipliers can be achieved by straightforward integration of arrays of SSDs in parallel in order to reduce overall impedance.[2] It is envisaged that the SSD structure can function as an electromagnetic emitter in the THz regime. Monte Carlo simulations have shown that by means of Gunn oscillations, frequencies reach 130 GHz in InGaAs diodes[3] and significantly higher, around 400 GHz, in the case of GaN structures.[4]

In this work, Gunn oscillations have been observed and modelled, using Silvaco Atlas simulations, in a planar InGaAs SSD as shown in Fig. 1(a). Fig. 1(b) shows the current response obtained when the voltage applied to the SSD is incremented in steps of 0.5 V every 50 ps. Current oscillations having a frequency of 250 GHz arise at a threshold voltage of 1.5 V which corresponds to the critical electric field required for Gunn oscillation. From the electron dynamics plots, we obtain evidence of charge dipole domain formation at the position of the vertical trench. These domains travel parallel to the conduction layer, as opposed to perpendicular to the layer in traditional vertical devices (Fig. 1c). The performances dependent on channel length, width and interface-charge density were analysed and recorded in terms of their oscillating frequencies and current amplitudes. When the channel is short (~ 0.5 μm) or narrow (~ 90 nm), the device is able to produce frequencies up to 320 GHz whereas increasing the interface-charge density oscillated at up to 600 GHz. By careful construction of an array that contains different geometries of SSDs placed in parallel, we expect to achieve the tuning of frequency in wide and narrow bands.

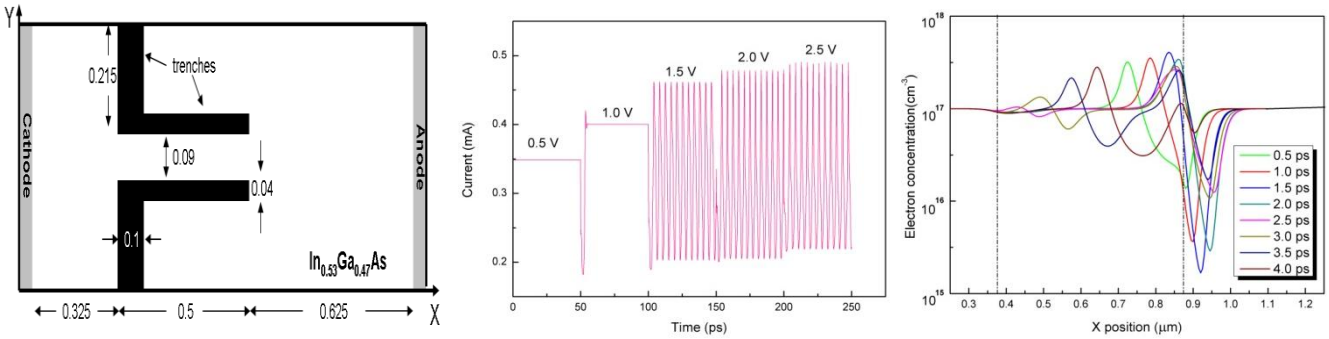

Fig. 1. (a) Geometry of the InGaAs SSD. (b) Current response for ΔV=0.5 V applied every 50 ps. (c) Electron density profiles along the centre of channel during one period of oscillation. The dotted lines represent the beginning and end of the channel.

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Novel, High Capacitance Nano-composite Dielectrics for Low-cost, Flexible Electronics

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The possibility of using naturally occurring or "man-made" organic and organic-inorganic hybrid materials for applications in the electronics and the semiconductor industry has been of great scientific and technological interest for several decades. As the total size of electronic components scales down to few nanometres and the fabrication of electronic circuits moves towards low-cost flexible substrates, the development of new high dielectric constant (so-called high-k) dielectrics that can be economically processed in ambient conditions and possess good mechanical strength is highly desirable. Organic and organic-inorganic hybrid nanocomposites are one very promising class of materials for future generations of bendable low-power electronic components and circuits.

The aim of this work is to develop novel, high capacitance dielectrics based on alternative nano-composite materials that combine very high dielectric constant values intrinsic to ferroelectric ceramic materials with low-cost and ease of processing characteristic for polymers that will pave the way towards low-cost fabrication and integration of high performance electronic components and circuits on flexible substrates.

Fabrication of Novel Unipolar Nanodiodes in InAs/AlSb Heterostructure

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The fabrication of self-switching devices (SSDs) in InAs/AlSb heterostructure using dry etching has been explored. The SSD consists of an asymmetric nanochannel tailored by two L-shaped trenches which insulate a two-dimensional electron gas (2DEG) as shown in Fig. 1(a). The *I-V* characteristic of a SSD is similar to that of a conventional diode, but the turn-on voltage can be widely tuned by simply changing the designed device channel width.[1-3]
The InAs/AlSb heterostructure combines high electron mobility and electron peak velocity while sustaining a high carrier density in the 2DEG.[4] The AlSb/InAs/AlSb 2DEG structure was grown by molecular beam epitaxy (MBE) on InP substrate. In order to relax the compressive lattice mismatch between the InP substrate and the active layers, a one-micron composite AlSb/$Al_{0.8}Ga_{0.2}Sb$ metamorphic buffer layer was used. The AlSb metamorphic buffer layer provides the high electrical resistivity required for device isolation. However, it suffers from strong oxidation in air and by moisture. Using wet etching for SSD fabrication has shown severe lateral etching as well as native oxide growth on etched areas, which affects the SSD geometry and electrical properties. Here we report on the fabrication of SSDs in InAs/AlSb heterostructure using electron-beam lithography (EBL) and reactive-ion etching (RIE) in CH_4/H_2 plasma in order to achieve anisotropic profile and reduce oxidation from side wall. The semiconductor had a substantially lower etch rate than the e-beam resist (PMMA), which was used in our fabrication. Therefore PMMA was not an effective mask for RIE due to the very low selectivity to main substrate. In order to overcome this problem, a hard mask was utilised. The sample was first sputter-coated with a thin layer of SiO_2, approximately 30 nm thick. SSD were defined in PMMA and etched in the SiO_2 layer by RIE with CF_4. The substrate was then etched by RIE in CH_4/H_2, owning the high etching selectivity of SiO_2. The SiO_2 layer was eventually removed either by an HF batch or RIE in CF_4.
The DC characteristics of several SSDs were measured at room temperature, which showed the expected diode-like behaviour. Microwave detection at frequencies up to 110 GHz has also been demonstrated at room temperature with this new material system. Due to the high electron mobility of the 2DEG, we expect that InAs/AlSb SSDs can be conveniently used as high-efficiency THz detectors.

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Time-Domain Modelling of Aperiodic Distributed Feedback Terahertz Quantum Cascade Laser

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Abstract

Aperiodic grating introduces defects in periodic sequences to create strong Bragg resonances, and it has gradually attracted interest for its ability to control electromagnetic (EM) wave localization. The additional degree of freedom introduced by the pitch length adjustment is beneficial for an aperiodic grating design of limited length with "useful" spectral response. Aperiodic distributed feedback (ADFB) gratings may be used as multi-band optical filters, and their incorporation into a laser can produce customized lasing modes at multiple frequencies, such as discretely tunable light output at user-defined frequencies. Time-domain modelling (TDM) is used to simulate laser dynamics owing to the calculation of carrier-photon interactions. In our work, we propose an improved TDM method for lasers using an aperiodic grating as a filter. The proposed method is also beneficial for modelling lasers with aperiodic grating distributed on the gain region. Therefore, defects, including those due to gain, loss, scattering, and dispersion, are introduced directly during the propagation of laser pulses. We use the improved TDM method to simulate the dynamic light output of an ADFB quantum cascade laser (QCL). We calculate the dynamic spectrum of the ADFB QCL by configuring the aperiodic grating, performing the improved TDM, and carrying out a Fourier transform to transfer the light output from time- domain to frequency- domain.

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Coarse Grain Mapping Method for Cellular Processor Array

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The recent development of single instruction multiple data (SIMD) processing mode used in image processing field leads to various pixel per processor arrays (also named cellular processor array or CPA) which can provide massive computational power to celebrate the processing speed, while maintain small power consumptions. The typical image or video resolution is high, e.g. 320X240(QVGA), 640X480(VGA), 1280X720(HD 720P), 1920X1080(HD 1080P), 2560X1600(WQXGA). However, the sizes of cellular precessor arrays nowadays are relatively small, e.g. 128X128.

The aim of this research is to establish a Coarse Grain Mapping Method (CGMM) that allows any CPA to be used as a coarse grain processor array without any hardware change. Coarse grain processor arrays have the ability to process images which have bigger resolution than the processor array itself, while losing some speed advantage. In a coarse grain processor array, each PE processes a block of pixels, e.g. 4x4, 16x16, 32x32, 128x128. The Coarse Grain Mapping Mehtod is purely realised by compiler at the compiling time. Once the compile process is completed, the ICWs for coarse grain mode are no different to the ICWs for fine grain mode from CPA's point of view. To realise more flexibility, this method is capable to process any form of pixel combinations, e.g. not only 2x2 but also 1x4, 4x1; not only 4 pixels per PE, but also 2 pixels per PE, 16 pixels per PE, only limited by the number of registers in each PE.

A Field Programmable Array Core for Image Processing

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FPGAs have recently been used for SIMD processing arrays due to the similarity of both being arrays of fine grained logic elements. They cannot offer a performance as high as ASICs but despite their lower frequency, they can still provide a good performance due to their parallel nature. An FPGA implementation of a fine grain general-purpose SIMD processor array is presented. The processor architecture has a compact processing element which is encapsulated into two CLBs and is then replicated to form an array of processing elements. A bit-serial 32 × 32 processing element array is implemented on a Xilinx Virtex-5 FPGA using the four-neighbour connectivity with area constraints. The regular array has the possibility to be scaled up using a larger FPGA. Binary and grey-scale image processing is performed and demonstrated. Binary edge detection of a 32 × 32 image is shown to be completed in 71 instructions. Sobel edge detection of a 32 × 32 8-bit grey-scale image is demonstrated to take 1041 instructions. The processor array operates at a frequency of 96 MHz and executes a peak of 98.3 GOPS (bit-serial operations) showing a good performance in a low to moderate sized processor array.

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Title	Tunable Terahertz Quantum Cascade Laser
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Abstract	Quantum cascade lasers (QCLs) are a remarkable invention in which many electronic and optical properties can be designed and engineered to user-defined values. On the other hand, there is a huge potential for photonic microstructures to define a devices optical characteristics. Incorporation of distributed feedback (DFB) grating structures into QCL devices has successfully justified the idea of combining electronic and photonic engineering. However, existing DFB QCLs, based upon either periodic or quasi-periodic structures, operate only at single or dual frequencies and are not able to offer tunability, a highly desirable feature. We have designed aperiodic distributed feedback (ADFB) microstructures in order to further improve the functionality of THz-QCLs by introducing electronically-controlled discrete tuning. ADFB THz-QCLs immediately allow for single- or multi-mode laser emission at user-defined frequencies. We have recently fabricated and characterized a range of ADFB THz-QCL devices and will present experimental data from devices both before and after incorporation of ADFB structures. Experimental results have been correlated with a number of simulations and modelling of photonic structures. We predict that these compact, coherent, discretely tunable THz-QCLs will act as significant enablers in the advancement of THz photonics and optical communication systems. Recently, a letter based on these results was submitted to the journal Nature. This work is funded by the EPSRC grant, Ref. NO: EP/G064504/1.

Characterization of LT-InGaAs-InAlAs semiconductor photo-mixers at 1.55 μm wavelength for Continuous Wave THz generation and detection

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The growth of semiconductor materials at low temperatures (LT) using the technique of Molecular Beam Epitaxy (MBE) gives rises to nano-clusters of arsenic precipitates which lead to femtosecond carrier recombination times. This in turn leads to devices that can emit and detect radiation from DC to a few THz. While LT-GaAs remains the most intensively studied material for ultra-fast optoelectronic applications, its rather large band gap energy imposes certain limits for lasers that can be used for switching or THz radiation. The key challenge thus is the synthesis of materials which combine the desirable properties of LT-GaAs while at the same time are able to be excited at the practical, well understood and cost effective telecommunication wavelengths of 1.3 and 1.5 μm. This work presents the structural, optical and electrical properties of a range of structures grown to operate at 1.55 μm. The structures consisted of Be doped multi quantum well layers and measured at different annealing temperatures and which have yielded dipole antennas with a THz signal to noise ratio exceeding 50dB, one of the highest ever reported for this material system. The exact role of the defects and their role in generating the radiation are studied in details.

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A Large Band gap, High breakdown $In_{.3}Al_{.7}As$-$In_{.7}Ga_{.3}As$ pHEMT for low power mobile communications systems.

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Abstract—A novel, large band gap materials, $In_{.3}Al_{.7}As$-InGaAs InP pseudomorphic High Electron Mobility Transistor (pHEMT) featuring extremely low leakage is demonstrated. The device's key attributes are a large band gap supply layer material (Eg~2eV) and very high mobility (~14,000 cm^2/Vs) quantum well channel in $In_{.7}Ga_{.3}As$. An all optical lithography process was used to fabricate devices with gate lengths of 1µm and widths ranging from 2×50 µm to 6×200 µm, the latter being the highest gate width ever reported for an InP-Based technology. A very low Schottky gate leakage is obtained from this devices with a value of only 100µA/mm at Vgs = -8V, yielding breakdown voltages in excess of 15V. The on-state impact ionisation gate leakage was reduced to below -8 µA/mm for V_{ds} = 2V, some 100x lower than in conventional InP pHEMTs. The device exhibits f_t of 27 GHz and f_{max} of 34 GHz making it suitable for application to at least up to X-Band. These high breakdown large periphery devices are ideal for both high efficiency power amplifiers (PA) and low noise amplifiers (LNA). A robust, thermally stable MMIC LNA using this pHEMTs has been designed and fabricated for the frequency band 0.2 to 3GHz for use in the Square Kilometre Array (SKA) radio telescope.

Localisation of Wireless Sensor Nodes Embedded Within Grain Silo

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Abstract **–** Wireless Sensor Networks (WSN) have been proven to operate successfully in remote and hazardous areas and have been a constant source of information previously thought to be hard to reach. Building on the increased potentials of WSNs, we propose using WSN to monitor grain conditions inside storage silos. To further enhance the usefulness of the collected data, we examine the possibility to derive the positions at which sensors observe their data. A novel localisation method has been successfully developed and implemented using information from a blend of Ultra Wide Band (UWB) pulses and Time Difference of Arrival (TDoA) techniques. Further, extensive experimentation is carried out in large silos (over 2m in depth), filled with grain, to establish whether it is possible to use Receive Signal Strength (RSS) information to compute sensor positions inside the silo.

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Mobile Platforms for Underwater Sensor Networks

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Abstract – The monitoring of wet storage ponds is an important aspect of maintaining safe and sustainable nuclear power generation. Across the world, there are over 700 storage ponds with over 200,000 metric tonnes of nuclear waste in them. Current pond monitoring systems are limited in both the spatial and temporal resolutions and the types of measurements, due to the hazardous nature of the process.

To overcome this problem, a method of gathering data using a mobile underwater sensor network has been proposed. Micro-Autonomous Underwater Vehicles (µAUVs) would be used as mobile instrumentation platforms which would support a suite of sensors. The µAUVs would be able to move to any position in a pond to take 'spot' measurements or could investigate the disposition of material in the pond.

The above titled project is tasked with the development of the mechatronic aspects of the µAUV, specifically the design of the hull, propulsion systems and relevant motion control and the power system. A prototype vehicle has been constructed and tested at a number of facilities.

Motion control for vertical movement and heading have been successfully designed and tested and simulations for full 3D control have been conducted. Several technical challenges have arisen due to the use of low-quality components, however the controllers have been designed to be robust to them.

The research project is part of an EPSRC funded WINES III initiative called Actuated Acoustic Sensor Networks for Industrial Processes (AASN4IP) and is a collaboration with the University of Oxford and several industrial companies.

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Submicrometer CMOS MMIC Design Applied to the E-Band (71-76GHz 81-86GHz)

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Abstract – This article presents a study of the potential in the design and development of CMOS MMICs for applications in the E-Band (77GHz-86GHz). The E-Band has been projected as the best solution for mobile and fix networks backhaul links and possible mobile terminal applications. Taking advantage of the main benefits of the Silicon technology in terms of cost, integration level and power consumption, the state of the art of silicon processes (90nm and 65nm), for E-Band applications are studied in this paper.

A new low loss transmission line structures are proposed, these new structures are aimed to reduce the losses in low resistivity silicon substrate, through the shielding of the transmission line. Finally, potentials of the further improvement in CMOS blocks design techniques, and their application in the development of low cost and efficient MMICs for E-band, are evaluated.

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Cooperative Strategies for Future Wireless Communication System

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***Abstract* –** High spectral efficiency wireless transmission with robust quality has always been a challenge for any wireless communication system. Combination of orthogonal frequency division multiplexing/access (OFDM/A) with a multiple-input and multiple-output (MIMO) system undoubtedly can satisfy the requirement for the challenge. Unfortunately, MIMO cannot easily be achieved in Mobile Terminal (MT). For this reason, cooperative diversity is introduced to achieve MIMO system in uplink. Cooperative diversity exists in two forms, which are relay type (RT) and multiuser pairing type (PT) cooperative diversity. RT technique is able to achieve *L* diversity orders proportionally with the number of relay terminal at the cost of reduced spectral efficiency. On the other hand, a maximum diversity order of two without spectrum efficiency is attainable using PT technique. However, existing PT techniques were mainly designed for code division multiple access (CDMA) systems, which makes this type of cooperative diversity may not be implemented in future wireless technology implementing OFDMA technology, e.g. WiMAX and LTE.

In this work, new approach of multiuser PT cooperative diversity that can be implemented in uplink (OFDMA) multiuser systems has been designed and examined. The investigation on synchronous and asynchronous uplink transmission show that the combination of PT cooperative diversity with OFDMA is able to achieve diversity order of two as well as performance enhancement by exploiting co-channels interference in comparison to RT cooperative diversity and direct transmission without reduced spectrum efficiency.

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Sequential Cooperative Spectrum Sensing Technique for Cognitive Radio System in Correlated Channel

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***Abstract* –** Cognitive Radio is proposed to opportunistically access the spectrum while the licensed user is idle. Spectrum sensing procedure to observe primary user's existence is vital to cognitive radio. Due to the nature of spectrum sensing that sensing slot occurs at the beginning of each packet frame and the slow-fading correlation in wireless communication channel. We aim to develop a novel spectrum sensing technique, which utilizes this channel correlation. By utilizing the local observations from previous sensing slots, cognitive radio user does not need to take many observations in each sensing period but relies on the previous sensing. The performance of this technique is shown to approach that of the conventional technique with equivalent number of time-bandwidth product. With the need for less number of sensing slot, this helps improve the overall utilization of the whole system as sensing slot can be used as data slot instead. In Hybrid-OR spectrum sensing technique, weighted local observations are aggregated to make local decision before sending to the fusion centre to make a final decision. Optimization on the weighting shows that equal weighting is the best when primary user activity is not considered. When primary user activity is considered, the equal weighting may, however, degrade the detection performance.

The Impact of the Signalling Between Macrocell and Femtocell on the Transmission Power

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***Abstract* –** A low power consumptions system and a higher data rates in mobile wireless networks are demanded nowadays while the capacity of the current macro cell networks is limited. In cellular systems, the main reason to reduce a cell size is to increase its throughput, which will then reduce the transmission power and ability to reuse the spectrum more efficiently, thus having a higher capacity in the system. Lowering the separation between the transmitter and receiver distance will hugely increase the capacity as in femtocells. Most of the attention of femtocells has been focused on this evolutionary process. A femtocell consists of a low power, short range (10-50 meters) home access point (AP) installed within the customer's premises and connected to the provider via a separate connection like cable modem or DSL. It serves mainly indoor users with a much lower transmit power compared to the macro cell. Hence, users in a femtocell network causes less interference to the other users. Femtocell networks are particularly attractive when some researches show that more than 50 percent of all voice calls and 70 percent of data traffic originate from indoors. Due to the high cost of licensed spectrum, macro cells and femtocells users will need to use the same frequency band and this arrangement is called co-channel deployment. The main challenge in femtocell network is on how to protect femtocell users against interference from macro cell users while exploiting as high spatial reuse of spectrum resources as possible within each femtocell. However, research shows that femtocell users causes very low interference to the neighboring macro cells and femtocells users.

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Estimation of Coupled Noise in Low Noise Phased Array Antennas

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Abstract **–**There is currently a great deal of interest in the use of phased array receivers for radio astronomy. The Square Kilometer Array (SKA) project plans to utilize phased arrays in at least three different forms: as sparse and dense aperture arrays on the ground, and as phased array feeds on dishes. At frequencies above a few hundred MHz it will be vital to obtain very low noise temperature performance from these arrays in order for them to be practical as radio astronomy receivers. Receiver noise coupled between antenna elements has been thought to be a significant contributor to overall system noise in such phased arrays.

This paper uses fundamental principles of noisy networks to estimate the noise waves emanating from the input of each LNA towards the antenna element. The theory has been implemented using MATLAB, and successfully used to predict the noise levels emanating from the input ports of two packaged amplifiers. The theory has been applied to an example two-antenna array model. Results from the noise wave analysis suggest that in reality the coupled noise contribution to system noise temperature should be quite small for practical low noise amplifiers of the type to be used in the SKA.

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Cyclostationary Spectrum Sensing in Cognitive Radio Networks

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Abstract **–** Cognitive Radio (CR) is a method for providing personalized wireless communications through dynamic and opportunistic spectrum sharing. The idea of cognitive users (CUs) sharing the spectrum with primary users (PUs) outlines the basic principle of CR systems. To coexist with PUs without causing unacceptable interference, a CU has to be aware of the presence of PUs. As PU's signals can be expressed as a cyclostationary process which exhibits statistical periodicities, cyclostationary spectrum sensing (CSS) has been suggested as a potential technique for scanning the licensed bands for PUs. A *k*th-order statistical approach is the most widely used method to perform CFD, especially in its 2nd-order form.

This report examines this 2nd-order CSS under two scenarios, individual sensing and cooperative sensing in CR networks. In the first scenario, an efficient algorithm for finding asymptotically optimal multiple lags for the 2nd-order statistical testing is proposed. This algorithm is based on an approximated asymptotical detection performance in which the prior knowledge of the 4th-order cyclic cumulants of PU's signals is not required. Secondly, cooperative CSS using analog forwarding in the parallel fusion model has been investigated, in which the additive white Gaussian noise channel is considered. To form a mathematically tractable test statistic, taking account of Gaussian noise, we propose an alternative local statistic to collect and report to the fusion center. Hence, an asymptotical chi-square test can be developed. Simulation results are presented to demonstrate the proposed.

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Low Loss 3-D Multilayer Transmission Line for Compact MMIC Matching Networks

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Abstract **–** At high frequency operation, passive circuitry that occupies large area is needed to perform important functions such as coupling, filtering and phase shifting in that high cost and small diameter MMIC. Coplanar waveguide (CPW) as an alternate to microstrip has received much attention to fulfill that requirement [1-4] since through-substrate via-holes are not necessary and fragile semiconductors need not be made excessively thin. The chip thickness as thick as 600 μm can be used allowing larger wafer sizes to be employed and individual component sizes are not limited. These can lead in reducing the fabrication cost. Since the requirement to increase the packing density and functionality of chips become stronger than ever in the microwave monolithic integrated circuits, then the conventional CPW interconnects are not suitable in realizing very low characteristic impedance. The solution would be to employ the 3-D multilayer technique [5-7]. In this work, dispersion of various characteristic impedance interconnects with low dissipation loss have been analyzed. The structures are fabricated using 3-D multilayer CPW technique. The dispersion characteristics of the 3-D interconnects with different signal width are investigated experimentally either for two or three overlapped metal layers. We demonstrate that the characteristic impedance of 9.7Ω can easily be achieved for multilayer interconnects with slot width of 15μm. The measured results also confirmed that the three overlapped metal layers technique can decrease the dissipation loss up to 55%. The experimental results indicated that the dispersion characteristics and losses are varied and much improved with different overlap dimension.

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Title: Connection to Shore Reliability

Abstract: Offshore generation is a critical component in producing a clean, secure and sustainable energy supply for the future. The amount of offshore generation is increasing worldwide. In the UK alone the Crown Estate has leased enough offshore development sites to provide a potential maximum capacity of 55GW. The interconnection of offshore generation has many advantages including, a reduction in volume of assets installed offshore, improved flexibility and network security. These advantages have led to a number of proposals to interconnect offshore generation such as the National Grids Integrated Network and the European Super Grid.

A major stumbling block for these proposals is the lack of HVDC circuit breakers, without which a fault on a HVDC cable would require all cables/ converters interconnected with the faulty cable to be de-energised, in order to isolate the fault. This is extremely undesirable and not acceptable in many cases. To date there are no commercially available HVDC circuit breakers for this application.
A thorough review of HVDC circuit breaker topologies has been conducted from academic papers, published patents and commercially available documentation. This poster will present and discuss selected topologies. In addition a new HVDC circuit breaker has been designed to improve on the limitations of the existing designs. This design is currently patent pending and therefore will not be disclosed in this poster. However initial simulation results from the new design will be presented.

Author: Ting Lei

Title: Wind Turbine Power Electronic System Reliability

Abstract: Electronic subassemblies in wind turbines have high failure rates but relatively short down time. This research is intended to investigate the converter failure mechanism by investigating a single wind turbine model in PSCAD. Both mechanical and electrical stresses on the converter should be examined. The purpose is to identify what dynamic behaviours can affect power electronics operation and then find ways to limit or avoid the risks within a design.

The simulation tool EMTDC / PSCAD has been chosen to implement the task due to its specific merits in simulating power electronic circuits and power system. It has been identified that the converter failures are mainly caused by thermo-mechanical cycling fatigue in power electronic components. This root cause is worsened by stochastic aerodynamic loading of wind turbines, particularly when operating below the rated wind speed, which may result in mechanical fatigue in the drive train and thermo-mechanical cycling effects in the generator and converter systems. The model that developed in this project has all the relevant parts involved including the machine and converter models, a lumped mechanical systems and the pitch control mechanism. This model is implemented to evaluate the effect of control and system changes on the converter systems and allow mitigation measures to be carried out to improve the overall reliability.
Different control strategies can therefore be examined through simulation with the model and critical stress factors can be alleviated. This model will be validated against experimental testing in the future. A back-to-back converter integrated is available for this purpose.

Author: Chengwei Gan

Title: Mechanical Emulation Techniques for Tightly Coupled Electro-Mechanical Systems

Abstract: Tightly integrated electro-mechanical systems are key features of many applications including smart grids and the more-electric aircraft concept, owing to the performance benefits offered by fully integrating the electrical and mechanical systems. It is increasingly necessary to investigate and mitigate these electro-mechanical interactions. However, in many cases, due to cost / safety issues, the use of the mechanical sources / loads in the research environment is restricted for examining these interactions. Then, dynamically emulating the mechanical source / load using hardware-in-the-loop (HIL) techniques become a cost effective alternative.

In this project, existing mechanical system emulation techniques are examined by means of a simulation model to evaluate their performance when applied to an aircraft power system test facility. A generic emulation technique, robust to time delays and unmodelled system dynamics is then proposed and demonstrated by means of a simulation model to emulate the behaviour of a gas-engine spool using an induction machine drive. In the future, the developed mechanical system emulation technique needs to be implemented in the lab environment before interfacing with electrical part for electro-mechanical interactions' examination. The generic robust emulation technique presented in the poster is applied to the emulation of the gas-engine spool dynamics, but the technique is generic and can be used to emulate other mechanical systems such as marine propulsion, vehicle drive-trains or wind turbines.

Mathematical Modelling of End-of-Life of Power Transformers in Perspective of System Reliability

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Widespread deregulation and privatisation of the electricity market in the 1990's has had the effect of increasing competition between utilities. As a result utilities have been forced to increase the cost-effectiveness of their operations to gain a competitive advantage. At the same time utilities must ensure that their obligation to provide a secure, continuous supply and high standards of reliability are maintained, failure to do so may result in large financial penalties as decided by the market regulator. An area where utilities can achieve this goal is via intelligent management and utilisation of large network assets.

System reliability is known to be influenced by component reliability, therefore utilities must ensure that assets installed in the network are replaced in a timely manner. One of the most abundant, expensive and critical components in the network are power transformers. The combination of cost, criticality and large numbers mean that it is essential life management procedures of transformer populations are implemented.

In this project the general methodology on how to create a mathematical model of transformer failure is discussed in order to determine how the probability failure is affected due to a series of operating scenarios and phenomena such as overloads, short circuits, lightning strikes, etc. Once the mathematical transformer failure probability model is built, the subsequent effect on system reliability can then be calculated taking into consideration the transformer age, condition, operating conditions and environment. Such a model can be vital to ensure the continued cost-effectiveness and security of a power system.

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Author: David Clark

Title: Central Partial Discharge Monitoring of High-Voltage Rotating Machines

Abstract: Partial Discharge (PD) occurs in High-Voltage plant and assets due to the localised electrical breakdown between conductors, this may be caused by voids within the insulation, manufacturing/installation imperfections or third party damage. On-line periodic and continuous monitoring of PD activity are recognised methods by which the integrity of the insulation system can be assessed during normal operating conditions, these techniques rely on measuring the short duration PD pulses (typically < 500ns) with wide-band Current Transformers without disruption to the electrical supply. On-line Monitoring of PD activity within rotating machines is regarded as being a key tool to interpret the levels of PD activity over time, to statistically analyse the results and allow comparisons with a PD results database. Central monitoring of rotating machines involves using a multi-channel monitor to simultaneously monitor, and trend PD activity levels in up to four rotating machines, with the monitoring instrument connected at the switchgear-end of the cable, up to around a kilometre or so away. Work has been carried out to establish the effects of the feeder cable length on PD pulse characteristics, and how the PD measurements can be understood and related to an area of PD activity within the machine. Further theoretical and field work is planned to develop improved PD diagnostic knowledge rules, and to evaluate the effects of sensor type.

Author: Ding Wang

Title: Linear Alternator Design for Use in Thermo Acoustic Engine

Abstract: The poster is concerned with a low cost, high efficiency linear alternator for use in a Torus Thermo Acoustic Engine, as a part of waste heat energy recovery system. The Thermo Acoustic Engine is designed and constructed in MACE, which generates acoustic resonance from the heat energy wasted from high power luminaire. The linear alternator will be driven by the acoustic wave. The alternator design utilizes the moving-magnet structure, which has been proved to be the most efficient type of structure by decades of experience. To achieve a high efficiency of the generator, the moving mass attached to the piston needs to be minimized since too high mass will reduce the power output. Also, a difficulty with the moving-magnet machines is that it has large cogging torque, which results from the axial magnetic attraction force in the alternator. In the poster, a novel method to overcome the problem of cogging force is presented, together with the testing results and analysis. Although the prime cost and moving mass rises by using the method, the overall performance of the alternator becomes much better.

Author: Ding Wu

Title: Control of Super-capacitor Energy Storage Device for Aircraft

Abstract: Due to the increasing demand of on-board load on an aircraft, the slow response power generator may not be able to respond quickly to a sudden large load change, resulting in electrical system stability. Therefore, improving power quality and stability of an aircraft electrical system has become an important issue.

The aim of this project is to build an energy storage device (ESD) and devise relevant intelligent control methods to improve the power quality and reliability of the aircraft electrical system. A super-capacitor, connected with the electrical system busbar via a converter, serves as the main energy storage unit that can either release or stores energy, keeping system voltage stable and reducing the effect of disturbance or sudden load change with the devised control methods.
A simulation model has been developed and simulated using computer software, and programmed into an active load system, which can emulate the operation of the ESD for testing in an emulated aircraft electrical system; the test results from simulation and emulation are matching and both validating the effectiveness of the energy control. A real ESD is under development to take over the active load system, and is expected to be finalized soon. Future work includes finalizing the whole ESD system, integrating it with the emulated aircraft electrical system, testing and comparing the results with the simulation.

Author: Jose Hermilo Ceron Guerrero

Title: Design of a High Torque Density Induction Motor

Abstract: Governments, institutions and individuals have realised about the importance of the reduction of pollution generated by our activities. This leads to degradation of our environment producing global climate change, which has direct consequences against humanity. It is increasingly difficult to ignore the pollution caused by internal combustion engines used in vehicular transportation. Researchers have been working hard on alternative vehicle systems to reduce the problem.

One of those alternatives is electric vehicles which represents a promising solution for human transportation. This key technology requires more research being undertaken on the electric motor that drives the vehicle. To date significant focus has been on permanent magnet motors for automotive applications. However increasing issues around the global supply of their rare-earth materials means the induction motor is worth considering as a lower cost option.

The main objective of this project ‘Design of a High Torque Density Induction Motor’ is to analyse the design of conventional induction motors for automotive drive applications with the intention of taking a radical look at the conventional design process and developing new designs that are fully-optimised in terms of torque and power densities for automotive drives.

Author: Siyu Gao

Title: Phase-Locked Loop (PLL) Technologies for Grid Synchronization in Modern Power Systems

Abstract: The survey has summarized the offshore wind power technologies to date and has made projections on the trend. Types of different wind turbines has been summarized and compared. Developments of power electronics and grid linkages have been investigated and summarized. Installation of different offshore wind turbine foundations and substations have been studied. Required equipment and specialist vessels have been identified. Different generations of offshore substations have been summarized. Their main electrical components have been identified. Projections on offshore energy have been made.

The wind turbine model aims to combine the mechanical and electrical properties of the turbine to give comprehensive results. The model is currently being built and is based on permanent magnet synchronous type wind turbine.

Author: Steven Jordan

Title: Multiphase Synchronous Generators for DC Aircraft Power Systems

Abstract: Multiphase machines present a number of advantages over their three-phase counterparts in a range of applications, particularly when considering DC electrical systems. The multiphase variant offers the possibility to remove filter capacitance, a heavy and expensive hazard in the electrical DC power network on-board aircraft. Other benefits of multiphase machines include increased power density and a reduction in de-rating factor under fault conditions. Of particular importance are the benefits arising from the increasing electrification of modern aircraft. The associated savings from a reduction in fuel burn, a direct result of the removal of pneumatic bleed air, can have significant economic benefits when considering the current financial climate.

This project considers passive diode rectification techniques as well as a controlled switching variant. Finite element modelling is utilised to investigate the harmonics within the air-gap flux when moving toward a multiphase machine design as well as the verification of the assumptions made with regards to the simulation results. Experimentation to characterise the BCI162 generator and validate the accuracy of the data supplied by the manufacturer is currently being undertaken.

Author: Xin Niu

Title: The Impact of Variable and Fixed DC Supplies on the Design of EV Traction Drives

Abstract: Electric vehicles (EV's) are a gradually growing field for electric traction machines due to energy and environmental related constraints [1, 2]. The traction system of an EV consists of an electric traction machine (TM), power conversion electronics and energy source(s). The energy source(s) provide a DC link supply for the traction system. The impact on the electric traction machine design from the DC link variation is investigated in this paper.

There are several options for energy sources or energy storage systems for the EV, including Internal Combustion Engine (ICE) Generator, Fuel Cell and battery. The general layout of the traction system of future EVs is shown in Fig. 1, with the options of energy sources and peak power buffers. The peak power buffer is used to compensate the voltage or constrain the voltage variation of the DC link during typical driving cycles, i.e. to boost the DC link using stored energy when the machine is accelerating and store energy when it is braking. Fig. 2 illustrates the combination of a battery and super capacitors (SC) that are employed to provide the energy to drive the EV and hence traction system for the DESERVE project, a TSB funded technology project. Although the DESERVE project focus was on how SC's could enhance battery life-time by reducing the voltage ripple on the vehicle DC link, the data of DC link voltage collected during the EV test were valuable for understanding the DC link characteristic and specification for the traction system. The data was also used to investigate the impact of DC link voltage variation on the design of the vehicle traction system. This is the main focus of this paper. A further consideration to machine and power converter design is that of system temperature variation. This will be discussed as a secondary consideration.

Spectroscopic Conductivity of Potatoes growing within Soil: With the aim to monitor growth, health, maturation and yield in situ and non invasively

Increasing population will ultimately lead to an increased demand on food supplies. This demand will lead to the requirement for enhanced farming techniques and more efficient crops with increased yield. The ability to monitor the growth and health of crops, such as potatoes, would provide enhanced knowledge of crop performance, and factors such as time to harvest. Frost, disease and bruising of potatoes results in significant crop wastage alongside a reduction in revenue through loss of earnings from diseased and undesirable crops.

Through spectroscopic electrical conductance measurements the β-dispersion of living cells was observed. The β-dispersion is a result of the internal cell structure of the potato and insulating layers between individual cells, creating a frequency dependant component. Damage to the potato cells, whether through physical force, frost injury or disease will have an effect on the spectroscopic conductivity if the insulating layers between cells may become damaged. It was hypothesised that damage to potatoes would remove the insulating layer between cells and therefore the capacitive component. This would result in a conductivity which showed no frequency dependency for damaged potato.
Tests performed on small $1cm^3$ sections of both freeze/ thaw and diseased potato showed a significantly different spectroscopic conductance when compared to those performed on healthy potato samples. The conductance showed an increase at very low frequencies which then remained frequency independent, indicating that the technique has the ability to detect frost injury and disease.
Internal blackspot potato bruising typically develops over a 72 hour period, with detection reduced to 12 hours with current test techniques. The aim was to further reduce this time providing knowledge of potato bruise susceptibility. This could inform of post-harvest control techniques used to reduce bruising. Due to the slow development of bruises it was decided to test variation in conductance over time for both healthy and bruised potatoes. Initial test data indicated that there was a distinction between healthy and bruised potatoes. Creation of a robust test procedure produced results which were unrepeatable and inconclusive with measured conductance showing no correlation to potato bruising.

The detection of frost damage and disease was confirmed through spectroscopic conductance measurements. The detection of potato bruising was not possible through observance of change in conductance over time. Future work should concentrate on improvement of the frost and disease damage detection with field trials in greenhouses with the aim to detect larger scale frost and disease damage in a soil based application.

Author: Paul Newill
Supervisor: Professor Trevor York
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Sub-surface imaging using Electrical Impedance Tomography: A COMSOL Multi-Physics modelling approach for simulating the electrical properties of soil with varying saturation levels

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Abstract

In light of climatic change, rapid identification of new plant varieties that will thrive in future climates is increasingly important. The root system is critical to plant water uptake but this cannot easily be assessed without destroying the crop or disturbing the plant/soil matrix through extractive sampling.

We are developing a new visualisation tool for seed breeders that will provide on-line data for individual plants in a screening programme. It will indicate how efficiently each plant utilises the water and nutrients available in the surrounding soil. This will facilitate the early detection of desirable genetic traits.

Visualisation of spatial water distribution takes the form of Electrical Impedance Tomography (EIT), a non-destructive and non-intrusive imaging technique. Measurements are to be obtained for individual plants thus allowing water utilisation levels for each specimen to be inferred.

An investigation into the relationship between soil moisture content and electrical properties has been carried out. A mixture model was implemented as a coupling mechanism between the Richards equation for describing fluid flow in an unsaturated soil and the electrostatics problem for predicting electric field lines. This facilitates the estimation of electrical capacitance measurement data for varying soil saturation levels. Experiments have shown that the finite element model (FEM) electrostatics simulation is accurate (error < 9%) and is able to predict capacitance measurements of soil at varying homogenous soil moisture levels within an average error of <6% based on the implementation of the mixture model.

We present the inverse problem, discuss the inherent challenges and present the early experimental results. These early studies stand as a proof-of-concept and have given the research team an understanding of the technical challenges that must now be addressed to take the current instrumentation into the food supply sector.

Parallel Algorithm for Imaging from Limited Views Tomography

Jose A. Cantoral Ceballos

Supervisor: Prof. Krikor Ozanyan

Tomography imaging of industrial subjects requires compliance with a particular environment. This results in severe limitations on the access and the deployable hardware resources, defining the situation of imaging by systems with limited resources, to be addressed by the future generations of imagers.
To account for these constraints the Sinogram Recovery Algorithm (SRA), based on sinusoidal Hough Transform, has proved to be a valuable tool to realise imaging from limited data. In this research, the algorithm is studied and parallelised aiming at the implementation of an embedded system capable of executing acquisition, reconstruction and visualisation, enabled by the latest software and hardware developments and system design. Parallelisation of the algorithm was achieved in MATLAB and, an early implementation of the parallelised algorithm has been accomplished in VHDL for FPGAs, providing results that show the adequacy of the method to perform real time imaging in an embedded system.

THz Time-domain Spectrometry

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ABSTRACT

Terahertz is a band of the electromagnetic spectrum between 100 GHz and 10 THz. Terahertz spectroscopy is a powerful technique for determining physical characteristics of materials. Applications for this technology include industry, medicine and homeland security. Terahertz Time-domain spectrometry (THz-TDS) is a technique that uses ultrashort laser pulses to generate and then sample a broadband THz radiation. We use a 800 nm 150 ns ultrashort pulse beam generated by a Ti:sapphire modelocked laser with a repetition rate of 76 MHz. This type of lasers is specially suited for driving GaAs emitters and detectors and they are widely used in THz systems, despite the fact that they are very sensible to changes in optical alignment and mechanical vibration. An ultrafast beam sampler splits the beam in two: pump beam (99%), and probe beam (1%). The pump beam is focused on a low temperature GaAs photoconductive antenna (PCA) biased with 160 V. Laser pulses produce carriers which are accelerated by the electric field to generate a broadband THz pulse. This pulse is collimated by an off-axis parabolic mirror before going to a sample and to a second parabolic mirror which focus the beam over a ZnTe crystal. The probe beam goes through a mechanical delay line and then to the same ZnTe crystal. The delay line is moved several times to produce a waveform scan. The probe beam pulse is used to sample the wider THz. This optically-gated detection allows time resolutions of a fraction of a picosecond. For our system we use a 2 mm thick ZnTe crystal. This detection scheme, also known as electro-optical sampling, relies on the Pockels effect, which consists in a change in polarization in the presence of an electric field (induced birefringence by the THz field). A linearly polarized beam is subject to phase retardation $\Delta\phi$, then it becomes elliptically polarized and its intensity components I_x and I_y are modified. A quarter wave plate change again the polarization to almost circular. An analyzer (Wollaston prism) separates horizontal and vertical components of the beam and these components are directed to a balanced detector. The amplitude difference between these components is proportional to the THz intensity. The system is completed by a lock-in amplifier which is a powerful tool for detecting low amplitude signals. The system is controlled by a personal computer with a LabVIEW program. After the THz pulse signal has been reconstructed, a Fast Fourier Transform (FFT) is applied to the data to obtain the absorption spectrum of a sample. This type of systems is difficult to setup since they are very sensitive to misalignment, being the delay line and the parabolic mirrors the most critical components. Specific alignment procedures are not detailed in the literature, so we needed to develop our own calibration method.

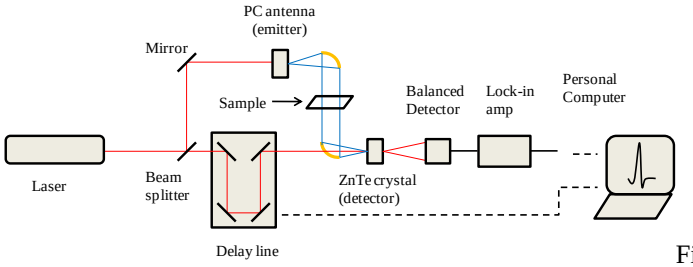

Figure 1. Simplified diagram of the TDS system.

In fig. 2, we can see a 2048 points FFT THz spectrum of an air sample. The spikes at 1.097, 1.163 and 1.410 THz are caused by water vapor absorption. These results match exactly with those found in the literature.

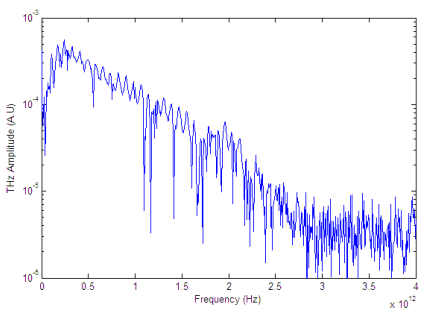

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Figure 2. Spectral response of the THz pulse through an air sample.

The system requires the support of several instruments; therefore, future work will include the integration of various functions in one single instrument using programmable logic as our first alternative.

A TRIAL INSTALLATION OF HIGH VOLTAGE COMPOSITE CROSS-ARMS

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Abstract: Four high voltage composite cross-arms have been installed as part of a non-energised trial taking place in the Scottish Highlands. The non-cylindrical geometry of their two main structural members offers improved mechanical strength-to-weight ratio compared to cylindrically-shaped insulators of similar cross-sectional area. The instrumentation system aims to monitor mechanical performance through the use of embedded strain gauges and a combination of a load cell, accelerometer and inclinometer at the cross-arm nose. An industrial data capture and control platform is used to capture sensor outputs and store them until retrieval. Networked cameras with local storage capabilities are used to capture video recordings of the cross-arms. The trial has helped establish handling, transportation and installation procedures. The first results from the instrumentation system indicate the resilience of the cross-arms to winds reaching up to 151 mph (243 km/h) while no irregularities regarding snow and ice accretion have been observed.

COMPARISON OF WIND FARM AGGREGATE MODELS FOR TRANSIENT STABILITY STUDIES

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Abstract

Use of aggregation techniques is getting common due to their ability to save valuable simulation time during dynamic stability analysis. An aggregated model can represent an entire wind farm (of any size) by just a few equivalent turbines thus reducing the number of differential equations that needs solving which in effect saves time. Such models are useful for system level studies as well as for online analysis. Several models have been proposed in the past which makes it difficult to choose the best one.

Therefore in this study three different models for wind farm aggregation are compared and tested against a detailed wind farm model. These models include Single Equivalent turbine model, Cluster Representation of the WF and Probabilistic Clustering model. In the first model, wake effects are ignored whereas in the others these are taken into account.

A large wind farm of 49 turbines connected with the grid through two main cables is tested in the case study. A 3-phase solid self-clearing fault is applied to one of the lines. Transient stability behaviour, reduction in simulation time and easy of setup of these reduced order models is compared with the full detailed model.

Damping Power Oscillations with VSC-HVDC to Enhance System Stability

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Abstract – Increasing demand and already strained AC transmission lines mean that HVDC links are likely to see ever increasing popularity as a method of cost effective bulk power transfer. As HVDC links are introduced it is important to investigate their capabilities for stability purposes as well as power transport.

This study presents a supplementary VSC-HVDC Power Oscillation Damping (POD) controller based on wide area measurement signals (WAMS). The controller is designed as Multi Input Single Output (MISO) using a Modal Linear Quadratic Gaussian (MLQG) methodology in order to target critical inter-area electromechanical modes. The approach has been tested on a large (16 machine, 68 bus) test network incorporating parallel HVDC/AC transmission and has shown improved damping compared to a traditional Power System Stabilizer (PSS) based controller structure utilizing local signals. The design process has incorporated the effects of wide area signal transmission delays. The proposed controller performance has been assessed through small and large disturbance analysis.

Assessing the Value of Employing Dynamic Thermal Rating on System-wide Performance

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***Abstract* –** The power grid is under pressure to maintain highly reliable supply under constrained expansion budgets and environmental policies. This can be achieved through realization of smart grid technologies and methodological advancements that would allow further improvement of asset utilization, economic operation and network security. This paper introduces a method for evaluating potential benefits as well as the technical limitations of employing dynamic thermal rating (DTR) on overhead lines (OHL) in a stressed network environment. The paper, initially models system-wide network performance under actual thermal ratings to investigate the benefits of DTR under specific operating scenarios as well as over static thermal rating (STR) on OHLs in a given network. Secondly, it investigates the benefit of implementing several additional long-term emergency rating-duration times for secure and adequate operation through a smarter ICT rule-setting program that improves network performance without compromising its reliability under contingent scenarios. The proposed methodology is employed on the IEEE 24-bus network test system suggesting a cost benefit model that balances the interests of both network operators and asset managers.

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