






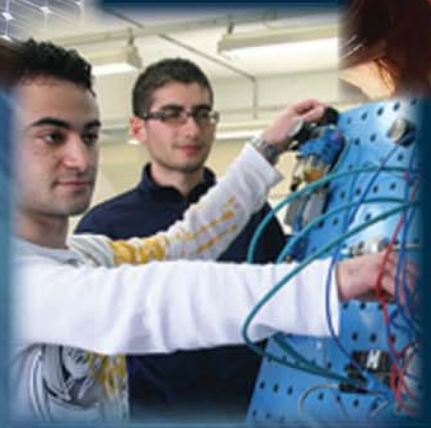

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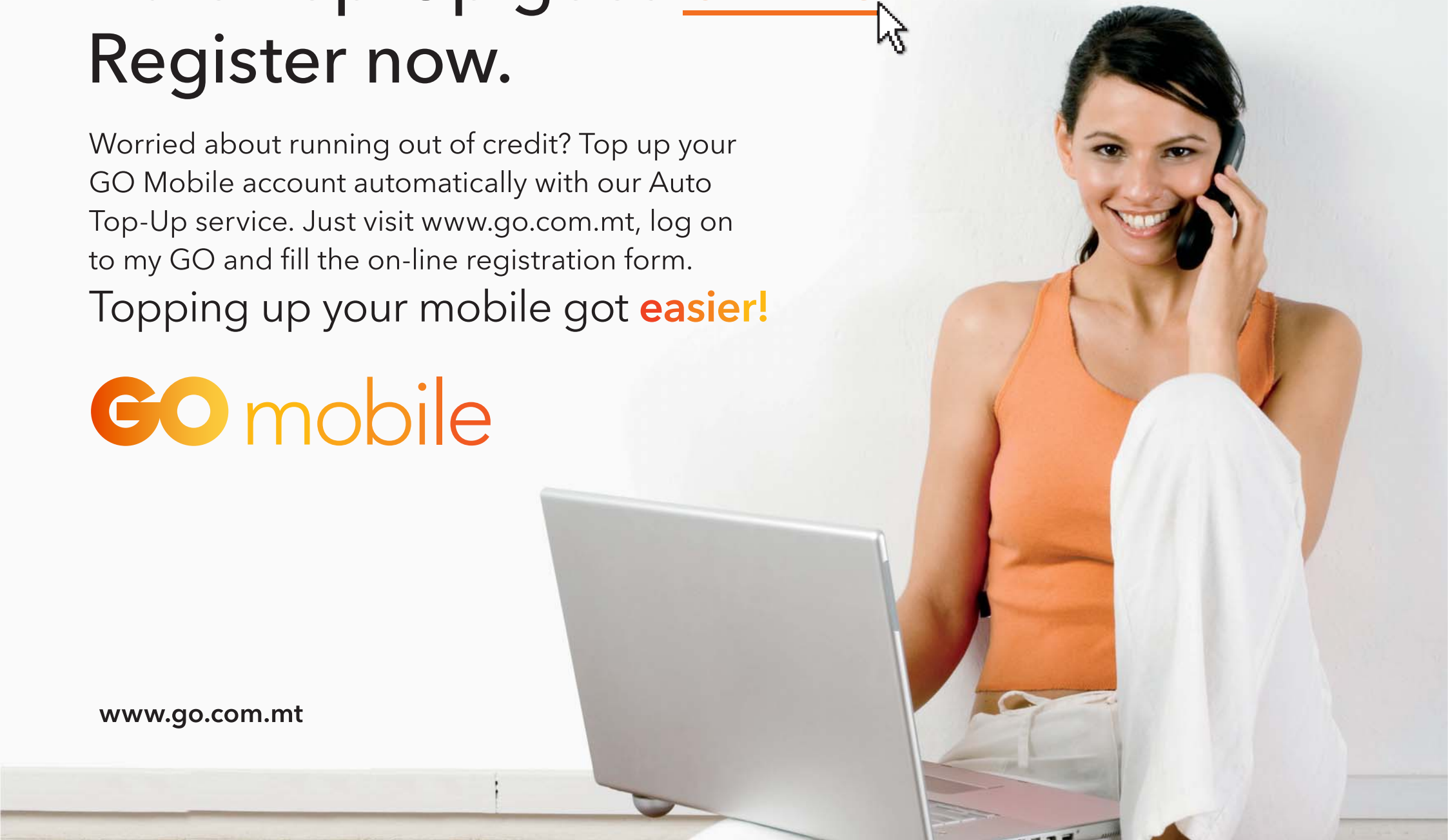

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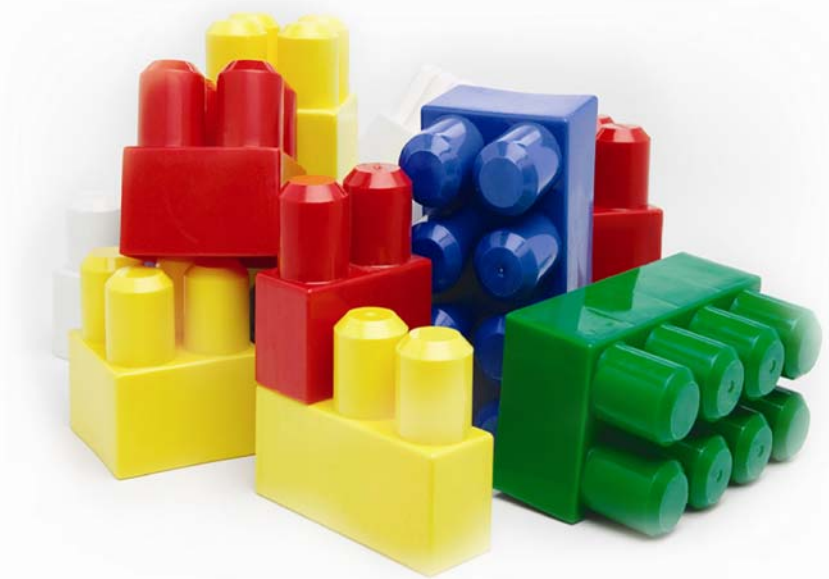

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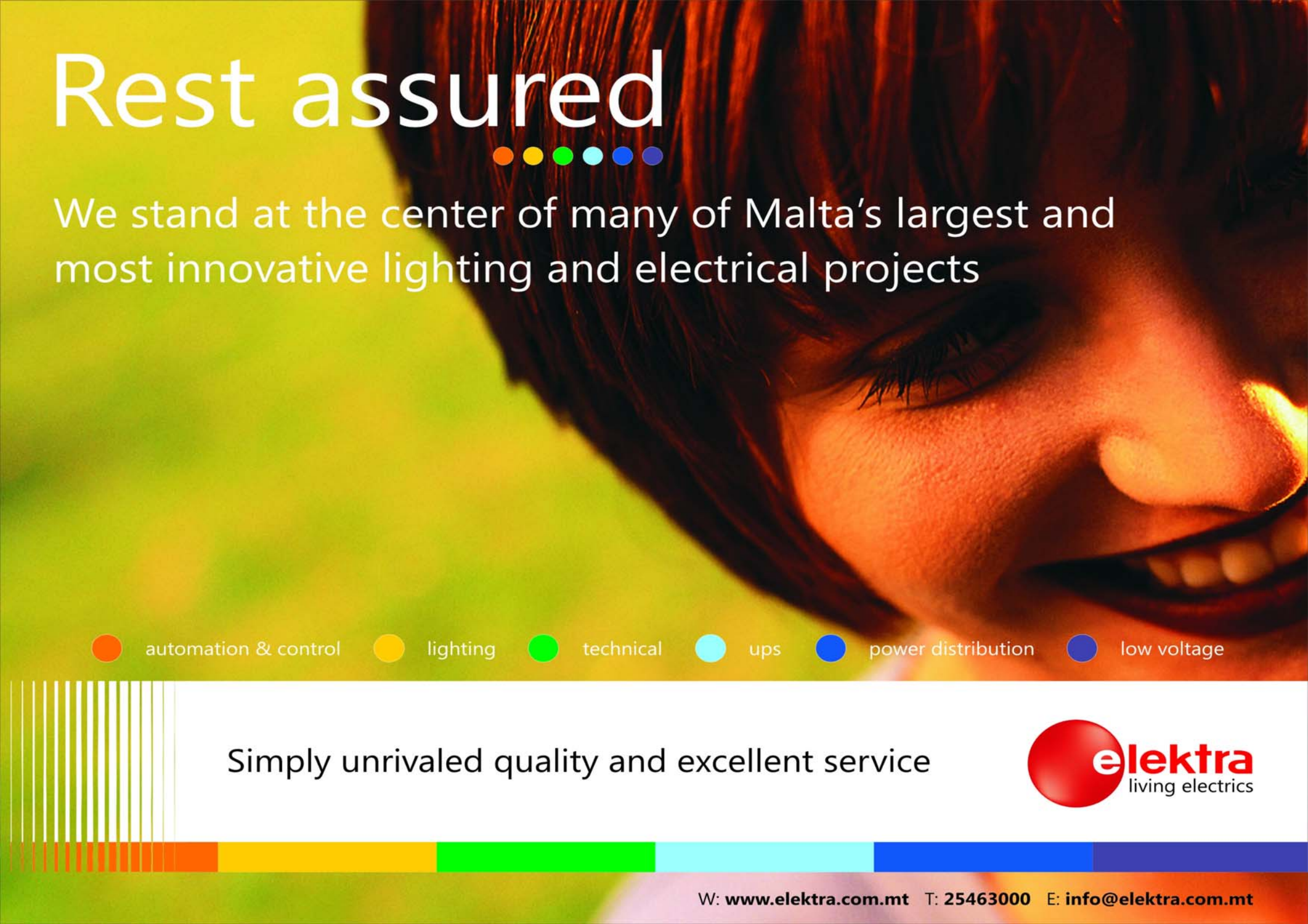
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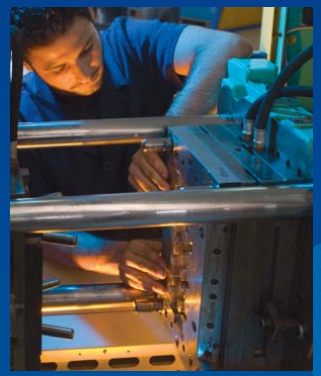

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Final Year Engineering Projects Exhibition 2008

University of Malta
Faculty of Engineering

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FOREWORD

In the Projects Exhibition of the Faculty of Engineering, we display the work that our final-year undergraduate students have carried out during the year as part of their dissertation. As one can see, the projects cover many fields and are a showcase of some of the work that goes on in our laboratories.

These projects are a great didactic tool. Through this final-year project, the student gains a deeper insight in the particular topic of his research, but it also enable him to gain a number of new skills and reinforce others gained in earlier years. These include the ability to work on one's own, the importance of time management and of carrying out tests and experiments according to established scientific principles and of interpreting the results, including negative ones, correctly. She or he will learn how to overcome the frustations of experiments that do not turn out well, of machines that break down, of bureacratic delays, of computers that hang up at the crucial moment, etc. And then there is the art of organising one's material into a dissertation that is readable, that is structured logically and shows up the work in the best possible light.

Academic staff also learn from these projects. Although one cannot expect too much from these projects, there is always something new for the academic supervisor, especially if the project is in an area which is relatively new for him or for her. Particularly useful (for the academic) are projects that build on earlier projects, and yet I remember a time when such projects were not considered appropriate; all projects had to be "new". I believe that I was the first staff member to break this unwritten rule; it was not the only unwritten rule that I have broken in my years at University, but that is another story.

I recall a former Rector reminding me that a University is a seat of learning and not just teaching. In other words, the staff are also there to learn and to create learning. This can only come from research. This is why there is such an emphasis on research at Universities. Research cannot be built up on final-year projects alone. Indeed, I have heard academics dismissing such work altogether; but I do not go that far. This means that we need MSc and PhD students to carry out longer and deeper research projects, ideally well-funded through grants from industry, EU or national funding programmes.

We already have a very good number of such projects, with postgraduate research students employed, some at research assistant level. The number of technical papers accepted in international conferences keeps growing from year to year. We are gaining momentum; one hopes that we do not falter on such issues as lack of adequate space and bureacracy.

I shall close this foreword by thanking the organising committee, chaired by Dr Jonathan Borg, for putting it all together, our sponsors for their support, the students for their projects without which we would not have this exhibition, the parents of the students, and the academic, technical and administrative staff for their work throughout the year.

Professor Robert Ghirlando
Dean, Faculty of Engineering

The annual exhibition of final-year engineering projects is always a happy occasion.

It is an opportunity for our University to celebrate the rich pool of talent of its graduates, and demonstrates, without shadow of doubt, that the engineering product of the University of Malta is world-class and the backbone of our industry.

The world we live in will continue to change rapidly and indeed an engineer will have to face technologies, in the course of his or her career, which haven't yet been imagined, less-still conceived. Today, perhaps more so than ever before, an engineer must be creative, must think outside the box, and must create or apply technologies to provide solutions for modern-day challenges.

We are proud that our engineering students get the theoretical, scientific and mathematical underpinning that is required to give them longevity and versatility in a world of rapid technological innovation. This said, our graduands, through their projects, have the opportunity to translate theoretical know-how into practical and innovative solutions to real-world problems. They are not merely ready to support our existing industries but they will undoubtedly become the pillars of tomorrow's industries.

The socio-economic development of our country requires our mechanical and electrical engineers to work in tandem with other professionals in other disciplines to create innovative and cleaner ways of generating and conserving energy, to devise efficient ways of managing and recycling waste, to create materials that enhance durability and longevity, to create automation to enhance production efficiency and accuracy. We see the advent of nanotechnology, we see the creation of complex instrumentation to control aircrafts, ships, and heavy machinery, and we see a brave new world unfold around us, heralded by the rapid developments in information and communication technologies that have been taking place in the past decade.

In short, it is a good time to be an engineer.

I believe that there is an engineer hidden in every one of us - let's design and build the future of our county together.

Professor Juanito Camilleri
Rector

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- Programmable Logic Control (PLC) Systems
- Robotic Manipulators
- Pneumatic/Hydraulic Control Rigs

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- DVT SmartImage Sensor and Accessories
- Various Actuators and Sensors
- PLCs
- Automation Training and Prototyping Facilities for Pneumatic and Hydraulic Systems
- Interfacing Hardware

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- CNC Vertical Milling Machine
- CNC Vertical Machining Centre
- 3D Scanning

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- Finite Element Methods Software ANSYS
- Impact Testing Equipment
- Sound Level Measurement Equipment
- Sub-sonic Wind Tunnel
- Tensile Testing Equipment
- Water Wave Generator

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- High Pressure Quench Vacuum Furnace
- Plasma Nitriding and Gas Nitriding Furnace
- Ion Beam Assisted Deposition Equipment
- Physical Vapour Deposition (PVD) Plant for deposition of hard ceramic coatings
- 9kW CO_2 Laser with 4-axis CNC system and powder delivery systems
- Pin on Disc Wear Testing Equipment, Coating Adhesion Tester
- Macro and Micro Hardness
- Tensile and Compression Testing Equipment
- Fatigue Testing Equipment
- Creep Testing Equipment
- Microscopes and specimen preparation equipment
- Scanning Tunnelling Microscope
- Salt Spray cabinet for Corrosion Testing
- X-ray Diffraction
- Salt Bath Equipment for treatments such as Martempering
- Gas fired furnace for Aluminium Castings
- Electric furnaces
- Automatic Degreaser for component cleaning
- CNC Machine Tool Centre for die manufacturing
- Sand Blasting Machine
- High Magnification Optical Microscope
- Stereo Microscope

POWER ELECTRONICS

- Harmonic Voltage and Current Measurement Set-up
- Grid Connected PV and Wind Systems
- High voltage and current DC supplies
- Passive/Active Filters for Power Factor Improvement
- Switching Frequency Current Sensing for Power Electronics and Control

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- CAD Systems (2D, 3D, Animation)
- CAD/CAM Systems
- Concurrent Engineering Research Facilities
- Thermoplastic Design Guidelines
- 3D Studio, AutoCAD, ProEngineer, Inventor
- 3D Scanner

SIGNAL PROCESSING

- Generic DSP Hardware
- Signal and Image Processing Software

GENERAL

- Networked Computer Laboratories
- Mail and Web Servers
- 100Mbits Switched Network in all offices and laboratories
- MATLAB and Simulink Simulation Software
- C, C++ and Fortran Programming Language Development

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Electronic Systems Engineering

Electronic System Design; Aviation Safety; Avionics; Traffic Collision Avoidance; Cockpit Instrumentation.

Industrial and Manufacturing Engineering

Concurrent Engineering; Intelligent Systems in Design and Manufacturing; Computer Aided Engineering Design; Product Development and Methodology; Rapid Prototyping; Industrial Sustainable Development; Industrial Robotics and Mechatronics; Robotic Grasping and Handling; Industrial Automation; Quality Engineering.

Industrial Electrical Power Conversion

Quality of Electrical Supply; Electric Vehicle Technology; Wind and P.V. Grid connected systems; Renewable Energy Systems; Electrical Energy Savings and Natural Daylighting; Electrical Machine Drives; Direct AC-AC Converters; Switching Frequency Current Sensing.

Mechanical Engineering

Thermodynamics/Fluids; Energy; Sound and Vibrations; Refrigeration; Structural Integrity; Pressure Vessel Design; Solar Cooling; Wind Turbine Design; Aerodynamics.

Metallurgy and Materials Engineering

Ion-beam Assisted Deposition; Laser Surface Engineering and Material Deposition; Plasma Assisted Physical Vapour Deposition, Austempered Ductile Iron.

Systems and Control Engineering

Computational Intelligence; Signal and Image Processing; Biomedical Signal Processing; Neural Networks; Machine and Computer Vision; Automatic Control Systems and Applications; Intelligent and Adaptive Control; Robotics; Biomedical Systems Modelling and Control.

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Biopattern
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Funding Source: EU FP6 ICT for Health

CCOPPS – Certification of Competences in the Power and Pressure Systems Industry
Department of Mechanical Engineering in a consortium with other European partners
Funding Source: EU Leonardo Programme

Computational Intelligence Techniques for Control of Complex Systems
Department of Systems and Control Engineering
Funding Source: National RTDI-2004

FastAhead – Strengthening Asian Higher Educatin on Advanced Design and Manufacture
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IDeLap
(**I**CT based design tool from the **De**velopment of Micro-parts for a **Lap**aroscopic Surgery tool)
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Department of Industrial Electrical Power Conversion in a consortium of European universities
Funding Source: EU Marie Curie Programme

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ACKNOWLEDGEMENTS

The Faculty gratefully acknowledges the following firms and organisations for financially supporting this year's Engineering Projects Exhibition:

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The Faculty also gratefully acknowledges the following organisations for kindly offering prizes to students who have shown commendable performance in some specific aspect of their B.Eng.(Hons) course of studies:

Chamber of Engineers, Group of Professional Engineering Institutions, RS Components, The Institution of Engineering Designers

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B. ENG. (HONS.) FINAL YEAR PROJECT ABSTRACTS

LEAN BASED ANALYSIS OF A MANUAL ASSEMBLY LINE

STUDENT: RODERICK G. ABELA

SUPERVISOR: DR. ING. CONRAD PACE
CO-SUPERVISOR: ING. PIERRE VELLA

Background

A current manual assembly line has certain characteristics, such as those related to material flow and resource utilisation, amongst others, which are unique to itself. Some of these characteristics may be influenced by the characteristics of the product being assembled in it. These characteristics are what make the line what it is, and it is through the study of such characteristics that problems can be brought forward such that improvements in their respect can be made. The never ending competition which is found in the manufacturing industry makes the task of performing such analysis to be regarded as a means of survival.

Project Objectives

The main objectives of this project are the following:

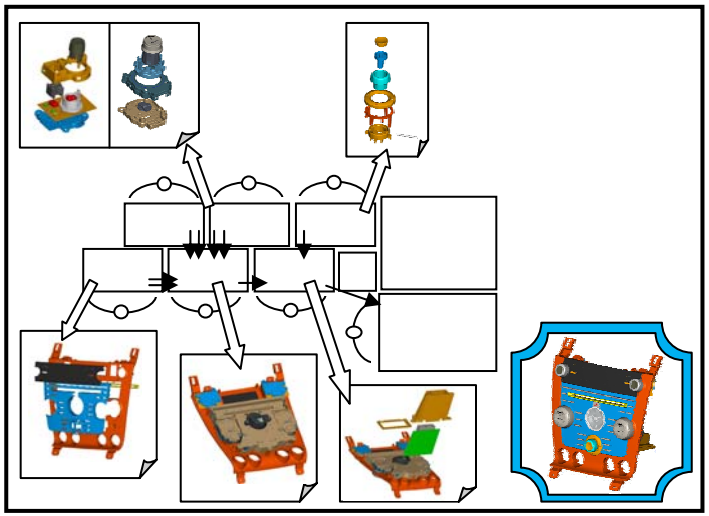
- Analyse an assembly line from a lean perspective.
- Propose and evaluate line improvements.
- Extrapolate the results by defining guidelines which would help industrial engineers design manual assembly line layouts and manual assembly stations.

The improvement proposals should make the line more efficient and effective and improve the quality of the characteristics of the line.

Project Methodology

The project was carried out as follows:

- Literature review on the concepts of Lean Manufacturing and Lean Assembly.
- Analysis of the general characteristics of the assembly line in question.
- Outline of the needs for the design of a manual assembly line.
- Outline, assessment and selection of proposed general layout solutions.
- Further analysis of the work performed at the individual stations.
- Outline, assessment and selection of proposed individual station solutions.
- Extrapolation of assembly line design guidelines.



Results and Achievements

The results of the solution presented were assessed to be quite satisfactory. A work sequence which increases the production rate by 57% is outlined. A layout which uses 55% of the original floor area and permits for a reduction in operator walking distance of 65%, whilst at the same time promoting efficient material flow, was designed. New part presentation methods are expected to reduce the time of the tasks in which they are involved by 50%. A significant reduction in the assembly time of four subassemblies is expected following work distribution revision. Finally, the guidelines outlined are regarded to serve as a good basis for industrial engineers in designing assembly lines.

UPGRADING AND EVALUATION OF THE NEW IAL ROBOT HAND

STUDENT: DAVID CASSAR

SUPERVISOR: DR. ING. MICHAEL A. SALIBA

Background

Many grippers used in industry today are simple pick and place robot end effectors of which the most common is the pinch type. Although these grippers are blind, deaf and dumb, they operate at extremely high speeds and reliability, and they are simple to control. However, such grippers can only grasp a family of very similar objects at most.

Research of construction of anthropomorphic hands has been ongoing. These biologically inspired grippers are similar to the human hand in shape, size and functionality. The reason such research was taken up is due to the outstanding complex grasping and manipulation that a human hand can perform. The main advantage of such grippers is the exceptional grasping versatility, not only with regards to objects of different shapes, sizes and weight, but also in their capability of using tools intended for humans.

The New IAL Hand using a screwdriver

Project Objectives

The aim of this project is the completion, upgrading, demonstration and testing of the New IAL Robot Hand built in a previous project.

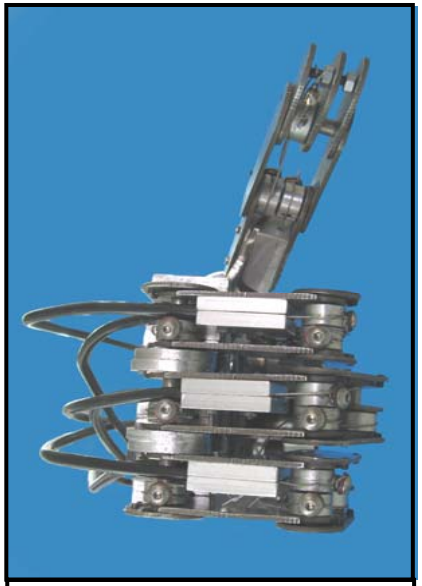
The project objectives are summarised below:

- Mechanical improvements deemed necessary along the way
- Conversion of joint actuation from single acting to double acting system
- Position sensing calibration and evaluation
- Force sensing calibration and evaluation
- Computer interfacing

The main goal of these objectives is the investigation of remote actuation and sensing, which would help minimize the weight and size of the hand, thus increasing the payload and the dexterity.

Project Methodology

The first step of this project was to perform mechanical improvements on the hand. The ease of dis/assembly was given great importance in the design stage of every modification. The major improvement of the system was its conversion from single acting to double acting. The hand and its sensing equipment were then interfaced with the computer through two DAQs. Position sensing followed. Here a large number of readings were taken and, for each joint, a relationship between the voltage reading and the respective angular position of the joint was found. This was then followed by force sensing which involved the loading of each finger with different weights and at different joint positions, and taking the respective readings.



Thumbs Up!

Results and Achievements

The mechanical improvements increased the chance of obtaining good results in the calibration of the sensing system. The position sensing was very successful and resulted with an average error of only 1.85°. The force sensing system did not give such good results, but can be improved with some modifications. Finally, computer interfacing allowed interaction between the hand and the user by clearly giving the readings obtained from the sensors and helping the user achieve the joints' desired angular positions.

CONTINUOUS DEVELOPMENT OF AN AUTONOMOUS GUIDED VEHICLE & PATH FOLLOWING

STUDENT: CHRISTOPHER CUTAJAR

SUPERVISOR: DR. C. PACE
CO-SUPERVISOR: ING. P. FARRUGIA

Background

The Department of Industrial and Manufacturing Engineering at the University of Malta has been working on Autonomous Guided Vehicles for a number of years. This year's project is the continuation on two previous ones. During the first project (2006) the current AGV platform was designed and built using a modular structure to allow other components to be included in the vehicles' system. During last year's project (2007) a simulation model for the guidance system of the vehicle and a path sensing system based on machine vision was developed.

Figure 1

Project Objectives

The main objectives for this year's project

- Development of new subsystems (both hardware and software) to facilitate the implementation of the guidance and path sensing systems.
- Developing further the path detection system and following systems.
- Evaluating the loading/unloading methods available, docking mechanisms for the current AGV platform and the conditions of illumination and their effects on the path detection system.

Project Methodology

Since robotics is an interdisciplinary field, during this project, problems from different areas where tackled. The project was carried out through the following phases:

- Literature review on general key issues related to AGVs and familiarisation with the previous vehicle structure, ***Figure 1***.

Figure 2

- Literature review, analysis, development and testing of a motor feedback acquisition system.
- Literature review, analysis, design and development of new 30:1 gearboxes and support legs for the vehicle platform, *Figure 4*.
- Development of a software based testing jig, for testing of the AGV's motors behaviour, unloaded & loaded.
- Familiarisation with previous vision system, developing of a testing jig, ***Figure 2*** and testing of the vision system.
- Evaluation of the loading/unloading and docking systems for the current AGV platform and illumination conditions and their effect on the path detection system.

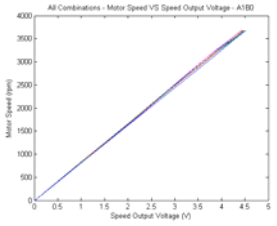


Figure 3

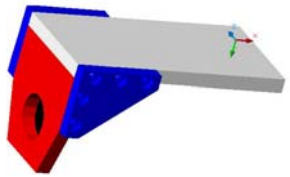


Figure 4

Results and Achievements

Testing of the unloaded AGV motor behaviour revealed that the usable bandwidth for control is only 80% of that stated by the manufacturer, since for the remaining 20% the change in motor speed is very small therefore negligible. The feedback acquisition system results were satisfactory, with excellent linearity and repeatability, ***Figure 3***. Testing of the loaded AGV motors resulted in a lead time, for the motor to attain the desired speed, of two seconds. The update time of the vision system is of only 50ms, meaning that the acceleration of the motors must be increased through the development of a PID controller. From tests of the vision system a set of tilt angles with an accuracy of about 90% was obtained. Finally tuning of the control algorithm for the vehicle with the new components was possible.

A COMPUTER-AIDED PART PROGRAMMING SYSTEM FOR THE SIEMENS ACRAMATIC 2100 CONTROLLER

STUDENT: AMANDA GALEA

SUPERVISOR: DR. ING. JONATHAN C. BORG
CO-SUPERVISOR: ING. PIERRE VELLA

Background

Currently, off the shelf CAM software packages available at the DME for use on the Siemens Acramatic 2100 Controller, have several shortcomings. These CAM software packages output code use a basic standard G-code and thus do not utilise the full potential of the controller. Though this produces a practicable output, this results in lower optimisation as well as efficiency and consequently higher cycle times. Secondly, in some cases, the program will require manual editing before it can run properly. Finally, since CAM software packages cannot reason the way a machinist can, they cannot optimise tool paths to reduce the cycle time to the extent required. These problems could be eliminated if the programming potential of the Siemens Acramatic 2100 Controller is fully exploited.

Project Objectives

The main aim of this project is to develop an in-house computer-aided programming tool, by which CNC programs, which fully exploit the potential of the Siemens controller, are generated automatically from part drawings created by the user on a CAD package. The tool should also take into consideration process parameters such as the required speeds and feeds, the tools required for performing a particular operation, and so on. Furthermore, the user should be informed when irregularities are performed while generating part drawings, such as using parameters which may damage the workpiece or the tool. This is a step towards Design for Machining. Part programs generated by the system should also be saved for future use.

Project Methodology

The steps followed to carry out this project were the following:

- Literature review on milling, CNC, CAD/CAM systems and CAPP.
- Practice with AutoCAD 3D, C programming and NC programming.
- Familiarisation with the Autolisp programming language.
- Implemention of the CAD part of the system and the part which creates the part programs.
- Optimisation of the part programs generated by the system.
- Testing of each part of the software.
- Transfer of part programs to the Siemens controller for graphical verification, by using the inbuilt 3D simulator.

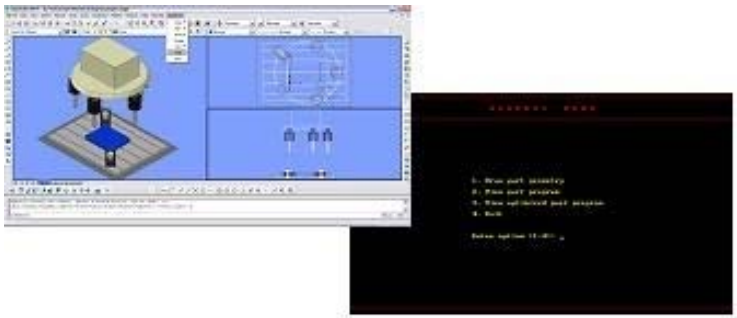


Figure 1. CAD subsystem (left) and the subsystem which creates the part programs (right)

Results and Achievements

A number of parts were machined successfully using the optimized part programs generated by the system. Also, the length of the part programs generated was substantially less than that produced by other available CAD/CAM packages, thus resulting in lower cycle times and increased efficiency.

MOBILE CAD FOR DFE

Project IM5

STUDENT: CHARLON GRIMA

SUPERVISOR: ING PHILIP FARRUGIA

Background

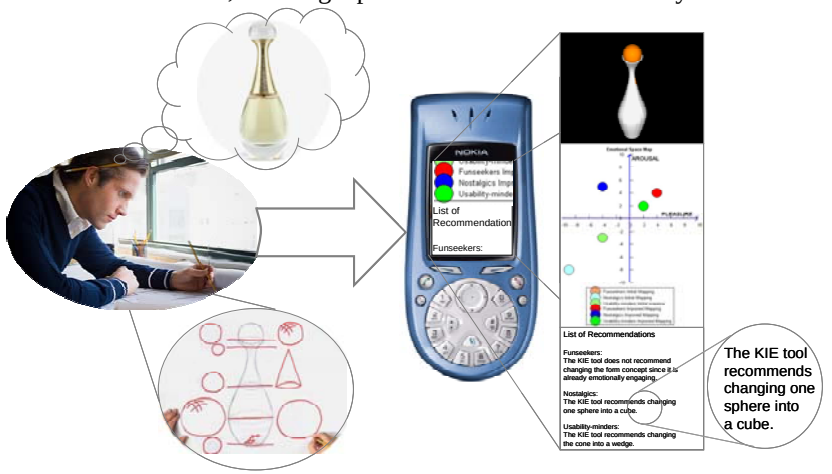
Merging emotional value into products has become an essential strategy for increasing a product's competitive edge in the consumer market. Indeed, this approach instills emotional value into products, to satisfy human emotional needs. Designers usually work outside their design office since ideas are usually stimulated. Combined with this, designers prefer externalizing their design intent using pen and paper as their sketching medium. In this regard, designers lack *mobile* computer-aided sketching (CAS) tools which truly link paper-based sketching with computer-based 3D modelling tools. As a step towards this direction a research prototype tool, mX-Sketch is continuously being developed at the Department of Industrial & Manufacturing Engineering at the University of Malta, that links *'freehand paper-based'* sketches with computer-based 3D modelling tools. However, with the current tool, it is not possible to provide emotional support about a form concept to satisfy the human emotional needs.

Project Objectives

The identified problem background brings forward a set of objectives for this project. The main aim of this project is to integrate an emotional support tool with mX-Sketch tool such that designers are provided with emotional guidance about a form concept generated from a paper-based freehand sketch, even when away from the design office. In this respect, the technical requirements which are required to improve mX-Sketch tool need to be specified in detail.

Project Methodology

The objectives that were defined provided a clearer perspective on how the research would be approached. First CAS tools and design for emotion theory were reviewed. This provided knowledge and in-depth understanding about the subject. This research, lead to the development of the framework architecture presented in the dissertation. A prototype tool was developed to implement the proposed framework architecture. Two case studies test the prototype tool in the design of two perfume bottles which are emotionally engaging for the user groups defined in the dissertation. This tool was then evaluated with six professional engineering designers and ten engineering students, who gave favourable comments, showing a positive attitude towards the system.



Results and Achievements

The predetermined improvements on mX-Sketch tool were developed, implemented and evaluated. These are the major steps involved to produce the full automation of the proposed system. The designer externalises his design intent onto a piece of a paper, converts it in prescribed sketching language (PSL), which the mx-Sketch tool is capable of interpreting, and sends it to the computer hosting mX-Sketch. Once mX-Sketch generates the script file, the Knowledge Intensive Emotion (KIE) is automatically launched, contributing to the provision of the emotional space map together with a list of recommendations to increase the emotional content of the form concept. Autodesk Mechanical Desktop® is then launched to generate a 3D virtual model. The knowledge generated from the prototype tool is then transmitted to the camera-phone. In this way the designers' aims are generated in a more efficient manner which better satisfies the human emotional needs.

PROPORTIONAL CONTROL OF A PNEUMATIC LINEAR ACTUATOR – SIMULATION AND IMPLEMENTATION ISSUES

Project IM6

STUDENT: JAMES GRIMA

SUPERVISOR: DR. ING. C. PACE

Background

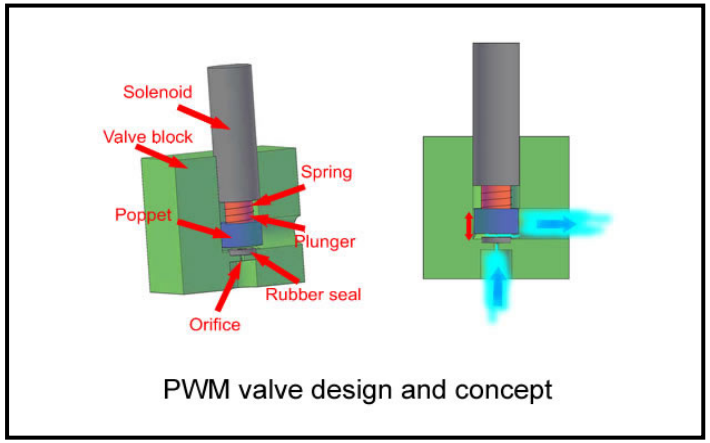
Pneumatics in engineering refers to the technology which uses compressed air to produce work. These devices are widely used in the robotic industry as pneumatic devices are generally the cheapest and the lightest amongst other competing actuation devices. Other interesting areas where pneumatic devices are used are in healthcare to help medical staff in handling patients and in the military. Here these actuation devices are used to reinforce human performance.

Project Objectives

The fact that makes these devices easily integrated with human beings is the compressibility of air. This also gives pneumatic device a cutting edge over other devices when it comes to handling fragile object, dealing with tolerances and operating under impact loading conditions. This same fact makes pneumatic devices hard to accurately control in terms of speed, displacement and force. This project regards the simulation analysis of a rodless pneumatic linear device in terms of performance characteristics from which a control device will be designed, fabricated and implemented.

Project Methodology

A simulation model was derived and built up to simulate the behaviour of the rodless pneumatic cylinder. A test rig was then built up to perform necessary experiments to optimize the simulation built. Apart from this, simulations of two types of valves namely, a spool type proportional solenoid valve and a Pulse Width Modulation valve were built up to analyse their performance. From the analysis performed the PWM valve was chosen as the controlling valve for the system. After determining the valve`s design characteristics through simulation, it was fabricated and tested



PWM valve design and concept

Results and Achievements

The simulation of the rodless pneumatic cylinder was successfully built, with the simulated performance having similar results to those gathered from the test rig. From this simulation the performance diversity between metering-in and metering-out at different situations were also concluded. The metering-out provided better control on the pneumatic cylinder while the metering-in provided greater flexibility over the steady state velocity bandwidths that can be achieved. The performance of a proportional spool type valve was also analysed by simulation. From this simulation, a suggestion to counteract the problem of stiction was derived. The PWM valve was also successfully simulated and from this simulation data regarding the frequency of operation, orifice diameter and other characteristics was gathered. Finally a PWM valve was designed and fabricated based on dimensions and characteristics derived from simulation analysis.

DESIGN FOR INTERCHANGEABILITY (DFI) IN SURGICAL TOOLS

Project IM7

STUDENT: MARIA RITA MUSCAT

SUPERVISOR: DR. ING. JONATHAN C. BORG
CO-SUPERVISOR: MS ALEXIA GRECH

Background

Laparoscopic surgical procedures are performed with minimally invasive surgical instruments which include an end-effector on the end of an elongated support tube opposite a handle. Currently available instruments have limited functionality and so surgical procedures requiring multiple functions are either performed with instruments through several incisions or else by repeatedly withdrawing and inserting instruments having the required functionality. Both approaches have drawbacks: in the former, the number of incisions must be minimized to reduce the postoperative pain and recovery time; and in the latter, exchanging instruments increases the operation time, surgeon looses train of thought and it is very expensive to keep the operating room adequately stocked with the range of instruments required by different surgeons for different surgical procedures.

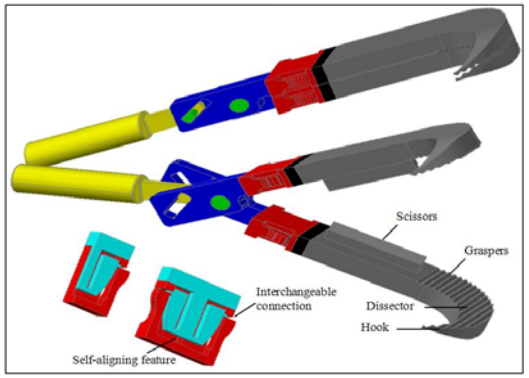
Project Objectives

Generation of:

i) a surgical end-effector offering a high degree of functionality (multifunctional) to reduce the repeated withdrawal and insertion of different instruments. The end-effector has interchangeable interfaces with the support tube so as to reduce the number of supporting tubes and handles so as to decrease costs incurred in manufacturing and purchasing cost as well as sterilization and disposal costs
ii) 3D model of the final solution
iii) Design for Interchangeability (DFI) guidelines

Project Methodology

A Medical Design Literature Review was first formulated including amongst others Design Methods and Principles; Minimally Invasive Surgery (MIS) advantages and disadvantages; and the Tools used and existing tool designs. The rest of the project followed the Basic Design Cycle. During the *Problem Analysis* the sequence and use of laparoscopic tools during surgery was studied and analysed after which a Product Design Specification and Quality Function Deployment were set up to establish the stakeholders requirements. The latter were used during the *Solution Synthesis* to develop several concepts. The final design concept, selected by means of Morphological Charts and Decision Matrices was drawn using CAED. A set of DFI Guidelines were generated during the *Solution Analysis* activity. By building a prototype and by interviewing several stakeholders, the newly designed laparoscopic end-effector was evaluated in the *Evaluation* activity.



Results and Achievements

The designed tool not only applies to Laparoscopic instruments but also to the majority of MIS instruments. The tool not only minimizes exchanges due to the multifunctional design but also reduces the costs incurred due to the interchangeable interface; both resulting in a higher operative efficiency. The set of guidelines generated not only apply to the medical sector but also to any design projects involving interchangeability.

AUTOMATION OF THE ASSEMBLY PROCESS FOR FORD IP SWITCHES

STUDENT: IAN MAMO PORTELLI

SUPERVISOR: DR ING. MICHAEL A. SALIBA
CO-SUPERVISOR: DR ING. CONRAD PACE

Background

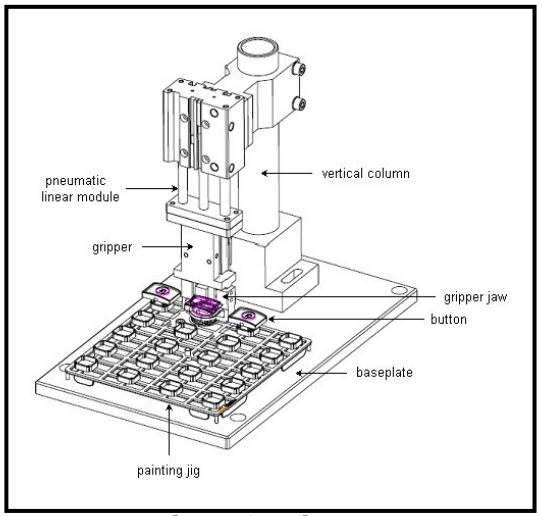
It is a common strategy among manufacturing organizations to start off with manual systems for the introduction of new products, and to gradually migrate to an automated integrated production as the demand for the product grows. The reason for this is that manual systems offer a fast and inexpensive means of getting started, but as demand grows and especially when the company is certain that the product will be produced in mass quantities and for a long time, automation can be considered on the grounds that it improves the production rate and cuts down on labour costs. In fact, the continuously growing demand for the production of Ford Internal Panel (IP) Switches at Methode is the main reason why an automated integrated production is currently being considered.

Project Objectives

The main aim of the project is to come up with a conceptual solution for the automatic assembly of various types of buttons, each to a socket of which only one type exists. The solution should meet all the industrial requirements set forward by Methode Electronics Malta Ltd., and an initial prototype has to be designed and constructed so as to model and test the most important aspects of the complete concept, which prototype will then be used as a stepping stone for the manufacturing of the final system.

Project Methodology

The 'Basic Design Cycle' and several standard design tools and methods helped in meeting the project objectives. The next step that was carried out after the identification and statement of the problem was a detailed analysis of the current manual process and of the components that need to be considered for automatic assembly by the new system. All specifications and functional requirements were clearly listed, and the necessary boundary conditions were assumed. The problem was then divided into a number of sub problems, and a brainstorming session was run in order to come up with sub solutions. A function-means structure and a morphological chart were developed and various sub solutions were selected and combined to generate the conceptual solution. Finally, a solution prototype was designed and manufactured, and tests were conducted to make sure that the handling system functions as required.



The Designed Prototype

Results and Achievements

The tests that were carried out show that the designed handling system is capable of picking up the different types of buttons without damaging or marking them in any way, which means that the major industrial requirement has been met. At this stage, a good failure modes and effects analysis (FMEA) was also carried out so that all the possible failure modes were considered and assessed, and their consequences studied.

DESIGN FOR EMOTION (DFE) OF COSMETIC PACKAGING

Project IM9

STUDENT: JOSEPH SWAIN

SUPERVISOR: DR. ING. JONATHON C.BORG
CO-SUPERVISOR: ING. OLIVER FENECH

Background

This project sponsored by Toly Products Ltd tackles one of the challenges faced by the cosmetic industry in recent times. The ever increasing competitiveness in product design substantiates the fact that good product functionality and usability are no longer sufficient effective differentiators in the market place.
As a result stakeholders' attention is shifting to other product attributes such as the pleasurable emotions experienced during interaction. For this purpose the design of product emotions (DFe) is today considered an important means for improving the prospects of a successful design.
Toly Product Ltd customers such as 'Chanel' are looking for the 'soft and 'smooth' aspects in their products and how these features can be included in products without gimmicks such as adding lubrication to increase the smoothness. The perception of a 'soft' pleasurable sound upon closing a compact case, or the 'smooth' torque movements of the lipstick are a few examples of such design strategy. These problems have to be tackled from two main aspects, the mechanism of the lipstick case and the selection of the material used.

Project Objectives

- Literature search in the field of DFe.
- Evaluate the actual market needs for such an emotional solution.
- Identification of the product features leading to emotions.
- Setting up a set of DFe guidelines for cosmetic packaging.
- Evaluate a set of final design solutions with potential stakeholders.
- Manufacture a set of pleasant cosmetic packaging prototypes.

Project Methodology

DFe of lipstick cases is a vast area. For this reason the main focus was based on the mechanism of the lipstick case i.e. how the lipstick content is going to be forced upwards and downwards and the material selection rather than going into certain detail on the actual outer aesthetics of the product.

Prototype A

Prototype B

Prototype C

Results and Achievements

A number of potential designs with different mechanisms were developed. Some of them even manufactured as shown in the above figures. These prototypes were evaluated both by Toly Products Ltd and by other potential customers. From these prototypes a set of DFe guidelines were constructed. These guidelines will help the designer to design products which will elicit emotional pleasure when used.

COSMETIC COMPACTS INTEGRATED TAMPER DEVICE

Project IM10

STUDENT: DUNCAN ZAMMIT

SUPERVISOR: DR. ING. JONATHAN C. BORG
CO-SUPERVISOR: MR. O. ZAHRA

Background

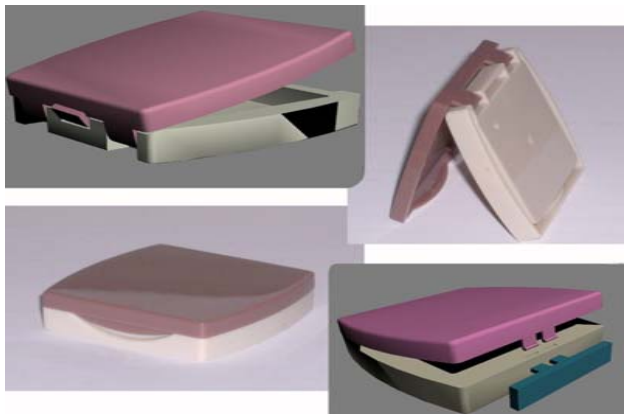
This project comes from an industrial problem being encountered by Toly Product (Malta) Ltd, manufacturers of world class cosmetic cases such as those for Chanel, Yves Rocher, Nina Ricci and The Body Shop. When cosmetic compacts are sold in shops, a tamper evident seal is normally added. This is a secondary process and adds production costs as well as being seen as an ugly feature. Generally stores order cosmetic products from the cosmetic manufacturers and place them on store shelves for consumer sales. A significant number of those products are tampered by consumers and considered as damaged. These would not be sold and need to be removed from shelves and sent back to the cosmetic companies to be replaced. Therefore returns are a cost drain for the cosmetic companies and also for the sales outlets

Project Objectives

The aim of this project is to explore design concepts that are an integral part of the compact i.e. when the product is manufactured / assembled by Toly, it will include a tamper protection that controls the extra costs incurred and will be neatly integrated into the overall design. Furthermore, the tamper device needs to be designed in such a way as not to interfere with the filling. Finally, the solution implemented should be useful across a range of products and be an extension / modification of the existing products.

Project Methodology

The design model employed in this project is 'the Basic Design Cycle'. The elements constituting to the cycle include: Function, Problem Analysis, Solution Synthesis, Solution Analysis, Solution Evaluation and The Decision. Various design tools were used including; Quality Function Deployment (QFD) which is a technique used to capture the "voice of the customer" and translate it into the required functionality and attributes of the product; Product Design Specifications (PDS) which sets out fully and in detail what will be required of a product, before it is designed; Morphological Chart to visually explore alternative means and combinations of achieving the product functionality; Creative thinking methods including brainstorming sessions, metaphorical thinking and Six Thinking Hats technique, Benchmarking, Decision Matrix; Failure mode and Effect Analysis (FMEA) to identify all possible failures in design, a manufacturing or assembly process and Design for X methods including Design for Aesthetics, Manufacture and Assembly.



Figures: Top right & bottom left represent the original cosmetic compact.
Top left & bottom right represent the two chosen concepts.

Results and Achievements

The aims of this project were reached as five potential concepts were developed from which two potential solutions were selected by making use of a decision matrix. Apart from these solutions, a literature search was conducted and classification of family of products was done. The manufacturing costs were estimated. Finally, virtual and physical prototypes of the selected solutions were produced and machined respectively.

A Variable Compression Opposed Piston Engine

Project M1

STUDENT: DAVID BORG BARTOLO

SUPERVISOR: PROFESSOR ROBERT GHIRLANDO

Background

The thermodynamic efficiency of an internal combustion engine is dependant on the engine's *compression ratio*. According to the Otto cycle, by increasing the compression ratio, the thermodynamic efficiency of the engine is increased according to:

$$\eta = 1 - \frac{1}{r_v^{\gamma-1}}$$

Where: η is the thermodynamic efficiency

r_v is the compression ratio

γ is the isentropic index of air

Project Objective

The work carried out in this thesis involved the design and implementation of a gearbox, to be mounted onto an opposed piston engine so as to *vary the engine's compression ratio while the engine is running*. The introduction of a gear setup between the two crankshafts would ensure that there is *no slip* in the drive and thus the engine's compression is maintained. By advancing or retarding one crankshaft relative to the other, the maximum and minimum separation between piston faces is altered. In an opposed piston configuration this would directly imply a change in the engine's compression.

Project Methodology

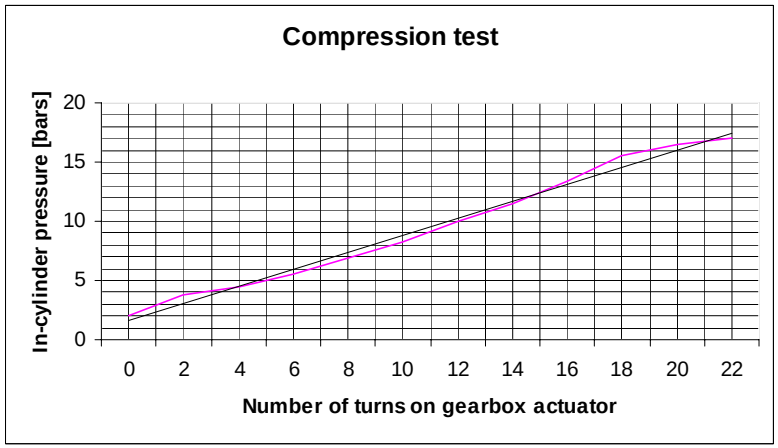
The gear train design was derived from a dynamic analysis of a set of idler gears while undergoing rotation about the crankshafts' axes. The gears used were rated for their power transmission capacity and a *Finite Element Analysis* was carried out on the gear train rig so as to ensure its structural integrity during all operating conditions.

Finite Element Analysis was carried out by first computing the loads being transmitted to the rig components while the engine is delivering 3kW- the maximum recorded power output being of circa 1.4kW. The symmetry of the gear train rig allowed for the analysis of only one set of idler arms and the full computed load was applied onto this one set – increasing the factor of safety further.

By varying the compression ratio of the engine, the ignition point had also to be varied so as to provide the ignition spark at the correct instance. Thus, the magneto was mounted onto an arm which is free to rotate about the upper crankshaft axis, enabling the setting of the optimum ignition point

Results and Achievements

Compression tests carried out on the engine have proven that the designed gear train is an effective means of introducing a phase difference between crankshafts and thus obtaining a wide range of compression ratios while the engine is running.



In-cylinder pressures of up to 17 bar have been measured. The setup allows for both integer and non-integer compression ratios.

INVESTIGATIONS ON THE HEAT TRANSFER PROPERTIES OF WALL STRUCTURES

Project M2

STUDENT: ALBERTA BUGEJA

SUPERVISOR: PROF. R. GHIRLANDO
CO-SUPERVISOR: DR. M. FSADNI

Background

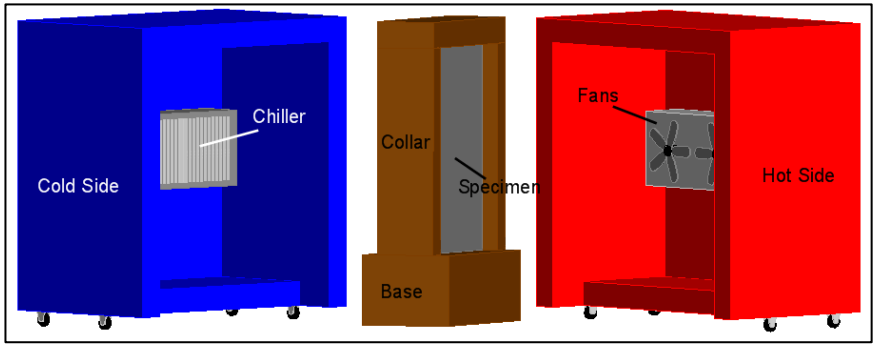
The electricity demand in the domestic and commercial sectors continues to increase, mostly for air-conditioning, which is used due to lack of thermal comfort in buildings. The energy balance of the climate system is being altered by changes in the atmospheric concentrations of Greenhouse Gases (GHGs) and aerosols, land-cover and solar radiation. Research on the thermal properties of local building materials must be carried out further. Investigations on the heat transfer properties of bricks and globigerina limestone were carried out in this dissertation. The effect of the addition of insulation to a brick wall was also investigated.

Project Objectives

The aim of this project is to determine the thermal conductivity of various local building materials using a Calibrated Hot Box. The objectives are to research methods for calculating 2D heat transfer problems, especially in adjoining walls' edges and corners, collect and understand data and methodologies from previous projects, conduct research on local materials that are currently used for building and apply researched theory to improve precision in obtained data.

Project Methodology

The calibrated hot box used in this dissertation was built by M. Fsadni in conjunction with the Institute for Energy Technology. The hot box is made of two well-insulated chambers between which the specimen to be tested is built. The walls of both chambers are made from 0.225m of expanded polystyrene, acting as insulation, with an outer plywood shell. The hot chamber and cold chamber are supported on wheels so that they can be rolled away from each other, leaving the specimen to be tested in place. Thermocouples are attached to the wall specimen surface, the back, bottom, top, left and right internal and external surfaces of both hot and cold side. The temperature readings from the thermocouples are monitored using a PC-based data acquisition system.



The thermal conductivity of the wall specimen was calculated by finding the heat transfer through the specimen. The heat input from the fans on the hot side of the box was measured. 1D and 2D heat transfer equations were used to calculate the heat losses from the box walls, edges, corners and collar. These were subtracted from the total heat input, in order to find the heat transfer through the wall specimen.

Results and Achievements

The U-value of 4.076W/m^2·K obtained for the brick wall was smaller than expected. This could be due to the change in level of humidity of the wall. The U-value for the brick wall with insulating paint was expected to decrease. In fact the U-value obtained was 3.70 W/m^2·K. The small decrease in the U-value shows that the insulating paint did not have a relevant effect on the thermal conductivity of the brick wall. A U-value of 1.43W/m^2·K was achieved for the brick wall with 5cm expanded polystyrene insulation. This type of insulation has proved to be considerably effective.

ANALYSIS OF A LOWER LIMB JOINT

Project M3

STUDENT: ALASTAIR CAMILLERI

SUPERVISOR: DR. ING. ZDENKA SANT

Background

The number of knee injuries is on the rise, partly due to increasingly sedentary lifestyles. The creation of a computational model of the knee joint is a valuable aid in the analysis of the peak stresses and stress distribution of this major joint. A further use is as the beginnings of the model for arthroplastry (joint replacement).

The knee has a great range of motion. Throughout that range it must support the body resisting forces up to five times body weight. Therefore it comes as no surprise that the joint is designed to minimize these loads as far as possible. Even the bony material itself is designed with these loads in mind and has correspondingly complex material properties.

Project Objectives

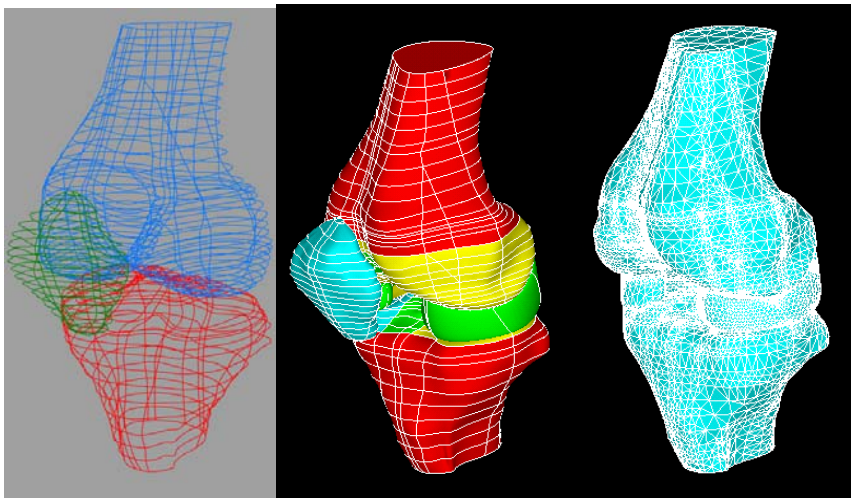
The aim of this project is to create a patient specific model of the knee, loaded in compression, from CT (computed Tomography) data.

- Create a solid model of the femur, tibia and menisci.
- Determination of suitable material properties.
- Analyse the stress and strain distribution of the joint under a compressive load.

Project Methodology

The project was begun with a comprehensive investigation of the biological and biomechanical structures, properties and behaviour of the knee joint. Following this a general review of the most commonly used modelling techniques was carried out. From this point the modelling objectives were defined in more precise terms in order to reduce the complexity to manageable levels by determining what assumptions (regarding material properties and superfluous detail) may be taken.

The model shown in the figure below includes the tibia (bottom), femur (top) and menisci (in between). The model was created by tracing the outline of the CT slices in a CAD (Computer Aided Design) package and connecting these outlines together vertically. The set of splines was imported into a FEA (Finite Element Analysis) software package. The FEA software available was ANSYS 11.0. Here the splines were joined to form areas and these areas used to create volumes. The volumes were meshed and the resulting model constrained and loaded. The creation of a meshed model requires that the material properties be defined. These were mostly found in literature but required some interpretation since some data was contradictory. The load used was computed from analytical biomechanics and was found to be 417 N.



Results and Achievements

Computation is in progress therefore no results are available at this time. The stress distribution in a healthy knee is fairly uniform despite relatively small contacting areas. That said, imperfections in a person's anatomy can alter the situation significantly. A handful of locations were identified that are likely to amplify stresses beyond the normal thresholds expected.

DESIGN AND CONSTRUCTION OF A WATER WAVE GENERATOR

Project M4

STUDENT: JAN CAMILLERI

SUPERVISOR: DR ING. TONIO SANT

Background

Many organizations and companies manufacturing sea-vessels, offshore structures or any other product whose performance is affected by water waves, are investing in water wave generators. By means of these generators these organisations can perform experimental testing to ensure that the design criteria are met. The University Of Malta, like many others, felt the need to invest in one type of these systems so that experiments that involve wave interactions can be performed, say to investigate the fatigue loading due to wave interactions on a dynamic similar scale model of an offshore wind turbine or to investigate the stability and performance of maritime structures.

Project Objectives

The main project objectives included:

- To carry out research on wave generating setups that currently exist at different laboratories, thus obtaining an idea of their design features and performance
- To design a wave generator that is able to produce deep water waves, in the available tank at the laboratories
- To construct the designed wave generator
- To test the wave generator at different settings

Project Methodology

In order to carry out the design in the most structured way possible, a design cycle was followed, where first the problem was analysed and as a result a well structured criteria was established. Afterwards, several potential solutions were put forward and the solution was chosen with the help of several design tools to ensure that the solution chosen satisfies best the criteria. Other critical features where determined in the same way. Then, several conceptual sketches were drawn and carefully analysed, thus helping in identifying small design features that were still to be tackled. Once these where tackled Design For X methods were implemented and various product issues such as safety and product flexibility issues were targeted. Then the analyses focused on determining the dimensions of each component so that the mechanism operates as intended. This section also included determining the forces and stresses acting on each component to verify that each component is able to withstand the forces it is subjected to during operation. The drawings were then drawn after which construction started. The components were cut, machined and assembled as specified in the drawings. Once the construction phase was finished the wave generator was assembled in place and testing was performed.

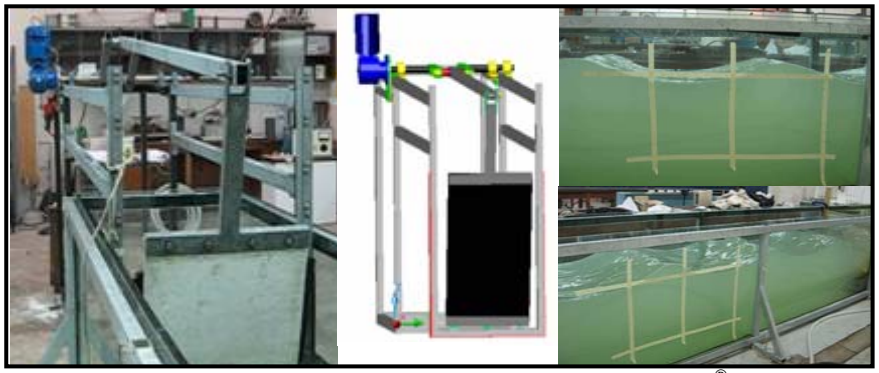


Figure 1: Showing the constructed wave generator, AutoCAD® model and photos of the waves generated

Results and Achievements

After going through the design cycle, a functioning wave generator was built (as shown in figure 1), that is capable of generating waves, whose characteristics are similar to real deep water waves. Some of these characteristics include frequency, surface profile and no particle motion at the bed (bottom of the wave channel).

STUDY AND IMPLEMENTATION OF FORCED INDUCTION ON AN FSAE ENGINE

STUDENT: MARLON CHIRCOP

SUPERVISOR: DR. ING. M. FARRUGIA

Background

The Formula SAE competition is a student based competition in which university students from around the world are challenged in using their skills and studies in order to design, build and race a formula style racing car. Rules dictate that an engine of 610cc maximum capacity must breathe entirely through a mandatory restrictor having a maximum throat diameter of 20mm when running on gasoline.

This inevitably limits power potential drastically and thus students need to make use of techniques such as programmable engine tuning, altering valve timing and turbocharging amongst others in order to get the best performance possible out of both the engine and car alike.

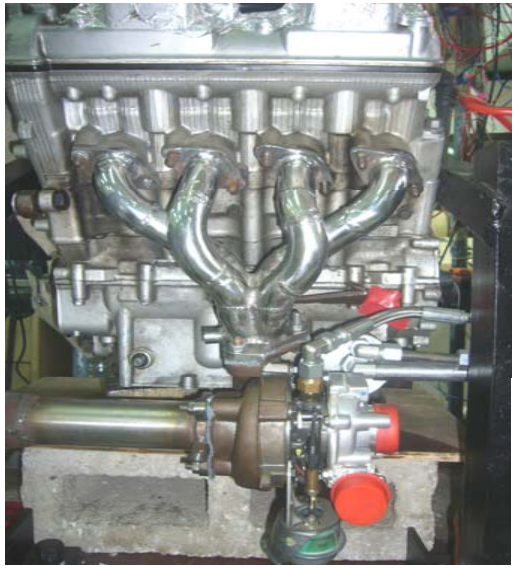
In this dissertation, a full physical conversion of a Kawasaki ZX6R 600cc motorcycle engine from naturally aspirated to turbocharged was carried out. The GT15V turbocharger used was provided by Honeywell Technologies and is of variable nozzle type.

Project Objectives

Project objectives included the study and learning about the different turbocharging setups which exist, turbocharging the Kawasaki ZX6R including the reduction of the engine's geometric compression ratio, the manufacturing of the intake and exhaust systems and the installation of an intercooling setup. Furthermore, a turbocharger boost control setup needed to be set up and the engine needed to be installed on an engine dynamometer and the Reata ECU and tuned for close to stoichiometric operation.

Project Methodology

The Kawasaki engine was first tested on the engine dynamometer in order to ensure correct operation prior to dismantling. After dismantling, an aluminium decompression plate was machined in order to reduce the geometric compression ratio from the stock 11.8:1 to 7.5:1 in order to obtain a knock free operation when the turbocharger comes on boost. The intake and exhaust manifolds were fabricated out of AISI/SAE 304 stainless steel. A carbon fibre engine restrictor was fabricated and a new throttle body was machined out of billet aluminium. The engine was later fully reassembled and set up on the dynamometer for testing. A new gasket design was machined and tested to ensure compression retention.



Results and Achievements

The new gasket design retained compression up to a test pressure of 55bars. Moreover, the engine was successfully tested for different compressor pressure ratios. For each MAP value both fuel and spark advance were tuned in order to ensure proper engine running.

TESTING OF RO MEMBRANES UNDER STOP/START CONDITIONS

Project M6

STUDENT: GILBERT COSTA

SUPERVISOR: PROF. R. GHIRLANDO
CO-SUPERVISOR: MR. R. SCHEMBRI

Background

Reverse osmosis (RO) plants consume a lot of electrical energy. In fact, they take some 3-4 kWh to produce 1 cubic meter of RO water. Therefore, if the RO plants could be stopped and started easily, they could soften the load curve at Enemalta. Hence, this could also be seen as a way of storing electrical energy. However, it is generally believed that stopping and starting RO plants will shorten the life of the membranes, but at the moment no clear data exists in this regard. Therefore, the aim of this project is to test RO membranes under stop/start conditions and hence, some data about this concept can be obtained.

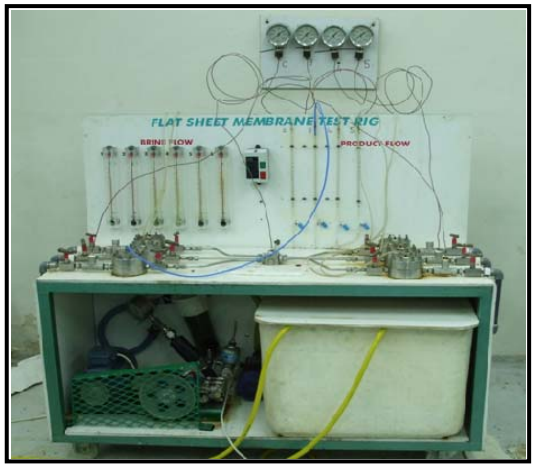
Project Objectives

In this project, the main objectives are:

- To analyse what modifications are needed to the Flat Sheet Membrane Test Rig so that it could function properly
- To determine and plot the control curve of water flux (J_1) against time as well as salt flux (J_2) against time for a flat sheet membrane
- To conduct tests on flat sheet membranes and obtain reliable data on the effect of intermittent operation on the life of RO membranes.

Project Methodology

In each test conducted, 3 membranes were tested in 3 different test cells simultaneously, and then, their average result was used. The first test conducted was run for 8 hours straight and was that of the configuration of the control curve. This test was done so that the other tests to be conducted later on could be compared with the results obtained from it. Subsequently, with reference to this research study, various tests were conducted by varying the stopping/starting frequency and the stopping/starting time duration. Each time, the tests were conducted for an 8 hour working period. Therefore, after obtaining the amount of product water produced and its conductivity, the water flux J_1 and salt flux J_2 could then be found out for each test. Hence, for every test done, graphs of water flux J_1 against time, and salt flux J_2 against time could then be plotted.



Final Flat Sheet Membrane Test Rig

Results and Achievements

After that all the results obtained from the various tests conducted were analyzed, it can be concluded that RO membranes are affected negatively under stop/start conditions. In fact, their performance after stopping/starting the test rig is reduced because the water flux decreases while the conductivity (and so the TDS) of the membrane under test does not decrease so much as in the configuration of the control curve.

HUMAN / BATTERY POWERED VEHICLE

Project M7

STUDENT: TERENCE DELIA

SUPERVISOR: DR. ING. MARTIN MUSCAT

Background

Cycling is one of the cheapest and cleanest forms of transport well suited for short-distance travelling. Unfortunately, cycling is disregarded by many people; the idea of having to pedal the vehicle uphill is what scares them off. Hence it was decided to design and build a vehicle which would be both human and also battery powered when necessary. This gave rise to the need of determining the ideal position in which a human is able to pedal efficiently.

Project Objectives

- Design and build a rig to measure human power output in various positions
- Design and build a simple dynamometer including transducers
- Do a range of testing and plot results by using LabVIEW
- Be able to decide on the seating position that gives the highest and also the most efficient power output for the eventual design of a human powered vehicle.

Project Methodology

- Carrying out a literature review on cycling, dynamometers and load cells
- Design and finite element analysis of the test rig
- Construction of the test rig
- Calibration of load cell and speed sensor
- Testing of dynamometer
- Running tests for various cycling positions at various loads
- Plotting of graphs for torque, speed and power for each test

Results and Achievements

At the time of writing, the dynamometer has been calibrated and tested for a number of thirty second runs in order to ensure stable torque loads and correct output values. Extended tests for different cycling positions are still to be performed.

A STUDY ON THE BUCKLING PHENOMENON

Project M8

STUDENT: BRIAN ELLUL

SUPERVISOR: DR. ING. MARTIN MUSCAT

Background

Buckling is a mechanical failure mode that occurs where compressive stresses are present. For example, when a slender rod is subjected to compressive end loads, at a particular load, it will bow out which signifies that buckling has occurred. The first published paper on this phenomenon dates back to 1759 where Leonhard Euler (1707-1783) published a paper on column buckling. Since then, various people studied this phenomenon for different structures such as frames, plates and shells either experimentally, analytically or numerically.

Project Objectives

The project is focused on the study of shells of revolution. It starts from the shell theory of general shape from where the nonlinear equilibrium equations and consequently the linear stability equations are obtained. The latter equations are then applied to shells of revolution. The linear finite element analysis for shells of revolution is presented as a background for the next section i.e. finite element analysis using ANSYS®.

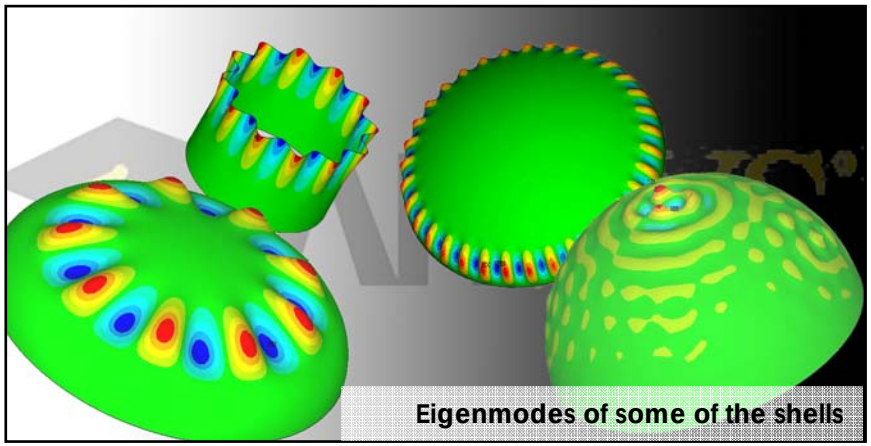
In the last section mentioned above, different types of shells of revolution were modelled using ANSYS® both linearly and not. An effort was made such that these models were written in a parametrical format using the features of APDL to make them easy to use although they are also explained in the dissertation. The results obtained from these models are then compared with experimental results which are available in literature.

Project Methodology

Buckling analysis by the finite element method, is carried out in two main parts:

- A linear analysis, also known as bifurcation or eigenvalue analysis.
- A non-linear analysis based on the results obtained from the previous linear analysis.

The scope of the linear analysis is twofold; First, it gives an eigenvalue which corresponds to the critical buckling load and secondly an eigenmode which corresponds to the shape of the structure when it buckles. The nonlinear analysis is then carried out, which includes nonlinearities such as, the stress-strain relationship of the material and geometric imperfections on the structure. The latter is obtained by updating the model's geometry from the eigenmode of the linear analysis. The output of such an analysis is a relationship between the applied load and the displacement of a point on the shell. The buckling load is defined as the load that produces a rapid increase in the displacement.



Eigenmodes of some of the shells

Results and Achievements

- The eigenvalue was found to be higher than the result obtained from the nonlinear analysis.
- The nonlinear analysis gives more accurate results than the linear one.
- Shells under pressure, buckles into a number of circumferential wavelengths.
- Nonlinear numerical buckling analysis of shells under pressure is difficult due to convergence problems of the solution.
- Generally, the load at which the solution doesn't converge corresponds to the limit load.

ANALYSIS OF SPINAL SEGMENT

Project M9

STUDENT: **GARETH GILSON**

SUPERVISOR: **DR. ING. ZDENKA SANT**

Background

Back pain is a common ailment for many people. According to figures published by the statistics department in America, back pain affects 90% of its population at some time or other in their lives. Currently research, together with surgical treatment, is costing the United States government around 100 billion dollars annually. Across the ocean, it is estimated that 25% of European adults are affected by pain caused in conjunction with osteoarthritis.

Project Objectives

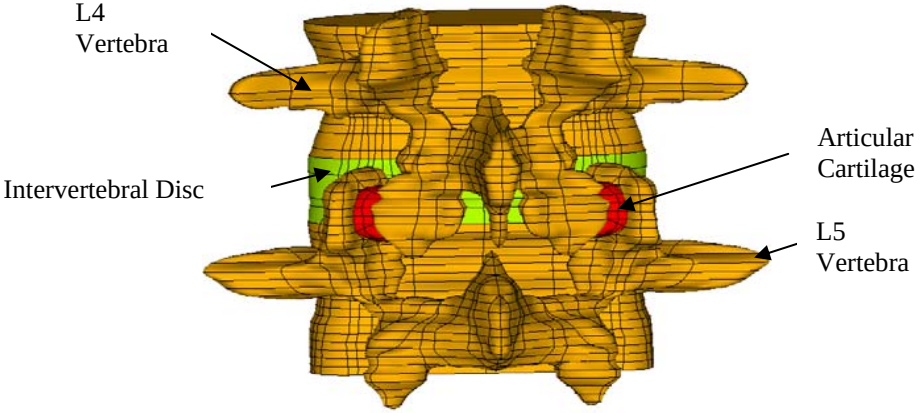
The aim of this dissertation was to create a **Spinal Segment** model of two adjacent vertebrae, that is the L4 and L5 vertebrae, together with the intervertebral disc (nucleus pulposus and annulus fibrosus), endplates and zygapophysial joints (i.e. articular cartilages).

The created 3D model was to be loaded in a way so as to simulate the loads encountered daily. That is, the section of the lumbar spine in question was to undergo **Axial Compression, Flexion**, **Extension**, **Lateral Flexion, Rotation** as well as a combination of the above.

Project Methodology

Firstly, JPEG images of the CT images were obtained. These were then imported into Rhinoceros Computer Aided software, better known as **Rhino3D**. This software was used to create a 3D line model of the two adjacent vertebrae as well as the intervertebral disc. Splines that divided the individual vertebrae were then drawn so as to facilitate area generation. The complete Rhino model was then exported to a finite element analysis package, **ANSYS**. Using **ANSYS**, areas were created by means of a Coon's patch and from these areas a volume was created. The articular cartilages were then created in the region where the superior articulate and the inferior articulate processes meet. Material properties (*Young's Modulus* and *Poisson's Ratio*) were then assigned to the individual components making up the volume. These volumes were then meshed, boundary conditions applied and then loaded.

The stresses and strains developed in the system were then plotted and analysed. Simulations were also created so as to better understand how the stresses and strains were developing within the system.



Spinal Segment

Results and Achievements

1. The finite element model of the spinal segment functions as expected.
2. Intervertebral disc and cartilages greatly deform while transferring loads from L4 to L5 vertebra.
3. Stresses induced in the cortical are larger than in trabecular bone.
4. Region of highest stress is in the location of the pedicles and the lamellae thus being the most prone to fracture. This strongly agrees with the existent available literature reviews.

INVESTIGATION ON VARIABLE SPEED OPERATION OF AIR CONDITIONING

Project M10

STUDENT: NADIA GRECH

SUPERVISOR: DR. MARIO FARRUGIA

Background

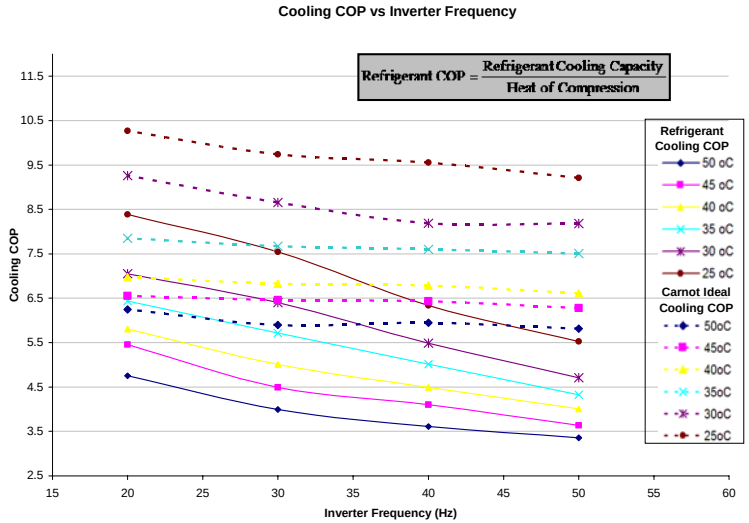
When designing air conditioning installations, they are designed with enough cooling capacity to satisfy the desired minimum temperature under the heaviest load. However, heat loads tend to be less than the maximum designed loads, thus the system will most often be working under part-load rather than full-load conditions. Operating at these conditions at fixed capacity will be more expensive than if the capacity were able to match the required load. Varying capacity refrigeration systems have been developed in order to track the required cooling load more closely. High quality air conditioners utilising inverter technology are advertised as capable of consuming around 30 per cent less energy than conventional systems.

Project Objectives

The main aim of this thesis is to investigate inverter operated air conditioners, by analysing research performed on such systems and implementing a three phase inverter on a refrigeration setup in order to determine whether the benefits related to such systems are justified. Such benefits must be quantified in terms of Coefficient of Performance and energy savings in order to justify the installation of these systems.

Project Methodology

- A literature review was carried out to research any other similar experimental investigations done previously.
- An air conditioning setup which had not been in use for a number of years was fixed and a three phase inverter was implemented on the system.
- Experimental testing was performed to investigate the performance of the system under steady-state conditions and for start-up conditions.
- The results obtained were analysed and compared with the results obtained from the literature review.



Variation of Cooling COP with frequency

Results and Achievements

From this experimental investigation, it is possible to conclude that an inverter system has a better performance than conventional air conditioners at part-load, as the reduction of speed to achieve a reduced cooling capacity allows for a greater COP to be obtained. Due to the softer start of the inverter, power required to start up is reduced, therefore it encounters less start-up losses. The inverter driven system requires a greater power input than the conventional system to operate at the same speed (50 Hz), however the inverter system will be operating at reduced speeds during most of the on-time. At these reduced speeds, the power required will be less than if the system were operating at fixed maximum speed under part-load conditions. These factors allow the inverter air conditioner to achieve energy savings when compared to conventional air conditioning systems.

MATHEMATICAL MODEL OF A VAPOUR ABSORPTION REFRIGERATION UNIT

Project M11

STUDENT: DANIEL MICALLEF

SUPERVISOR: DR. ING. CHRISTOPHER MICALLEF

Background

Vapour absorption systems are an alternative to the more common vapour compression systems used in air conditioning and refrigeration. The major difference is that absorption units are thermally activated. This means that it is possible to use sources of heat energy, such as the sun or hot exhaust gases from an engineering process, to power the unit. This contrasts with the need of compression systems to make use of electrical power which may have been produced by the burning of fuels causing further environmental concerns.

Project Objectives

- To carry out an extensive literature review on absorption systems engineering including current and possible future developments
- To develop a mathematical model for a single effect absorption system employing lithium bromide-water and water-ammonia absorbent-refrigerant pairs
- To implement the mathematical model by developing a computer program in order to extract useful engineering information

Project Methodology

The mathematical model requires the calculation of a large number of equations which would be too cumbersome to solve manually. Hence the model had to be implemented by writing a computer program. The programming language used was Microsoft® Visual Basic.NET. By inputting the necessary operating conditions of the system, the program gives the user useful information regarding the conditions of the system such as the COP (which is a measure of the system's efficiency). Apart from this, the program was designed in such a way as to enable the user to obtain graphs containing useful design data.

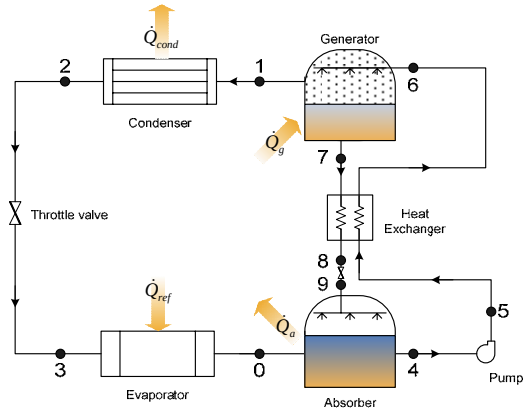


Figure 1 Line diagram of a vapour absorption refrigeration unit

Results and Achievements

An insight into the behaviour of absorption systems was obtained by studying various relationships between parameters. The trends obtained are essential for the correct design of such systems if they are to operate in an optimal manner.

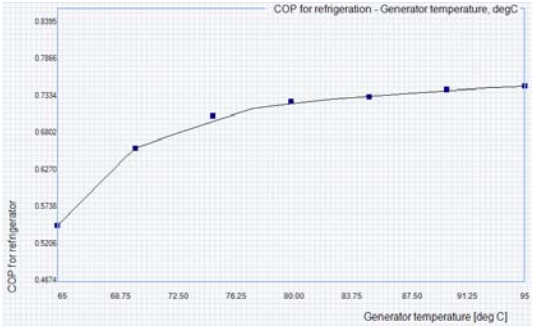
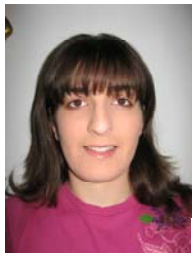


Figure 2 Graph obtained from program for COP against generator temperature

INSTRUMENTATION OF ENGINE DYNAMICS



STUDENT: RENÉE SULTANA

SUPERVISOR: DR. MARIO FARRUGIA

Background

The manual work to control and read the various parameters involved during engine testing consume a lot of time and tedious work. A graphical language produced by National Instruments, named LabVIEW© is used to acquire analogue signals directly from electronic sensors which are substituted for mechanical sensors. LabVIEW© is used to interpret these acquired signals into meaningful readings and to perform logic required to generate signals to control the dynamometer and engine.

Project Objectives

In this study, the major objectives are:

1. To set up the data acquisition system to acquire analogue signals to get readings from the engine and to generate signals to control the engine.
2. To monitor and control the electrical dynamometer entirely through LabVIEW©.
3. To acquire data for experimental purposes used for a laboratory session as part of a credit studied in the second year of the engineering course.

Project Methodology

The necessary outputs namely, speed set-point, load set-point, throttle position set-point, local/remote signal, tachometer signal, torque signal, throttle position sensor (TPS) signal and emergency stop, were located in the dynamometer console and connected in reference single ended (RSE) mode to the SCC-68 connector block for data acquisition. The engine cooling water is cooled by a counter-flow heat exchanger. The four main temperatures of the heat exchanger, that is the entrance and exit temperature of the engine cooling water and coolant respectively are sensed with four thermistors and monitored through LabVIEW©. An attempt was made to get an indication of the amount of power absorbed and generated by the engine, directly from the 3-phase supply. Each phase is connected to and 800:5 current transformer and a 240:4 voltage transformer to scale down the current and voltage for the data acquisition device to obtain these measurements. A program is built in LabVIEW where with the use of the data acquisition device, the dynamometer and engine are monitored and controlled through a desktop computer.

Manual system: Engine, Dynamometer and control console

Control Room: Monitor and control engine from PC

Results and Achievements

An important result is that the engine power found from the torque and rotational speed is different from the power generated to the 3-phase supply. An achievement is that computerization of the engine testing makes the job safer to perform since monitoring and control are accomplished away from the engine itself. Also it makes it easier for the lecturer to explain the engine dynamics while the engine is running since the students can gather the required information for the report from the computer in the control room and thus away from the noisy engine.

Design of an Ultra – Streamlined Human/Powered Road Vehicle

Project M13

STUDENT: DAVID OSCAR VELLA

SUPERVISOR: DR. TONIO SANT

Background

In nature different species have specialised different parts of their bodies as a means of survival. *Homo sapiens* is the species that developed its brain. We have used this intelligence to go beyond what nature has given us, surpassing the limitations of our body.

Unfortunately we have become dependant heavily on energy and communication. One fundamental aspect of today's society is the car. They have developed greatly over the years, yet it is only with recent targets of preserving our planet that work is being carried out to make them more efficient. Various problems such as the increase in the cost of oil and pollution call for a change in the way affairs are tackled.

In an effort to go back to nature we must apply our intelligence and recreate tools the way we once did, i.e. tools that can firstly magnify the power the human body can release whilst compensating where it lacks.

Project Objectives

This thesis seeks to present a vehicle that can harness the power the human body can provide, for locomotion. Since human power is limited, the main objectives can be summed as follows:

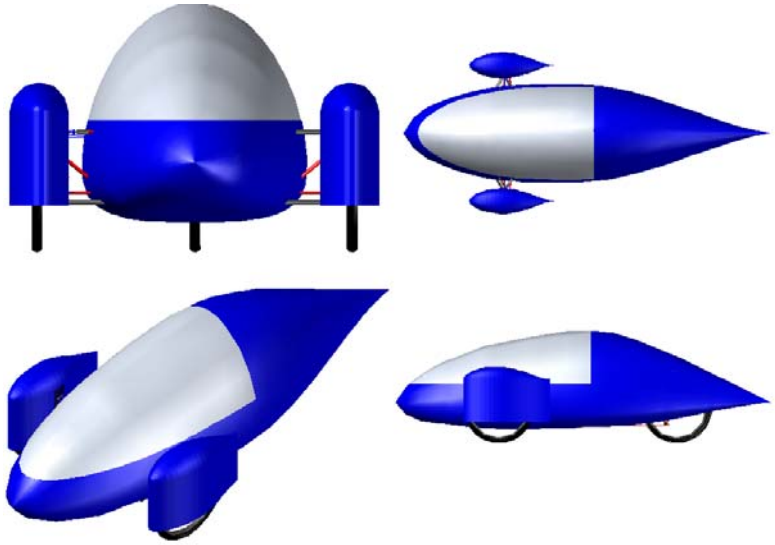
- To create a vehicle that can utilise human power as a means of motion, whilst having alternative power to go beyond human limitations in terms of endurance and speed
- To maximise vehicle efficiency by providing a streamlined body, a major power loss in conventional human powered vehicles such as bicycles, together with other energy saving mechanisms

Project Methodology

The first step is that of gaining information, namely on human power capabilities, on aerodynamic vehicle design and on general vehicle design.

The next step is that of creating the actual vehicle. Analysis is then carried out using calculated or standard loads to ensure that the components will hold up well to use, and that the vehicle will provide safety for the driver.

The final step consists in the creation of a model for drag analysis in a wind tunnel. This helps to identify the efficiency of the overall design and how the vehicle will perform.



3rd angle presentation of the resulting vehicle

Results and Achievements

The results simply show that creating a human powered vehicle for every day use is possible. The result is not a vehicle for environmentalists. It is not a vehicle for the rich. It is the vehicle nature designed us to build.

INVESTIGATING THE AERODYNAMIC BEHAVIOUR OF AN NACA0012 AEROFOIL AT LOW REYNOLDS NUMBERS

Project M14

STUDENT: DONNA M. VELLA

SUPERVISOR: DR. ING. TONIO SANT

Background

A significant number of research efforts are being conducted in the field of aerofoil low speed aerodynamics, in particular when operating in unsteady conditions. They are fuelled by the fact that this would lead to a more successful design of certain rotor systems since rotorcraft blades are susceptible to large unsteady and vibratory loads, also in the low Reynolds number regime. There is also a growing realisation that a better knowledge of unsteady flows can be exploited for improved control of micro unmanned flight vehicles that normally operate at low speeds. Unsteady aerodynamics can be complicated. A typical case is that of wind turbine blades which are constantly working in complex environmental conditions. Challenges exist in understanding and predicting the dynamic stresses and aeroelastic response of the blades subjected to unsteady flow phenomena. It is important to note that such phenomena also occur when the aerofoil operates at fixed angle of attack. A typical example is when flow separation occurs on the upper chamber at large angles of attack.

Project Objectives

The aims of the dissertation were to

(1) construct a new and improved wind tunnel test rig for testing a NACA 0012 aerofoil.

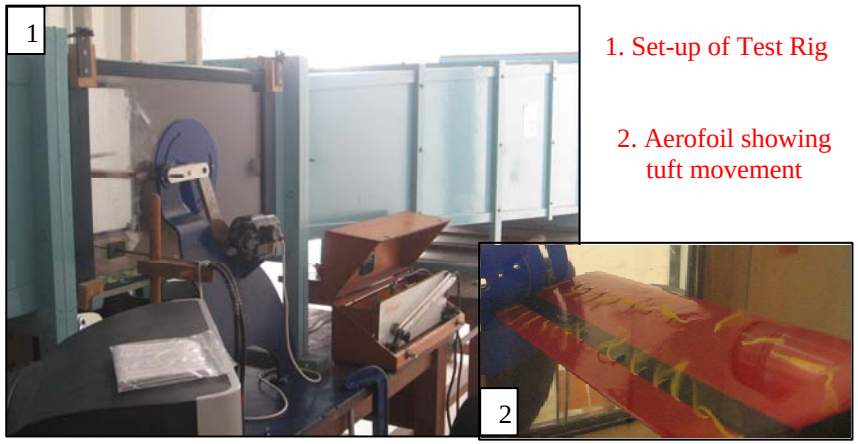
(2) couple the test rig with an electronic controller and data acquisition system computer using Labview© software for measuring the induced aerodynamic forces at different operating conditions using strain gauge techniques.

(3) conduct various tests using the setup to investigate the unsteady aerodynamic behaviour at low Reynolds Numbers of the aerofoil, at both fixed angles of attack and time varying pitching (i.e. unsteady angle of attack) at low reduced frequencies only.

(4) investigate the results obtained for the aerodynamic load measurements and flow visualisation using tufts.

Project Methodology

To measure the aerodynamic force, an auxiliary arm (which positioned outside of the wind tunnel and clamped at the free end) was designed and equipped with strain gauges. The angle of attack of the aerofoil was controlled with a 24V DC motor via a link mechanism and the angle was read by a rotary encoder. For the control of the system and logging of changing parameters LABVIEW© was used. Tufts where attached to the aerofoil for flow visualisation.



1. Set-up of Test Rig

2. Aerofoil showing tuft movement

Results and Achievements

From photo 2 it is clear that the aerofoil was experiencing flow separation after reaching an angle of attack of 15º. The concurrent analysis of the detailed aero-load measurements and the tuft experiments successfully enabled better understanding the aerodynamics of the subject aerofoil.

THE CONSTRUCTION OF A VAPOUR ABSORPTION TEST RIG

STUDENT: GLENN ZAMMIT

SUPERVISOR: PROF. ROBERT GHIRLANDO

Background

The environmental consequences of mankind's technological and social progresses have become so evident that they cannot be ignored any longer and suitable action had to be taken. For these reasons, the international community has set up and ratified various protocols, such as the Kyoto and Montreal Protocols. However these international agreements do not eliminate the environmental damage that is being done but only reduce it. New environmental friendly technologies are to be sought that would allow us to keep living at the current standards while eliminating its negative side effects. Vapour absorption technology could be used to provide environmental friendly cooling and reduce the negative impact on the environment of the refrigeration and air-conditioning industries in their struggle to make life more comfortable.

Project Objectives

The aim of the project was to build a vapour absorption refrigeration test rig to be used later for experiments with 'free' heat sources. All components of the unit had to be designed after proper researching and the unit had to be built and tested at the Faculty laboratories. The unit had to work using water and lithium bromide with the former being the refrigerant and the latter being the absorbent. The experiments would then help to understand better the actual operating characteristics of vapour absorption machines with different sources of heat input and thus predict their behaviour in real life operation.

Project Methodology

The project started with an in-depth study of refrigeration theory in general and vapour absorption in particular. This was followed by a preliminary design stage where the components to make part of the system were identified and modelled. Based on this modelling, design calculations were carried out to identify the major system requirements, namely the energy transfers involved and the heat transfer areas required. Once the design calculations were ready, the detailed design of all the components of the systems was carried out. The components of the unit were then built and the whole unit was assembled together. Calibration tests on some pumps were carried out to find a suitable solution pump, which once found was attached to the unit. Once the assembly of the absorption unit was complete, it was checked for air leaks and the required temperature and pressure gauges were attached. The unit was then filled with the required amounts of water and lithium bromide and some tests were carried out to confirm the unit's operational capabilities.

The fully assembled vapour absorption refrigeration test rig

Results and Achievements

The vapour absorption unit was successfully built with a theoretical refrigerating capacity of 300W and an ideal coefficient of performance of 0.75 The unit was built entirely of copper tubes and pipes and required approximately 650 grams of lithium bromide and 800 grams of distilled water. The maximum temperature in the unit is 80^{o}C and the pressures inside it are below atmospheric.

FATIGUE LIFE PREDICTION OF PRESSURE VESSEL COMPONENTS

Project M16

STUDENT: JOHNNY ZERAFA

SUPERVISOR: DR. ING. M. MUSCAT

Background

One of the many ways in which a material can fail is by the fatigue phenomenon. Although its causes may seem to be trivial, fatigue has been and may be the cause of catastrophic failures. Hence, it is an important factor to be considered much time before any structure or component is built. The three main life prediction methods are the stress-life approach, the strain-life approach and the crack propagation method. In this dissertation, the focus is put on the stress-life approach since it is mostly related to the European Pressure Vessel Directive. The fact that a number of factors influence each life phase, such a lifetime prediction is sometimes not straight forward as it may seem. A lot of data must accompany these calculations. However, the most useful results are obtained by the use of the simplest fatigue calculations.

Project Objectives

- Perform a study on fatigue analyses and review previous departmental work;
- Understand the available design philosophies and life prediction methods.
- Study and explain further the fatigue assessment procedures available in the European Pressure Vessel Code MSA EN 13445-3;
- Conduct life prediction exercises on pressure vessel components using the European Pressure Vessel Code MSA EN 13445-3 methodology and the finite element analysis software ANSYS®.

Project Methodology

In this project, apart from providing a wide view of the basics of the fatigue phenomenon, a study on life prediction was also done. The focus was put on one of the main approaches. This is the Stress-Life Approach. This method was preferred from the other methods since Clause 18 (Detailed Assessment of Fatigue Life) of the Pressure Vessel European Directive, is mostly based on it. Another reason is that this study was done on pressure vessels subjected only to high fatigue cycles. Clause 18 of the Pressure Vessel European Directive was studied and fatigue checks on pressure vessels components were performed using the code it provides. The working of these examples was accompanied with the use of FEA rather than by experimental methods. The published working in this dissertation was compared with that of other organisations published in the DBA manual.

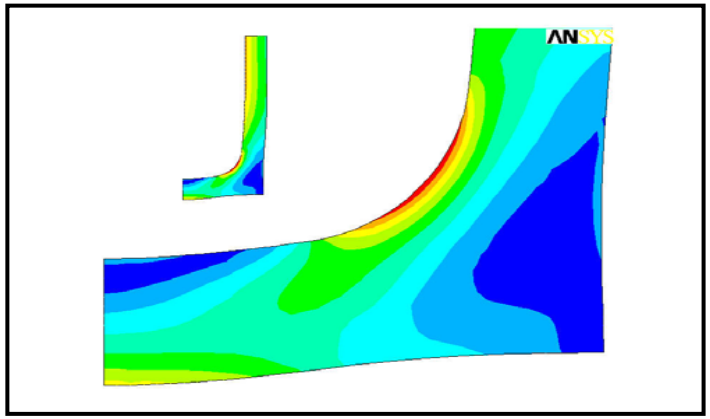


Figure 1 Plot of nodal stress intensity (Tresca)

Results and Achievements

From this study, the essential theory concerning the fatigue phenomenon and the life prediction methods was explained. This theory served as a ground for understanding and use of clause 18 of the European Pressure Vessel Code MSA EN 13445-3. In turn, using the procedure indicated by the same clause, two fatigue checks including the use of finite element analysis were performed. The results obtained are very close to those provided by the DBA manual. These can serve as detailed examples for subsequent works.

TESTING OF ADI GEARS

Project MM1

STUDENT: MARK BEZZINA

SUPERVISOR: MS. ANN ZAMMIT

Background

Gears are machine elements designed to transmit a rotational force to another gear or device. During transmission, gears are constantly being subjected to shock loads and bending fatigue stresses, and therefore a tough core is desirable. Conversely, on the surface, a hard and wear-resistant case is required to increase the resistance to fatigue crack initiation and to endure the compressive stresses between the interlocking gear teeth.

This combination of properties is traditionally satisfied by carburised steel gears which offer both a tough core as well as a hard skin. However, these type of gears are increasingly being replaced by ADI, which can offer a number of important advantages over carburised steel.

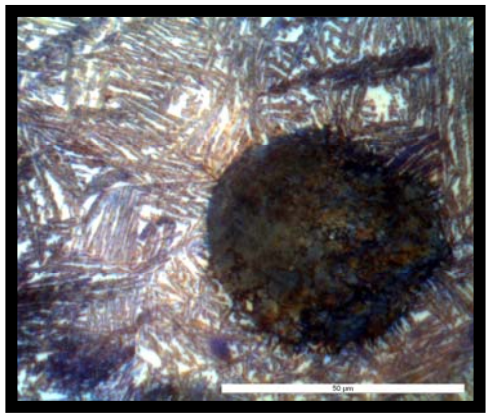
Project Objectives

The objectives which were to be achieved through this dissertation can be summarised as follows:

- To improve on the design of a gear-testing rig and render it functional.
- Produce austempered ductile iron and carburised steel gears from raw materials.
- Shot peen the ADI gears produced using shots varying in size and hardness.
- Study and compare the results obtained after all gears were tested on the gear-testing rig.

Project Methodology

Gears of two different types of material were produced so that their performance could be subsequently compared with one another. EC 80 DIN 2162 steel and cast (ductile) iron were used to produce carburised steel and ADI gears. After the latter were shot peened using different types of shots, the gears were subjected to three torque stages in accordance with the C-Type gear tests typically carried out on FZG testing rigs. Subsequently, the gears' surface finish, the hardness attained and their performance with respect to wear resistance were evaluated.



A carbon nodule in a matrix of high carbon austenite and ferrite "needles" [Etched with 2% Nital Solution, Mag. 1000x]

Results and Achievements

The results obtained in this dissertation show that through appropriate surface engineering treatments such as shot peening, ADI gears can effectively perform at par with carburised steel in terms of wear resistance. Hence, ADI can be used to replace steel as a material for gears in a vast number of applications, bringing about significant advantages such as cost savings and a higher strength to weight ratio. This latter benefit implies that such a replacement would result in substantial reductions in fuel consumption and emissions if applied to certain products such as those deriving from the automotive and aerospace industries. This is of particular importance nowadays due to the ever growing concern regarding environmental issues.

EFFECT OF SHOT PEENING PARAMETERS ON THE FATIGUE PROPERTIES OF ADI

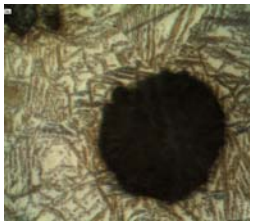
Project MM2

STUDENT: PETER PAUL BUGEJA

SUPERVISOR: MS. ANN ZAMMIT

Background

Modern engineering applications are increasingly demanding materials that fulfil a spectrum of requirements, which are sometimes impossible to be satisfied by a single material. For instance, gears are an extensive field of interest which offer quite a challenge. When in service, a gear is repetitively subject to cyclic load, creating surface fatigue. Fatigue is feared by many as it leads to the catastrophic failure of components which theoretically should not fail.



ADI microstructure

Shot peening

Austempered Ductile Iron (ADI) is an attractive material with mechanical properties approaching those of steel and having a lower density and better damping properties. This makes ADI attractive to engineering applications especially gears. But ADI gears are susceptible to fatigue beyond certain stress.

Surface treatments are carried out on components in order to enhance their fatigue characteristics. A mechanical surface treatment used to improve fatigue properties is shot peening, in which the surface is bombarded by spherical shots inducing a residual compressive stress which enhances the mechanical properties including its fatigue resistance.

Project Objectives

The aim of this thesis was to:

- study the effect of shot peening parameters, mainly shot size and hardness, on the fatigue properties of ADI
- select an optimal peening process to be applied to ADI gears

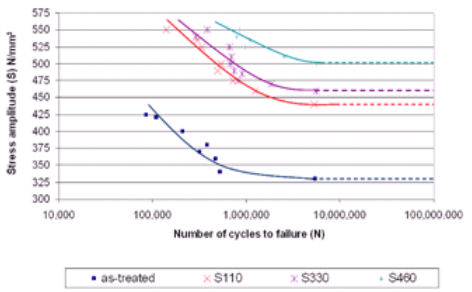
Project Methodology

First part of the test consisted of testing 'SEMCO zir H', a coating used to prevent decarburization during the heat treatment. Subsequently rotating-bending fatigue tests were carried out to investigate the effect of shot size and shot hardness on fatigue characteristics of ADI. Fatigue specimens were manufactured out of ductile iron keel blocks according to standards. These were then coated in order to prevent decarburization during the heat treatment. Following the austempering process, the ADI specimens were polished and shot peened in a controlled manner using specific shot peening parameters. The relationship between stress amplitude (σ) and the number of cycles to failure (N) was obtained by fatigue testing peened specimens, using increasingly larger loads, with all other conditions kept constant. This data was then plotted on S-N curves as shown below.

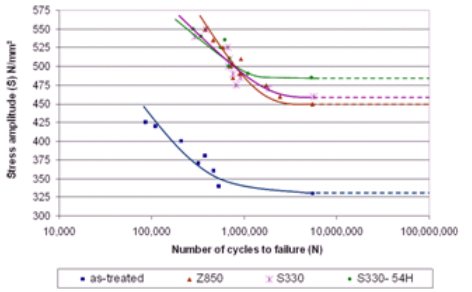
Results and Achievements

- 'SEMCO zir H' coating managed successfully to prevent scaling and decarburization during the austempering process.
- Shot peening successfully increased the fatigue characteristics of as-treated ADI. From graphs, shot peening with larger shots produced a higher fatigue performance, with an improvement in fatigue life of up to 50 percent achieved by S460 shots.

S-N curves of superimposed results obtained for shot size variations at constant hardness

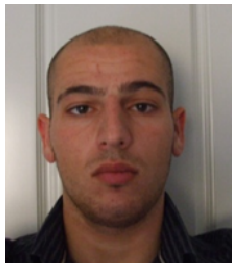


S-N curves of superimposed results obtained for shot hardness variations at constant size



DEGASSING AND GRAIN REFINEMENT OF ALUMINIUM CASTINGS

Project MM3



STUDENT: SIMON BUGEJA

SUPERVISOR: ING. KENNETH ZAMMIT

Background

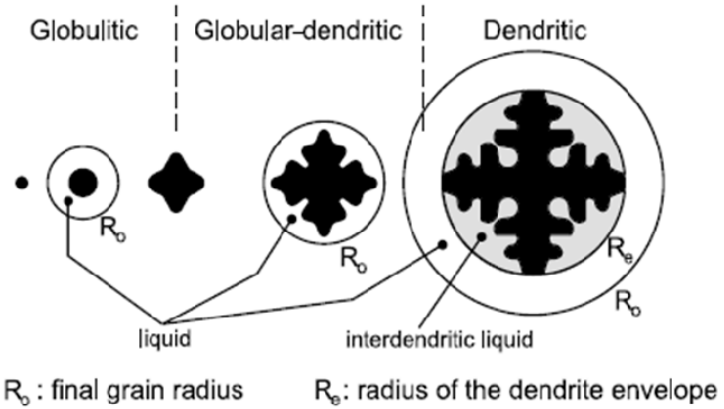
Aluminium is a material which is used extensively not only because it is found in large amounts as ore in the earth's crust but also due to its high strength-to-weight ratio. Aluminium casting is a process which has found widespread use. The solubility of hydrogen in molten aluminium is higher compared to the amount of hydrogen the may be contained in the solid phase. For this reason when the material is exposed to excess hydrogen, the latter forms a second phase. Since hydrogen is a gas, the second phase will result in voids, which adversely affect the mechanical properties of aluminium. Due to the undesired effects described, studies have been carried out to generate pore free castings with superior mechanical properties and any possible defects in aluminium sheets are eliminated. This study is adopted on the solutions adopted to eliminate porosity and coarse grains, namely degassing and grain refinement.

Project Objectives

- To study of the effects on the final casting porosity when degassing the aluminium melt using Degasser 190 tablets as the degassing agent,
- Refining the grain size of the cast microstructure by using Al-Ti-B and Al-Ti-C as grain refiners
- The effects of important parameters such as process duration and temperature will also be analyzed.

Project Methodology

Porosity in aluminium is caused by the precipitation of hydrogen from the liquid state, by shrinkage during solidification, and more commonly by a combination of these two effects. Measures taken to eliminate these types of porosities were by using degassing tablets and a good feeding system. A fine grain structure is very important to obtain a casting having good mechanical porosities. Grain refiners such as Al-Ti-B and Al-Ti-C are added to the molten metal such that upon dissociation, additional nucleation sites are available.



Formation of Dendritic structure

Results and Achievements

The results obtained were successful. As regards to the reduction of porosity in the samples, the latter was completely eliminated by a combination of additions and process modifications, namely by degassing, fluxing and by using a good feeding system. As regards grain refinement the objectives were also achieved since a very fine and uniformly distributed dendritic structure was achieved. Even though successful results were achieved more work can be done in the grain refining area especially in studying the effects of process duration.

On The Mechanical Properties of Automotive Seat Foams: A Preliminary Investigation

Project MM4

STUDENT: TRISTAN DEBONO

SUPERVISOR: DR. S. ABELA

CO-SUPERVISOR: PROF. J. N. GRIMA

Background

Materials play an extremely important role in innovative product design. Competition in the automotive market, constrains companies to invest in research and development. This dissertation is the introduction to a new research program for Methode Electronics Malta Ltd. The final objectives of this project is to fully understand the behaviour of the foam used in automotive seats, this is required to be able to predict its behaviour either through mathematical models or finite element simulations, the same way we understand and predict metals and polymers today.

Project Objectives

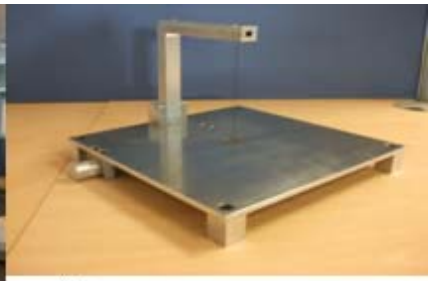
As this dissertation is a preliminary investigation of a more detailed research project, the main objectives in this phase are:

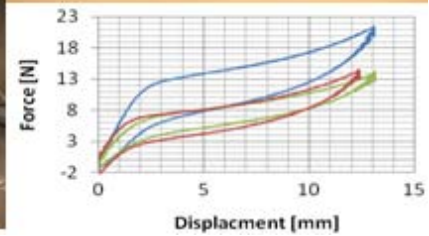
- To understand the basic composition, structure and manufacturing methods of foam, in particular automotive polyurethane seat foam.
- To build suitable test equipment and carry out basic material testing on automotive polyurethane seat foam samples, from which the company can determine the suitability of foam as an innovative material for future sensing and switching equipment.

Project Methodology

The project was carried out as follow:

- Literature review on foam composition, microstructure, manufacturing methods, testing and applications.
- Detailed design of testing equipment required to carry out compression tests, compression set tests and recovery time tests on automotive seat foam samples accurately, together with the design of a hotwire cutting jig in order to produce repeatable sample dimensions.
- Construction of the testing jig using a Parker linear positioning table driven by a servo motor as an actuator together with a Futek 21kN load cell and Solartron LVDT as sensors.
- Programming of the test procedures in C++.
- Construction of a hotwire cutting jig to cut specimens to required size.
- Testing of samples and validation of tests using other equipment.
- Evaluation of the results.





Results and Achievements

The data obtained from the compression tests and compression set tests will be used to model the behaviour of automotive polyurethane seat foam under compression and release. This data is also required to understand which region of deflection these foams can be best used in various applications.

LASER BEAM WELDING OF ALUMINIUM

Project MM5

STUDENT: YANICKA FAVA

SUPERVISOR: ING. JOHN C. BETTS

Background

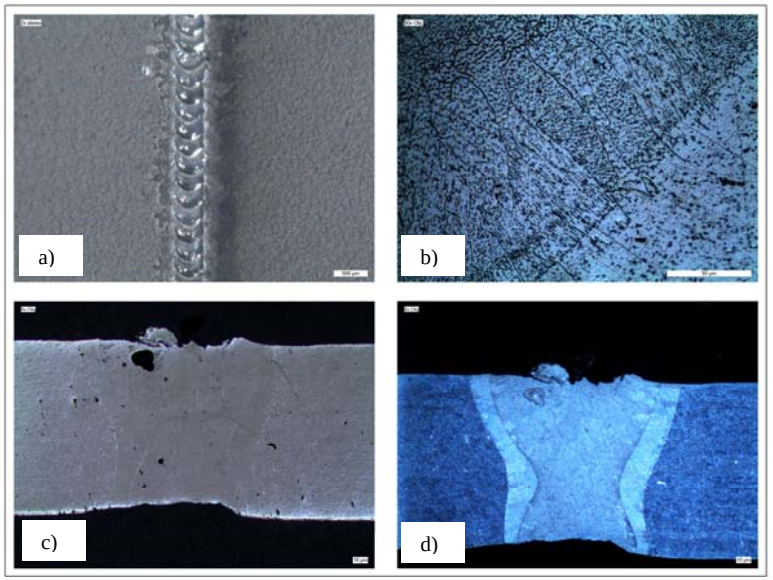
The integration of aluminium alloys in body structures and frames in the automotive and aerospace industries has been found to be desirable because of their light-weight properties and good strength-to-weight ratio. The high values for the optical reflectivity at the CO_2 laser wavelength associated with aluminium alloys are known to inhibit the laser welding of such alloys. On the other hand, welding of aluminium alloys using a laser beam proves to be highly advantageous because it offers precise heat input, narrow weld beads and narrow heat-affected zones.

Project Objectives

The present study aims to identify suitable process and material parameters to produce a good quality butt weld for the particular aluminium alloy in consideration. Once these are set, they will be used to assess whether they would be adequate for repeatability on the industrial level. These objectives are to be achieved by varying a number of parameters and then analyzing the outcomes obtained by using various techniques and equipment. This project also aims to try and identify the constituents present in the aluminium alloy.

Project Methodology

- Background information was collected by a review of the literature.
- Welding was carried out on 1.3mm thick aluminium plates of dimensions 50 x 100mm which were constrained to produce a butt weld.
- Several laser and material parameters, including beam traverse speed, laser power and plate surface conditions, were varied in order to achieve a wide variety of results. The weldments produced from the laser runs were then sectioned, ground and polished. Etching was then carried out to reveal the grain boundaries in the aluminium sections.
- The samples were then viewed under an optical microscope or by means of SEM/EDX analysis to investigate the resulting microstructures obtained. Micro-indentation hardness testing was also carried out.



a) Top view of a weld produced under pulsing conditions, b) The different microstructures obtained in the weld metal, c) Section of a weld showing a gas pore at the top, d) Same weld as in c) showing the differnet heat affected zones after etching

Results and Achievements

The results obtained indicate that the parameters for achieving best results are using a speed of between 250 - 300mmmin^{-1}, a power of 3kW and using Argon as the shielding gas. Selection of the optimal parameters for butt-welding aluminium plates together was based on the quality of the weld microstructure obtained; discontinuities such as the presence of gas pores, nitride inclusions and lack of penetration were some quality factors considered. Repeatability was not achieved, so it can be concluded that the parameters cannot be used reliably without further investigation.

A THEORETICAL APPROACH TO TOOTHED ADJUSTMENT FEATURES

Project MM6

STUDENT: MARIELLA FENECH

SUPERVISOR: D.R. STEPHEN ABELA
CO-SUPERVISOR: D.R. MARTIN MUSCAT

Background

The toothed adjustment feature can be applied in different situations; a typical example is a switch which can be fitted in different applications. In such a hypothetical system the switch would be made up of different components assembled together, but for the scope of this dissertation, only the feature between the coupler and the plunger are considered. That is the toothed adjustment feature. These latter two components mate together in such a way as to achieve the required adjustments as shown in the diagram.

Project Objectives

The main objectives of this thesis are the following:

- A theoretical relationship between peak to peak occurrence (incorrect meshing of teeth) and teeth diameter/pitch;
- A material selection process which can enhance the advantages of the coupler and minimize the number of failure cases;
- A theoretical relationship between push down force (loading of teeth) and teeth diameter/pitch,

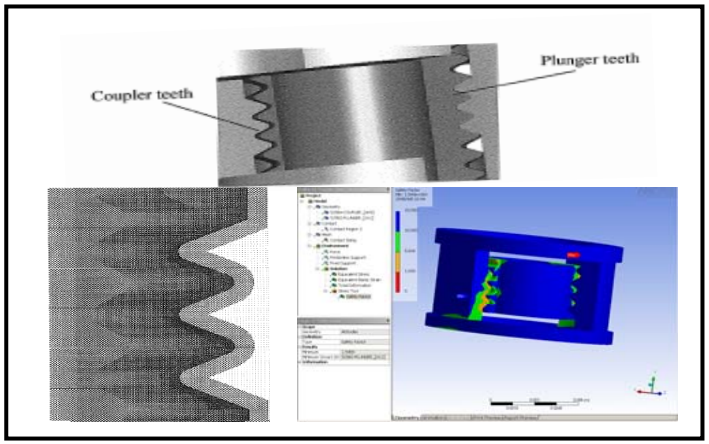
Once a relationship has been determined, it will be used to design prototypes that will give the best compromise.

Project Methodology

The project was carried out as follows:

- Literature review with regards to materials, design for assembly, tolerances and statistics;
- Analytical analysis on peak to peak occurrence;
- Material selection process for the coupler;
- Tensile test conducted on POM Acetal Hostaform and PBT Pocan 30% GF;
- Mold Analysis for the plunger,

and finally an FEA analysis in determining the failure points and the ideal diameter for the coupler.



Results and Achievements

The main conclusions that could be derived are: the increase in diameter of the coupler and decrease in diameter of the plunger will simultaneously increase the clearances between the teeth of both mating parts and the probability for correct meshing of teeth during assembly; from the material selection process, it proofed that the best material for the coupler is Polyamide (PA) Nylon – PA6, PA66; and considering the fact that the plunger is equal to 8.1 mm, the diameter of the coupler should not be greater than 9.02 mm nor should be smaller than 8.95 mm, as there will not be enough clearances between the mating parts in order to engage during assembly.

A STUDY OF ADHESION BETWEEN POLYMERS AND STEELS

Project MM7

STUDENT: DAMIEN GATT

SUPERVISOR: DR. STEPHEN ABELA

Background

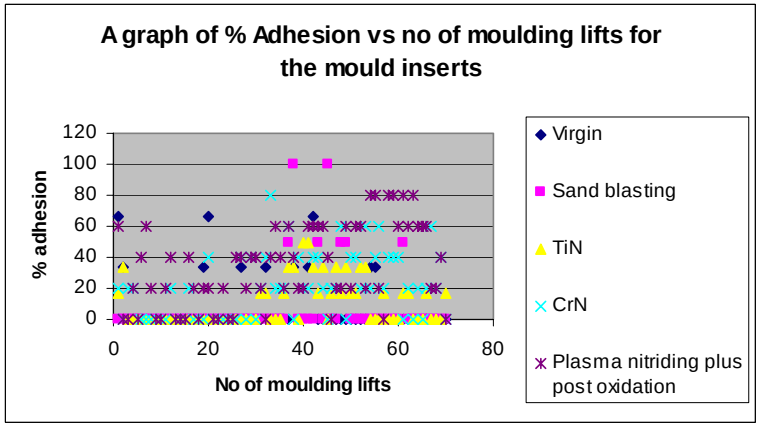
A high proportion of polymer artefacts are produced by moulding. There are two major problems with moulding which limit the production rate and cause difficulties in the automated removal of the moulded product. These two problems are mould sticking (where the moulded product sticks to the mould) which is greatly dependent on the type of polymer used, and mould fouling which involves the build-up of deposits after a number of cycles, sometimes even a small number of cycles. The general approach to reducing the above difficulties is by the use of mould release agents which, however, involves many limitations. This project aims to solve the mould release problem by surface engineering (the mould). It is worth noting that this study is Industry based where the moulds were tested in a compression moulding machine in collaboration with Trelleborg Sealing Solutions.

Project Objectives

- To introduce different surface engineering techniques on the mould inserts;
- To devise a set-up to mould release properties of the insert using a pull test (tensile test);
- To compare the surface energy value for the surface engineered inserts
- To find the effect of surface roughness on mould release and study the other dominant adhesion theories for each coating;
- To find the mould release properties for the inserts in the compression moulding machine.

Project Methodology

Twenty-six Stavax mould inserts were used. Some inserts were kept for laboratory tests while the others were used for investigation in compression moulding. The different surface treatments included PAPVD coatings of TiN and CrN, Plasma nitriding and post-oxidation, and sand-blasting. Laboratory tests carried out on the inserts included finding the contact angle each surface makes with mercury, surface roughness measurements both before and after compression moulding, and finding the pull force required to separate a pair of mating inserts (from each different surface modification type) from a polyurethane adhesive. The compression moulding tests were carried out using Viton (fluoropolymer) rubber. The aim of compression moulding was to plot a graph for percentage adhesion versus number of moulding lifts for each different surface modified type insert. The inserts were investigated after compression moulding for any signs of fouling, coating deadhesion and corrosion. The compression moulding graph



Results and Achievements

The Sand blasting inserts gave the best results in compression moulding as can be seen in the graph above, followed by the virgin (unmodified mould inserts). This was mainly due to the fact that these inserts were the least affected by the mechanical theory of adhesion, where the most corrosion resistant and the possible evolution of metal fluoride helped as it acted as a release agent.

The seriousness of the problem and the possible variations of the other coatings that can be tested (e.g. PTFE coatings, DLC coatings, Ion implantation, Multi-layer coatings) makes further study on this topic very suitable. However, I firmly believe that this project could pave the way for further research.

INVESTIGATION OF A PLASTIC INJECTION MOULDING DEFECT

Project MM8

STUDENT: CHRISTINE GRIMA

SUPERVISOR: DR. ING. J C BETTS

Background

Injection moulding is one of the main processing techniques for the conversion of raw polymers into various products for a wide variety of applications. The part being studied has the form of a wheelbarrow made out of POM – a thermoplastic copolymer. The handles of the wheelbarrow fracture when under tension due to brittleness at the junction of a vertical section to a horizontal connection. This project focuses on a realistic and hands-on issue highly encountered by the Maltese industry – improving a product's mechanical properties to conform to quality requirements.

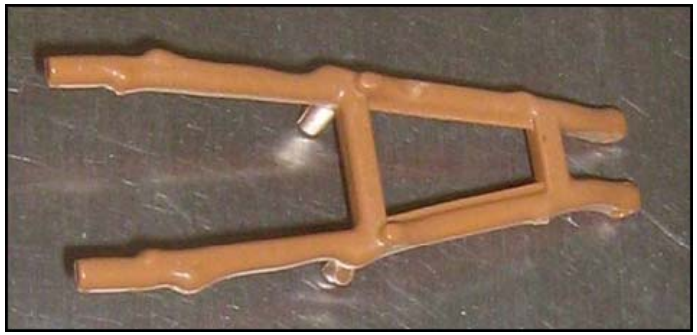
Project Objectives

The main objectives for this research project include:

- Determining the defects in the parts and indentifying the parameters relevant to injection moulding
- Highlighting the most effective interactions among the parameters outlined relevant to the part defects
- Applying a statistical approach for designing the experiments to be followed and for producing the parts
- Flexure testing of batches of the final parts produced to check whether the failure rate of the parts has been reduced

Project Methodology

Three main production sessions were outlined for carrying out the two main tests planned. Firstly, a sample of the Reference Parts was produced. Then, a Screening Experiment with six injection moulding parameters was carried out to examine the most relevant ones for the study. Minitab15 Statistical Software was used to highlight the strongestinteraction. The machine settings for the Optimiser Run were set and a sample of the same size as that for the reference parts was produced. These optimised results have been compared to the results obtained for the reference parts to show clearly the improvement transpired by this study. The parts were tested in flexure mode by means of a manual tensile tester, so specially designed clamps to fit into the machine had to be designed to ease off such a non-standard testing method.



The Wheelbarrow Design

Results and Achievements

The load and extension of each part handle were recorded such that the failure rate of each sample could be calculated. Some of the samples tested for the Screening Experiment had a higher failure rate than that for the Reference Parts, some had just about the same failure rate and some less. After performing an analysis by means of statistical plots, the strongest interaction resulted to be between Holding Pressure, Holding Time and the Moulding/Coolant Temperature. None of the parts tested in the Optimiser Run failed, and so the study undergone may be considered as having been successful, basing on samples representative of the batch size considered.

LASER DEPOSITION OF METAL MATRIX COMPOSITE SURFACES FOR COMPONENT MODIFICATION

Project MM9

STUDENT: MONICA SULTANA

SUPERVISOR: ING. J. C. BETTS
CO-SUPERVISOR: MR. M. FENECH

Background

The exposure of components to different environments often results in damage to the component which consequently would need to be replaced. The introduction of surface engineering techniques launched a different way how to tackle this problem. This new idea put forward some techniques which could be used for component modification rather than replacement. Laser Material Deposition (LMD) is one of the competing surface engineering techniques used for this purpose. LMD can be defined as the production of a clad layer which fuses with the substrate by using a laser beam.

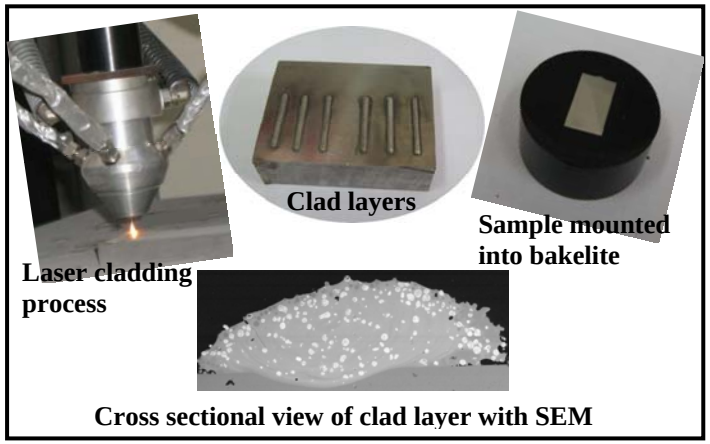
Project Objectives

The aim of the thesis is to deposit a layer of metal matrix composite (MMC), namely a mixture of Stellite 6 and WC-Co, using the laser for component modification. The objectives set include finding the ideal set of parameters to produce clad with optimised characteristics, to use optical and SEM imaging in order to determine suitability of the parameters used and to perform hardness and corrosion tests on the clad layer and the substrate.

Project Methodology

Laser cladding was performed using a Rofin Sinar Triagon 9000 9kW CO_2 fast axial flow laser with a coaxial delivery setup. Deposition of Stellite 6 with WC-Co agglomerates onto AISI 420 was initiated using the powder feeding method.

The samples were analyzed using a Nikon Optical Microscope and SEM/EDS equipment. Micro-hardness tests and corrosion tests were also performed.



Cross sectional view of clad layer with SEM

Results and Achievements

Survival of WC-Co agglomerates proved to be possible since some of the WC-Co agglomerates survived within the clad layers that were produced. Their properties of high hardness contributed to the high values of hardness obtained for the clad layers compared to the substrate.

A set of parameters was considered as the ideal clad after considering the properties of the tracks produced and the results obtained from characterisation.

INTERFACING OF FLIGHT COMPUTERS FOR AN AIRBORNE ELECTRONICS PLATFORM

PROJECT ES1

STUDENT: WARREN AZZOPARDI

SUPERVISOR: DR. ING. DAVID ZAMMIT-MANGION

Background

Embedded communication networks are playing a very important role in embedded and safety critical systems. Networking is being used to give greater system design flexibility, improve diagnosability, and most importantly when some critical data needs to be transferred safely from one point to another. In today's modern aircrafts, "Fly-by-wire" control systems are being implemented in which critical functions are performed entirely by networked computers. As this shift forward in avionics using digital technology is taking place, the importance of designing inexpensive control networks for dependable real-time operation is increasing dramatically.

Project Objectives

The main objective of this project was to implement the Ethernet, CAN-Bus and I^2C protocols for embedded communication. These protocols are to be used in the development of an airborne avionics suite for unmanned aircraft applications. The aim of the project was to implement these protocols on a selected ARM processor and to test the written drivers to make sure they are working appropriately and according to the published standards.

Project Methodology

- Phase 1: The Ethernet, CAN-Bus and I^2C communication protocols and their message formats were reviewed.
- Phase 2: An appropriate ARM processor capable of supporting the required buses and communication protocols was selected. An integrated development environment (IDE), development toolchain and debugging tools to help in writing the software drivers were also selected.
- Phase 3: An assembly coded startup file and a linker script for the selected processor were developed.
- Phase 4: The Ethernet, CAN-Bus and I^2C protocols were developed using the Keil IDE and the GNU compiler on the NXP LPC2378 processor as part of the MCB2370 development board.
- Phase 5: Test programs to test the communication protocols on the development boards were finally written.

Photo of the setup during Ethernet testing

Results and Achievements

The drivers for Ethernet, CAN-Bus and I^2C protocols to be run on the ARM processor for embedded communication have been implemented successfully and test programs have been written which transfer data between two embedded nodes without any problems. Arbitration procedures and other features of each protocol implemented have also been tested to verify that the functionality obtained is the one intended.

AN AUTOPILOT FUNCTION FOR LANDING IN FIXED WING AIRCRAFT

STUDENT: GILBERT CASSAR

SUPERVISOR: DR. ING. DAVID ZAMMIT MANGION

Background

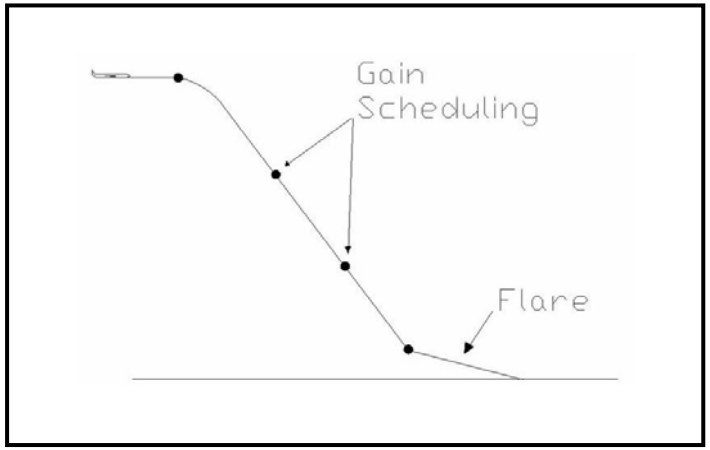
Due to the advances in Flight Dynamics and Performance of modern aircrafts, flight has become possible over a very wide flight envelope. Due to these advancements however flight became possible at many different Flight Conditions (changes in Mach, dynamic pressure, pull of gravity…) and this corresponded to large variations in coefficients that describe the Flight Dynamics of an Aircraft. For a given Aircraft, a dynamic mode that was stable and damped at one particular Flight Condition could become unstable in a different Flight Condition. Even if a dynamic mode is stable, it may result in lightly damped oscillations which cause discomfort to the passengers and make it difficult for the human pilot to maintain trajectory well. Autopilots are Automatic Flight Control Systems that can provide relief to the human pilot and also carry out special manoeuvres such as in the case of an Automatic Landing.

Project Objectives

This project aims to design a set of controllers which are used together to provide an automated landing for a Boeing B-747 Aircraft. The Controllers must make the Aircraft hold the desired Glide Slope Trajectory down to the runway without any deviations in the Longitudinal or Lateral Axis. When the Aircraft reaches an altitude of 15m above the runway the Control will switch to a Flare Controller which will reduce the rate of descent of the Aircraft while holding the front of the aircraft pitched up so that a smooth landing on the rear landing gear is ensured.

Project Methodology

This project deals with the most popular technique used in Autopilots: Gain Scheduling. The concept is to obtain Small Perturbation Models for different Altitudes and Flight Manoeuvres so that the Feedback Gains Applied will be a function of the Altitude, Airspeed and Steady State Flight Condition. In the case of the Landing Autopilot, a Small Perturbation Model will be obtained at different Altitudes for a Steady State Descent and the Controllers will be designed based on these Small Perturbation Models using Optimal Control Techniques.



Results and Achievements

A set of continuous-time Glide Slope Couplers and Lateral Stabilizers have been designed for the desired scheduling points. A prototype Flare Controller was also achieved to guide the Aircraft towards Touch Down. The Controllers were tested on a Non-Linear Model of the B-747 which the Controllers were originally designed for and the desired response as expected from the Linear Simulations was obtained.

SWITCHED HIGH FREQUENCY PULSED WELDING SET

STUDENT: STEPHEN DALLI

SUPERVISOR: PROF. CARMEL PULE`

Background

Some materials as aluminium and magnesium form an oxide layer very fast making them difficult to weld. The removal of oxide layers by etching acid is now replaced by the control of the rise time and polarity of the welding current and voltage waveforms used in the electric source feeding the power to the arc. Since aluminium is a very good heat conductor, heat is dissipated very quickly during the welding process. The rise time of a pulsed current will concentrate the heat to the welding zone instead of allowing it to be dissipated, resulting in less power needed to obtain a good weld. The high frequency switching also allows the transformer size to be reduced and to minimize the current zero crossing time which allows the arc to be extinguished.

Project Objectives

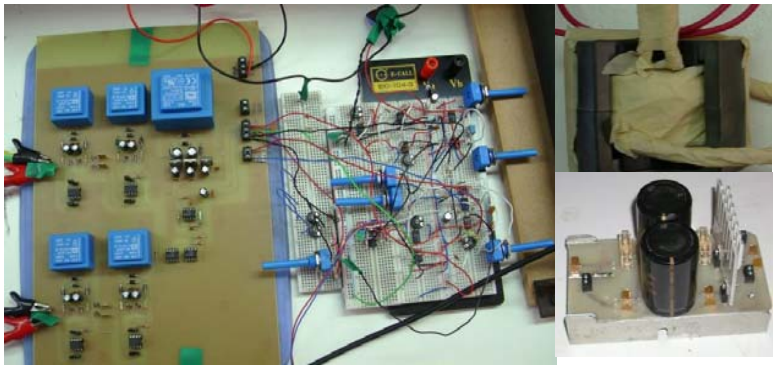
The project consists in researching in the electrical characteristics required to weld various materials. Analyzing different inverter topologies and also constructing a full bridge inverter with the adequate gate driving circuit and snubbing circuits in order to obtain a high frequency switched welding power source with constant current and pulsed current control. The intention of the project is also to research high frequency welding sources which would operate at 100KHz with a suitable current waveform to clean oxide layers on the welding surface.

Project Methodology

The final project consisted of 4 sections:

- DC voltage supply consisting of a rectifying voltage doubler producing a DC link voltage of 650V peak.
- The MOSFET full-bridge inverter with the adequate snubbing circuit
- The gate driving circuitry
- The control system

Once the delays, rise and fall time of the MOSFETs were obtained by testing them one by one, the dead-time needed was calculated and the half bridge topology followed by the full bridge supplying a ferrite transformer were tested. The circuitry was first operated at low voltage to ensure that no damage was done during the fine tuning of the circuit. The current and voltage waveforms where observed when loading the secondary side of the transformer. The control system provided the dead-time necessary and using a current transducer a closed loop system was constructed to obtain an adequate constant and pulsed current control.



Results and Achievements

Using the constructed control system a pulsed current output was obtained at enough power to maintain an arc between the work piece and the electrode. The transformer produced an output of approximately 60V when open-circuited to be able to start the arc. The voltage is then dropped down by the control system when short circuited to maintain an appropriate welding current.

RESCUE PERSONNEL ENVIRONMENT MONITORING SYSTEM

PROJECT ES4

STUDENT: MARK ALAN MCKEON

SUPERVISOR: PROF. C. PULÉ

Background

Modern-day fire-rescue and fire-fighting personnel enter hazard zones with a standard set of equipment consisting of a Self–Contained Breathing Apparatus as well as an Automatic Distress Signal Unit. The latter sounds a high decibel alarm when sufficient motion is not detected, and the former is a breathable air-supply system that gives notice of remaining cylinder pressure via a mechanical pressure gauge. Units with digital readouts are commercially available but give no more information than their mechanical counterparts. Knowing the pressure of an air cylinder allows mental calculations of 'time-to-whistle', which is a low pressure level (indicated, once reached, by a mechanical whistle) when breathing can no longer be adequately supported and evacuation of the personnel is the top priority.

Monitoring of the user's gear is an area where enhancement is possible. Monitoring of the environment in which personnel are working is an area that, so far, relies solely on observations made by the personnel themselves.

Project Objectives

The goal is to design an onboard package that is able to provide personnel with information about Temperature, Cylinder pressure and Time-to-Whistle. In addition, an attempt to design an intelligent unit capable of indicating the possibility and probability of flashover (spontaneous ignition of hot combustible gas and vapour) will be made. The main feature will be a unit capable of keeping track of the user's movements, and hence position, using accelerometers in 3-dimensions.

Project Methodology

Each separate system was developed using LabVIEW software for BlackFin Digital Signal Processors, with real or simulated hardware sensors providing the necessary input data.

The motion tracking system was tackled using principles based on double integration. An acceleration signal was integrated, resulting in a velocity signal. Another integration step gives a displacement signal. This signal can be plotted to give a visual indication of position vs. time. Using three accelerometers a 3D map of movement can be drawn. If no motion is detected for a pre-set time, the Automatic Distress Signal is triggered.

Time-to-whistle estimation was tackled by sensing air-pressure in the cylinder and air-flow from breathing. Based on the volume of air remaining in the cylinder and the air-consumption per-minute, time-to-whistle can be calculated.

A formula for relating the probability of flashover to air-temperature and the oxygen percentage in air was developed empirically through hands-on-research. The formula was applied in software, with inputs from temperature and oxygen sensors.

Self-Contained Breathing Apparatus

Results and Achievements

Each system was developed to a degree where their use in a real-life situation would be possible, though very fine calibration would be necessary to achieve results of high accuracy.

AN INDUCTION MOTOR VECTOR DRIVE FOR HIGH PERFORMANCE EV APPLICATIONS

STUDENT: NEVILLE AZZOPARDI

SUPERVISOR: DR JOSEPH CILIA

Background

As the price of oil continues to rise and the effects of climate change are felt around the world, research for cleaner and more affordable means of transport is crucial. An Electric Vehicle (EV) gets its energy from remote power stations where CO_2 emissions can be contained with filters or eliminated with the use of renewable and sustainable energy sources such as wind turbines and photovoltaic cells.

In recent years, as part of a continuing research carried out at the University of Malta, sponsored by ST Microelectronics and Abertax Group, an internal combustion engine car was converted into an EV. For safety reasons load tests cannot be performed on the road, hence a test rig was designed and built to replicate the EV's control system under load conditions.

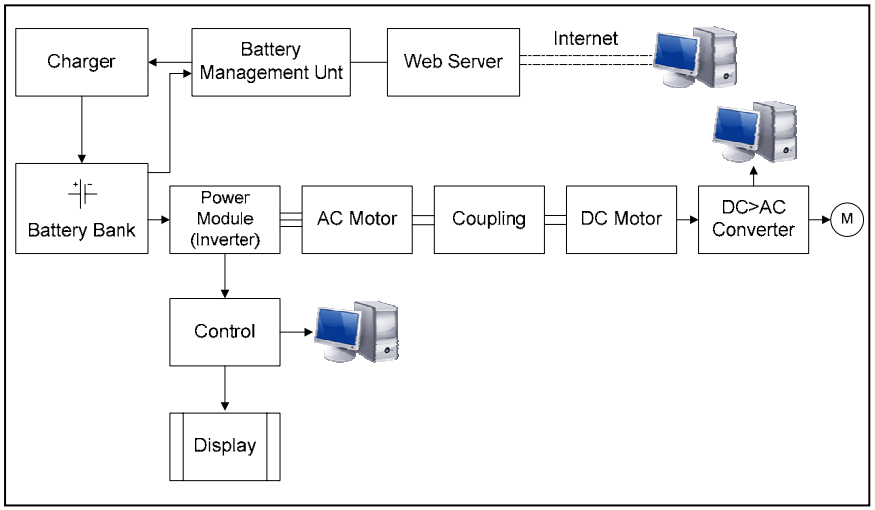
Project Objectives

The project objectives are the:

- Design and implementation of the gel battery management system
- Interfacing of the digital speedometer
- Setup, modification and testing of the load rig circuitry
- Design of the motor coupling to load motor
- Analysis of the motor behaviour running under V/F, slip and vector control
- Analysis of the motor behaviour under different load tests.

Project Methodology

The EV's induction motor was coupled to a DC motor which acts as a load. With this setup, most of the electrical energy used during load tests of the motor is recovered and supplied back to the mains. The power source of this test rig is a set of twelve gel type batteries. These batteries were connected to a battery management system (BMS), donated by Mentzer Electronic, which monitors the state of charge of every battery and identifies faulty batteries. The BMS was connected to the internet via a web server so that the user can check the battery state of charge or control the charger from any computer with an Internet connection. The electronic circuitry needed to power the motor was modified and rebuilt. This comprises of two modules, the control module and the power module. The motor was controlled in three different modes namely V/F, slip and vector control. Different load tests were performed using all control modes and the results were compared.



Results and Achievements

The setup of the test rig proved to work reliably even under load. From the results obtained from load tests, it was proved that in V/F control the motor has a small speed error which depends on the slip of the rotor. This error is present both in steady state and transient conditions. Slip control compensates for the rotor slip and therefore there is no speed error during steady state. During transients however a small speed error is still present for a short time. Vector control deals with the transient parameters of the induction motor and therefore no speed errors are present both in steady state and during transient loading.

UNIVERSAL DYNAMOMETER FOR TESTING ELECTRIC DRIVES

PROJECT E2

STUDENT: RODNEY BONELLO

SUPERVISOR: DR. CEDRIC CARUANA
SPONSOR: CARLO GAVAZZI

Background

A dynamometer refers to a system that is able to emulate different types of loads. These loads can be linear, non linear and discontinuous. This consists of a load machine, a power electronic converter that will drive the machine and a controller that will force the output of the converter such that the load machine will follow a specified Torque-Speed characteristic. The load machine can then be connected to the test machine and a specified load can be emulated to the test machine to investigate how the test machine and its converter will behave when subjected to a particular type of load.

Project Objectives

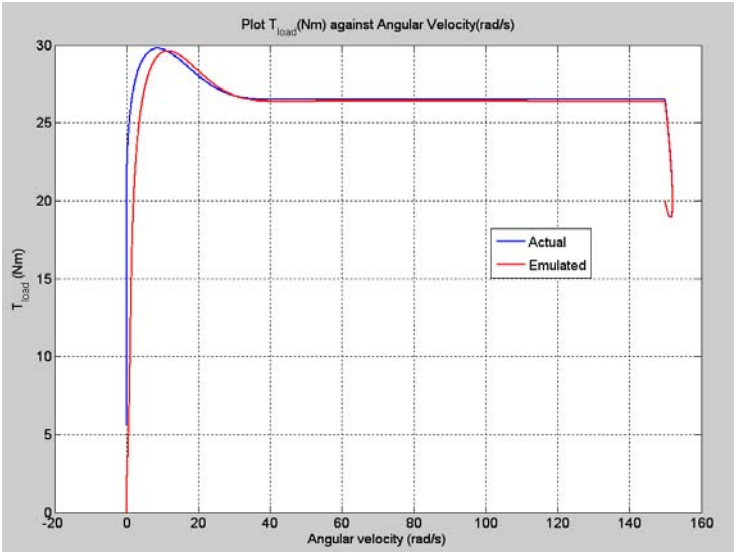
The project objectives are the implementation of the controller for the dynamometer that controls the load machine which in this case is an Eddy Current Brake in order to emulate desired Torque-Speed characteristics

Project Methodology

- The first part of the project dealt with the identification of the features, capabilities and limitations of the rig to determine the limits of what can be implemented and to calibrate the meters for correct measurements

- With the first part complete, Torque and Speed measurements were used to build a model of the dynamometer's plant. The plant consists of the Eddy Current Brake which is the load machine and the Converter feeding the Eddy Current Brake.

- With the plant modeled, the controller required to implement the dynamometer was designed. The controller, Eddy current Brake and Converter are the three components needed for load emulation and therefore forms the dynamometer. The controller was first simulated in Matlab in the complete dynamometer loop to see how this behaves theoretically. Once the control law of the controller is obtained then this was implemented in a microcontroller and interface circuits linking the microcontroller to the plant and sensors were designed. The dynamometer was then implemented.



Torque-Speed curve for a load with J_{emul} = 0.13, B_{emul} = 0, a_2 = 0, T_{const} = 20Nm, = 50, w_{ref} = Step of 150rads^{-1}

Results and Achievements

The results include a set of Torque-Speed characteristics that were emulated on the test rig. The achievements include the possibility that one investigates how a an inverter, soft-starter or any other equipment supplying the motor will behave when the motor is subjected to different types of loads.

DIRECT TORQUE CONTROL OF AC MACHINES

STUDENT: NOEL CIANTAR

SUPERVISOR: DR. CEDRIC CARUANA

Background

In DC motor control the flux and torque producing currents are naturally decoupled. The Direct Torque Control (DTC) scheme enables the control of the induction motor in the same way as a separately excited DC motor. What is unique to the DTC scheme is that the control variables are the electromagnetic torque and the stator flux. This characteristic leads to a very high dynamic performance. In Direct Torque Control, if the electromagnetic torque and stator flux are kept within their hysteresis bands by selecting appropriate inverter voltage vectors, an independent control over the electromagnetic torque and stator flux is achieved.

Project Objectives

The principal objective of the project was to implement and test the Classical DTC algorithm. This task had to be accomplished in software through Simulink, and on an experimental rig, set up in the Power Electronics Lab. The experimental rig was designed and put together in a previous project. No-load and locked rotor tests had to be performed in order to extract the induction motor's parameters. A modified DTC scheme was to be tested in Simulink and used to show how a reduction in torque ripple is achieved. The relationship between electromagnetic torque and slip frequency under constant flux level operation was to be verified, to ensure correct operation of the DTC control methodology.

Project Methodology

Since the experimental rig was not in use for a very long time, the first thing done was to test and fine-tune the rig and verify that that all boards concerned with data acquisition and processing were functioning properly. A faithful model of the experimental setup was then designed in Simulink. Specific tests were performed in order to extract the induction motor's parameters. Several tests were performed both in software and hardware to analyze the DTC performance. A suggested modified DTC scheme was implemented to reduce the ripple in the torque estimate. Finally software and hardware results were compared and any discrepancies present explained.

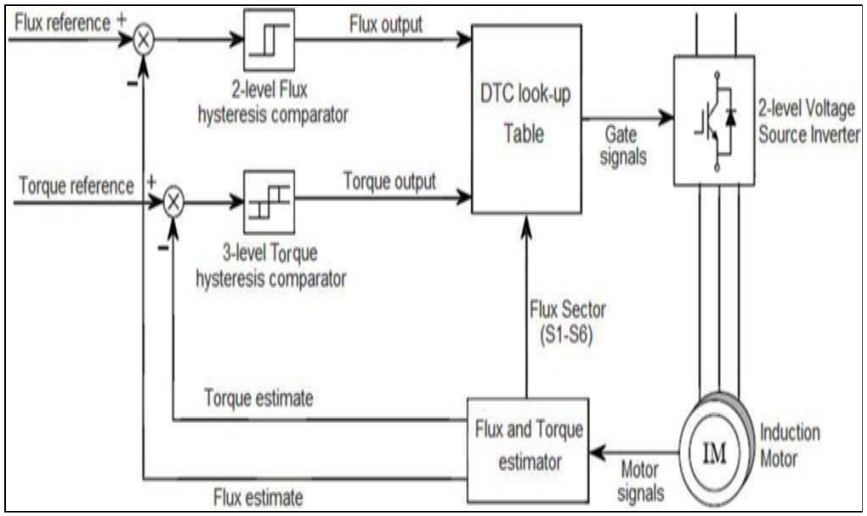


Figure 1: Block diagram of Classical DTC scheme.

Results and Achievements

Tests showed that under constant flux level operation, changes in torque did not affect the magnitude of the stator flux, and under constant torque operation, changes in the stator flux magnitude did not affect the torque value. The relationship between electromagnetic torque and slip frequency was verified for different mechanical speeds. This crucial verification ensured correct operation of the DTC algorithm. A noticeable reduction in torque ripple was achieved after implementing the suggested modified DTC scheme. A maximum figure for the percentage tolerance allowed between the actual induction motor parameters and those used in the stator flux and electromagnetic torque estimator in order for the DTC algorithm to perform well was obtained.

DC ELECTRONIC LOAD WITH ENERGY RECOVERY

STUDENT: JOSEPH CUSCHIERI

SUPERVISOR: DR. ING. C.SPITERI.STAINES
CO-SUPERVISOR: ING.M.SCICLUNA

Background

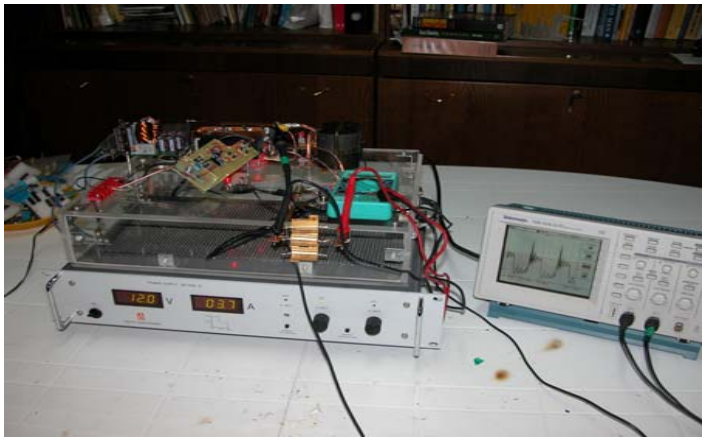
Delta Electronica Ltd., the firm that sponsored this project, produce switched mode power supplies for export having different ratings ranging from 600W to 6000W and with output voltages ranging from zero to 400volts. All of these power supplies are tested and part of these tests involve the active loading of all the power supplies to check their performance under the full range of their outputs. The loading is done using either resistive loads or active loads using transistors but in both cases the energy of the output is dissipated as heat. The idea was to use the converter that is being designed to be able to do the full loading tests that are being done today but to be able to feed back this energy onto the grid so that most of it is not wasted but recuperated. This shall result in saving of energy in line with the Green policies of the company but also in reduced electricity costs which are presently a big burden to the company.

Project Objectives

The main idea behind this dissertation was to design a DC to DC converter that could be used to transform a range of voltages starting from 7.5volts DC to 400volts DC to a constant voltage of 360volts DC. This voltage was then to be used in conjunction with an inverter to change this 360volts DC to 230volts AC which can then be connected to the Enemalta grid. The resultant product of this design is then to be used in the testing of switched mode power supplies in the way as shall be described hereunder.

Project Methodology

The beginning of any design process is the selection of the topology that one will work with. Many types of DC to DC converters were considered; a few were selected and studied in further detail and even designing some circuits and doing tests and simulations. It was decided that the Fly-Back Converter was the most appropriate for the application. As a first try a Fly-Back converter was set up using readily available components like transformer and switching MOSFET transistors. Some measurements and observations were done especially noting the switching waveforms on the drain of the switching MOSFET. The circuit used for this learning phase was a low power circuit. The design was then developed for larger powers. Purpose-made transformers were designed and wound and the switching circuit was developed and the higher switching power MOSFETS were used. In developing the circuit a number of difficulties had to be studied and resolved including the effect of leakage inductance, limiting of the oscillations on the switching transistors, use of snubber circuits, use of bifilar windings etc. At first it was more important to get the correct waveforms and proper operation of the various components but then attention was given to get the circuit operating to the performance as specified initially by my tutor.



Results and Achievements

The DC to DC converter was designed, implemented and was made fully functional with specifications very close to the target figures. The implementation required proper design of the HF transformer, its energy recovery winding and snubber circuits. The circuit was tested under different load conditions. Although the input voltage range was limited to 80V, the converter was able to boost the voltage to the required voltage level.

SINGLE-PHASE MULTI-LEVEL CONVERTER

STUDENT: TYRON JOHN ELLUL

SUPERVISOR: DR.ING.M.APAP

Background

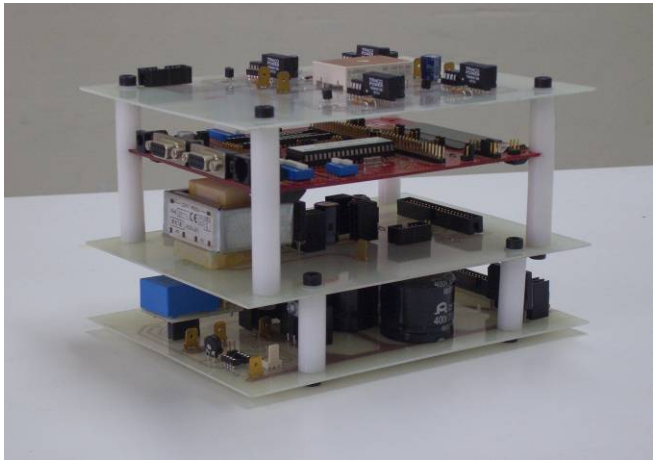
Inverters provide the most compact solution to obtain a controlled AC voltage provided a DC source is available. The DC source can either be a battery or a fuel cell, which is the case when the converter is used in mobile drive application, or rectified AC mains. These converters are made of fast switching semiconductor devices which can therefore produce the fist harmonic at their very high switching frequency or beyond. If the switching frequency is made higher, the higher the first harmonic will be such that smaller filtering components can be used.

Project Objectives

The objective of this project is to show that a nine level converter with a specific topology can provide harmonic cancellation up to multiples of four times the frequency modulation index. A converter consisting of a high power DC supply and an inverter under the control of a micro-controller will be constructed. This converter will be used to verify the multi-level operation and actual harmonic cancellation. If the project will be successful, it will be used as variable amplitude, variable frequency AC power supply.

Project Methodology

The operation of a nine-level converter and its theoretical harmonic cancellation is verified via computer simulations but actual construction of a nine-level converter is not possible due to the costs involved. However a three-level converter was built and tested. By verifying the harmonic cancellation of the built three-level converter one can be sure that there will be the expected harmonic cancellation in a similar way when going to high levels of output The nine-level converter is obtained by, constructing another 3 identical three-level converters and connecting them in two series pairs. This forms two five-level converters which make the load see 9 levels of output when connected cross them.



Results and Achievements

The results obtained from the built three-level converter show that there is the desired harmonic cancellation and therefore the harmonic cancellation up to multiples of four times the frequency modulation index is possible in practice. This is confirmed by the simulation results, that is, a nine-level converter will produce it first harmonic at 80kHz if unipolar switching at 10kHz is used within each of the four modules.

SINGLE PHASE GRID CONNECTED INVERTER FOR PHOTOVOLTAIC APPLICATIONS

STUDENT: JOHN LICARI

SUPERVISOR: DR. ING. CYRIL SPITERI STAINES
CO-SUPERVISOR: DR. ING. MAURICE APAP

Background

During the last few decades many engineers researched the development of clean, renewable energy and the most economic way of generating energy sources. One of the renewable energy sources is solar, particularly photovoltaic (PV) power generation. This project is concerned with the interconnection of a PV array to an existing utility grid. This involves the conversion of DC PV power to AC power of suitable quality to be transferred into the grid.

Project Objectives

The goals of the project were to:

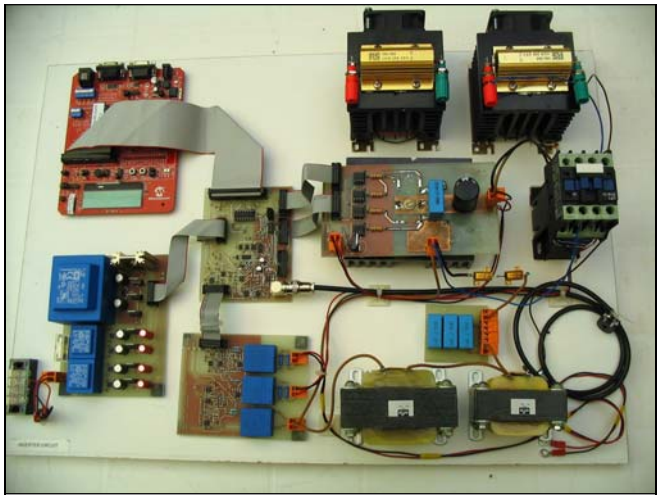
- Design an LCL output filter for output smoothing
- Design a PLL for grid synchronisation
- Design a current controller for magnitude and UPF control
- Simulate the grid connected inverter in MATLAB®
- Build the hardware
- Implement the PLL and current control algorithm in a dsPIC
- Connect with the grid

Project Methodology

A 1 KVA, 230 VAC rms, 50 Hz DC-AC inverter has been constructed. The inverter was controlled using a digital signal processor (dsPIC30F4011) which manages a high frequency unipolar PWM scheme, the current control and the phase locked loop (PLL). Current control was achieved using PI control method in which the output feedback is read using the ADC, and adjustment was then made to each value in the control loop. A 10 kHz switching frequency was used which is the maximum operating frequency of the Semikron IGBT module. The software algorithm incorporated overload protection, which shuts down the inverter in the case of high currents flowing into the grid or into the inverter.

A thorough design of the LCL filter for grid connection was done and special attention was made to reduce self resonance due to this filter.

Prior to building the inverter, the system was simulated in SIMULINK® and MATLAB® in order to design the PI controllers, both for the current control and the PLL using the SISO® design tool. When the simulation results were satisfactory the hardware was constructed.



The constructed single phase grid connection inverter

Results and Achievements

A 1KVA prototype was constructed, and this was tested under 150VA conditions. First, a passive load was used for testing and then connection with the grid through a variac was performed. The prototype was found to perform satisfactorily both with the passive load and the utility grid.

AN INVESTIGATION ON THE CONNECTION OF WIND FARMS IN WEAK POWER SYSTEMS

PROJECT E7

STUDENT: ANTHONY MAGRO

SUPERVISOR: DR.C.CARUANA

Background

The ever growing presence of wind energy in existing power grids has instigated new challenging scenarios in the power industry world wide. The requirements for modelling and interpreting the behaviour of wind generation plants in a grid connected environment has led to significant research interests in the power community. The renewable energy targets promoted by EU directives necessitate a tangible and realistic solution to be devised for the Maltese islands. This project investigates the modelling of wind generation in weak power systems. The successful modelling of embedded wind generation allows the development of a grid connection study for a proposed wind farm in the Maltese power network allowing the effect of wind energy integration to be highlighted.

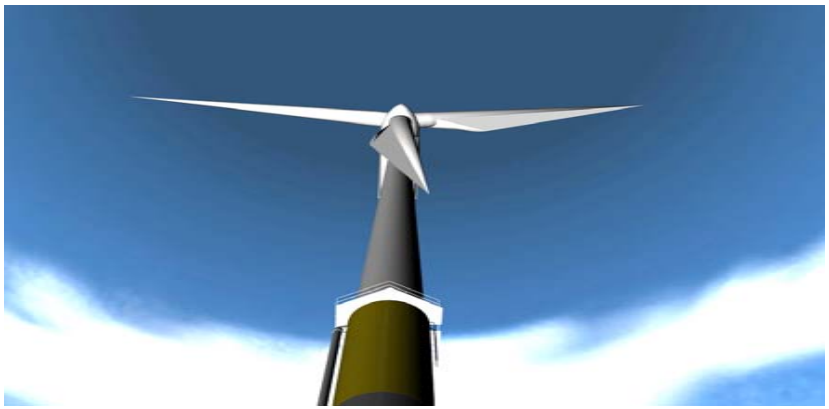
Project Objectives

The main project objectives may be summarized as follows:

- *Investigating the effect of wind energy penetration in the Maltese network.*
- *Modelling of DFIG wind turbine in a power system simulator model.*
- *Wind farm electrical system design and layout.*

Project Methodology

The IPSA® power system simulation suite is used, allowing full integration of DFIG machines in a power system context. The study commences with a single-machine DFIG network and continues by investigating the grid connection aspects of a proposed 40MW DFIG based offshore wind farm in the Maltese power system. The wind farm model is integrated in the Maltese power system model and the ability of the proposed plant to satisfy Grid Code connection requirements is analysed. The impact of the proposed wind generation plant is investigated allowing the necessary provisions within the power network and the proposed plant to be highlighted. The requirements for the secure operation of the system with high levels of wind energy penetration are investigated allowing solutions which improve network security to be identified. The third part of the investigation considers the electrical design of the connection substation and the wind generation plant. A preliminary wind energy yield study for the selected site is included in the investigation.



Results and Achievements

This dissertation successfully outlines the issues relating to the grid integration of bulk wind energy plants in a small power system highlighting the main power engineering issues and outlining methods to mitigate the loss of system security. The findings of this research may be readily extrapolated to any wind energy project associated with the Maltese power system as it highlights the power system issues which are inherent to the Maltese network. The modelling of the DFIG generator and the analysis leading to improved Code compliance allowed the successful simulation of the necessary performance requirements. The design of the wind farm's electrical plant provided an insight in the typical design arrangement of the proposed plant.

SINGLE PHASE PWM AC CHOPPER

STUDENT: IAN SPITERI

SUPERVISOR: DR. MAURICE APAP

Background

The PWM AC Chopper offers an "all silicon" solution for the AC-AC conversion providing a variable voltage fixed frequency output. This converter makes use of two bi-directional switches one connected in series with the supply whilst another one connected in parallel to the load. The series bi-directional switch regulates the power flow to the load whilst the bi-directional switch connected in parallel to the load provides a freewheeling path to discharge the energy stored within the load in case it were inductive. Due to this configuration two constraints must be obeyed namely, avoid short circuit of the supply and open circuit of the load. This enforces the converter to perform a commutation sequence depending upon the polarity of the load current. The use of bi-directional switches for the development of the converter offers advantages namely, four quadrant operation is possible, small filters are connected at both output and input to eliminate the harmonics and improved power factor and sinusoidal current are achieved.

Project Objectives

The objective of this thesis was to build a prototype of the PWM AC Chopper and observe the harmonic spectrum at the load terminal and compare these harmonics with the simulation model for the PWM AC Chopper and the full wave Phase Controller.

Project Methodology

The hardware required for the current sensing, commutation sequence, gate driver circuitry and the clamp circuit were designed, tested thoroughly and then implemented on PCB boards. A microcontroller was used for the software implementation to perform the control algorithms and was debugged to check the registers were being loaded to the correct value. The whole system was brought up together and tested at low voltages. For the protection of the converter apart from the clamp circuit a 1Ω resistor was connected in series with the input terminal to limit the input current in case if the constraint of avoiding short circuit is violated and avoid the destruction of the power module. The voltage at the input was then increased by the use of a variac and the output was noted.

Results and Achievements

A single phase PWM AC Chopper was built which was tested and the results were compared to the simulation results. The results obtained from the PWM AC Chopper showed that the level of harmonics at the output and input of the voltage and current waveforms is much less for the PWM AC Chopper then for the full wave phase controller. Also the first harmonic sideband is centred at the switching frequency (i.e. 2KHz) for the PWM AC Chopper. Therefore small filters could be use to eliminate the harmonics.

INTERPRETATION OF SCRIBBLED LINE DRAWINGS

STUDENT: FRANCO BUSUTTIL

SUPERVISOR: DR KENNETH P. CAMILLERI

Background

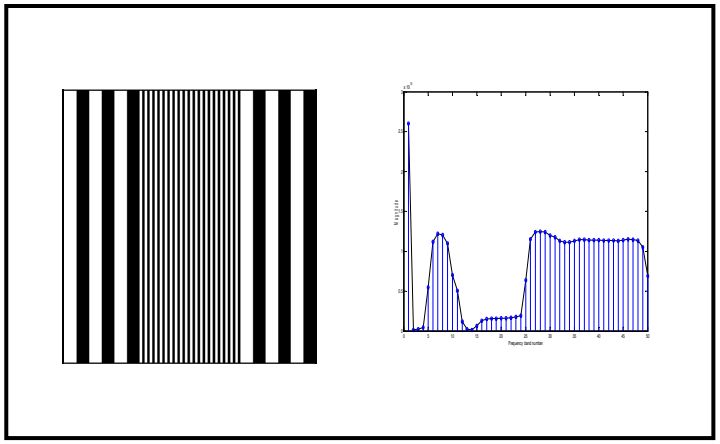
The project is focused on the formal interpretation of scribbles. Scribbled drawings are still to this date widely used especially on paper which allows people to express themselves more freely than what current computer technology may offer. Unfortunately due to the non-formal characteristics of scribbles, there are very limited solutions in analyzing off-line scribbles. A solution that was presented earlier in tackling this problem was to use Gabor filter responses to group the line strokes into solid areas and later use a line-vector algorithm to represent the image in line vectors.

Project Objectives

The objective of this project is to obtain a more localised response of the image in order to obtain a dynamic multi-resolution response. This is mainly because multiple resolution scribbles cannot be correctly distinguished on a global filter scheme basis as was used before. Hence more localized techniques are used in order to capture efficiently the local characteristics of the image.

Project Methodology

In the dynamic method, the image is split into regions according to the frequency content of the regions. The energy distribution is examined by running a series of test masks (annulus shaped) in the frequency domain. After this *scan,* according to which filter scheme captures the energy content of the region, the region is assigned to this specific filter scheme. This is the so called dynamic filter scheme selection method. The problem with this method is that a transition from a region to another adjacent region with different filter schemes result in a sharp transition, hence the region size is very pronounced. Another method which was used that improved greatly this problem was the dynamic adaptive filtering scheme method. This method creates a filter scheme according to where in the frequency scan of the region might one capture the most energy.



Results and Achievements

Shown above are a test grating (left figure) and its corresponding frequency annuli response. Most of the energy is seen to be in 2 bands of frequencies. This corresponds to the dual frequency content of the test grating. For convenience sake, the test grating's orientation is at 0 degrees, however rotating the image would give the same result as the annuli capture energies at constant frequency contours in all orientations.

This was the basic structure which then was utilized in the 2 methods mentioned before to scan the frequency domain of the image or region in question.

EYE GAZE TRACKING

STUDENT: STEFANIA CRISTINA

SUPERVISOR: DR. ING. KENNETH P. CAMILLERI

Background

The idea of using one's eyes to control and operate systems is very appealing. Advances in technology throughout the years have permitted the realisation of such a concept into practical systems. Eye gaze trackers have found their way into various applications ranging from the study of the eye movements and gaze attention to actual human-computer interfaces. In human-computer interfaces, the eyes are used as the controlling medium and the acquired gaze data serves as an input to the controlled device. In the case of a physically impaired user, for instance, the user's gaze direction serves as an input to the computer, replacing the use of the mouse and the keyboard.

Project Objectives

The objective of this project was to implement a gaze tracking system to be used in a human-computer interface and which allows the user to control the computer using one of the eyes.

A non-intrusive, visible light dependent tracking system is proposed. Particular attention was paid to robustness against variations in light and code optimization to ensure the use of the system in real-time applications. The system setup consists of a simple and inexpensive web camera with a resolution of 320 by 240 pixels mounted on a stand and focused on one of the user's eyes. The proposed eye gaze tracker was implemented in MATLAB.

Project Methodology

- Review the existing methodologies of eye gaze tracking
- Implementation of the tracking system which includes the following stages:
  - Eye region extraction using motion detection (fig.2(a))
  - Iris region extraction using a Bayesian framework with Maximum Likelihood (fig.2(b))
  - Circle fitting to the iris region using the circular Hough transform (fig.2(c))
  - Mapping of the iris centre coordinates to the screen coordinates enabling the user to move the mouse pointer using one of the eyes
- Development of a GUI to enhance the interactivity between the user and the system
- Evaluation of the implemented system and the tracking results obtained

Figure 1: Setup of the implemented system

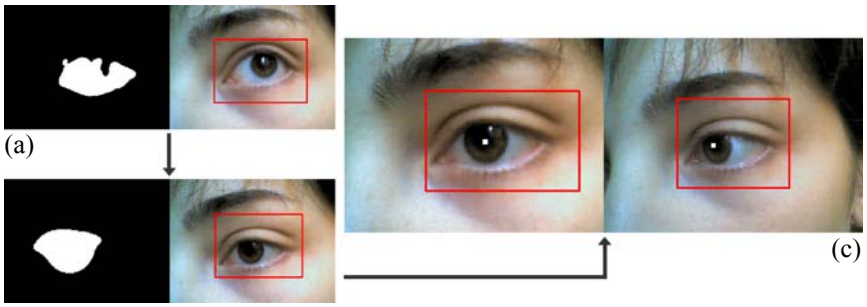


Figure 2: Screenshots taken during system simulation showing results from each stage of the implemented system

HAPTIC CONTROL OF A JOYSTICK FOR AIRCRAFT SIMULATION

STUDENT: CLINTON GRECH

SUPERVISOR: DR. ING. S. FABRI

Background

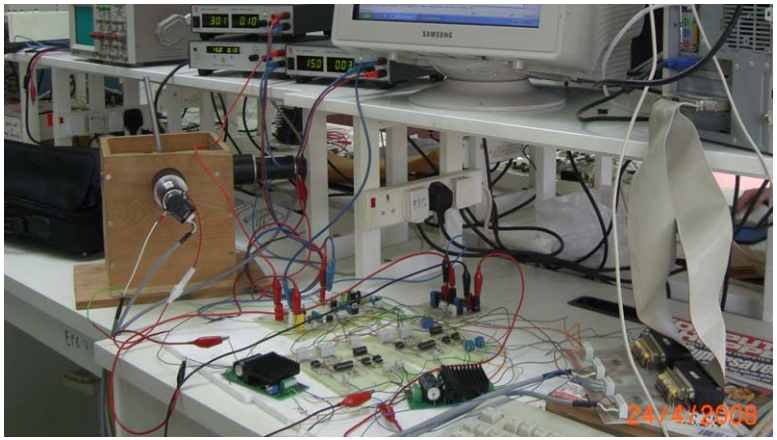
Haptic feedback is the science of touch. When using a purely mechanical flight control systems to fly an aircraft the pilot can feel the forces that the rudder, elevator and aileron are undertaking, however this is not possible in an aircraft using fly-by-wire or in a flight simulator. A Haptic feedback joystick can reconstruct such feelings through sophisticated control algorithms and D.C. actuators. This aids the pilot to have a better understanding of the aircrafts' manoeuvres. Haptic control finds also extensive use in Virtual Environment research and development. Using such devices in conjunction with visual and audio feedback, we can help 'virtual reality' to better approximate 'reality'. The areas where we find this application are in aerospace, medical and also in the gaming industry.

Project Objectives

- Review of haptic force feedback as applied to flight simulators.
- Design and development of a mechanical test rig consisting of a two degree of freedom (DOF) joystick coupled to DC motors. The joystick is designed to resemble as closely as possible a passenger aircraft sidestick. The DC motors are interfaced using designed electronic circuits to a computer where the haptic controller is installed.
- Development and implementation of a fast torque controller capable of supplying the demanded torque from the haptic controller running at a slower rate.
- Testing and evaluation of the effectiveness of the haptic controller on the test rig.

Project Methodology

First a comprehensive literature study for a better understanding of haptic interaction which applies to flight simulators was done. Also research on impedance control and inverse dynamics was performed for a full understanding of the problem and possible controller implementation. The second phase consisted in setting up the test rig, namely a joystick having 2 D.C. actuators for 2-DOF and the design and development of the electronic interface needed between the actuators and the controller for filtering and signal conditioning. The third phase was the mathematical modelling of the test rigs, design and simulation of the inner loop controller and also the outer loop impedance controller which encompass the inverse dynamics and the haptic equations. Finally the last phase was to implement and test the controllers to obtain the actual results and tune the system accordingly for optimum response.



Results and Achievements

The physical results of the impedance position controller were very close to the ones obtained from the simulations. This was due to the inverse dynamic control implemented which cancelled out almost all the non-linearities of the joystick mechanism. The programmed haptic reaction desired at the joystick could be felt by the human operator. The joystick was also used to follow the trajectory of a circle in a given time and also to simulate virtual environments such as a square and circular obstacle. These were implemented with success.

ADAPTIVE CONTROL OF A ROBOTIC MANIPULATOR

STUDENT: MARK ANTHONY SAMMUT

SUPERVISOR: DR. ING. SIMON G. FABRI

Background

The modelling and control of non-linear systems, such as a robotic manipulator, can be very complex for traditional controllers due to the complicated and highly coupled dynamics of the system. An Inverse Dynamics Controller tries to account for these non-linearities and imposes a desired response. This would be ideal if all the plant parameters are known and constant, and no outside disturbances act on the plant. In reality though, a manipulator may be used to pick up objects, thus changing its parameters, while non-linearities such as static friction, gearbox backlash, and measurement noise are difficult to model. An adaptive controller is needed to deal with time-varying conditions, disturbances and noise, by 'learning' in real-time. The scheme adopted involved the use of an Artificial Neural Network to estimate the plant's non-linear functions and unknown parameters, and a Kalman Filter to train this Neural Network in real-time. Neural networks are able to approximate practically any dynamic function, provided the network is large enough.

Project Objectives

The objectives of this project were: to design and implement a 3 degrees-of-freedom (DOF) Inverse Dynamics Controller to control the physical robotic manipulator available in the laboratory in an accurate manner; and to design and implement an Adaptive Control scheme using ANNs and a Kalman Filter that can cater for any time-varying parameters by training the Neural Network to 'learn' these functions in real-time, and investigate its performance.

Project Methodology

These fore-mentioned objectives were tackled by:

- Modifying the robotic manipulator plant available in the laboratory from the previous 2 DOF setup to a more complex and versatile 3 DOF plant.
- Modelling the plant using MATLAB© and Simulink©
- Designing and implementing an Inverse Dynamics Controller on the dSPACE© environment.
- Designing an Adaptive Control scheme using Gaussian Radial Basis Function Neural Networks, and a Kalman Filter algorithm to tune the weights of this Neural Network. This was done initially for a 1 DOF plant, then successively for a 2 DOF and a 3 DOF manipulator.
- Implementing this adaptive controller on the dSPACE© environment to investigate its performance on the actual plant.

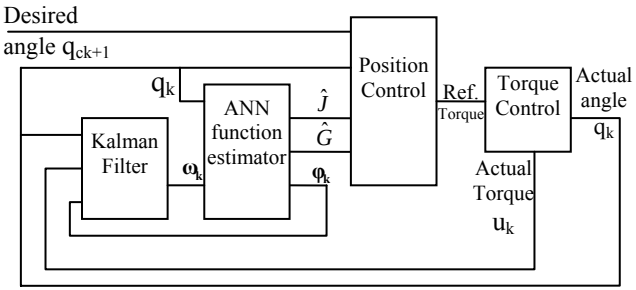


Figure 1: Adaptive Control Scheme

Figure 2: Robotic Manipulator

Results and Achievements

Results showed that the Inverse Dynamics Controller was very accurate and reliable as long as no outside disturbances acted on the plant, but resulted in huge errors when weights were attached to the manipulator to alter its dynamics. By contrast, the ANN Adaptive Controller was successfully implemented for up to 2 DOF, and was shown to be able to 'learn' and adapt itself quickly to the unknown plant dynamics and to subsequent changes introduced by the addition of weights on the links. During the implementation of this scheme on the 3 DOF plant, a number of challenging issues emerged, such as the large memory requirements and processing capabilities needed for this algorithm to be implemented successfully on higher order systems.

FACULTY CLOCKS

STUDENT: MARIA AGIUS

SUPERVISOR: ING. PAUL P. DEBONO

Background

The goal for this project is to design a model for wireless time displays and message boards to be used in the faculty. A single-line LED display which can be hung up in each class, will act as a clock and message board. It will be controlled by a micro-controller. The micro-controller will receive time updates from a server, and forward these updates to its neighbours.

Set-up for the LED display

Project Objectives

The project will consist of a standalone PC working as a main server for the system. Messages will be composed using a tailor–made graphical user interface designed for the server. The server will manage the system and send updates to the microcontroller that will drive the display.

The microcontoller that will control the LED display is an 8051 running the PAULOS real-time operating system. Once it receives the data, it will run a checksum to check the data intergrity. It will ask for a retransmission if the checksum is not correct. Otherwise, it will send an acknowledgement and forward the information to the neighbouring board. The microcontroller sends time, date and messages to the LED display according to the data received.

A routing algorithm was designed using C, bearing in mind that in reality there will be more than one display to provide the faculty with full coverage.

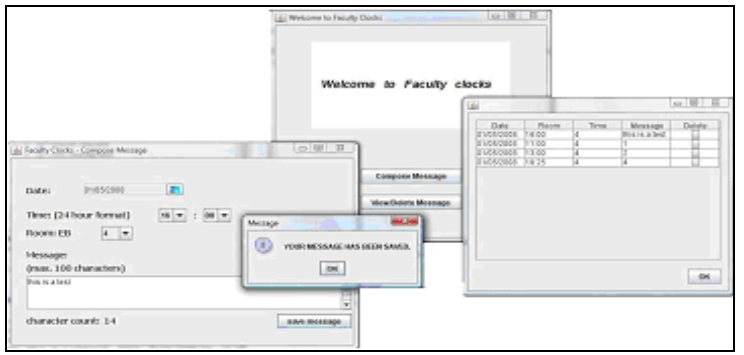
Bluetooth serial adapters will be used to provide wireless full duplex communication between the server and the microcontroller. Communication occurs between two adapters at one time. The adapters are Class 1 with a 100m line of sight range.

The LED display used offers an active area of 53 x 610mm having 7x80 dots with 5mm pixels.

Project Methodology

System modelling was carried out as follows:

- GUI design to allow users to compose, view and delete messages
- Service program design whose function will be to send date, time and message updates to the micro-controller over bluetooth serial adapters.
- Build RS232 tranceiver circuit for microcontroller.
- Use of PaulOS real-time operating system to carry out the following tasks:
  - Receive data and store it for further processing
  - Send date, time and messages to the display
  - Send acknowledgements back to server
  - Forward information to neighbouring display (routing algorithm)



Screenshots from graphical user interface

SIMULATION OF SPATIAL AUDIO RECEPTION USING HEADPHONES

STUDENT: RUDI AGIUS

SUPERVISOR: PROF. ING. P. MICALLEF

Background

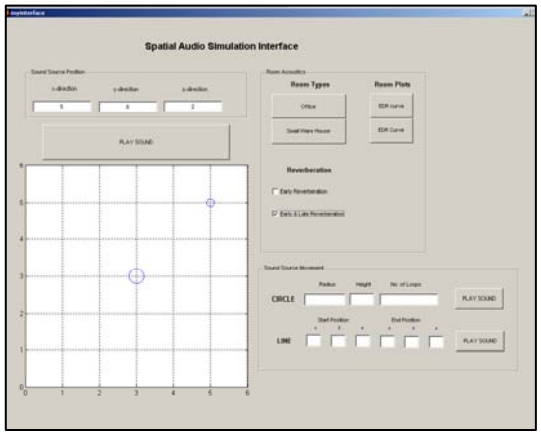
In the past few years, interest in the computer synthesis of 3-D sound has increased significantly. In several important areas, accurately synthesized spatial sound is of great value and of growing importance: human/computer interfaces for workstations, sound output for computer games, aids for the visually impaired, virtual reality systems, "eyes-free" displays for pilots and air-traffic controllers and spatial audio for teleconferencing. The simplest way to produce three-dimensional sound is to physically position loudspeakers at many different points in space. However, this multi-channel approach is both cumbersome and expensive. Fortunately, it is also possible to generate fully three-dimensional sound using only two-channels. Three localization cues must be simulated in order to produce a virtual 3D sound source; these are the elevation cue, the azimuth cue and the distance cue.

Project Objectives

The main objective was to create a realistic virtual surround system using headphones.

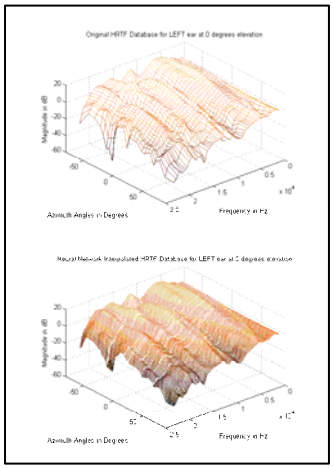
Project Methodology

An extensive literature review was done on the basic principles behind the human auditory system together with the theory behind virtual surround systems and room acoustics modeling. Head-Related Transfer Functions (HRTFs), which capture all of the physical cues to source localization, were used as a basis to develop the system. Before the main algorithm was implemented, a considerable amount of pre-processing was made to create a usable HRTF database which would ensure the quality and efficiency of the spatial audio system. The pre-processing involved using a Radial Basis Function Neural Network in order to create a denser database of HRTFs at 1º angular separations. Different Rooms were simulated using room acoustic modeling techniques. Early reflections were simulated using the Image Method while spatialized reflections and late reflections were simulated using a recursive digital reverberator. An algorithm was implemented which was able to turn a mono sound source into a moving 3-D sound source using the methods described above. A simple GUI interface was also developed to facilitate testing. Work on the real-time implementation of this system was also started. Namely an algorithm using a Genetic Algorithm with an embedded Gradient Lattice adaptive filter was designed in order to reduce the order of the HRTFs by IIR approximation. Subjective listening tests were performed to validate the quality and accuracy of the spatial audio system.



GUI Interface

Part of Original HRTF Database (Top)



Neural Net. HRTF Interpolation (Bottom)

Results and Achievements

Smooth spatial audio in motion was successfully implemented. The Neural Network HRTF interpolation provided smooth movement of the sound source whilst the room acoustic modeling provided the necessary sense of space which is found in realistic environments. The Genetic Algorithm using the gradient adaptive lattice filter was also successful in generating stable IIR filters of order as low as 39 to approximate the FIR HRTFs of order 200. The GA with the adaptive filter also converged at a considerably lower number of generations than that using a pure GA for IIR approximation.

DIGITAL MODULATION LIBRARY

STUDENT: STEPHEN VICTOR ATTARD

SUPERVISOR: DR. ING. VICTOR J. BUTTIGIEG

Background

Digital modulation is the technique of representing digital information in such a way that it can be transferred through a communications channel (via microwave, satellite or cable) as an analogue signal to be received at the receiver and converted back to the intended digital data. The principal device required at both the transmitting and receiving ends is the modem (modulator/demodulator), which is coupled with carrier frequency circuitry (antenna, power and low noise amplifiers) via sampling and quantising digital circuitry (ADC/DAC). The modem performs DSP operations using at its core a dedicated CPU and memory to carry out the conversion from the baseband signal or digital data to an RF modulated carrier and vice versa.

Project Objectives

The main objective of this project was to develop a library of optimised routines which can be implemented on anything from general purpose to dedicated DSPs which carry out the modulation and demodulation processes. The developed functions are intended to run efficiently on various DSPs which might have different core architectures (such as fixed and floating point) and have a data source and sink which can be binary or m-ary. The developed library was to be configurable and portable for such scenarios using little or no changes to the algorithm code itself, and only requiring code modification to the external shell to suit the host hardware.

Project Methodology

The three basic digital modulation techniques were implemented using a variety of methods and tested for correct operation. When this was achieved, the routines were optimised for good noise immunity, CPU performance and simple demodulation routines. The implemented schemes include FSK, PSK, QAM and their variants, (M-FSK, M-PSK and M-QAM) as well as synchronisation methods which take into consideration non-ideal channel conditions and non-synchronised transmitter and receiver.

The methodology used was: reading data from the data source at the modulator, generating a local oscillator to be used as the data-carrying carrier, and modulating by the input data. This analogue representation is then transmitted across the communications channel by outputting the instantaneous digital representation of the modulated signal to the DAC which then conveys the analogue signal to the channel. At the demodulator, the incoming waveform is read as digital samples via the ADC into the DSP. The demodulating algorithms are applied to the input samples to extract the phase, frequency and amplitude information of the received waveform for the duration of one symbol period. The discrete data element corresponding to the specific phase, amplitude and/or frequency information is extracted and the digital data sent to the data sink.

Figure 1 – DSK6416 (right) carrying out FSK modulation and demodulation;, DSK6713 (left) generating noise and using the generated noise to corrupt the QAM signal of the DSK6416 prior to demodulation.

Results and Achievements

The functional elements developed in this project are M-FSK (M = 2-16), M-PSK (M = 2,4,8,16,32) and M-QAM (M = 4,8,16,32,64,128) and a carrier recovery scheme using the Costas Loop for BPSK. Also, a BFSK modem was implemented using a Manchester line encoding scheme.

The performance of the developed routines was tested in order to obtain an insight into the performance of the modems in a practical communications channel, subject to AWGN. The bit error rate versus energy per bit to noise power spectral density of the modems were plotted and compared to standard values. The computational efficiencies of the routines were tested on a 32-bit fixed point DSP by using vendor software tools to obtain CPU load percentage statistics.

BUILDING A HIDDEN MARKOV MODEL USING C++ FOR SPEECH APPLICATIONS

STUDENT: RENÉ AXISA

SUPERVISOR: PROF. ING. PAUL MICALLEF

Background

During the last few decades, researchers studied about the science of speech and came out with many theories and algorithms that can be used to implement various speech applications. One of the most important algorithms that was studied and expanded in late 1960's and early 1970's is the Hidden Markov Model (HMM). The popularity of the HMM has increased for two reasons. Firstly, the models are very rich in their mathematical structures, and secondly because these models work very well in practical applications such as speech and speaker recognition, and speech database annotation.

Project Objectives

The main aim of this project was to build a HMM that can be used in speech applications. Although there is a known software application that does this task - the Hidden Markov Model Toolkit (HTK) - it has various drawbacks. The HTK does not offer handles to important parameters. Moreover it neither has a Graphical User Interface (GUI), nor the possibility of further development. On the other hand, an excellent GUI environment like Matlab does not have a good inbuilt HMM toolbox. Therefore a new application with handles to vital parameters was created. It also has the possibility of having a GUI, however this is not done in this project. The new application may also be used for pedagogical matters since it gives the chance to manage the parameters and thus to compare their results.

Project Methodology

The C++ environment was used to implement this application. The reasons behind this choice are various. C++ programming offers good memory control along with the use of Object-Oriented Programming techniques. While being a good tool in the present, these benefits make the application future-minded, thus making forthcoming development possible.

The HMM requires a set of Cepstrum Coefficients. The Mel-Frequency Cepstrum Coefficients (MFCC) were chosen from various types since they are the most popular Cepstrum-based audio features. These vectors were found using the procedure shown in Figure 1 and applied as input to the HMM. Their centroids were found from the Linde-Buzo-Gray (LBG) algorithm.

The HMM uses the Baum algorithm to achieve better results. It also makes use of the Forward-Backward procedure to compute the needed values efficiently. Through iterations, the HMM is trained to recognise a sound or a group of sounds from speech. A block diagram of all the program is shown in Figure 2.

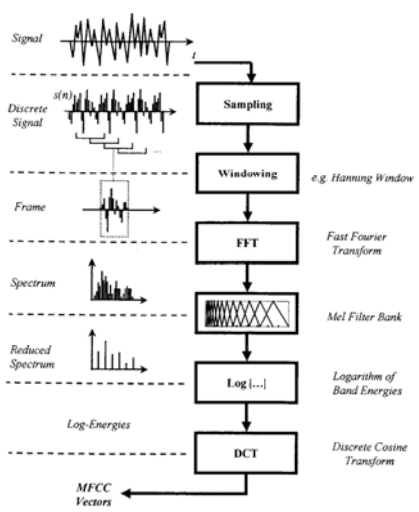


Figure 1

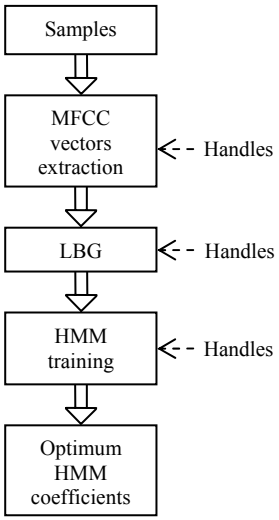


Figure 2

Results and Achievements

Testing of individual methods, classes and group of classes was done along the way through the program development. It is also intended to compare results of this program to results obtained from the HTK application, giving the same input.

AN FPGA IMPLEMENTATION OF AN ADAPTIVE WINDOWING PEER-TO-PEER WIRELESS PROTOCOL

STUDENT: NICHOLAS PAUL BORG

SUPERVISOR: DR. ING. CARL JAMES DEBONO

Background

Wireless sensor networking is an emerging technology that has a wide range of potential applications including environment monitoring, surveillance, medical systems, and robotic exploration. These networks consist of large numbers of distributed nodes that organize themselves into a multihop wireless network. Each node is equipped with one or more sensors, embedded processors, and low-power radios, and is normally battery operated. Reporting constant measurement updates incurs high communication costs for each individual node, resulting in a significant communication overhead and energy consumption. A solution to reduce power requirements is to select, among all data produced by the sensor network, a subset of sensor readings that is relayed to the user such that the original observation data can be reconstructed within some user-defined accuracy. This project looks into such a solution and determines its feasibility.

Project Objectives

The aim of this project is to design a suitable data reduction algorithm and a contention-free based TDMA, peer-to-peer protocol. The two are integrated to build a smart wireless sensor network. Interface hardware, including RF transceiver modules and test jigs, are also developed. The system is tested using a publicly available, real-world temperature data-set.

Project Methodology

The project was carried out as follows:

- Literature review dealing with mainly about wireless sensor networks, communication protocols and data reduction algorithms;
- Design of a data reduction algorithm;
- Design of a contention-free based TDMA, peer-to-peer wireless protocol;
- Design and simulation of a software model;
- Development of a wireless smart sensor node on FPGA using VHDL;
- Searching for and extracting suitable real-life test data;
- PCB design and implementation of the different blocks;
- Modular testing.

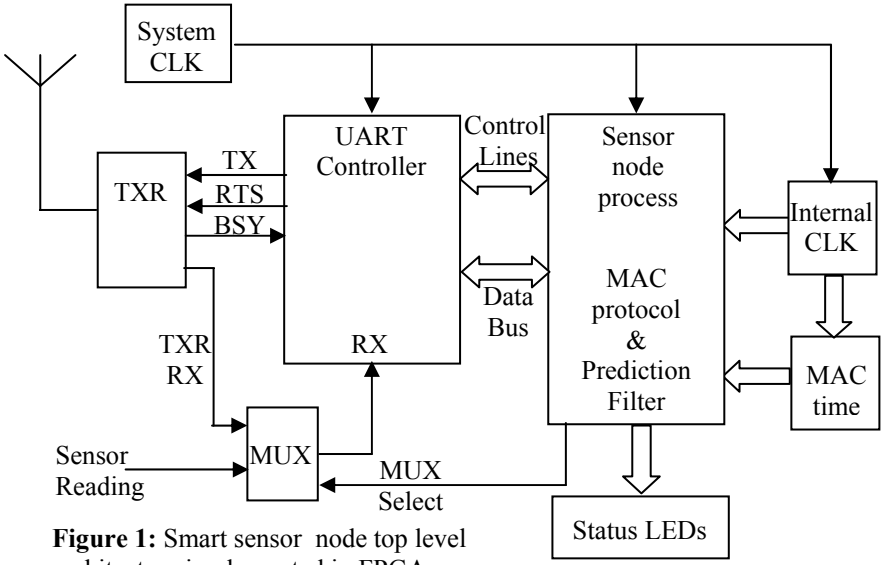


Figure 1: Smart sensor node top level architecture implemented in FPGA

Results and Achievements

The data reduction algorithm achieved a communication reduction of more than 90% whilst ensuring an accuracy of 0.5 degree Celsius. This result confirms that this method greatly increases the lifetime of a wireless sensor network.

PROPELLER CLOCK

STUDENT: MICHAEL BUGEJA

SUPERVISOR: ING. PAUL. P. DEBONO

Background

The propeller clock is basically made up of a strip of vertical LEDs rotating at high speed that change their on-off states frequently in order to create the visual 'floating text' effect. The frequent change in the LEDs' states and the fast speed at which they are rotating creates the effect of having a large LED display, however in reality only one column made up of 32 LEDs is used.

The propeller clock is not only an accurate clock but also has a number of other functions such as the displaying of banners, temperature, etc.

Project Objectives

The main project objective was to design a propeller clock that has:

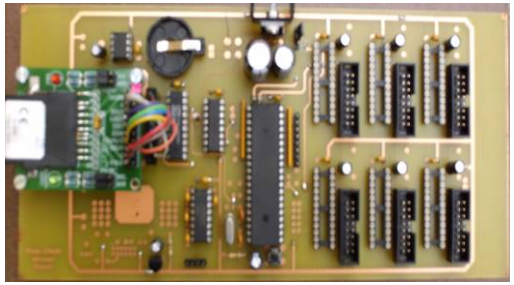
- An 8051 core microcontroller that controls all the hardware.
- A multicolour display using 32 RGB (red-green-blue) ultra bright LEDs
- An accurate real-time clock with battery backup.
- An SD/MMC card interface used to store LED states used to display banners, characters, etc.
- An infra-red remote control decoding to allow the user to easily control the clock's basic functions.
- An RF receiver used to program the SD/MMC remotely by using user friendly software designed specifically for this application.
- A DS18S20 temperature sensor to read the surrounding temperature.

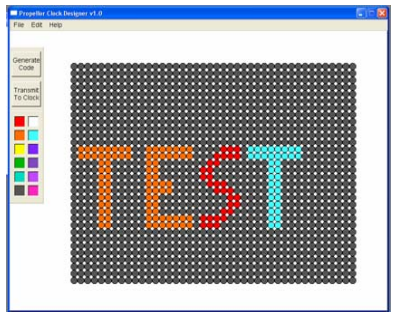
Project Methodology

The first step was to design the schematic of the all hardware that will be connected to the motor's shaft. Once this is finalised the next step is to design and fabricate the printed circuit boards. The hardware was tested to ensure that it is functioning as required. This was done by developing specific test code to test the hardware individually.

The stand, motor, copper brushes and slip-rings and power supply were also set up. The remaining hardware was then assembled together to finalise the propeller clock and test the complete system.

The application software was also developed to allow the user to design a banner and then program the SD/MMC easily in order to display it on the propeller clock.





Results and Achievements

All printed circuit boards together with all the other hardware have been implemented successfully and are functioning correctly. The 8051 core MCU software is also complete and has been tested. The application software is well past its initial stages and can be used to generate the hexadecimal values used to program the SD/MMC.

A fully functioning propeller clock should be completed by the deadline.

WEB BASED INTERACTIVE SYSTEM FOR DISTRIBUTED APPLICATIONS

STUDENT: IAN BUHAGIAR

SUPERVISOR: PROF. ING. PAUL MICALLEF

Background

An important factor which has led to the growth of the internet is the ease of professional website development. A generic platform was required for the successful implementation of a number of applications so that they become available on the internet as easily as possible.

Project Objectives

The aim of this project is to identify methods by which one can setup a web based interactive system on which various website applications can be developed for different tasks. Such system should lead to the development of websites which are aimed to be low cost, robust, secure, support multi-lingual content, aesthetically professional, fast to develop and easy to maintain at the same time. The flexibility of the chosen system was examined by implementing on it a handler to achieve the first web based Maltese language Text to Speech (TTS) software.

Project Methodology

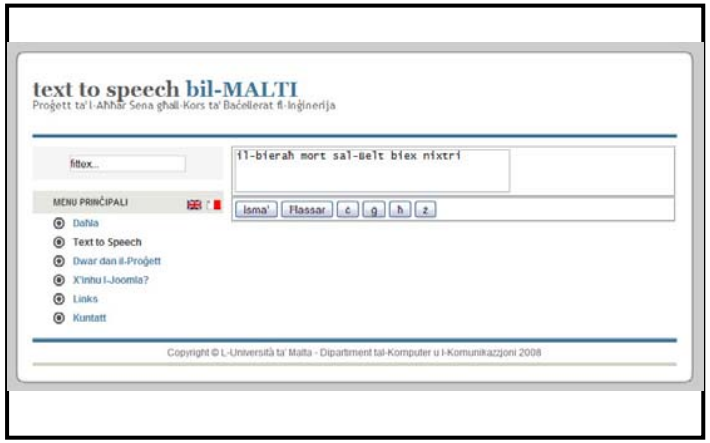
Initially the performance of five web based open source Content Management Systems (CMS) was carried out with reference to the already defined parameters. The study lead to the choice of Joomla as the platform on which the application should be developed on.

Due to the complexity of the TTS system already developed it was suggested that other than re-coding it all in PHP, a PHP handler is to be used so that the system will be accessible within a web environment. A WAMP (Windows Apache MySQL PHP) virtual server was setup over a Windows operating system using the EasyPHP software so that the C based TTS could be executed.

Although the main TTS block was left intact; the original C software was heavily modified in its output and input stages so that it would be able to interface with a web based environment.

After implementing the PHP handler on the CMS, a bilingual framework was developed so that the website would be also accessible in Maltese.

Finally various Search Engine Optimisation techniques were implemented so that the website's ranking on major search engines would be increased.



Results and Achievements

The results obtained clearly show that open source content management systems offer a free platform on which high quality and secure websites can be developed with limited knowledge of web development. The flexibility of such systems makes them ideal for various application developments. In this case, the first online Maltese language TTS system was successfully implemented. Such an achievement will surely help to facilitate more the better usage of ICT technologies by the visually impaired members within our community.

VIDEO STREAMING OVER BLUETOOTH

STUDENT: DAVIDE CATANIA

SUPERVISOR: DR. ING. SAVIOUR ZAMMIT

Background

On-demand video is gaining a lot of popularity amongst mobile users. However the cost associated with transferring large amounts of video data to and from a mobile phone is still relatively high. The idea here is to use Bluetooth technology to interchange video data between a mobile phone and a PC. The PC having the Bluetooth dongle can then retrieve data from the IP network, or forward data received from the Bluetooth network to the IP network, at a very low cost. With most modern mobile phones containing a Bluetooth radio chip and larger screens with higher resolution, and USB Bluetooth dongles costing less than 10€, it is evident that such a system would provide a very cost-effective solution to streaming video data onto mobile devices. The project carried out is concerned with finding the suitability of Bluetooth technology to stream video data to and from a mobile phone.

Project Objectives

The main project objectives were to:

- Research previous work related to video streaming over Bluetooth.
- Implement a Symbian OS series 60 mobile phone application that can send and receive video data through a Bluetooth link and play the received data after having received sufficient data for playback.
- Write an application on the PC having the Bluetooth dongle so that it can communicate with the mobile phone and receive video data from the mobile phone and play the received data once sufficient data is received.
- Analyze the performance of Bluetooth video streaming in an implementation environment using different protocol configurations.

Project Methodology

The first step in the project was to write a mobile phone application which could receive and send data through Bluetooth sockets. Standard RFCOMM and L2CAP sockets provided by the S60 SDK were used and a strategy to receive data through sockets, store the data, and launch the video decoder/player once enough data is received was implemented. On the other end, software was written for a Linux station having a Bluetooth dongle attached to it, to enable communication through Bluetooth sockets, between this station and the mobile phone. By parsing through a pre-encoded video file, the Linux station then sends these packets through its sockets to the mobile phone.

Similarly the respective sockets were programmed so that the mobile phone can send video data to the Linux station. While the Linux station receives and stores this data, an external player is launched automatically in another process to start decoding and playback just after receiving a few packets. Also implemented was a prototype where the mobile phone starts capturing a video, encodes it in H263 video format, and streams it to the Linux station in real-time. After a small delay the Linux station will start displaying this video stream while receiving more video frames, encapsulated in Bluetooth packets, from the mobile phone's video camera.

Results and Achievements

Software for the mobile phone and the Linux station was successfully written and video streaming over Bluetooth has been effected and tested both on the S60 emulator and on an actual mobile phone. It has been shown that by proper encoding of the video file and suitable packetization, video streaming over Bluetooth can be achieved very easily with minimal delays.

MIMO MESH SYSTEMS

STUDENT: KRISTIAN CINI

SUPERVISOR: DR. ING. SAVIOUR ZAMMIT

Background

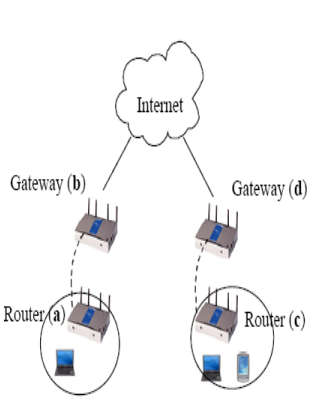
The growth of WLAN technology with data rates reaching 54 Mbps with IEEE 802.11a/g and even higher than 100 Mbps with the advent of IEEE 802.11n standard, raised the interest to extend hot spots to hot zones. Thus recently wireless mesh networks (WMNs) have emerged, where mesh routers form a self-configuring self-organising wireless backbone for client access. Despite recent advances, many research issues regarding limited network capacity still exist. Multiple-input multiple-output (MIMO) is a solution to boost network capacity of WMNs using multiple antenna elements at both ends of the link to provide spectral efficiency enhancement in multi-path fading environments at no extra cost of power or spectrum. STBC and SM are two widely known techniques which respectively provide optimal diversity and multiplexing gain.

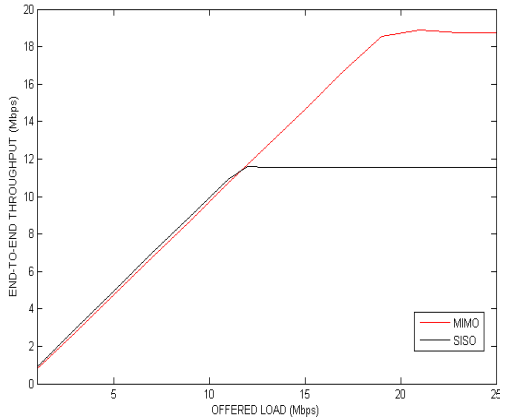
Project Objectives

- Set up a framework over which realistic ns-2 simulations of WMNs on IEEE 802.11 wireless technology can be done, and study the impact of MIMO techniques on such networks.
- A comprehensive performance study that shows significant throughput improvement of MIMO WMNs with respect to multi-radio WMNs.
- Provide valuable insight about the scalability advantages of MIMO WMNs and in particular quantify its cost effectiveness.

Project Methodology

According to the current ns-2 simulator implementation, the received power is calculated by means of a path loss model and if this is higher than the receiver sensitivity, a packet is successfully received. This channel modelling approach attempts to approximate the statistical behaviour of the PHY layer at a low run-time computational cost without faithfully capturing the PHY layer characteristics. Hence, ns-2 was extended to simulate the packet error probabilities for IEEE 802.11a WLAN using SISO and MIMO technology in urban environments. A pre-computed table having the PER values at each SNR level for each of the eight WLAN transmission modes is referenced to ns-2. Moreover, ns-2 was also extended with small-scale Rayleigh fading, a multi-channel multi-radio module and was also modified to accommodate link adaptation at the MAC layer using the well known RBAR technique.





Results and Achievements

The ns-2 framework was validated through tests compared with related literature. Therefore, a setup which can faithfully simulate WMNs using MIMO technology was successfully created. The first results indicate a high performance boost when MIMO is used on multi-radio WMNs. For a grid WMN having AP-AP distance of 100m, a maximum throughput of 18.758 Mbps is achieved using MIMO in comparison with 11.534 Mbps with SISO WLAN devices for a single multi-hop, thus achieving a gain of 62.6 per cent. Furthermore for the same SISO throughput performance, an improvement in coverage area of 490.5 per cent was also measured.

SIMULATION OF OFDM SYSTEMS

STUDENT: JASON DEBRINCAT

SUPERVISOR: DR ING. SAVIOUR ZAMMIT

Background

Orthogonal Frequency Division Multiplexing (OFDM) has been successfully implemented in a wide range of digital communication applications over the past few years, such as Wi-Fi, WiMax and DAB. This new technology is of great interest to researchers in Universities and research laboratories all over the world. So the performance of OFDM is thoroughly evaluated in this thesis. The objective of this project is to build a flexible software simulation of OFDM. This simulation is used to analyze the performance of this modulation technique over different parameters.

Project Objectives

- The study of Orthogonal Frequency Division Multiplexing transmission technology.
- The design and study of Orthogonal Frequency Division Multiplexing technique in a Multipath Fading Channel.
- To compare the Bit Error Rate (BER) performance for different communication channels.
- To compare the theoretical and simulation results for different communication channels.

Project Methodology

- A good literature review is made in order to grasp all the basics of OFDM. Hence various white papers and related websites are consulted.
- The OFDM physical layer and a Rayleigh fading channel are simulated using MATLAB code. The software is implemented with different baseband modulation techniques, such as BPSK and *N*-QAM.
- The channel estimation is also implemented in the OFDM software. The channel estimation is fundamental to correct amplitude and phase shifts due to frequency selective and time varying nature of the radio channel.
- All the designed software is tested with different values to guarantee a reliable interpretation.
- A study of the OFDM physical layer in the Rayleigh fading channel is also made. This study shows the bit error rate (BER) for the various combinations of OFDM parameters, modulation types and convolutional encoder rates in the radio multipath channel.

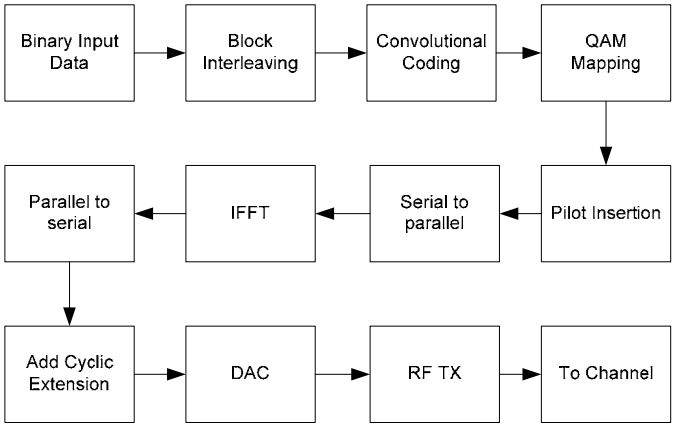


Figure 1: OFDM Transmitter

Results and Achievements

The time and frequency spectrums are plotted for all the transmitter and receiver stages. These plots clearly show the data from the input to the output constellation. The Power Spectral Density of the OFDM symbol is plotted for different number of subcarriers. The bit error rate (BER) vs. signal to noise ratio (SNR) is plotted for different channel conditions. These experimental graphs are also compared to theory.

AUTONOMOUS HEALTH MONITORING SYSTEM

STUDENT: CLIFFORD DE RAFFAELE

SUPERVISOR: ING. PAUL P. DEBONO

Background

The general cost of building a new hospital in the past few years has increased drastically. This, supplemented with the perpetual crisis of medical staff shortages, has necessitated that government institutions and health-care providers promote the concept of personal healthcare evermore towards the patient. Aiding heavily such a campaign is, without doubt, the emerging mentality of tracking personal well-being and attempting to prevent or control diseases before they become serious

Project Objectives

This thriving market for high technology devices used for personal health provides the background for this thesis, which involves the physical construction of a toilet equipped with luxurious and comfortable features. Integrated in the design is a health monitoring system, which daily examines ten biomedical urine parameters, net body weight, blood pressure and heart rate. All the devices and instruments are interfaced to an 8051 microprocessor which co-ordinates the tasks, communicates with the user via an LED display and maintains a user profile for activation of several features in the restroom.

The design incorporates an automatic sliding door equipped with Infra Red (IR) detection sensors. Seat warming is performed by the lavatory to a pre-defined temperature, together with other bidet features, including massage functions, and a warm air drying system. An automatic lid opening feature is presented and this also includes a 'soft close' mechanism. Features such as background lighting, soft relaxing music and courtesy aim lights are routinely performed by design. Finally the toilet automatically performs air deodorization, and water volume controlled flushing.

Project Methodology

A literature review was initially performed which provided ample coverage of Health monitoring systems, combined digital devices, urine health parameters and implementation of proposed schemes such as personal health record and telemedicine.

This was followed by review on high technological toilets, real-time operating system properties and respective functions and microprocessor selection, considerations and capabilities. The determination of functions to be performed was done, and hardware research and comprehension of mechanical restrictions were concluded.

The design and construction of physical components to create the required mechanical functions for toilet features were carried out, together with design and simulation of electronic circuitry, manufacturing of a Printed Circuit Board, installation of Surface Mount Devices, and global testing of the board. Subsequently the interfacing of PCB with microcontroller was achieved and simulation of tasks and debugging of software were executed. Finally, hardware implementation with microprocessor, optimisation of routines, calibration of parameters and fine tuning of mechanical devices were concluded.

Results and Achievements

Testing was performed in every stage of construction, as well as extensive testing was executed on the integrated system. Subsequent to calibration, the lavatory performed as required. Results and functional exhibitions were obtained that allowed the complete system to be qualified as a success.

DESIGN OF A PLUG N' PLAY SMART WATER HEATER

STUDENT: MARIA KATHLEEN ELLUL

SUPERVISOR: DR. ING. ADRIAN MUSCAT

Background

Today's world consists of rising prices for the use of fuel and in turn electricity. Due to this, there is a need to find an alternative resource and a more efficient way of using everyday household products.

One household product, which uses a lot of electricity inefficiently, is the water heater. From my initial studies of usage patterns of hot water, it has been seen that there is no need to keep the water inside the water heater warm during certain periods of the day. To solve this problem, one may switch off the water heater manually or make use of a timer but for most people this is not an option. If the water heater was capable of learning when it is suitable to heat the water then the water heater may be more efficient and will not need to be switched on and off manually or make use of a timer.

Project Objectives

The objective of this project is to design a system that studies a historical time series trend so that it can predict future time series. This idea is applied to a hot water heater by studying the history of hot water usage inside a home to be able to predict the next hot water use and heat the water inside the hot water heater accordingly. This will make the hot water heater more efficient.

Project Methodology

The project was carried out as follows:

- Physical study on the hot water heater
- Study of hot water usage of a family of three
- Study of how using hot water effects the temperature of the water inside the hot water heater
- JAVA based computer model of the hot water heater based on the previous study on the effects of temperature inside the water heater and of the hot water usage
- Study of mathematical time series prediction algorithms
- Implementation of a chosen time series prediction algorithm

MULTIPOINT PRESENTATION SYSTEM

STUDENT: JÜRGEN GRECH

SUPERVISOR: DR. ING. VICTOR BUTTIGIEG

Background

Today most lecturers make use of visual aids during their lectures. Usually slideshow software such as Microsoft PowerPoint or Adobe Reader is preferred with many lecturers. For this to be possible, a dedicated computer or laptop is required in every lecture theatre, which brings about several inconveniences; mainly cost expenses, maintenance and room allocation. Such a computer would be highly underutilized as a slideshow requires little processing power. Also, education around the globe is undergoing many changes and the rapid developments in communication and information technology has resulted in an expansion of different online learning methods.

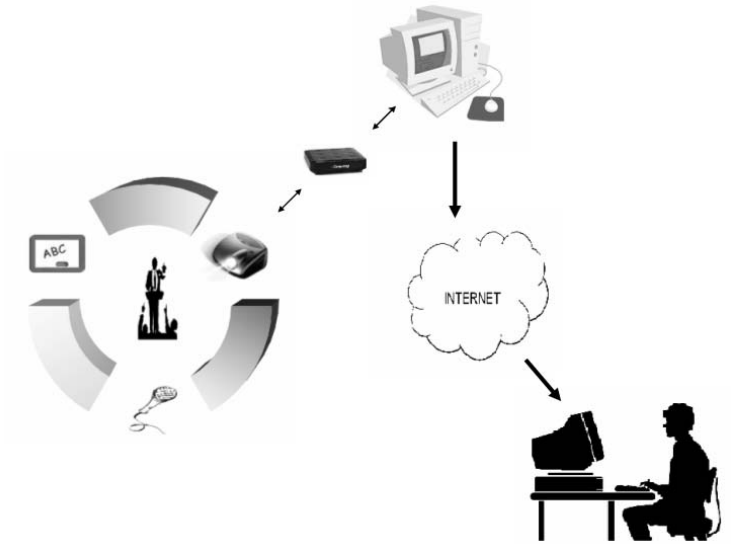
Project Objectives

This project is meant to make use of new technological ways to help with the sharing of information in a lecture theatre. The following ideas were tackled:

- Development of a system which makes use of a thin client, host computer and web server to access, store and retrieve lecturers' presentation material.
- Development of a presentation recording software capturing on screen activity, whiteboard images, audio input and speech recognition.
- Development of an online portal and presentation player to enable students to download a recorded presentation and replay at any time, with as much multimedia features as possible.

Project Methodology

A lecturer is allowed to access his/her presentation material through a thin client, connected across the faculty's network to a host pc. Upon starting the thin client, he/she is greeted by a login procedure. This manages access validation and automatic connection to the lecturer's presentation material. The lecturer needs to upload his material onto a web server through the web portal developed at a convenient time before the start of the lecture. The log-in information is then used to automatically retrieve the uploaded material from the web server. The lecturer needs only to press the START button for the on-screen and audio recording, whiteboard image capturing and speech recognition processes to begin. When the lecture draws to an end, the collected material is compressed and made available for students to download over the internet. A Presentation Player was developed for an interactive viewing of the lecture, by merging together the presentation video, whiteboard images and a SEARCH function. The speech recognition information is used by the SEARCH function to allow students to look for a particular word and automatically forward or reverse the presentation video to the required position in time.



Results and Achievements

The setup shown above was implemented successfully. Two simultaneous presentations were run on different thin clients connected to a common host pc across the faculty's network. The processing power of the host pc is the fundamental controlling factor limiting the number of running clients.

LOW-DENSITY PARITY-CHECK CODE SIMULATOR

STUDENT: JANICE RAPA

SUPERVISOR: DR. ING. VICTOR BUTTIGIEG

Background

In digital communication systems, the key to reliable transmission is forward error correction. Coding of data allows error correction and control to be performed.

Low-density parity-check (LDPC) codes are one of the most recent developments in coding theory. Although LDPC codes were discovered by Gallager in the 1960's, their practical application to coding has only recently been found (1996) and implemented. Nowadays they are accepted as coding standards for new wireless and satellite communication systems such as DVBS-2, WLAN and WiMAX.

LDPC codes are a class of linear block codes. A linear block code takes blocks of *k* bits each and converts them into distinct codewords of *n* bits. Thus the code is usually defined as an *(n,k)* code.

Project Objectives

- Simulate LDPC codes by implementing an encoder and decoder in the Matlab® environment.
- Implement the weight bit flipping (WBF) decoding scheme as a compromise between complexity and computation density.
- Implement modifications on standard WBF algorithm to achieve better performance and compare.

Project Implementation

Simulink®, Matlab® provides a way to visually build a model of a system by utilising blocks. System-functions (S-functions) were used to create custom blocks which can be used within Simulink like any other block. These S-functions were written in C++ mainly due to the platform portability of C++.

A LDPC encoder block and a decoder block were created. The decoding algorithms implemented were the bit flipping (BF) algorithm, the weighted bit flipping (WBF) algorithm and the modified weighted bit flipping (MWBF).

The additive white Gaussian noise (AWGN) channel was used to simulate the noisy channel and binary phase shift keying (BPSK) was used for modulation and demodulation of the data.

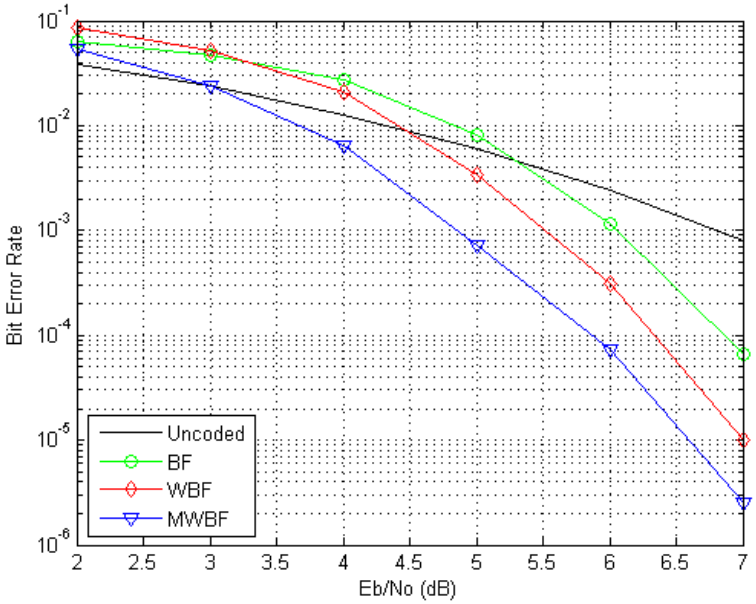


Figure 1 – BER vs Eb/No graph for Gallager (273,191) LDPC

Results

The results obtained from the simulations compare well with published results. The BF algorithm has the least complexity and computational density but its error performance is the worst. The MWBF algorithm provides the best error performance with only a slight increase in complexity and computational load.

ANALYSIS AND SYNTHESIS USING CONTINUOUS WAVELET TRANSFORM

STUDENT: CHRISTIAN SPITERI

SUPERVISOR: PROF. P. MICALLEF

Background

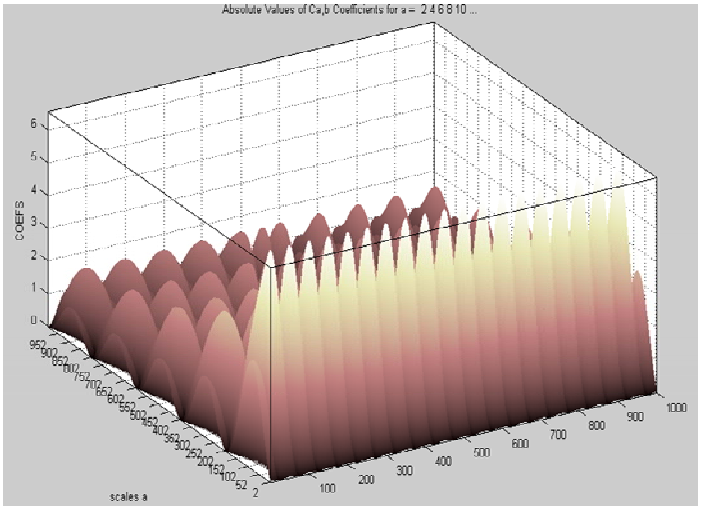
Two important features that are generally needed and requested from a speech signal or any other form of signal are frequency information and the time localization of the particular frequency found in the signal. The Fourier transform fails to give both features since time information is lost while Short time Fourier transform lacks flexibility. Thus the wavelet transform was developed, in particular, the continuous wavelet transform. The latter is defined as the sum over all time of the signal multiplied by scaled and shifted versions of the wavelet function. The results are a number of coefficients representing how closely correlated the wavelet is with that particular section of the signal. The wavelet is a small wave and is a waveform of effectively limited duration that has an average value of zero. It is generally non-predictable, asymmetric and irregular.

Project Objectives

The main objective of the thesis is to apply a discrete signal within the Matlab environment, and perform continuous wavelet transform on the signal to obtain a new signal representation and information about the signal itself. The signal is represented by coefficients at different scales and times in this case. After the transformation, several coefficients are to be chosen using the gradient-descent method, which identifies local maxima out of all coefficients, and synthesis of the signal is obtained by using inverse continuous transform using the chosen coefficients only. The continuous wavelet transform in this case is also a form of coding since a signal can be represented by a certain number of coefficients only.

Project Methodology

Various signals were formed in Matlab and these included sums of sine waves and signals containing low frequency for long durations and, high frequency bursts for short durations. The continuous wavelet transform was applied to the signals and a matrix of results at different scales and shifts was obtained. The matrix was sampled to produce a matrix with relevant data only and this relevant data matrix was subjected to the gradient descent method to identify local maxima of the coefficients.



Results and Achievements

A relation between scale and frequency exists and thus from the continuous wavelet transform result, one can know the particular frequency present with the help of scale and where it is located with the help of the shifts of the wavelet. Testing using signals with known frequencies rendered maximum peaks in the resultant matrix, at scales and shifts that correspond to the frequencies present at particular times of the signal. Hence a way to get information about the signal was achieved. Apart from this the difference between the reconstructed signal, using various coefficients only, and the original signal was noted. Obviously the more coefficients taken, the better is the synthesized signal. The difference was quantified to observe the relation.

HOW LONG DOES A MESSAGE TAKE TO TRAVERSE AN INFRASTRUCTURE-LESS DATA NETWORK?

STUDENT: CLAYTON TABONE

SUPERVISOR: DR. ING. ADRIAN MUSCAT

Background

Imagine if you could send messages with your mobile device over Bluetooth. Imagine also that this message could arrive to your friend's mobile phone even if he is currently not in range. Sending messages over such a network would be free since it does not use nor require access to the mobile phone operator's network. This network can also provide great benefits in areas where network coverage from the mobile phone operator is not available. Nowadays it's not uncommon to have short range transmission devices incorporated in mobile phones. This system would provide a very useful application for that short range transmission device such as Bluetooth or WiFi which you might have left unused in your mobile phone, PDA or even laptop and with a system similar to the one discussed in this project you could use your device to save money on text messaging costs.

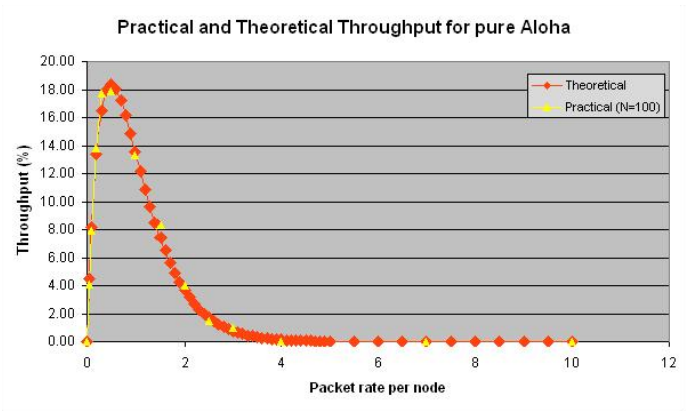
Project Objectives

This project proposes a system which would make use of short range transmission capabilities available in portable devices to create an infrastructure-less data network. The routing protocols which will be used are those which are currently used for mobile ad-hoc networks. The project will try to evaluate the performance of such network as the network traffic and distance between transmitting nodes varies. The performance of different routing protocols for such a system will be analysed.

Project Methodology

The main tasks of the project are depicted underneath:

- Conduct research on ad-hoc and sensor networks, discrete event-based system simulation and mobility models for ad-hoc networks
- Design the layout of the program using proper object-oriented design techniques in order to make the program as modular as possible
- Specify the parameters of the physical layer and implement the free-space path loss propagation model
- Implement the Aloha protocol with capture effect
- Verify the behaviour of the simulator and the Aloha protocol by comparing the achieved results with proved results
- Add mobility behaviour to the nodes by developing a simple mobility model or using an existing model and integrating it with the simulator
- Implement the flooding protocol with the capability to retransmit after timeout
- Implement a location-assisted routing protocol
- Compare the behaviour of both routing protocols under varying conditions
- Obtain readings from the system and draw conclusions from these readings



Results and Achievements

When the project is finished an estimate of the average delay for a packet delivery over the modelled network under various conditions can be obtained.

ECG DATA LOGGING SYSTEM

STUDENT: EVAN JOE DIMECH

SUPERVISOR: DR. IVAN GRECH

Background

An Electrocardiogram (ECG) signal is an electrical signal generated by the heart's beating. The potential created by heart contraction spreads electrical currents from the heart throughout the body. The spreading of electrical currents due to heart activity, create different potentials at different points on the body. This electrical signal can be sensed by electrodes, strategically placed on the skin surface of the patient. The graphical representation of an ECG signal is used as a powerful diagnostic tool for examining functions, conditions and abnormalities of the heart. Hospitals make use of portable ECG data logging systems which the patient can carry with him whilst continuing with his everyday life. Such portable ECG data logging systems are used to build a patient's ECG monitoring history used to diagnose heart arrhythmias.

Project Objectives

The proposed system can record ECG data for a determined amount of time decided by the ECG technician and store the ECG data in file format (FAT16) on a Secure Digital (SD) Memory Card. Eventually the patient can connect the system, to a router or switch which is connected to a server and eventually uploads the ECG data file onto the server. This avoids the difficulty of patients to return the ECG recorded data weekly, while the ECG technicians can examine better the smaller samples of patients ECG history.

Project Methodology

The ECG signal for monitoring purposes has a bandwidth of 0.5-40 Hz. This is an AC signal generally around 1 mV peak to peak. The ECG signal is measured by an ECG amplifier, which is a bioelectrical amplifier with a gain of 1000. The proposed design makes use of a single channel ECG amplifier, in this case, two electrodes are used and the bioelectrical potential difference between them is measured, contributing to a single channel system input. The front end ECG amplifier consists of four main parts, an instrumentation amplifier (IA), a DC restorator acting also as a high-pass filter (HPF), a low–pass filter (LPF) and a right leg drive amplifier. A microcontroller based embedded system was designed, capable of acquiring and converting ECG data to digital format and storing the recorded ECG data. The system also interfaces with a network in order to upload the recorded ECG Data File onto a server. All system hardware and software were carefully implemented and tested.

Fig 1 – ECG Data Logging System Display

Results and Achievements

An ECG Data logging system, designed to be portable, with user friendly interface, capable of acquiring a suitable ECG signal, digitize it and eventually storing the recorded ECG signal in file format on an SD Memory Card. Eventually the recorded file can be uploaded remotely via Ethernet using Trivial File Transfer Protocol onto a TFTP server. Both the signal acquiring and the file transmission were successfully implemented and tested.