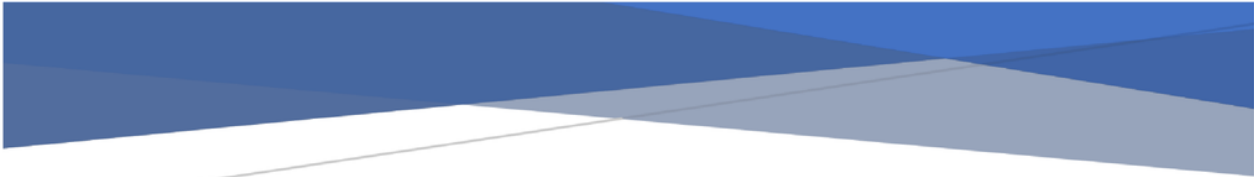


Assignment 1 -Major Project

by Michael Lewis

FILE	5293_MICHAEL_LEWIS_ASSIGNMENT_1_- MAJOR_PROJECT_165676_1372634238.DOCX		
TIME SUBMITTED	18-JAN-2019 07:06PM (UTC+0000)	WORD COUNT	7430
SUBMISSION ID	99447793	CHARACTER COUNT	44244



MAJOR PROJECT – PSDE 6019

Applicable sections contain: **5005 words**

mike lewis

Contents

Table of Figures.....	2
1. Executive Summary.....	3
2. Introduction	4
3. Project Background and Problem Definition and Constraints.....	5
3.1 Project Background.....	5
3.2 Problem Definition	5
3.3 Constraints	5
3.4 Professional, Environmental and Ethical Considerations	6
3.5 Legal, Contractual and Safety	7
3.6 Risk Assessment	7
4. Functional Design Specification and Test Plan	8
4.1 Measurable Performance Parameters.....	8
4.2 Technical Requirements.....	9
4.3 Features to be Included	9
4.4 GUI Detailed Specifications.....	9
4.4.1 Main Menu Layout.....	10
4.5 Test Planning.....	11
5. Literature review.....	12
5.1 Existing Method	12
5.2 Existing Solutions on the Market	14
5.3 Potential Solutions	16
5.3.1 Solution One - FPGA.....	16
5.3.2 Solution Two – Microcontroller	18
5.3.3 Solution Three – PLC	20
5.4 Solution Comparison.....	22
6. Project Planning, Work Breakdown Structure and Management Techniques.....	23
6.1 Work Breakdown Structure.....	23
6.2 Project Budget Tracker.....	24
6.3 Gantt chart	26
7. Conclusion and Recommendations	27
8. Works Cited.....	28
9. Appendix	31

Table of Figures

Figure 1 - Main menu layout and options.....	10
Figure 2- Spacer blocks & positioning plate.....	12
Figure 3 – Search coil & measurement setup.....	12
Figure 4 - X-Axis field measurement example	13
Figure 5- Brockhause XYZ scanner specs	14
Figure 6 - Brockhaus XYZ scanner	15
Figure 7 – FPGA system overview.....	17
Figure 8 - Microcontroller system overview.....	18
Figure 9 - PLC system overview	20
Figure 10 - Three solution comparison table.....	22
Figure 11 - Work breakdown structure (WBS).....	24
Figure 12- Screenshot of budget tracker	25
Figure 13 - Gantt chart.....	26

1. Executive Summary

This report contains an extensive plan to solve the problem of Automated magnetic field plotting of a pulse of magnetic field lasting 300uS. The manual method used to date is inefficient and wastes employee resources, so a small investment to create an automated jig will benefit the company in the long run.

Three solutions have been explored to solve this problem, with one best solution chosen to go forward with suitable evidence contained to justify the decision. This report contains extensive time, resource and cost planning to ensure the solution can be deliver on time, in a manner set out in the initial specification.

Existing solutions that exist on the market today have also been investigate, with a cost that is magnitudes larger than the budget for the project described in this report. The relative low cost and high probability of completion on time means this is a good investment with a high likelihood of seeing a beneficial return.

The end product will have an easy to use interface, selectable menu options, and meet all current workplace health and safety requirements. The data gathered from the automated jig will be **at least** as accurate as the data gathered from the manual plotting of the magnetic field amplitude, but a higher degree of repeatability and accuracy between tests is expected (with the removal of human error).

2. Introduction

The overall aims of the project are to gain knowledge and understanding of quality management techniques and the application of that knowledge in a real-world scenario managing a complex project. The project is based in the workplace will reflect how projects are managed in a modern company. The end goal of the project being a finished product that has been planned, designed and build in a professional manner; akin to a product that a company would pay a contractor to design and build for them.

The project will involve extensive planning and require a critical understanding of project specifications, design and management methods. The constraints that effect the major project must be understood as well as all standards and regulations that apply to the project.

Modern management techniques will be employed throughout the project to ensure the end product is delivered in the way specified in the initial specification. Another aim is to realistically plan for the future throughout this report, to later compare with the final outcome of the project. Realistic planning and predicting potential problems are essential to achieve these aims and goals, if the end product does not match the product details in the specification, the planning phase of the project will have been poorly performed.

3. Project Background and Problem Definition and Constraints

3.1 Project Background

The project is based in a company that manufactures medical equipment. Specifically, the piece of equipment the project is based around is a machine that creates a repetitive high-strength magnetic field. The goal of the project is to create an automated jig to measure the magnetic field output of the device as far as 20cm away from the device. The strength of the magnetic field means many of the off-the-shelf magnetic field measurement devices are not rated for this high-field strength.

3.2 Problem Definition

The problem that is being solved is; to measure the peak magnetic field of a physically large coil, with the magnetic field being created and collapsing in 300uS. The peak magnetic field strength has to be measured in a 3-dimensional space, of roughly 20cmx20cmx20cm. Each point in space will have **three** different peak magnetic field values; X, Y and Z components; the project must be automated and include features to accurately measure all of these values, and map them to a format easily read by humans.

The current method of magnetic field measurement involves manually moving a search coil over the coil to be measured, and taking each X, Y, Z reading manually for each 1cmx1cmx1cm special region above the coil. The current process is incredible time consuming and allows plenty of opportunities for human error to affect the results.

A full description of how this is currently carried out in the workplace is described in detail on page 12, under the title: **5.1 Existing Method**.

3.3 Constraints

One constraint the project will face is the use of the correct materials within the magnetic field. The strength of the magnetic field is high enough to have a negative impact on any metallic parts and electric parts, therefore the Z (vertical) axis must be constructed with a non-conductive plastic, as this will be the only part of the machine that will be within the magnetic field.

Another critical constraint is to minimise the wiring in the magnetic fields effective area; Due to the massive amount of energy used to produce the magnetic field, very large

currents can be induced in any wires within this area, which will damage components and pose a hazard to the user of the machine, or anyone who comes into contact with the machine while its operating.

The Z-axis motor cannot be located within the magnetic field area either; Currents will be induced in the windings and any permanent magnets will be de-magnetised by the strength of the magnetic field.

3.4 Professional, Environmental and Ethical Considerations

Ethical engineering incorporates topics such as: environmental/sustainability limitations, ethical engineering practices, health and safety, security risks, intellectual property, codes of practises.

One way to ensure the parts used are environmentally friendly is avoiding the use of any of the following black plastics: amorphous polyethylene terephthalate (APET), crystallised polyethylene terephthalate (CPET), polyethylene (PE) and polypropylene (PP). Although these plastics are fully recyclable, the common black pigment used cannot be detected by the recycling plants sorting machines. (WRAP, 2018)

Avoiding these plastics, and avoiding ordering parts which are packaged in these plastics ensures that the plastics can be recycled and won't end up in landfill.

Any plastics that are used throughout the project will be fully recyclable. The frame of the machine will be made of aluminium, which can be reused or recycled at the end of the machine's life. All peripheral components will be sourced from ethical manufacturers where possible, and avoid buying components that have been made by underpaid or poorly treated workers, for example; Avoid importing components with no CE mark or recognised markings.

To ensure the machine is efficient and environmentally friendly, there will be a limit to the maximum power the machine can draw, described in the FDS. There will also be an auto-power off feature to the machine, if the machine has been idle for a set period of time.

In general, the project will have very little environmental issues as it's a one-off jig and all parts and materials are environmentally friendly. All components for the project will be

ethical and environmentally sourced, if possible. Any scrap or leftover parts will be recycled if possible or disposed of in the most environmentally friendly/ethically as possible.

3.5 Legal, Contractual and Safety

The dangers of high-strength magnetic fields on humans is not entirely known, particularly when the magnetic field stimulated certain regions of the brain. However, studies suggest that some types of High-frequency repetitive transcranial stimulation [Continuous high-magnetic field bursts to the brain] have caused seizures, or as it says in the article “Twenty-five seizures were identified. Potential risk factors emerged such as sleep deprivation, polypharmacy, and neurological insult. High-frequency-rTMS was involved in a percentage of the seizures. “ (Christine E Dobek, 2015, p. 2975) although one of the main points of the article was a particular type of antidepressant used in conjunction with rTMS, the risk is still apparent and cannot be ignored. More studies have been carried out on lab rats which may be an indicator of possible health issues with repetitive high-frequency magnetic fields on the brain (Thomas A. Houpt, 2003).

The risks associated with this type of high-magnetic fields can be mitigated in a couple of ways:

The magnetic field will be held at the bottom of the jig as to make it improbable that the magnetic field can reach the users brain. The output will NOT be repetitive, instead one high-strength pulse will output and be measured at a time, which mitigates the higher danger that high-frequency field output has. The jig will be automated, which means that a user does not have to assist of take any measurement, which takes the user away from any potential dangers.

3.6 Risk Assessment

Unfortunately, the risk assessment contains roughly 1700 words and cannot be inserted into the report. Please refer to the appendix (**Page 31**) for the current risk assessment for the use of TMS in the workplace.

4. Functional Design Specification and Test Plan

The magnetic field produced is a decaying sine wave that lasts for 1 cycle. The range of frequencies of the sine wave is from 2.5KHz to 4KHz. The device must measure the X, Y and Z component of this 1 cycle sine wave to determine the peak magnetic field for each of the X, Y and Z components. As the wave will only last from 250uS to 400uS the machine must process and save the maximum magnetic field value for each axis in 1 second. The 1 second buffer allows ample time for the data to be processed and saved, and for the machine to move to the next testing location.

4.1 Measurable Performance Parameters

1. Must be able to measure a magnetic field of at least 2 Teslas, exactly as described in the above paragraph.
2. Must be able to move automatically in three-dimensional space
3. Must be able to measure a magnetic field in an area of at least 20cm x 20cm x 20cm and measure at least 500 points.
4. The measuring device (Search coil) must have 3 coils perpendicular to the X Y Z axis'.
5. The 3 search coil readings must be sampled and held to find the max value using an appropriate circuit, the circuit must hold the value for a minimum of 600uS.
6. The values gathered from the three search coils must be saved onto a semi-permanent storage medium: E.g. EEPROM, NVRAM etc.
7. The magnetic field strength outside of the test jig must be kept within safe levels using shielding if required: The field must not exceed 500 microteslas, as stated by the National Radiation Laboratory report on the safe occupational exposure level. (Health, 2008, p. 12)
8. The positional accuracy for all axes' must be +/- 1mm.
9. The noise emissions from the machine must not exceed 75dB.
10. Include an auto-power-off feature when the machine is idle to save on power.

4.2 Technical Requirements

1. Supply voltage: 240VAC single phase
2. Motor rating 12-24V, 50W each
3. Overall power consumption must not exceed 1KVA
4. IP rating – IP44

4.3 Features to be Included

The main mechanical features of the machine will consist of a three-axis cartesian gantry, with the search coil assembly being the payload that the gantry will be positioning. Although a full custom mechanical design is not yet completed, the general construction of the axis must be a cartesian style gantry system.

The GUI for the system must be simple and easy to use and be interfaced with any standard PC terminal. As designing professional modern GUI is not in the budget, a simple text-based interface will suffice that will have the user push a number corresponding to the choices on screen. The GUI will serve as a way for the user to start the machine, manually adjust the axes', view the position of the motors, show any errors, view the last magnetic field values saved, as well as other small features that will make the jig easy to use and understand.

4.4 GUI Detailed Specifications

The GUI which will provide a means to control and monitor the machine will have to include the following:

- Text based menu system
- User chooses menu by inputting a character or number
- The GUI will contain the following menus:
 - Manual control – allows user to move all axes' manually
 - Semi-auto control – Input a position and the machine will move to position
 - Auto-Control – Machine will run and test automatically
 - Monitor menu- Displays positions of all axes', last search coil measurements, current position
 - Home menu- homes the machine to its initial position

- Service menu – requires password to enter but allows things such as: Erase memory, inspect memory, view/modify any offsets, sensor I/O check. This menu will also contain the calibration section.

4.4.1 Main Menu Layout

The menu system must appear as it does in

Figure 1. The user must press the corresponding letters A to F on their keyboard to access one of the options. The service menu **MUST** prompt the user for a password each time the option is selected.

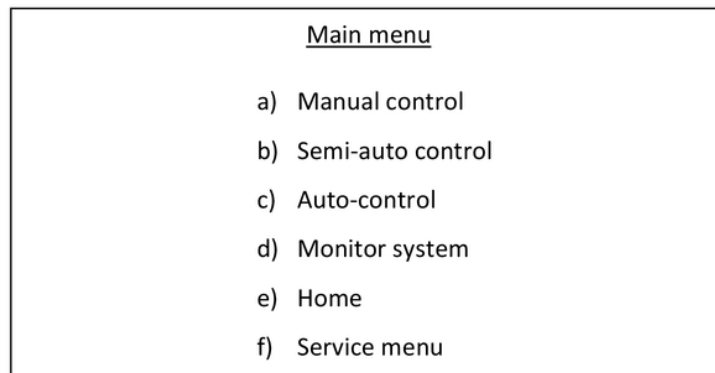


Figure 1 - Main menu layout and options

4.5 Test Planning

Name/Description of test	Expected outcome	Pass/Fail
Produce a magnetic field of 2 Teslas, measure peak field with search coil	The pickup coils should all be able to measure a peak field of up to 2 teslas	
Machine in manual mode. Move along X, Y and Z axis	Each axis should move both directions in manual mode when the command is sent from the PC	
Produce a magnetic pulse and allow the search coil to measure pulse	Ensure that the peak value of the magnetic pulse is held by the sample and hold circuit for at least 600uS	
Set the machine to run in auto mode	The machine should automatically start measuring, based on the settings provided by the user	
Ensure the data is being saved correctly	Once data has been collected, remove power from machine for 30 seconds, turn back on and ensure the data is held in the EEPROM/NVRAM	
Measure the magnetic field outside of the machine when the magnetic pulses are being fired	The magnetic field strength outside the machine must be below 500 microTeslas	
Manually move all axis 10mm, one at a time	The axes must land between +-1mm of the 10mm moved	
When the machine is running in auto, measure the noise emissions from outside of the machine	The noise level outside the machine must be below 75dB	
Leave machine in idle for 5 mins untouched	The machine should automatically power off	
Measure the power consumption of the machine in auto mode	The power drawn must not exceed 1KVA	

5. Literature review

5.1 Existing Method

The existing solution that is being replaced is the manual process of measuring the magnetic field strength of stimulating coils. Figure 2 shows the spacer blocks and positioning plate respectively. Figure 3 shows the search coil and how the measurement equipment is assembled.

The positional plate is what sits above the stimulating coil and allows the spacer blocks and search coil to be located in the peg-board style indents. The spacer blocks hold the search coil at a fixed angle and distance from the positioning plate, either 10mm, 20mm and 30mm heights. This setup allows the search coil to be placed in the correct orientation relative to the stimulating coil being measured.

Figure 3 [picture 2] shows the zero position of the search coil above the direct centre of the positional plate. There are 10 positions to the left and right on the positional plate that the search coil and blocks will be positioned. This is referred to as the x-Axis. At each position the stimulating coil is fired and the peak magnetic field value is recorded.

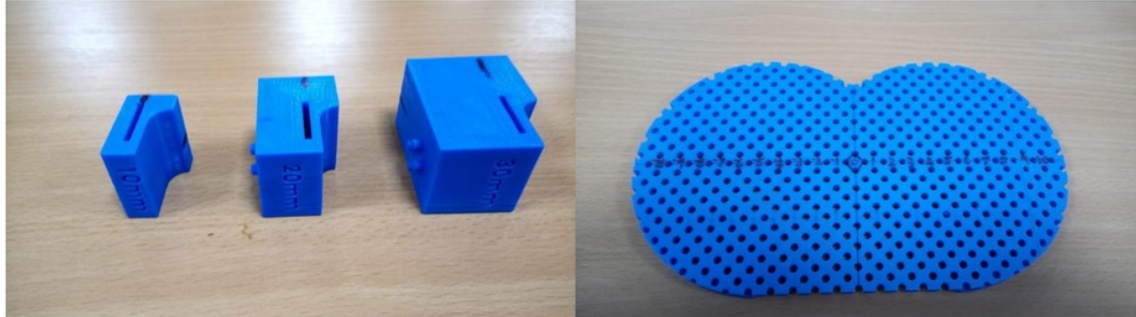


Figure 2- Spacer blocks & positioning plate

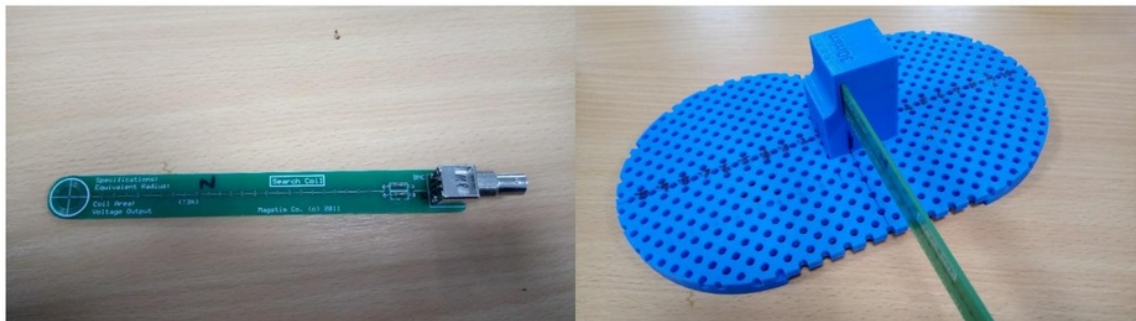


Figure 3 – Search coil & measurement setup

Once the peak magnetic field at each point along the X-Axis has been measured, there should be 21 data point that represent the peak X-Axis field strength at the chosen height.

Once the data points have been graphed it should look similar to the graph in Figure 4, instead having only one plot. The three separate plots on the example graph shows the comparison on three different stimulation coils. The graphs' X-axis represent the physical position the search coil was placed when the measurement was taken.

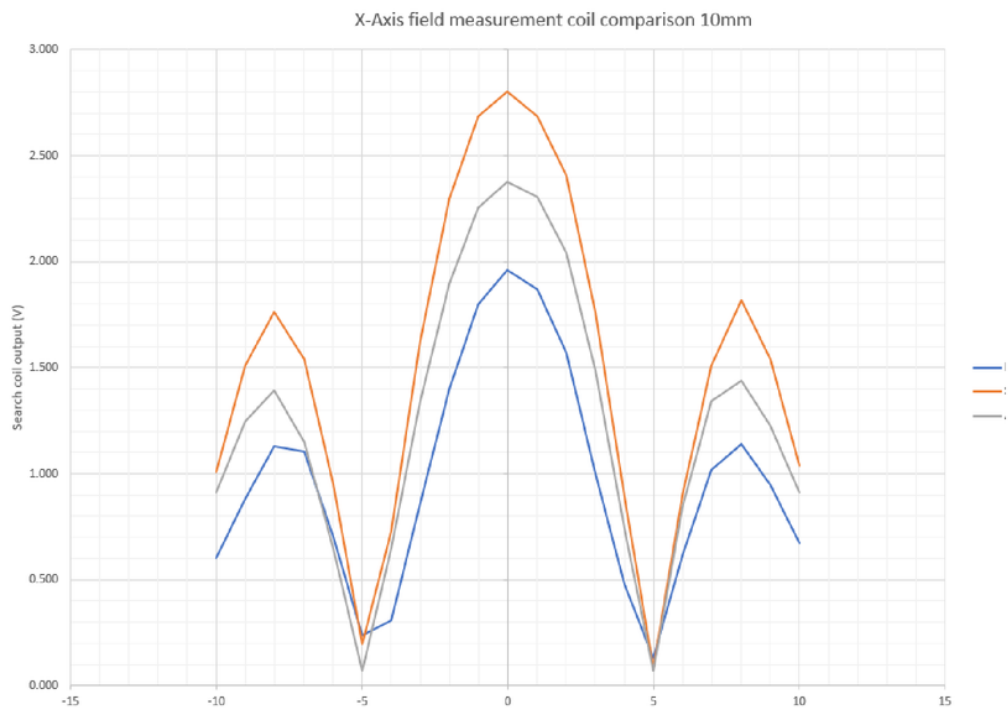


Figure 4 - X-Axis field measurement example

5.2 Existing Solutions on the Market

There is a solution that meets the FDS that is currently on the market. A company called Brockhaus produces a XYZ magnetic field plotter fitted with a gaussmeter. The specifications for this machine are shown in Figure 5. This device operates with a cartesian gantry system, a gaussmeter and custom-made software allowing the user to interface with a PC.

Although this solution is perfect for the project, the basic model has been quoted at 65,000 Euros, which far exceeds the projects budget. The full technical specifications are in the appendix of this report. A photo of the machine from the technical specifications are shown in Figure 6.

Technical data:	XYZ Field Scanner
Worktable:	approx. 500 x 500 mm
Axis movement:	400 mm, steps of $\pm 0,1$ mm, accuracy $\pm 0,01$ mm, speed max. 50 mm/sec
Rotational movement:	angle resolution 360° / 9000
Measurement of field strength:	with three-channel Gaussmeter GM 460
Software:	– field recording: direction, amplitude, north / south pole display, – vector plot up to 3D (adjustable scale), – contour plot up to 3D (adjustable scale) – XYZ position and field values indicated according to position of cursor – storage of measuring results – printout – Export files (Excel/ASCII/Database)
Cabinet:	measuring table with container
Dimensions:	2100 mm x 900 mm x 900 mm (height x width x depth)
Mains supply:	230 V, 50 – 60 Hz

Figure 5- Brockhause XYZ scanner specs

(Dr. Brockhaus Messtechnik GmbH & Co. KG, 2018)



Figure 6 - Brockhaus XYZ scanner

(Dr. Brockhaus Messtechnik GmbH & Co. KG, 2018)

5.3 Potential Solutions

To achieve all that was described in the FDS, three potential solutions will be investigated to narrow it down to one final solution. As the mechanical side of the project has been established, it will be the electronics and control aspects that will need a solution.

The three solutions are: FPGA, Microcontroller and PLC. The criteria used to judge each of the solutions are: Applicability to FDS, physical size, cost of device, cost of peripherals and software, maintainability.

5.3.1 Solution One - FPGA

An FPGA (Field programmable gate array) is a device that can be programmed based on configurable logic blocks. They are programmed by the interconnections between the logic blocks. The benefits to these devices are: operating speeds up to 500MHz, programmable logic blocks suitable for many different applications, relatively low price point. (Xilinx Inc., 2018)

The chosen FPGA for this solution is one from the Spartan-6 LXT range, which is advertised as '*I/O Optimization at the Lowest-Cost with Serial Connectivity*' (Xilinx Inc., 2018, p. 6)

The product details page also specifies some of the key characteristics of the range of device:

- 3,758 – 23,000 Slices [Each slice = 4 Lookup tables and 8 flip-flops]
- 6.4 – 33.8 Mb of configurable memory
- Total I/O from 190 to 540 (Dependant on package)
- Serial connectivity

(Xilinx Inc., 2018)

A device from this range of FPGA will be suitable and can meet the demands described in the FDS.

The device will also satisfy the requirements of the main menu set out in the FDS. The device can be configured to communicate on the UART bus which will enable communication to a PC terminal. The basic text-based menu can be achieved in this manner, explained in the **official** Xilinx Wiki. (Xilinx-wiki, 2018)

Figure 7 shows a system level overview of how the FPGA will control all peripherals. The directions of the arrows show the signal direction. As the chosen FPGA does not come with non-volatile memory, some will be added externally.

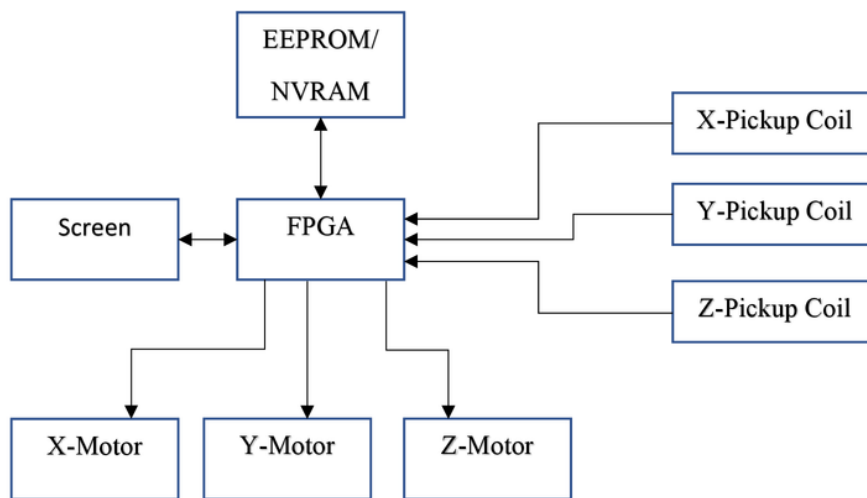


Figure 7 – FPGA system overview

Cost Breakdown

A suitable FPGA was found on a supplier's website at the price of £113 per unit (Farnell, 2018). The chosen device was a spartan-6 LXT with 480 I/O, 400MHz speed and 101261 cells; this FPGA meets all specifications set out in the FDS.

Unfortunately, the software is not free for this family of FPGA. A UK supplier of this software quotes a price from £2,345 to £3,363 for various types of license (Digi-key, 2018). Assuming the screen used is a PC terminal which would add no cost, the total price for the FPGA and software required to program it is at least £2,458.

$$£113 + £2,345 = £2,458$$

5.3.2 Solution Two – Microcontroller

One large supplier of Microcontrollers is Microchip technologies. This company produces the PIC microcontrollers and has also acquired the Atmel brand (Microchip, 2019). This company is also a well-known and respected brand, which has a vast range of microcontrollers with various specification on offer.

Figure 8 shows the system level overview of the control circuitry. It is almost identical to the FPGA system, without the need for added NVRAM/EEPROM as the chosen microcontroller has some built in with ample storage space. The microcontroller will communicate with the PC on the UART bus to display the menu.

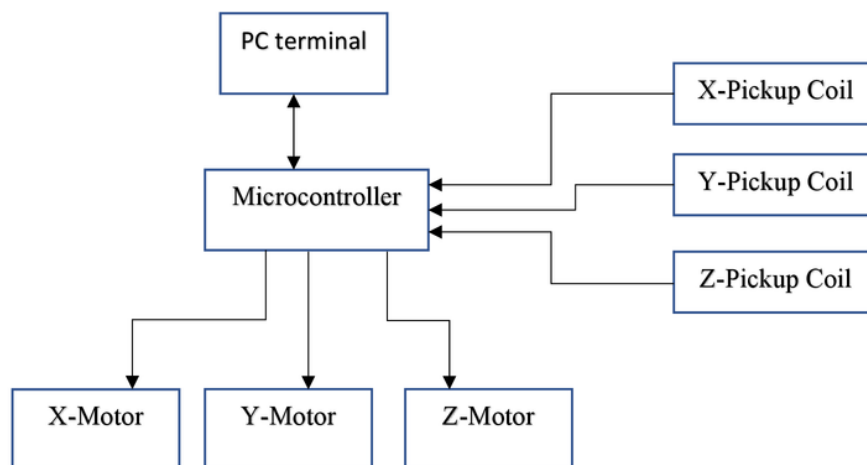


Figure 8 - Microcontroller system overview

Cost breakdown

Fortunately, Microchip have released a free piece of software to program many AVR and SAM devices, their website even states that the software Supports 500+ AVR and SAM devices (Microchip, 2019). This will reduce the cost of the Microcontroller solution substantially as the software to program many other types of controller cost Thousands of Pounds. Please see cost breakdown in sections: 5.3.1 Solution One - FPGA and 5.3.3 Solution Three – PLC; for the full price of the software required to program different devices.

The ATmega328p controller has been selected as this is a device that is compatible with the free Atmel studio software. The CPU is an 8-bit AVR with 23 programmable I/O, analogue inputs and outputs, a plethora of communication protocols available and 1Kbyte of built in EEPROM (Microchip, 2015).

The total cost of this device from a reputable supplier Mouser Electronics costs £1.64 per unit (Mouser Electronics, 2019). To program and debug these devices using the Atmel Studio 7 software requires a programmer known as the Atmel ICE programmer. Farnell offers this device for £73.22 (Farnell, 2018). One of the many communication protocols offered by the ATmega328p chip is USART, which can interface with any terminal program running on a windows PC. For this reason, the cost of a screen will not be factored in as the main menu can be displayed on any windows PC. The PC and USART configuration can also be easily setup to allow the windows keyboard to interface with the Microcontroller.

This brings the total cost of the microcontroller solution to:

$$£1.64 + £73.22 = £74.86$$

5.3.3 Solution Three – PLC

PLCs are widely used and easily available as they are used extensively in industry. The brand of PLC being used will be Siemens. The reason Siemens brand PLCs are being used is the fact they are a trusted brand which produces reliable products and offer a vast range of choices and modular upgrades (Siemens, 2019).

Figure 9 shows the system overview using a PLC as the controller. The chosen PLC contains EEPROM that can be used to store the data values from the pickup coils. Unfortunately, the screen used will be a compatible HMI which will add a considerable cost to the project.

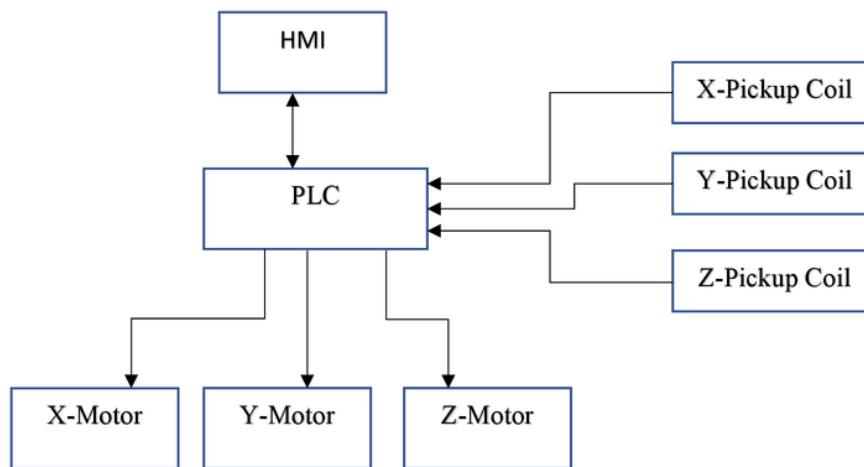


Figure 9 - PLC system overview

Cost Breakdown

A plethora of suppliers have been used to try and source the most cost-effective solution. The Parmley Graham website sells a one-year subscription to Simatic step 7 TIA portal professional for £331 (Parmley Graham, 2016). A suitable PLC that is compatible with that version of software was found on Farnell; a Siemens S7 1200 for £348 (Farnell, 2018). The PLC has 14 digital inputs, 2 analogue inputs and 10 outputs, and has all the features and I/O to satisfy the FDS and achieve the project goals. One of the necessary features of the project is an interface for the user to monitor and select various options from the menu. Siemens has a touchscreen HMI that is compatible with the S7 1200 and the STEP 7 software. A

suitable HMI was found on Automation24's product page for £284.37 (Automation24, 2019).

This would bring the total cost of the PLC, screen and software to:

$$£331 + £348 + £284.37 = £936.37$$

Further research found another supplier selling a suitable PLC in a cost-effective kit. RS sells a kit containing: Siemens S7 1200 AC/DC/RLY for £473 (RS, 2019). Studying the datasheet shows the CPU module is the relay type module with the voltage recommended being 84 – 264Vac, which is not suitable for this project. The PLC in this kit is also lacking I/O; only 8 inputs and 6 outputs being available without an upgrade. (Siemens, 2018) (RS/Siemens, n.d.)

Therefore, the only viable path down the PLC route would be sourcing components individually, totalling a minimum price of £936.37.

5.4 Solution Comparison

The table below shows how each of the three solutions compare to one another judged on: Price of controller, Size, I/O, contains NVRAM/EEPROM, Software cost, cost of screen/interface.

It's important to note that the full budget for the entire project is £5000. This means the controller, software and screen cost must be kept to a minimum as the expected costs of mechanical parts and electrical parts requires the majority of the budget.

	FPGA	Microcontroller	PLC
Controller cost	good (£113)	Very good (£74.86)	Bad (£348)
Software cost	Very bad (£2,345)	Very good (free)	Bad (£331 for 1 year)
Screen/Interface cost	Very good (PC screen)	Very good (PC screen)	Bad (£284.37)
Size of controller (Smaller is better)	Very good (Chip)	Very good (Chip)	Very bad (Large housing, requires extra panel)
Contains NVRAM/EEPROM	NO	YES	YES
Number of I/O	Very good (190 to 540)	Good (23 programmable I/O)	Good (16 inputs, 10 outputs)

Figure 10 - Three solution comparison table

From the above table, it is clear to see that the Microcontroller scores the most very goods and goods, making it the most viable solution. As the FPGA will take up half the budget, that solution cannot be used. The FPGA was included in the comparison table anyway to make it a fair decision. The PLC would be a satisfactory solution but does not score as well as the Microcontroller.

Even though any one of the solutions could successfully meet the FDS and achieve the projects goals, for the reasons stated above, the Microcontroller will be the chosen solution.

6. Project Planning, Work Breakdown Structure and Management Techniques

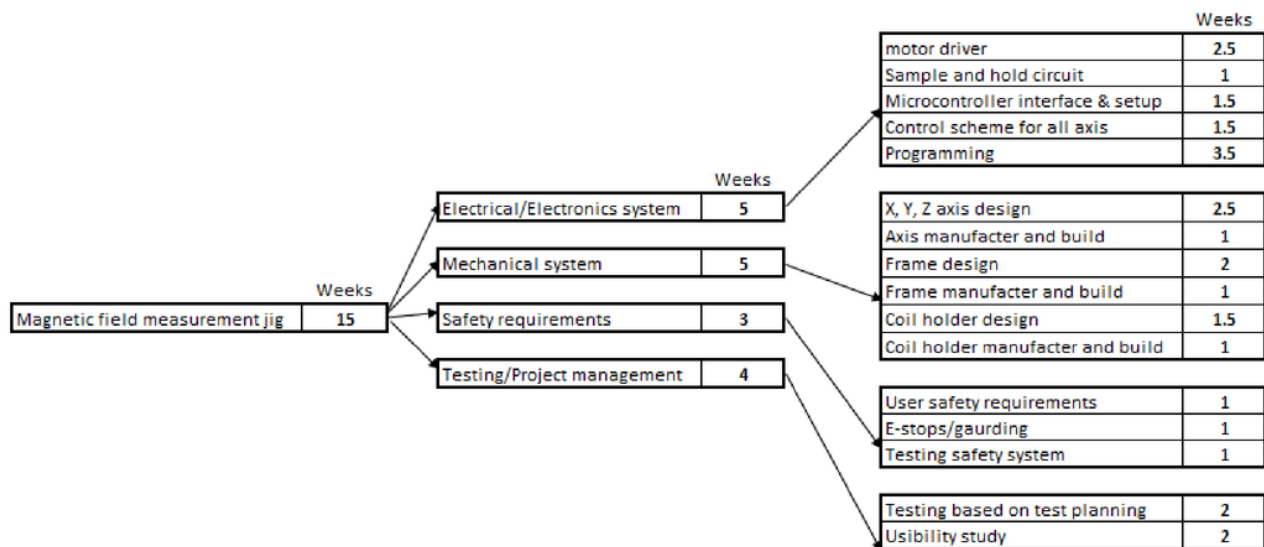
The management techniques used throughout the project are: Time management, resource management and budget management.

To manage the time allotted to perform the tasks necessary are laid out in the WBS and Gantt chart. The tasks have been broken up into sub tasks and a time slot has been allotted for each. The Gantt chart goes even further to put a particular day to each sub tasks time allotment.

The resource and budget management go hand in hand. The budget has been split into categories which allows a percentage of the budget to be spent on a particular type of resource (Electrical, mechanical etc.). Using the management techniques allows the entire project to be mapped out onto relatively few sheets of paper. This is a useful reference throughout the project to ensure everything is on track and the budget is still available for future tasks.

6.1 Work Breakdown Structure

The WBS shows the simplest breakdown of the project's timescale in terms of weeks. The design, build and test phase of the project totals 15 weeks. The 15 weeks has been broken up into 4 different sections; Electrical, mechanical, safety and project management; which have also had weeks assigned based on how long each section is expected to take. The 4-section have been broken down further into individual tasks, the tasks have been assigned times which reflect how much time each task is expected to take. It's important to note that the sum of the individual task don't add up to the initially planned 15 weeks. This is because many tasks will either overlap or be carried out simultaneously, rather than one after another. The WBS is useful for a general overview of which parts of the project need the most time, as well as which individual task may need more time allocated. The WBS will be developed further into a fully detailed Gantt chart.



Please see gantt chart: work weeks not one after another, some tasks overlap or are simultaneous. This means the sum of the individual weeks for each task may not equal total time allowed for project

Figure 11 - Work breakdown structure (WBS)

6.2 Project Budget Tracker

A budget tracker has been designed on Excel to keep track of the project's finances throughout the project's life. A bar at the top of the tracker shows how much money has been spent relative to the total projects budget. The first four items listed in the budget sheet shows how much of the budget has been split between different categories: Electrical, mechanical, software and controller. As parts are ordered, they are entered onto the sheet under the appropriate category, and the total budget is adjusted automatically.

Figure 12 shows the budgets that have been assigned for the four different categories. An example product has also been entered to show how the budget gets adjusted.

[illegible]

25

6.3 Gantt chart

The Gantt chart has been designed using excel and is easy to update or make changes as the project progresses. The red box highlighting the 16th of January shows the current day of the project. Each task has a percent complete box to track the progress of each task individually. Milestones have been incorporated into the chart to keep track of the important dates where the project should shift from one phase to another. Ample time has been allowed at the end of the project schedule to allow for extra time to deal with unforeseen circumstances.

Major Project - Magnetic field measurement jig Project Schedule

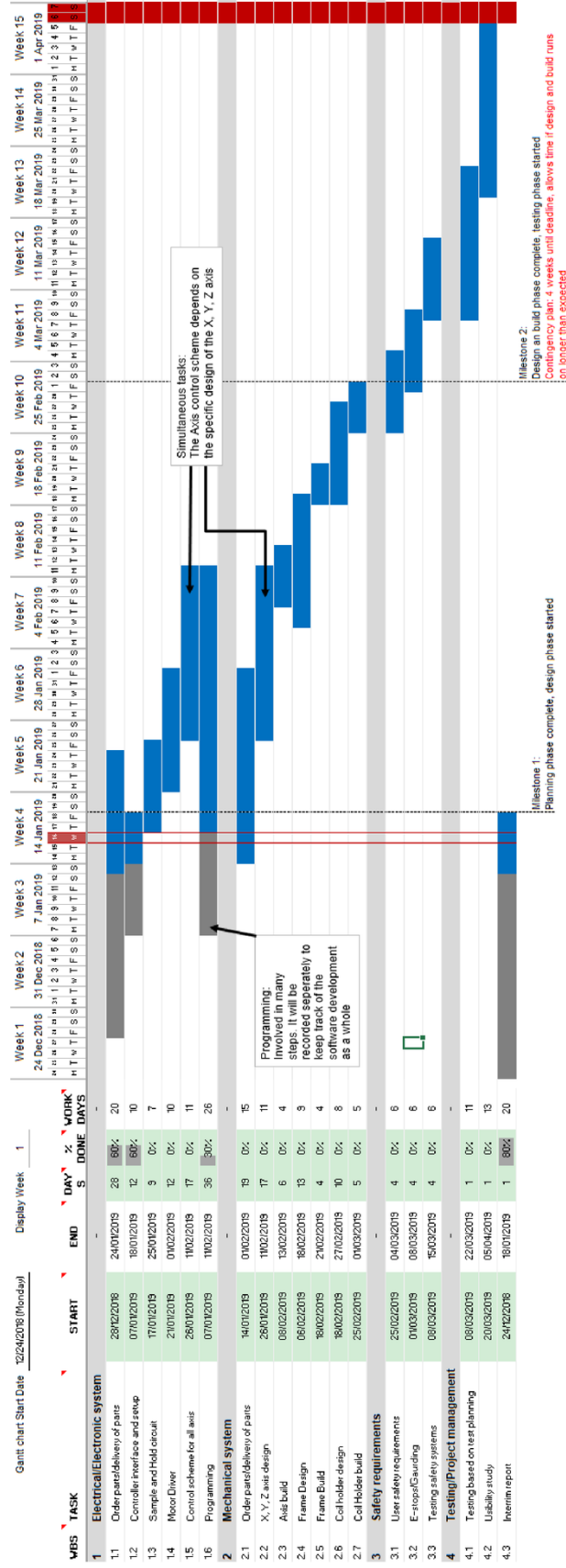


Figure 13 - Gantt chart

7. Conclusion and Recommendations

The project in its current state consists of a well-planned and documented report setting out all the work that needs to be done to complete the project before the deadline. The Gantt chart shows all the steps needed to achieve all of the project goals in the allotted timeframe, which have been planned in a way to ensure the completion of all tasks. Very little work has been allotted for the last 4 weeks of the project to allow other tasks to run over slightly and still meet the deadline.

As shown in the Gantt chart, the setup of the Microcontroller has been started which involves some programming of the device. Some of the parts have also been ordered: ATmega328P chip, Atmel ICE programmer, as well as one Nema 13 stepper motor for some initial testing.

The major decisions that have been made are: Choosing the Microcontroller solution: This is a decision which effect most of the project, as many sub-components of the project will have to be setup and interfaces differently with a different type of controller. Another major decision was to allow a 4-week buffer at the end of project, for the reasons previously discussed. This will compress the workload for the first two thirds of the project, but it is still possible to complete all these tasks with time to spare.

The major achievements made so far is the extensive planning of all tasks that follow this report. This should allow a smooth design and build phase with some contingencies planned in, with a reasonably high probability of the project being completed in time.

However, should unforeseen circumstances arise that make the project incompletable in time, the projects barebones features will still be designed and built to show the company the project can still be completed given more time, money or resources. For example; Construct 1 working axis, prove the accurate measurement of magnetic field for the X, Y, Z components, prove the automatic logging of all gathered data. This is the final contingency and is **unlikely** to occur due to the planning of the project.

8. Works Cited

Dr. Brockhaus Messtechnik GmbH & Co. KG, 2018. *XYZ field scanner*. [Online]

Available at: <https://brockhaus.com/measurements/products/hardmagnetic/special-h/xyz-field-scanner/?lang=en>

[Accessed 5 12 2018].

Automation24, 2019. *SIMATIC HMI Basic Panels (2nd generation)*. [Online]

Available at: <https://www.automation24.co.uk/simatic-hmi-basic-panels-2nd-generation>

[Accessed 04 01 2019].

Christine E Dobek, 1. D. M. B. J. D. Z. J. D. a. F. V.-R., 2015. Risk of seizures in transcranial magnetic stimulation: a clinical review to inform consent process focused on bupropion. *Neuropsychiatr Dis Treat.*, 11(1), pp. 2975-2987.

Digi-key, 2018. *Software*. [Online]

Available at: <https://www.digikey.co.uk/products/en/development-boards-kits-programmers/software-services/784?k=ise%20design%20suite>

[Accessed 6 12 2018].

Farnell, 2018. *ATATMEL-ICE-BASIC*. [Online]

Available at: https://uk.farnell.com/microchip/atatmel-ice-basic/debugger-atmel-arm-avr-basic-kit/dp/2407172?gclid=Cj0KCQiAj4biBRC-ARIsAA4WaFim0zveTRxMskcXpcADRWeimZ8mrZ8unNFhuqvHbEBx1hZgBirN-9YaAu0BEALw_wcB&gross_price=true&CAGPSPN=pla&CAWELAID=120173390000400611&CAAG

[Accessed 11 1 2019].

Farnell, 2018. *Product page for FPGA*. [Online]

Available at: <https://uk.farnell.com/xilinx/xc6slx100-3fgg676c/fpga-spartan-6-480-i-o-fpga-676/dp/2760151>

[Accessed 6 12 2018].

Farnell, 2018. *Siemens S7 1200 compact controllers*. [Online]

Available at: <https://uk.farnell.com/simatic-s7-1200-compact-controller>

[Accessed 03 01 2019].

Health, M. o., 2008. *ELECTRIC AND MAGNETIC FIELDS AND YOUR HEALTH*, Christchurch: National Radiation Laboratory.

Microchip, 2015. *ATMega328p datasheet*. [Online]

Available at: http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf

[Accessed 11 1 2019].

Microchip, 2019. *Atmel studio 7*. [Online]

Available at: <https://www.microchip.com/mplab/avr-support/atmel-studio-7>

[Accessed 10 1 2019].

Microchip, 2019. *Microchip acquires Atmel*. [Online]

Available at: <https://www.microchip.com/announcements/microchip-technology-inc-acquires-atmel>

[Accessed 10 1 2019].

Mouser Electronics, 2019. *ATMEGA328P-PU*. [Online]

Available at: <https://www.mouser.co.uk/ProductDetail/Microchip-Technology-Atmel/ATMEGA328P-PU?qs=K8BHR703ZXguOQv3sKbWcg==>

[Accessed 12 1 2019].

Parmley Graham, 2016. *Product page*. [Online]

Available at: <https://www.parmley-graham.co.uk/siemens/plc-s/s7-300/software/tia-portal-step-7-professional/6es7822-1aa00-0yl5>

[Accessed 20 12 2018].

RS/Siemens, n.d. *Siemens - Simatic S7-1200*. [Online]

Available at: <https://docs-emea.rs-online.com/webdocs/14a4/0900766b814a40bc.pdf>

[Accessed 6 01 2019].

RS, 2019. *PLC CPUs*. [Online]

Available at: <https://uk.rs-online.com/web/p/plc-cpus/8644002/>

[Accessed 5 01 2019].

Siemens, 2018. *Siemens datsheet*. [Online]

Available at: <https://docs-emea.rs-online.com/webdocs/1639/0900766b81639d68.pdf>

[Accessed 6 1 2019].

Siemens, 2019. *Products and services*. [Online]

Available at: <https://new.siemens.com/global/en/products/automation/systems/industrial/plc/s7->

[1200.html](#)

[Accessed 2 01 2019].

Thomas A. Houpt, 1. D. W. P. J. M. B. E. H. B. a. J. C. S., 2003. Behavioral Effects of High-Strength Static Magnetic Fields. *The Journal of Neuroscience*, 23(4), pp. 1498-1505.

WRAP, 2018. *Recyclability of black plastic packaging*. [Online]

Available at: <http://www.wrap.org.uk/content/recyclability-black-plastic-packaging-0>

[Accessed 5 12 2018].

Xilinx Inc., 2018. *cost-optimized-product-selection-guide*. [Online]

Available at: <https://www.xilinx.com/support/documentation/selection-guides/cost-optimized-product-selection-guide.pdf#S6>

[Accessed 1 12 2018].

Xilinx Inc., 2018. *What is an FPGA*. [Online]

Available at: <https://www.xilinx.com/products/silicon-devices/fpga/what-is-an-fpga.html>

[Accessed 1 12 2018].

Xilinx-wiki, 2018. *Setup a Serial Console*. [Online]

Available at: <https://xilinx-wiki.atlassian.net/wiki/spaces/A/pages/18842446/Setup+a+Serial+Console>

[Accessed 2 12 2018].

9. Appendix

THIS PAGE IS INTENTIONALLY LEFT BLANK. Appendix content starts on next page.

RISK ASSESSMENT – Use of Transcranial Magnetic Stimulation (TMS)

RA Ref:	RA/008/MARK	Address:	
Work Area:	Marketing, Engineering and at external premises.		
Work Activities:	Use and demonstration of Transcranial Magnetic Stimulation (TMS)		

Ref	Task Description	Hazard	Person(s) Affected	Current Control Measures	Risk
1.	Use of TMS on employees to demonstrate physical response to electrical stimulus.	a. Employee has adverse reaction to stimulus invoking seizure or epileptic fit.	Individual being stimulated	A high level of research has been carried out into the use of TMS and various safety papers have been written outlining the possibility of adverse reaction to stimulus occurring and those conditions which can be invoked. Persons responsible for carrying out TMS are aware of the potential side effects and those considerations which need to be made prior to stimulation.	Low/Medium

			First Aiders are available on site in case of medical emergency. Administrators of TMS however have not first aid training.	
b.	Failure of electrical equipment leading to electric shock.	Individual being stimulated	All electrical equipment is designed and manufactured with inbuilt fail to safe systems to prevent electrical shock. The company are regularly audited to BS EN 60601-1:2006 – 'Medical electrical equipment – Part 1: General requirements for basic safety and essential performance' to ensure compliance with the Standard.	Low
c.	Invocation of other medical condition following stimulation.	Individual being stimulated	A high level of research has been carried out into the use of TMS and various safety papers have been written outlining the possibility of adverse reaction to stimulus occurring and those conditions which can be invoked. Persons responsible for carrying out TMS are aware of the potential side effects and those considerations which need to be made prior to stimulation. First Aiders are available on site in case of medical emergency. Administrators of TMS however have not first aid training.	Low/Medium

	d.	Excessive stimulation leading to medical condition or adverse reaction.	Individual being stimulated	A high level of research has been carried out into the use of TMS and various safety papers have been written outlining the possibility of adverse reaction to stimulus occurring and those conditions which can be invoked. Persons responsible for carrying out TMS are aware of the potential side effects and those considerations which need to be made prior to stimulation. First Aiders are available on site in case of medical emergency.	Low/Medium
	e.	Noise levels exceeding 80dB(A) and causing hearing difficulties.	Individual being stimulated	First Aiders are available on site in case of medical emergency. Administrators of TMS however have not first aid training.	LOW
2.	a.	Use of TMS on themselves to demonstrate physical response to electrical stimulus.	Individual being stimulated	A high level of research has been carried out into the use of TMS and various safety papers have been written outlining the possibility of adverse reaction to stimulus occurring and those conditions which can be invoked.	Low/Medium

				Persons responsible for carrying out TMS are aware of the potential side effects and those considerations which need to be made prior to stimulation. First Aiders are available on site in case of medical emergency. Administrators of TMS however have not first aid training.	
3.	Use of TMS on themselves to investigate various responses to stimulus for research of new products.	a.	Excessive stimulation leading to medical condition or adverse reaction.	Individual being stimulated	Low/Medium
4.	Use of TMS on persons other than employees to demonstrate response to electrical stimulus.	a.	Stimulation leading to medical condition or adverse reaction.	Individual being stimulated	Low/Medium

					First Aiders are available on site in case of medical emergency. Administrators of TMS however have not first aid training.	
--	--	--	--	--	---	--

Ref	Corrective Action(s)	Assigned to	Reassessment Date	Remaining Risk
1.	Safety papers generated following research into TMS cite particular conditions as being inappropriate for TMS to be carried out, i.e. prone to epilepsy, taking medication, pregnancy etc. At present there is no way that the Company can demonstrate that appropriate considerations have been made by individuals performing TMS on themselves to rule out any pre-existing medical condition that could be triggered or exacerbated by such procedures. It is highly recommended that a questionnaire or other equally appropriate measure is installed to ensure that all necessary considerations are made prior to performing such procedures. It is further recommended that additional questions are posed to individuals undergoing TMS over and above those stipulated in the 2009 Safety Paper by Rossi to include questions on Migraine, Depression, MS and Sleep Deprivation. Furthermore, the question regarding medication should include reference to drugs. Question 6 in the paper asks 'do you have metal in the brain/skull (except titanium)	NL/SJ/AMN	24/4/11	Low
2.	At present there is no assessment of the number of times that any one person demonstrating or using TMS on themselves is stimulated and the number of times that a coil is fired against particular regions of the head. Individuals should be aware of the number of firings directed at the head to ensure that levels are not exceeded. This can be monitored with the introduction of the safety questionnaire.	Those undertaking TMS on themselves	24/4/11	Low

3.	In the event of TMS being applied to the head of individuals, the potential (no matter how small) exists for that individual to suffer adverse medical conditions including seizure/epileptic fit. At present, there are usually 4 First Aiders on site to provide emergency medical assistance, however TMS is also applied off site when demonstrating at other premises or exhibitions. It is recommended that any individual applying TMS to others is trained in appropriate first aid procedures should any persons sustain any type of seizure or fit to ensure that emergency first response first aid is administered whilst waiting for the Emergency Services to arrive.	AMN	24/4/11	Low
4.	Individuals are using TMS on themselves as an aid to researching response in the process of developing new equipment and products. Although individuals are highly aware of the conditions that they need to consider before using TMS, they do not always carry out stimulation in the presence of other persons in the Department. The Paper entitled 'A Review of the Safety of Transcranial Magnetic Stimulation' published by the Company states that precautions and guidelines include 'procedures should always take place in appropriate surroundings in the presence of staff capable of managing convulsions should they occur'. This is not currently actual practice. In the event of an adverse medical condition occurring following TMS persons may require urgent medical attention. Performance of such procedures whilst alone could have serious implications where other persons are not aware of medical emergencies and could endanger life, particularly in the event of seizure or epileptic fit. It is recommended that appropriate procedures are adopted (and documented) to ensure that all persons administering TMS are always in the presence of individuals who can raise the alarm in the event of an emergency.	SJ	24/4/11	Low
5.	The Paper entitled 'A Review of the Safety of Transcranial Magnetic Stimulation' published by the Company states that precautions and guidelines include ' <i>Wearing of earplugs by all subjects and investigators/therapeutic staff when frequencies ≥ 1 Hz are used</i> '. Additionally, the paper stipulates that ' <i>It is important that both individuals undergoing rTMS procedures, and those administering it, wear earplugs or earmuffs at all times</i> '. This is not currently practiced and could lead to temporary tinnitus	Administrator of TMS	24/4/11	Low

	or auditory problems. In addition, the above Paper sets the specific noise level upon which scientific research is based as 85 dB(A). The revised Noise at Work Regulations have lowered this limit and now specify the level as 80dB(A), which should be considered. Safety Questionnaire covers those undertaking TMS the administrator should ensure they are wearing earplugs.			
6.	The Paper entitled 'A Review of the Safety of Transcranial Magnetic Stimulation' published by the Company states that <i>'In addition to these considerations [those included in the questionnaire as composed by Rossi et al.] there are also considerations of who should do TMS and the consensus being reached is that a minimal level of training in an established laboratory should predate an experimenter using TMS under their own authority'</i>. Additionally, Rossi et al. state that <i>'The Principal Investigator of a TMS or rTMS study does not need to be a licensed physician, but should be an expert in TMS with knowledge about principles, physiology and potential side effects of the technique'</i>. At present formal training is not provided or documented. Who undertakes TMS in the workplace?	SI/AMN	24/4/11	Low

References
Health and safety at Work at Work etc. Act 1974 Control of Noise at Work Regulations 2005

Additional Comments

Original Assessment Date:	9/11/11	Assessor:	
Re-Assessment Date (following CA):	24/4/11	Review Date:	9/11/12

Assignment 1 -Major Project

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

65/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

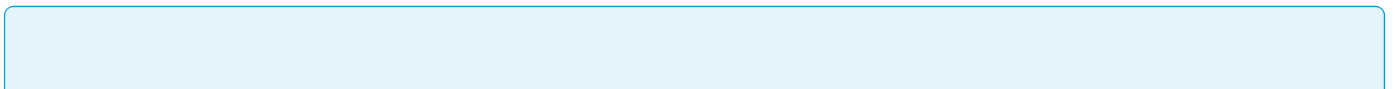
PAGE 37

PAGE 38

PAGE 39

PAGE 40

GRADING FORM: NEW CSG-RUBRIC



1. ENGAGEMENT WITH LITERATURE



A very good review of solutions from a good range of credible sources with critical evaluation. However, the existing method belongs in the background section of the report. (8/10) Extensive evidence of reading from a wide range of sources in the citation list with referencing conventions correctly applied. Citations and reference was of a good standard and Harvard referencing conventions were consistently applied.(4/5)

12

2. KNOWLEDGE AND UNDERSTANDING



Background is briefly stated but little of the company and its products the existing method should also be contained in this section and the mark given is based upon it. Nothing said about the commercial, economic or social context. (6/10) Some consideration given to the project constraints but is limited to the dangers of the strong magnetic fields that occur. Mention is made of sourcing of components from ethical manufacturers by use of the CE mark but citations are needed from credible sources. No consideration given to codes of practice or intellectual property. Legal issues have been explained in relation to the magnetic fields

23

causing health dangers and the methods used to mitigate the effect on the machine. (10.5/15) Good consideration given to the environmental impact of plastics and recyclable materials. (3.5/5) Good consideration is given to risk, health and safety, a detailed risk assessment is contained in the appendix. However, more rigor expected (3/5)

3. COGNITIVE AND INTELLECTUAL



The problem has been briefly and clearly stated. However what was being done is described, but why it is being done was vague. (3.5/5) A very detailed FDS was provided in the report giving technical specifications which should ensure a good end-product with many aspects that could be tested. However, no budget or time scales given. (8/10) A testing plan given with expected outcomes to meet the requirements of the FDS, though further details could have been supplied. However, some of the test parameters lacked clarity and context, for example how far is “outside the machine”. (2/5) Good conclusions made with plans for moving forward but is mainly descriptive. (2.5/5)

16

4. PRACTICAL APPLICATION



Good critical choice of final solution but table of comparison should have a scoring system and no overall cost have been included. A better method of comparison should have been used rather than “bad and good”. (2/5) Good use of management techniques through WBS, Gantt chart and project

8

tracker with time allowed for over run. However, milestones could be included in the Gant chart. However, WBS does not conform to any standard methodology i.e. the sum of each level does not equal its parent level. (6/10)

5. TRANSFERABLE SKILLS



Good overview but a little too generic in parts, you should be more specific about which solution was chosen and all that has been achieved to date. More of an introduction and overview and lacked any specific details. (2.5/5) Report is generally well structure and written with clear diagrams and images. However, word count has been exceed by 1405 words. Introduction has been written in a generic way, tells the reader nothing about the project and read more like an introduction to the module rather than your specific project. A signed copy of the project proposal should be contained within the appendix. (3/5)

5.5