SCHOOL OF ENGINEERING

EEET2256 – INTRODUCTION TO EMBEDDED SYSTEMS

MAJOR PROJECT - TOPIC LIST - 2024

1 AIMS

(i) To design, simulate, implement and test an interface to an external device using Microchip Studio 7.0 and an ATmega32A microcontroller.

(ii) To interpret manufacturer datasheets and decide on the appropriate additional peripheral(s) to be used within the ATmega32A microcontroller.

(iii) To extend existing the knowledge gained in previous laboratories and build on verified solutions.

(iv) To demonstrate the design workflow when developing complex microcontroller interfaces and communicate the outcomes to a wider audience.

(v) To develop a large-scale Assembler / C project that will require numerous sub-modules that are required to work together to achieve a common complex task.

(vi) To interpret design specifications from a worded description and successfully implement the corresponding firmware.

2 INTRODUCTION

In this project you will use Microchip Studio 7.0 to develop a complex project that builds on the knowledge gained from previous laboratory assessments. In developing the project, you must work with one additional student (maximum group size of two students) strictly from the same laboratory session and demonstrate your achievements to the Laboratory Demonstrator throughout the remainder of the semester. The application that your group will develop is to be written in Assembler and C and will be deployed to a physical ATmega32A microcontroller over the course of the project period.

The project runs over four weeks (weeks 8, 9, 10, 11) and the final demonstration will occur during your laboratory session in Week 11. A late penalty of 10% of the total marks possible per calendar day late will apply for written (code and report) submissions past the due date / time. The submission will not be accepted if more than five days late unless special consideration or an extension of time has been approved. Your written submission will only be considered complete when the report as well as the corresponding code is submitted to Canvas by both students. The presentations must be completed during your officially scheduled laboratory session in Week 11 otherwise the corresponding grade will be automatically forfeited.

In Week 11 during your laboratory session you will present the outcomes of your project (10% of the available course grade). This involves a demonstration of the tasks achieved over the course of the project to the Laboratory Demonstrator. The final report (15% of the available course grade), which fully describes your achievements, is due on Friday, Week 12 at 11:59pm via Canvas (Turnitin). The entire code tree (both in Assembler and C) is to be submitted by the same due / date time otherwise the assessment will be considered incomplete and late penalties will apply to the report component. Both students in the group are required to submit identical reports and code to the Canvas website (one report, written and submitted by both students in the group)

The aim of the projects is to allow your group to build a relatively complex design in Microchip Studio 7.0 that controls / uses some aspect of external hardware and can deployed on the OUSB-IO Board. **All work must be original, and plagiarism will be taken very seriously. You must develop all the code between the group and hence reference code is not permitted.** The projects are expected to require approximately 20 hours per student to be completed successfully.

The topics have been devised to allow students to complete the project using the OUSB-IO development hardware available in the physical laboratories without the need to purchase additional items. As the semester is incomplete not all relevant material has been presented, however you should have enough knowledge to begin working on the actual topic as of Week 8. More technical details will be presented during the remainder of the lecture series.

The topics and outcomes presented in Section 3.0 are non-negotiable and students must select from the provided list unless a prior arrangement has been made with the Course Coordinator. Furthermore, students are required to inform their Laboratory Demonstrator as to which project they have selected and their corresponding group member details.

The code is to be written in both Assembler and C to **compare and contrast** the two implementations. You should take particular note with respect to the overall code size, execution speed and maintainability. It is suggested that the Assembler interface is considered first as it will provide a more detailed understanding of the underlying hardware.

3 TOPIC LIST 2024

a) Digital Safe – Using the membrane keypad, develop a digital safe application that can store up to eight user combinations. The combinations are to be a minimum of eight digits and can be changed via an included programming mode. The LEDs can be used to indicate the digits being entered and also represent whether the ‘lock’ has been successfully opened. A different LED can be used for to represent each user lock. For added complexity, a timeout can be applied if an incorrect code is entered. Furthermore the user codes can be stored in the EEPROM (Electrical Erasable Programmable Memory – advanced) so they do not need to be entered every time the firmware is updated, or the processor reset. A method to decide which user is accessing the system should also be considered.

b) Four-zone Alarm System – Using the membrane keypad simulate a four-zone alarm system. The alarm must accept a eight-digit code which is used to arm / disarm the system. The code must be able to be changed via the membrane keypad. To simulate a zone being triggered, the #, * A and B buttons on the keypad can be used. When the system is armed a delay should occur to simulate the occupants leaving the area. If the alarm is triggered, then a LED should flash at a rate of 5Hz to simulate a strobe light and another be lit to indicate a siren has been activated. If triggered, the alarm should return the armed state if the correct code has been entered and the siren and strobe LEDs reset.

c) Calculator – Using the membrane keypad develop an integer calculator to add, subtract and multiply up to four numbers (minimum of 16-bit computations). The results are to be displayed on the LEDs. You will need to carefully consider how to display results that are greater than 255 or negative (Hint: use an additional key to switch between the upper and lower 8-bits.). To increase the complexity, you can include division. When performing a division, the quotient and remainder can be displayed separately. Given that the ATmega32A has limited division support a reminder that division is repeated subtraction until a value of less than zero is obtained. The calculator must support mixed operations in the one calculation (i.e. use addition, subtraction and multiplication in one calculation).

d) Stopwatch / Timer – Using the ATmega32A timers, develop a stopwatch / timer application with the input taken form the membrane keypad. The LEDs should act as a display to indicate the time remaining or elapsed. As the timer is nearing completion, the LEDs should flash and then remain fully on when the timer expires. The timer should accept minutes and seconds as inputs. The value of the timer is to be displayed on the LEDs as it is entered, or the system is paused. One of the keypad switches could be used to switch between timer and stopwatch modes.

e) Your own project – you can specify your own project outline or suggest a variation on the ones above. Note that any variations must use the same resources as the others - some combination of internal and external hardware on the OUSB-IO Board. For minor variations, check with your Laboratory Demonstrator. Submit any brand new project proposals for pre-approval by the Course Coordinator before Week 8 via email (eeet2256@rmit.edu.au).

Your design **MUST** use the OUSB-IO Board and **MUST** be programmed in Assembler and C. The system can be powered over the same USB interface that you use to program the board.

4 REPORTING REQUIREMENTS

The assessment schedule and a description of the required documentation appears below. Please ensure that you thoroughly read through the assessment rubrics to understand the required outcomes of the project.

During the Semester

To ensure that your project is running to schedule it is strongly recommended to develop a Gantt chart. The Gantt chart should be used to log the progress of the project as well as indicate the responsibility of each group member. The Laboratory Demonstrators will be instructed to check from time to time on your progress against your plan. This is designed to help you and is not part of the assessment. You should update the Gantt chart as you proceed in order to reflect your real progress against milestones.

Week 11 – Project Technical Demonstration

You will be required to demonstrate your complete project to the Laboratory Demonstrator during your allocated laboratory slot in Week 11. Each group will have approximately five (5) minutes to describe and demonstrate their technical achievements. A further two (2) minutes will be made available for questions. Additional material, such as diagrams and images can be used to support the discussion. The demonstration component accounts for 10% of the total available course grade. Note that the assessment is informal and will generally involve physically deploying the code to an OUSB-IO board and running though the features you have developed. It is essential that that the project is functional prior to the assessment time as no compensation will be given if the project is not ready to view at the scheduled time.

Week 12 – Project Technical Report

You are required to individually submit a group final project technical report (maximum of ten (10) pages in body of report) describing the work undertaken during the project. The report should be written in such a way that it can be read and understood by another Engineer with a background in

ATmega32A design and development. Note that the same report is to be submitted by both group members.

The report (and background material relating to the development of the project including schematics, PCB layouts and **source code**) must be submitted to Turnitin (via Canvas) by Friday, Week 12 at 11:59pm. The report accounts for a further 15% of the available course grade.

As a general guideline the project report should include, but not be limited to, the following sections:

- Title page: include the project title, the date, student ID and name(s) and the revision number.
- Executive summary: state the main achievements of the project. This is a summary of key findings, achievements and measurements. It is not an introduction. The words limit is 150.
- Table of contents: section titles and page numbers for your report.
- Introduction: provide an overview and define the scope of the project.
- Essential background information: a brief indication of what references and external information were sought and used. The background information should be limited to technical information that is relevant to explain the concepts and problems addressed in the project.
- Technical work and Results (You may choose own section titles here): this part may contain a description of the process used to develop the deliverables and a complete description of what has been created. You can elaborate on your achievements and compare obtained results with those in literature or other known solutions. A comparison should be undertaken against the original deliverables of the project and what has been delivered. If discrepancies exist then the reasons should be elaborated (even incorrect or unexpected results and still worth discussing). This section should form the bulk of the report. Technical content may include diagrams, relevant truth-tables and block diagrams explaining the code (both in Assembler and C) utilised in realising the solution. Simulation results can also be included in the report to explain / demonstrate project outcomes.
- Discussion and Conclusion: You should provide a discussion of the results, clearly stating their achievements, lessons learnt and possible future works.
- Appendices: These must also be properly titled and should contain details which are of secondary importance in understanding the report. Examples include program listings, schematics, detailed specifications of important components, and derivation of not so well known mathematical functions or theorems used in the report. Note that the full code solution does not need to appear in the appendices as it is to be submitted electronically. Appendices will not be assessed and hence any material that you wish to have graded must be in the main body of the report.

5 PROJECT GROUP REQUIREMENTS

Forming a group with a colleague for the project will be your responsibility. Groups must consist of no more than two students (in the same laboratory session) and both group members must contribute equally to the workload. It is a requirement to work in a group for this assessment.

It will be assumed that all group members have contributed equally towards the group-based assignment, unless all group members have formally acknowledged uneven contribution and have submitted a document detailing individual team member contribution via a weight distribution metric for all group members. This document must be submitted with the assessment task and needs to be personally signed by all group members to be considered. Final assessment and weight distribution of grades for group assignments will be made at the discretion of the course coordinator.

Please notify your Laboratory Demonstrator and the Course Coordinator (via e-mail) in a timely manner if there are issues with group members not contributing so alternative assessment arrangements can be organised.

6 REPORT ASSESSMENT PROCESS

The project report requires your group to develop a comprehensive document which details how the outcomes of the assessment were completed (maximum of 10 pages of content). The report should be a ‘standalone’ document which details the topic that your group undertook and the steps taken to arrive at your presented solution. The design process should be clearly articulated and the tasks undertaken by each group member discussed. Ensure that you have described the outcomes of your code and provided clear screenshots of the register window (or other sections) to support your discussion. Simulations should be provided to allow a contrast between theoretical results and your code outcomes. Photographs can be included to demonstrate a particular outcome. You should compare the outcomes between the assembler and C level implementations.

The report is to be submitted to ‘Turnitin’ and must achieve a similarity index of 10% or less to be accepted for assessment. If your submission exceeds the prescribed index, it will be considered late and required to be revised until it reaches the required index. Please note that Turnitin may flag the submission of your group partners report - if it does you will need to exclude that one source to ensure that the submission is less than 10%. This will be taken into account when the report is assessed.

EEET2256 – Final Technical Demonstration Assessment Schedule (Week 11)

The Project Technical Demonstration accounts for a total of 10% of the course grade for EEET2256. The demonstration is to be marked out of 100 and then will be converted to an appropriate percentage. When marking the demonstration factors such as technical complexity, clarity of presentation, technical content, demonstrated technical skills and analysis of results should be considered.

	0 – 49 (NN)	50 – 59 (PA)	60 – 69 (CR)	70 – 79 (DI)	80 – 100 (HD)	Score (%)
Presentation - Style (10%)	Relies entirely on reading from notes and / or did not look at assessor. Unable to convey to assessor the nature of the project. Unable to answer questions posed by the assessor. Vague contribution to the discussion / relies on other group member(s).	Relies heavily on notes and / or makes little eye contact with assessor. Struggles to clearly explain the nature of the project to assessor. Struggles to answer questions posed by the assessor. Limited contribution to the discussion / relies on other group member(s).	Refers to notes at times but makes reasonable eye-contact with assessor. Nature of the project is conveyed reasonably well and is generally understandable. Responds to most questions but answers some incorrectly / lack of confidence. Discussion is vague and relies on prompts from group member(s).	Has little to no reliance on notes and makes good eye contact with audience. Shows an understanding of the nature of the project and conveys this well to assessor. Can answer all questions with reasonable confidence. Time is evenly split between group member(s) however limited indication on the individual contributions.	No reliance on notes and presents in an effective and innovative style. Clearly explains the nature of the project and generates enthusiasm for the topic with the assessor. Answers questions confidently and correctly. Time equally divided between both group member(s) with clear evidence of individual contributions.	
Presentation / Demonstration - Technical Content (90%)	Minimal technical content presented. Inappropriate or insufficient details to support results, e.g. opinions stated instead of facts. No analysis of results or comparison against original aims. System has not been simulated to determine whether it is functionally operational. Investigation method not discussed or described poorly. Have not been able to solve technical problems at an appropriate level.	Understands some of the topic but struggles to make connections with the results. Investigation method discussed but is flawed. No alternative methods described. The simulations developed do not demonstrate sufficient technical complexity or are lacking in analysis. Poor comparisons drawn between original specifications and the presented outcomes. Limited ability to solve technical problems or incorrect / inappropriate	Superficial evaluation of results presented. Investigation method is generally sound, mention has been made to alternative methods but justifications may not have been given for why one method was used over another. Functional simulations have been performed to verify the sub-module design, however may not include all possible states / or contain minor errors or invalid assumptions. Comparison between expected outcomes and actual results lacks	Sound analysis of results presented. Investigation method used has been described and justified. Some alternative methods have been considered and described. Functional simulations are verified against the system output. Advanced diagnostic techniques have been used to determine (and rectify) errors where appropriate. Comparison of actual results versus original specifications is sound. Technical detail is correct and informative.	In-depth analysis of results presented. Investigation method(s) well demonstrated and justified. Alternative methods have been thoroughly researched. Functional simulations are complete and verify complete system functionality. Demonstrated ability to resolve errors and implement appropriate solutions. Excellent comparison between actual and expected results. Clearly demonstrated ability to solve technical	

	Technical skill and complexity of solution are inadequate. Presented outcomes are not satisfactory. System is not in working condition and / or system is not available for assessor to see.	methods applied. Technical skill and complexity of the solution are marginal. Group has performed little technical work over the project. Minor parts of the system may be working but largely it does not work to specifications.	technical detail. Technical problems have been addressed and solution is adequate although cumbersome. Fair progress has been demonstrated by the group. System achieves most of its specifications but may stop working intermittently or have an inconsistent output. System may need to be constantly reset to negate errors in the design.	Has demonstrated an ability to solve technical problems using standard accepted techniques. Good progress has been demonstrated by the group. A system has been developed that works to required specifications. System was well demonstrated to show its effectiveness and reliability.	problems using advanced methods. Exceptional progress has been demonstrated by the student. An innovative system / solution has been developed that works exactly as specifications require. Extra functionality may have also been included.	

EEET2256 – Final Technical Report Assessment Schedule

The Project Technical Report accounts for a total of 15% of the course grade for EEET2256. The report is to be marked out of 100 and then will be converted to an appropriate percentage. When marking the report factors such as technical complexity, clarity of discussion, appropriate choice of detail, demonstrated technical skills and analysis of results will be considered. Important concepts must be clearly explained, and sources quoted appropriately.

	0 – 49 (NN)	50 – 59 (PA)	60 – 69 (CR)	70 – 79 (DI)	80 – 100 (HD)	Score (%)
Reference Reading and Theoretical Backing (10%)	Report contains limited relevant background information and restates simple facts. Significant technical errors are present in the report illustrating gaps in knowledge.	Basic background theory presented covering the topic on a superficial level and missing key technical details. Technical errors exist in the document which raises concerns on the presented outcome.	Background theory (device operation) is sound and covers many of the relevant areas of the project. Report is technically sound, however may be lacking in appropriate technical detail.	Background theory (device operation) shows good research abilities and covers most of the relevant areas of the project. A solid technical discussion has been held demonstrating an in-depth understanding of the topic.	Background theory (device operation) demonstrates exceptional research skills covering all relevant topics for the project. A comprehensive summary of considered techniques have been presented and fully discussed which have led the successful completion of the stage of the project.	
Logical and Convincing Presentation / Layout Diagrams and Photographs (10%)	Report contains a large number of spelling and grammatical errors. Figures are incorrect / difficult to interpret and no discussion has been held on the material presented.	Some spelling and grammatical errors present. Supporting figures are present however may not be 100% clear or limited discussion has been held on their meaning.	Spelling and grammar was of an acceptable level. Graphs and figures were clear but may have had unclear titles/captions. Figures have been linked back to the main text.	Spelling and grammar mostly correct. Graphs and figures are mostly clear and labelled. A discussion has been held on the figure and how it relates to the project.	Exceptional use of language. No spelling / grammatical errors. All figures are clear and well labelled. A thorough discussion has been held on their meaning and purpose.	
Technical Merit (80%)	Functional block diagram of system is not present / does not describe the relevant I/O. Design simulation is inadequate or not discussed. Deployed code was non-functional / results incorrect. Design / schematic / relevant portions of code	Functional block diagram of system is present however does not describe the relevant I/O or is lacking in detail. Design simulation has been performed, however no discussion has been held. Partially functional code with poor verification and justification.	Functional block diagram of system is sufficient and describes the basic I/O requirements. Design simulation is suitable and important features noted. Simulation output was operational however results were not explained. Code is functional however limited	Functional block diagram and of system is well constructed. Simulation output demonstrates a fully operational design and important features discussed. Code is functional and described in detail. Design / schematic relevant code presented	A comprehensive functional block diagram has been developed listing essential details. Simulation is exceptional and comparisons have been clearly drawn between theoretical and experimental results. Simulated design was fully operational, and a complete comparison	

	not presented. Investigation method not discussed or described poorly. No analysis performed on results obtained. Unable to make links to theoretical concepts and / or irrelevant facts were used to try to explain results. The techniques employed do not demonstrate a sound technical understanding of the topic. Results have not been presented in a coherent fashion with limited discussion. Conclusions are not present or are technically flawed. Significant issues exist with the outcome of the project. Deployed code was non-functional / results incorrect.	Design / schematic relevant code presented. Simulation was partially functional with questionable results presented. Superficial analysis of results presented. Results have not been linked back to existing theory presented in the technical literature review section. Can make basic links to theoretical concepts but lacks in-depth understanding. Significant gaps exist in the analysis of the results. Inappropriate conclusions have been drawn from the presented results. Outcomes are marginal and rely on existing work rather than demonstrating the groups' ability. The techniques demonstrated highlight sufficient gaps in the groups' knowledge. Conclusions are lacking detail. Partially functional application with poor verification and justification.	discussion on design verification / justification. Design / schematic / relevant code presented. A reasonable analysis has been made of results, but may be lacking some depth. Can make reasonable links to theoretical concepts to explain results. Investigation method undertaken is adequate, but group may not have considered more effective alternatives. Slight gaps exist in the students' knowledge. Conclusions are sufficiently detailed however no technical justification has been presented. Outcomes are acceptable however a more thorough analysis should have been performed to explain unexpected results. Code developed is functional however limited discussion on design verification / justification.	and appropriately justified. A good analysis of results presented. Investigation method undertaken was sound and appropriate for the project. Group demonstrates they have a firm grasp of the theoretical aspects of the project. Outcomes are well documented and have been thoroughly explained. Unexpected results have been considered and an appropriate hypothesis formed. Conclusions and recommendations are justified and a solid technical discussion is present. Code developed is functional and described in detail.	drawn between the theoretical and experimental results. Developed code clearly meets all prescribed targets and verified with supporting documentation. Design / schematic / relevant code presented and fully explained. In-depth analysis of results presented. Advanced investigation method proposed that shows solid understanding of project requirements. Group demonstrates an advanced comprehension of the topic and has successfully completed the project. Conclusions made should be justified and well explained. Outcomes are exceptional. Code deployed clearly meets all prescribed targets and verified with supporting documentation.	