Module: External Peripherals/Communication Protocols

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Introduction

This modules will introduce students to the three most common inter-chip communication protocols/buses.

Learning Outcomes

At the end of the semester, the student will be able to:

1. Identify/Define important parameters in UART, I^2C & SPI communication
2. Differentiate communication protocols (UART, I^2C & SPI) in terms of speed, topology, hardware and software complexity.
3. Select the correct communication protocol for different applications
4. Be able to build a communication bus for UART, I^2C & SPI and connect peripherals to microcontroller
5. Be able to write a simple program to transfer data between microcontroller and peripherals using UART, I^2C & SPI
6. Be able to observe a non-working circuit and provide a reasonable procedure to diagnose and solve the problem

Module Assessments

Pre-lab quiz : the intent is to help the instructor assess what knowledge/questions students have/need and direct students accordingly. This also serves motivate students to prepare for the labs.

- Formative: helps instructor assess students current knowledge/questions
- Graded: worth a small amount of grade overall, but enough to motivate students to study
- Individual: since the lab is a group exercise, I want to give attention to the individual, to make sure the teams are balanced and both students have the skill necessary to make the most of the lab.
- Topic: relevant content for that week's experiment.
- Learning Outcome: outcomes 1 and 2
- Example questions: *"Draw the circuit diagram for the connection between a microcontroller and two I^2C devices.", "Describe what is clock stretching and give at least one example of its use"*
- Bloom's cognitive level: for the first question 1 through 3, the pre-lab quiz does not require students to have deepened their understanding to a higher Bloom's level, but should be able to remember, understand and apply the knowledge given in the pre-lab material. The second question requires some higher level (1 through 5), as students need to state the reasoning for the implementation of "clock-stretching", but since it is part of the standard, it could also be considered low (as low as 1), as students could simply memorize it (but that's not the intent)

Post-lab demonstration : after completing the lab, students are required to show the instructor the experiment and answer questions from a pool available to the instructor

- Summative: the demonstration requires students to complete all the steps necessary for the experiment (sums the experiment)
- Graded
- Individual/Team: the experiment is done in teams, but participation and the questions are answered individually
- Topic: relevant outcome for the current lab.
- Learning Outcome: outcomes 4, 5 and 6
- Example questions: *"Show me an arbitraty sentence on this display", "what would happen if this wire were to be disconnected?"*
- Bloom's cognitive level: 1 through 5, the lab experiments allow students to make a few design choices. Besides building the circuits and programming the microcontroller, students are expected to justify their choices and be able to adapt it to new uses.

Muddiest point : on the last lecture before a lab occurs, allow students to hand in questions that might be remaining about the next week's experiment

- Formative: should help the lecturer know where students are and help students self-assess what they need to study.
- Ungraded
- Individual (anonymous)
- Topic: current (or previous) week's material
- Learning Outcome: no particular, but should aid in achieving all LOs
- Example questions: *"What topic in this week was the least clear to you? Was there any topic we spent "too long" on?"*
- Bloom's cognitive level: 5? Students should justify their decision, not simply define and describe them.

Mid-term Exam :

- Summative: should assess the summation of all knowledge acquired until the end of this module
- Graded
- Individual
- Topic: should cover the content for the semester so far, but a bigger emphasis on the larger concepts and application. Since this is a practical class, technologies can change overtime, but the larger concepts should remain.
- Learning Outcome: 1, 2, 3, 4, 5 & 6
- Example questions: *"After adding a 3^{rd} peripheral in the I^2C bus, the microcontroller cannot communicate at 400kHz, falling back to 100kHz. A thorough examination shows no wiring mistakes. After connecting a oscilloscope to the data line, you see the data signal rises too slowly. Explain what is happening and propose a solution."*
- Bloom's cognitive level: 1 through 5. This problem requires students to troubleshoot a problem. It is likely not a problem they would have encountered in the lab, but given the information, students should be able to deduce the problem and select the proper solution (reduce the pull-up resistor's value, to reduce the time-constant). Since the exam is "standardized", we don't measure "create" levels (as open ended questions require more time and are harder to assess, we leave these to the final project).

Final Project Proposal : after having experienced some labs, students should be able to propose a solution to a problem. They don't need to propose a ground-breaking development, but at least something useful. Part of the grade is based on how well they can sell the idea/convince the instructor of the usefulness of their proposed project

- Formative: the proposals should help students think of the project, but students are allowed to change their topic/problem by requesting it to the instructor
- Graded: this should motivate them to put thought/time/effort into the project early on and help them scaffold the project.
- Team
- Topic: combining different sensors/actuators to solve a daily problem.
- Learning Outcome: while it doesn't contribute specifically to a LO at this point, this serves as scaffolding for the final project, in which all learning outcomes are present.
- Example proposal topic: *"We plan to create a device that senses vibrations in a common washing machine and that displays a text message when finished."* or *"We plan to measure the acceleration in a football helmet and log the information to detect/estimate concussions"*
- Bloom's cognitive level: 1 through 5, although they are acting creatively (level 6), as far as the course material goes, they only to know what they can/cannot accomplish.

Other Assessments[1]

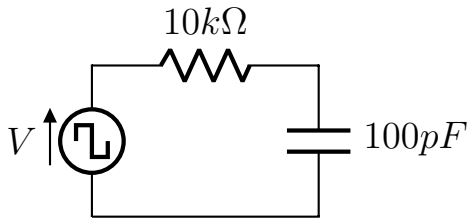
Take-home C exercise a short exercise given to students in the first lecture.

- Formative: intent as a refresher of programming. Students have the opportunity to relearn the syntax, if they forgot it.
- Graded: the main intent is to serve as self-assessment, but since it's take-home, I think it will work better as graded. Should be worth very little in the final score.
- Individual: should make sure ALL students have a minimum level of understanding at the beginning of the semester
- Topic: C programming (an overall refresher)
- Learning Outcome: no particular learning outcome for this assignment, as it is a refresher exercise
- Question example: "Write a program that takes a number as an input and returns the value squared"
- Bloom's cognitive level: 1 through 3, students are required to write "original" code in the exercise, but it involves mostly applying fixed syntaxes and simple examples, rather than analyzing a bigger problem and creatively designing a solution

[1] these don't belong to this module, but I had prepared them before realizing the assignments all had to belong to a single module. I've decided to keep them here, even if they were not part of the assignment per se.

Circuits refresher quiz : a short quiz on the basic circuits used in the communication protocols.

- Formative: the goal is to make sure students have the basic prerequisite knowledge to follow the course
- Non-graded: the main intent is to help students know what they do/don't understand and what they need to study
- Individual: should make sure ALL students have a minimum level of understanding at the beginning of the semester
- Topic: Electrical circuits → RC circuits, rise-fall times, diodes;
- Learning Outcome: no particular learning outcome for this assignment, as it is a refresher exercise
- Question example: *"Given the RC circuit below, calculate the time constant and calculate how long it takes for the voltage at the capacitor to reach 90% of its final value."*



- Bloom's cognitive level: 1 through 3, since the main focus of the class is not circuits, students are not required to have the highest level of understanding in circuits, but should be able to interpret and adapt "standardized" circuits.

Final Project Report :

- Summative: The final report summarizes what was learned during the Final Project (and, arguably, over the entire semester)
- Graded: A bigger emphasis on the grade is on the quality of the report and thoroughness. The final quality/success of the project will be evaluated as well, but it's most important that students have learned important lessons than to produce a marketable product.
- Team: responsibility for the report is shared between students.
- Topic: the specific topic depends on the project decided upon by the team, but all projects should demonstrate integration between a microcontroller and other peripherals.
- Learning Outcome: outcomes 2, 3, 5, 6, 7 and 8 from Syllabus

- Example questions: *"Show me an arbitrary sentence on this display", "what would happen if this wire were to be disconnected?"*
- Bloom's cognitive level: 1 through 6. Students are expected to use the knowledge gained during the course to creatively solve a problem of their choice.

Final Exam :

- Summative: should assess the summation of all knowledge acquired in the semester
- Graded
- Individual
- Topic: should cover the content for the whole semester, but a bigger emphasis on the larger concepts, so exam can be closed-book. Since this is a practical class, technologies can change overtime, but the larger concepts should remain.
- Learning Outcome: outcomes 1, 3, 5 and 6 from Syllabus
- Example questions: *"After adding a 3^{rd} peripheral in the I^2C bus, the microcontroller cannot communicate at 400kHz, falling back to 100kHz. A thorough examination shows no wiring mistakes. After connecting a oscilloscope to the data line, you see the data signal rises too slowly. Explain what is happening and propose a solution."*
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