UESTC 1008

Microelectronic Systems
Course Assessment

• 70% Examination

• 15% Laboratories
  – You must do at least five (5) of the Projects and the Design Project to receive a passing grade in this course.

• 15% Class Test
  – The date for the test will be announced later this week.
Course Objectives

• By the end of this course, you should be able to:
  – Explain how a microcontroller functions.
  – Program a microprocessor to perform tasks that utilize the inputs and outputs of the mbed.
  – Understand how to interface microprocessors to other components.
  – Identify parameters from the datasheet and use them in calculations.
Course Topics

- Brief introduction to digital logic
- Survey simple embedded electronic systems
  - Interfacing to peripherals - discrete components, circuits, displays, etc.
- Study a modern microcontroller
  - mbed development board
    - NXP LPC1768 microcontroller
    - ARM Cortex-M3 core
- Explore the microcontroller operation at various levels
  - High level programming in C/C++
  - Overview of more basic control – assembly language

Goal is to get you comfortable with using a modern microcontroller
Books

• No required textbook

• Recommended, not required:
  – “Fast and Effective Embedded Systems Design: Applying the ARM mbed” by R. Toulson and T. Wilmshurst
Laboratories

- Week 4/Lab session 1
  - Getting Started with the mbed
    - Register on the mbed website
    - Connect to the mbed compiler website
    - Run a program
  - Start Projects 1-9
- Week 8/Lab session 2
  - Complete Projects 1-9
  - Begin plans for design project
- Week 10
  - Blacksboard course site survey
    - Description of project
    - Identify components needed for your design
- Week 12/Lab session 3
  - Help session
- Week 16/Lab session 4
  - Demonstrate your mbed design project
Each one of you will receive a mbed microprocessor board.

- You and your lab partner will use either yours or your partner’s mbed during the first two lab sessions.
- You will use it to complete a design project, a project that you will have to:
  - Decide on yourself; you must come up with the idea.
  - Design, construct, and demonstrate yourself; there won’t be instructions given to you.
- Save for use in at least one course during Year 2.
- The mbed website [www.mbed.org](http://www.mbed.org) is going to be a key resource for the work on microcontrollers.
Project 1-9 Milestones

- You must complete at least 50% of the milestones of the 9 projects to receive the credit for the Weeks 4 & 8 lab session.
- You will be assessed during the lab sessions.
  - Specific “milestones” are described in the lab instructions.
  - When you have completed each milestone, call a demonstrator.
    - You can call the demonstrator over for each milestone or work through several and call the demonstrator. However, do not expect to show all 9 milestones at once.
    - You and your lab partner must answer questions about each project.
      - This is a team effort! You will not receive full credit if you can answer the questions, but your lab partner can not.
Design Project

• Individual Effort
  – Idea for design can be your own or found by looking at other design projects on the mbed website, in a book, or elsewhere.
    • Creativity will be part of the grade so your own idea is worth more as is your variation on other’s designs
  – However, you must:
    • Write the code for the mbed yourself.
    • Determine the components that are needed for the design.
    • Construct and test the design.
    • Describe the design during the demonstration.
  – Work should be documented in your lab notebook
Laboratories

• You MUST have a bound, A4 notebook for laboratories
  – A loose-leaf refill pad or spiral bound notebook is NOT acceptable
    • This means that you must have one for the lab this week!

• Lab books will not be collected
  – Work will be marked at the time
What do we look for in a lab book?

• This is what we would like you to record in your lab book:
  – Brief aim of each experiment
  – Anything special you had to do
  – What you observed (fix printouts into your book)
  – Calculations with the results
  – What you learnt from the experiment
    • All this should be written as you do the experiment

• What we don’t want to see:
  – Material copied from the instruction sheet
  – Results written on scraps of paper to be copeed in later
  – Anything copied from someone else’s lab notebook at all!
What do we look for in a lab book?

• Real lab notebooks are not “works of art”. They almost always have crossings out, corrections etc
• What level of detail is needed?
  – A good guide is to think about revision
• All material in the course may be used in exam questions, including the lab material
• The most important thing to explain is why you did something
  – Why did you choose a given component?
  – Why did you do the calculation?
  – Why did you write the code in that particular way?

Imagine that you are explaining the experiment to someone else.
Embedded Systems

• Almost every electrical product contains an electronic system to control its operation.
• It is called an embedded system because it improves the function of the product in some way, but is not itself the primary purpose of the product.
  – Many aspects of the car are controlled electronically by a microcontroller (MCU or µC) – a computer on a chip
Approach 1 – discrete components

In the past, embedded systems would have been constructed from discrete components (transistors etc) or small scale integrated circuits. This approach is now largely obsolete.

• For example suppose you needed a timer (in a washing machine for example, but they are very common – electric toothbrushes for instance).

• In the past, this may have been made using a famous integrated circuit called the 555. It comes in an 8-pin package and costs about 25p (2.5 ¥), but needs several external components (resistors, capacitors, etc.).

  • You can buy a complete microcontroller for less than £1 (~ 10 ¥). This is more that the 555, but it does a better job and needs no external components (well a decoupling capacitor is a good idea – see later).

Today, most microcontrollers, include timers, run automatically in the background, which leaves the main processor free to carry out other tasks.
Approach 2 – buy a computer

At the other end of the scale, you could buy a computer “off the shelf” to do the job. This is commonly done for ATM cash machines, for example.

Advantages

• Standard hardware with no development needed
• Operating system provides all basic services
• Historically, this is different to microcontrollers where there was no operating system, but this has now changed
• Wide range of application software available

Disadvantages

• Large
• Uses lots of power
• May use unreliable operation system (e.g., Windows XP)
• Prone to crashes, which is not good for safety critical applications
Approach 3 – application-specific integrated circuit (ASIC)

This is the Apple A5 integrated circuit (IC) found in 5th generation iPod and iPad mini.

Very expensive to design  $100M (614 ¥)

Includes:
• 2 ARM cores
• Numerous processor data control paths
• IO control
Approach 4 – configurable hardware

A less expensive approach is to use general-purpose hardware that can be configured to perform a given function.

Typically, these contain a large array of logic gates and flip-flops, whose connections can be programmed to give the desired operation.

Most common of these are field programmable gate arrays (FPGAs).

- They are designed by specifying the desired function using a type of programming language, a hardware description language: VHDL or Verilog for example.
- Computer-aided design software then works out the connections needed inside the chip. The same language can be used to design ASICs, including microcontrollers.

There is no clear-cut distinction between this approach and microcontrollers – an FPGA can be configured to act as a microcontroller.
Approach 5 – microcontrollers

This approach uses a device with (nearly) fixed hardware, with many functions built in, whose operation can be programmed in a versatile way: microcontrollers (μC or MCUs).

It incorporates many of the functions that require extra “peripheral” devices in a desktop computer, which simplifies the overall system and lowers the cost. The design is optimised for controlling embedded systems – reacting to signals from the environment and controlling sequences of operations, rather than processing data, hence its name.

We will be focus on a modern microcontroller, the NXP LPC1768, during this course.
What is a microcontroller?

• It is a microprocessor with memory and peripherals attached to the inputs and outputs (I/O or IO).
• It is used to create low cost, efficient, dedicated systems that combines (integrates) hardware and software to make (implement) specific applications.
  – Example: Most washing machines have microcontrollers in them to regulate the wash cycle.
    • The inputs include cycle selection, water level, tub balance.
    • The outputs include switches for hot and cold water, lights to show the point in the cycle, motor to spin the tub, buzzer to signal the end of the cycle.

What is different from your computer?

Microcontroller
- Primary purpose is to control a system.
- Input = analog/digital signals
- Output = analog/digital signals
- Event or Command driven
  - Response is due to either a change in the input or data entered by person, autonomous systems rely on only sensors.
- Reactive
  - Physical world in the loop
- As fast as needed

Computer
- Primary purpose is to perform calculations.
- Input = keyboard, game console, etc.
- Output = display, monitor
- Command driven
  - Response is due to data entered by someone
- Reactive
  - Human-in-the-loop
- As fast as possible
Microprocessors

- The overall microprocessor market for 2012 was worth $56.5 billion.
  - Intel still held the top spot with 65.3% of the overall microprocessor market.
  - Qualcomm now occupies the second place spot with 9.4% of the market courtesy of its ARM mobile processors for smartphones and tablets.
  - Samsung came in the third spot with 8.2% market share thanks to a huge number of processors in production for Apple devices.
  - AMD was in fourth place with only 6.4% market.
  - Freescale was far behind with 1.9% of the market
  - NVIDIA with 1.4% market

Qualcomm, Samsung Push AMD to Fourth Place in Processor Market, by Shane McGlaun - May 21, 2013 7:50 AM
http://www.dailytech.com/Qualcomm+Samsung+Push+AMD+to+Fourth+Place+in+Processor+Market/article31594.htm
Microcontrollers

Despite challenges, Renesas still dominant in MCUs, by Dylan McGrath 3/21/2012 04:49 AM ED
Where the money is made.

It is interesting to compare the number of units shipped with revenue for different types of components.
Dictionary

- microcontroller - 单片机
- microprocessor - 微处理器
- embedded system - 嵌入式系统
- memory –内存
- peripherals - 外部设备
- hardware - 硬件
- software - 软件
- input - 输入
- output - 输出
- autonomous - 自主
- kiosk - 报亭

from http://dict.youdao.com/