Embedded Systems

Reviews for Midterm Exam I

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Introduction to Embedded Systems

- What are ***embedded*** systems?
  - **NOT seen/noticed** unless something goes wrong
- Why do we care about embedded systems?
  - From iPhone to Boing 787, to space shuttle and satellites
- **Typical Characteristics:**
  - **Single functioned, tightly-constrained, reactive & RT**
- Constraints and design tradeoffs:
  - Cost (NRE vs. unit), performance, time etc.
- Design challenges & metrics

Hardware Architecture

- Basic components: hardware
  - Transistors and gates vs. **logical gates**
  - **Combinational** & **sequential** logic circuits
  - Timers and **Counters**
- Customized Greatest Common Divisor
- General hardware architectures
  - von Neumann vs. Harvard
- Computing engines in embedded systems
  - Microprocessor, microcomputer, microcontroller
  - Digital signal processors (DSPs)
  - Graphics processing units (GPUs)
- **Understand hardware words**
  - Data, address or instructions

Instruction Set Architecture (ISA)

- Overview of ISA: outside view
  - Inst. Types: arithmetic/logic, data transfer & flow control
- **Address modes:**
  - **Immediate, direct & indirect, Register direct/indirect indexed, PC relative**
- Register Transfer Language (RTL): inside view
  - Registers & register operations: read & write
  - Concept of data-path
  - Instruction cycle: fetch, decode, execute, next
- Example: a simple ISA & processor design
- Case study: ISA for ARM processors

I/O Interface

- Overview of I/O interface
  - Types of devices & communications; **Bus** vs. ports
- **Bus** in computing systems
  - Hierarchical buses: system bus vs. I/O bus
- **I/O Addressing**
  - Standard I/O mapping
  - Memory-mapped I/O
- I/O control: **Interrupt** and **DMA**
  - Arbitration: who can use the communication media?
- Error checking and correction

Communications

- Communication **protocols**
- Parallel communication
  - Peripheral Component Interconnect (PCI)
- **Serial communication**
  - RS232, **UART**, I2C, USB and PCIe
- Real time communication
  - Event vs. time driven; CAN, FlexRay etc.
- Wireless communication
  - RFID, Wifi, Bluetooth, Zigbee etc.

Sensors/Actuators and AD/DA Conversion

- Sensors and actuators
  - **Quantization** and sampling
  - Uniform vs. non-uniform quantization
- Analog-to-Digital converter
  - Dual-Slope and **Successive Approximation**
- Digital-to-Analog converter
  - Binary weighted
- Digital signal measurement
- Device interfaces
- Control: Proportional, Integral, & Derivative → PID

Labs 1, 2 and 3

- Lab 1: PRIZM controller and Handfollwer
  - **Cross compilation** concept
- Lab 2: Serial communication: PRIZM vs. RP3
  - Serial setup: baud rate etc.
  - Read/write primitives on both sides: bytes vs. string
- Lab 3: Customized Comm. Library/functions
  - Comm. Protocols: what to send/receive on both sides?
  - PRIZM: retrieve command, parameter(s), action, send ack.
  - RP3: modular functions: setup serial comm., send command, receive ack., action functions etc.