CSE 466: Software for Embedded Systems

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- Assisted by: Doug Beale, Waylon Brunette, and Kevin Chan

- Class Meeting Times and Location:
  - Lectures: MWF 9:30-10:20 A.M. EE 045
  - Lab: Tues. Section 1, 2:30-5:20 P.M. Sieg 327
    Thurs. Section 2, 2:30-5:20 P.M. Sieg 327
What is an Embedded System?

- It’s not a desktop system
  - Fixed or semi-fixed functionality (not user programmable)
  - Lacks some or all traditional human interfaces: screen, keyboard, pointing device, audio
  - May have stringent real-time requirements (Hard and Soft)
  - Usually has sensors and actuators for interface to physical world

- It may:
  - replace discrete logic circuits
  - provide feature implementation path
  - Make maintenance easier
  - Protect intellectual property
  - Improve mechanical performance
  - Replace analog circuits
What is an Embedded System

- Figures of Merit for embedded systems

  - Reliability – it can never crash
  - Safety – Involves things that move and can harm/kill a person
  - Power Consumption – may run on limited power supply. Want slowest possible clock, least amount of memory. **You will always be resource constrained!**
  - Cost – Engineering Cost, Mfg Cost, Schedule tradeoffs
  - Product life cycle issues: maintainability, upgradeability, serviceability
  - Performance
“To Have and Have Not” ...

- We don’t have
  - User Interface
  - Dynamic Linking and Loading
  - Virtual Memory, Protection Modes
  - Disk
  - Processes

- Instead we have
  - Real Time Kernel (very small OS) (If we’re lucky)
  - Tasks (threads)
  - Task communication primitives
  - ADC
  - Timers
  - Event Capture
  - PWM
Task: Tachometer (external interrupt)
now = getTime();
period = then - now; //overflow?
then = now;
return;

Task: FanPWM (periodic, hard constraint)
count++;
if (count == 0) GP0 = 1;
if (count > Thi) GP0 = 0;
return;

Task: TempControl (periodic, soft constraint)
if (Temp > setpoint) Thi++;
if (Temp < setpoint) Thi--;
if (period<min || period>max) GP4 = 1;

Task: Main
Thi = 0;
setup timer for 1ms interrupt;
setup timer for 100ms interrupt;
while (1);
Capacity

Assume:
- 8 MHz processor @ one instruction/cycle
- Assume fan runs between 30Hz and 60Hz
- Assume 256ms period on speed control PWM, with 1ms resolution.

What percent of the available cycles are used for the temperature controller?
- \[ \frac{\text{total instructions in one second}}{\text{(8m I/sec)}} \]

How much RAM do you need?

How much ROM?
Resource Analysis of Temp Controller

Task: Tachometer (external interrupt)
now = getTime();
period = then - now; //overflow?
then = now;
return;

Task: FanPWM (periodic, hard constraint)
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<table>
<thead>
<tr>
<th>Task</th>
<th>ROM</th>
<th>RAM</th>
<th>Instructions/Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tach</td>
<td>~4</td>
<td>2 (period, then)</td>
<td>4 * 60 = 240</td>
</tr>
<tr>
<td>FanPWM</td>
<td>~8</td>
<td>1 (count)</td>
<td>8 * 1000 = 8000</td>
</tr>
<tr>
<td>TempControl</td>
<td>~10</td>
<td>1 (THI)</td>
<td>10 * 2 = 20</td>
</tr>
</tbody>
</table>

Total Instructions/Sec = 8260, at 8MIPS, that’s .1% utilization
Other resources? local variables, stack
Class and Lab Policies

- Lecture
  - See Syllabus and Schedule. Generally coordinated with design problems
  - Mondays– this week’s lab assignment
  - Wednesdays– background and some theory
  - Fridays– discuss lab and more background for next lab

- Homework assignments will be short but will precede lecture. Probably 1/week. Graded on an “effort” basis (1, 2, or 3 points). Must be turned in prior to start of class when due.

- Lab
  - Implementation of the design, as specified in class
  - Lab reports due prior to start of next lab section (2:30pm)

- Exams
  - Two, based on lecture, lab, and reading

- No Final

- Reading and Source Material assigned as needed
Business Matters

- Lecture slides will be on line after class
- Go to the 466/schedule link for links to lecture slides, labs, etc.
- If you have a home PC, get and use the tools!
- The Documents:
  - Atmel CD-Rom Data Books
  - ATmega16 Datasheet– on CD, on web, in course pak
  - Prototyping with the Design Kit on web
  - HWLab web page docs
- “Lab equipment required for the duration of a course or project must be first checked out from the Lab Manager and secured with a deposit check of $200 made payable to "University of Washington" (note that this check will not be cashed but will be returned to the student upon the return of all checked-out equipment in good condition).” from lab policy…
- When it’s ready, sign-up for CSE466 mailing list (majordomo)
Grading

- Lab reports: 10pts each. Demo required

- Homeworks: 3 points each (will be scaled by difficulty)

- Ratios:
  - Lab: 25%
  - Homework: 25%
  - Exams total: 40%
  - Class Participation: 10%
The course will focus on software issues in embedded systems including use of an advanced 8-bit microcontroller and its development environment, interrupt programming and management, and peripheral interfacing and drivers.

Laboratory assignments will use prototyping boards, Personal Digital Assistants, LEDs, stepper motors, A/D converters, IrDA communications, and accelerometers.
CSE466 Syllabus-2

- Introduction: What is an Embedded System.
- AVR Development Tools
- Reading the AVR datasheet
- The Rule of (Ohm’s) Law
- Memory spaces
- Timers, Interrupts, A/D converters
- Interrupts; Stepper motors
- Interrupt-driven Task Structures
- Accelerometers; Semaphores
- Control, Hysteresis & Feedback
- Pulse-width measurement
- Closing the loop
- Palm and IrDA
- Event-driven OS programming
- Noise & bypassing; Testability
- Debugging tools: Logic analyzer
- Pulse Width Modulation & DACs
- Safety, Ethics, and Societal Impact
- Design Trade-offs Memory, Speed, Power, Cost
- Serial Interfaces: SPI, I2C, USB
Compile the code and download; blink the 7-segment display