Embedded Systems

Final Project

Outlook

- **Future lecture topics:**
  - AVR and C programming
  - Serial interconnect buses: I^2C, SPI, …
  - Serial communication: RS232, …
  - ADC and DAC
  - Hardware: voltage regulators, batteries, transistors as switches, I/O port expansion techniques, mixed supply voltage designs, …
  - …
- **Students are encouraged to:**
  - Utilize devices with I2C, SPI, serialcommunication
  - ADCs and DACs
  - …

Project

- Two students per team (same as for labs)
- Need to clear the project with instructor:
  - Provide a first draft of project summary for review (one per group)
  - Format: text-file → see slide 6
  - → upload to ICON by: March 29
  - Project must be approved!
    - → *reality check*: is the project too easy, too hard, too expensive, …
  - Once approved, upload a final project summary to ICON (deadline: April 5)
- Mid-project review: TBA (mid-April)
- Active participation in Q/A sessions will be required!
- Project completion deadline: May 1
  - Project check-off; upload of design report (→ document your design (decisions), calculations, options/alternatives investigated (even if not selected for final design) … !)
- Poster/project presentation: May 2 (external judges!)
- Overview of remaining labs:
  - Lab 4 (due: March 27), Lab5 (due: ~ mid-April)

Next Steps

- Discuss the project with your partner
- Generate a project description and upload it to ICON
  - You will loose points if you are late with your upload!
- Once approved
  - Search for suitable parts
  - Compare parts (look at datasheets)
  - Order parts ASAP
  - Start working on the project …
- Provide final (design) report
- Demonstrate project to Instructor/TAs
- Generate Poster for presentation & upload to ICON
- Present your poster
  - At least 2 external judges

Project - Rules

- **Must:**
  - use at least one (better: >1) reasonably complex new peripheral or subsystem that was not used in LABs

    OR
  - use a different microcontroller (family) !
- **Comparable complexity to Lab4 or Lab5**
- **No IoT/Arduino/Raspberry_PI HW/SW platform!**
- **No "download" projects!**

- **Selecting a good project:**
  - **Think about your interests, but also current/evolving technology trends**
  - **Current events → needs**

  →Q: Could you successfully sell your "product"?

Format of Project Summary

Names, project title, description (one paragraph), SW, and HW.

Joe Six Pack & Coco Lane

Pharmacy Answering Machine

The project involves using a SpeakJet speech synthesis IC to create an answering machine for a pharmacy. The machine will begin with a welcome message about the pharmacy, and will then describe options to the users. The user may choose from the list of options by pressing a button on the keypad, and upon doing so, can hear the store hours, check if a prescription has been filled, or enter a prescription to the business. The SpeakJet will be used to synthesize voice, and the keypad will be used to get input from the user.

Software: assembly language/C, libraries, …

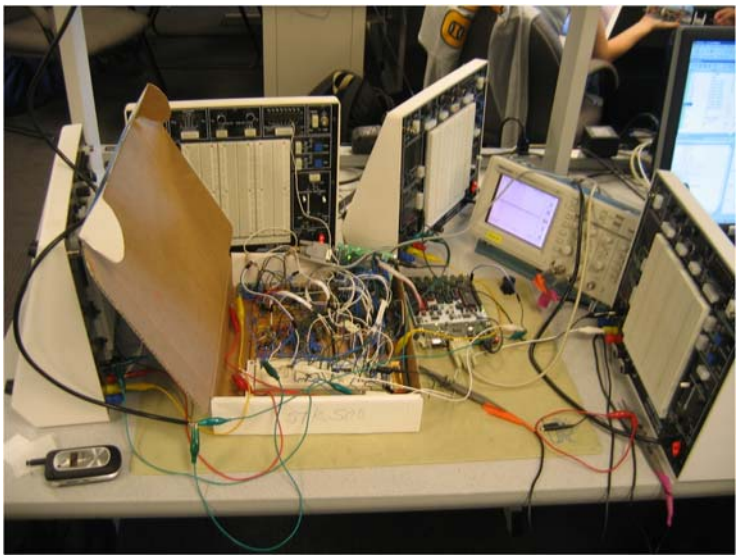
Hardware: microcontroller, ICs, other HW, …

Submit plain text file via ICON! (no fancy formatting; no Word or PDF files)

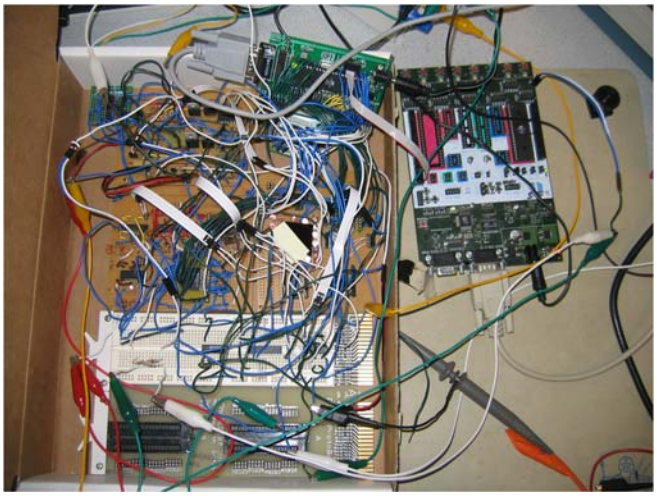
Project Documentation

- Once your project is approved, it's time to :
- Identify issues and sub-problems
  - E.g., wearable activity tracker → device size, weight, power consumption, battery technology, sensors, …
- Formulate a viable solution
  - Often an iterative process
  - Document selected/final solution
  - Also, briefly describe all investigated solutions
  - Document design process → similar to a lab book
- Also, this is a good approach for selecting a project (reality check)!

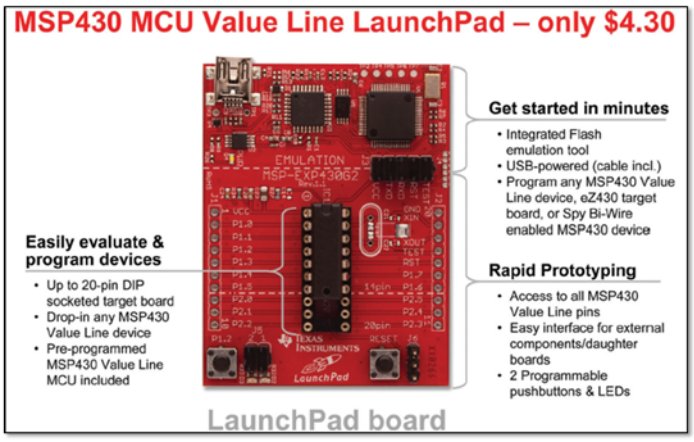
Stuff to Avoid



Stuff to Avoid



Can Use Other MCU

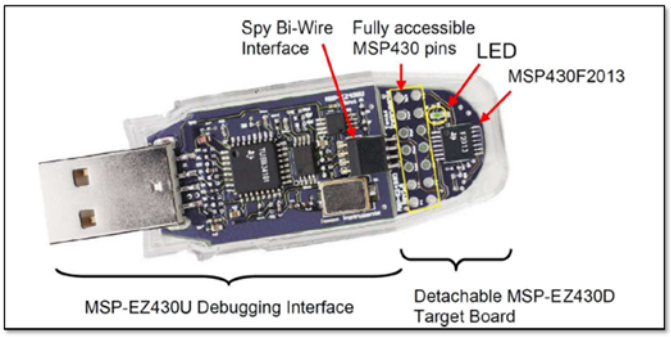


Can Use Other MCU

eZ430-F2013 Development Tool

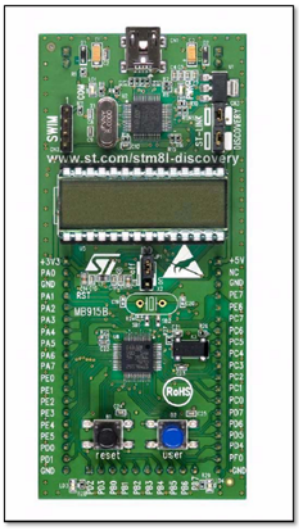
$22

Can Use Other MCU



- MSP430x2xx Family User's Guide, SLAU144
- MSP-FET430 FLASH Emulation Tool User's Guide, SLAU138
- MSP-FET430 FLASH Emulation Tool User's Guide Errata, SLAZ027
- eZ430-F2013 User's Guide (this document)
- IAR Embedded Workbench KickStart Version
- Code Composer Studio MCU Edition

Can Use Other MCU



- STM8L152C6T6 microcontroller, 32 KB Flash, 2 KB RAM, 1 KB EEPROM in 48-pin LQFP
- On-board ST-Link with selection mode switch to use the kit as a stand-alone ST-Link (with SWIM connector for programming and debugging)
- Two red LEDs; LD1 for USB communication, LD2 for 3.3 V power on
- Designed to be powered by USB or an external supply of 5 V or 3.3 V
- Can supply target application with 5 volts and 3 volts
- Two user LEDs, LD3 and LD4 (green and blue)
- Two push buttons (User and Reset)
- I_{DD} current measurement
- LCD 28-pin DIP (24 segments, 4 commons)
- Extension header for all QFP48 I/Os for quick connection to prototyping board for easy probing

$11

Resources

- **Use of a peripheral device with 1-wire interface**
  - **www.maxim-ic.com**
- **Other sources of intelligent peripheral chips:**
  - **Texas Instruments**
    www.ti.com
  - **National Semiconductor (TI)**
    www.national.com
  - **Parallax http://www.parallax.com/**
    Propeller (multiprocessor)
    Sensors
  - **Polulo Robotics http://www.pololu.com/**
  - **Sparkfun https://www.sparkfun.com**
    Motors, controllers, gears, + more

Resources

- IR Communications/Object Detection
  - e.g., using and IR LED and PNA4602M Detector
- RF Communications
  - e.g., using TWS-434A/RWS-434A RF Modules
- Control of Relays
  - e.g., using ULN2803 peripheral driver
- Accelerometers
- GPS receivers
- RC servo motors (PWM control)
- Sparkfun Electronics https://www.sparkfun.com
- …

Magazines

- Circuit Cellar
  - http://circuitcellar.com/
- Elector Magazine
  - www.elektor.com
- Nuts & Volts
  - www.nutsvolts.com

Sensors/Peripherals

Fingerprint Sensor

http://adafruit.com/products/751

Coin Acceptor

http://adafruit.com/products/786

Camera

See Sparkfun

RIFID

See Sparkfun

MP3 Engine

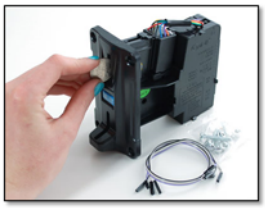
See Sparkfun

GPS Receiver

See Sparkfun

Coin-Based Water System

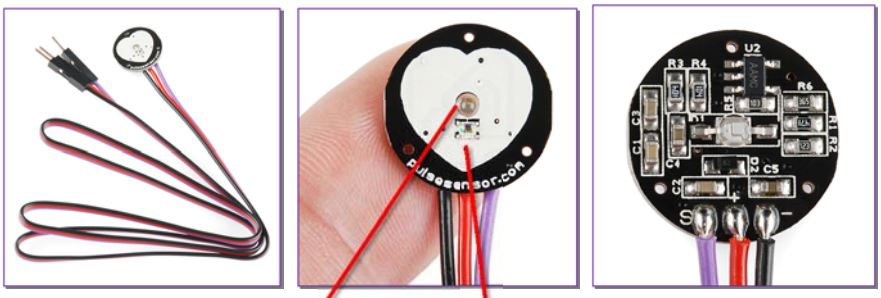
Coin Acceptor



Electrical Valve

Water Bottle

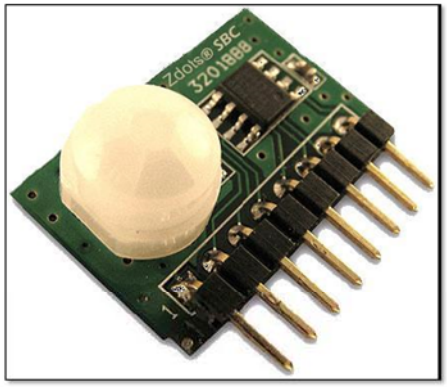
IR-Based Heart Rate Sensor



SparkFun Electronics

Potential low complexity!?

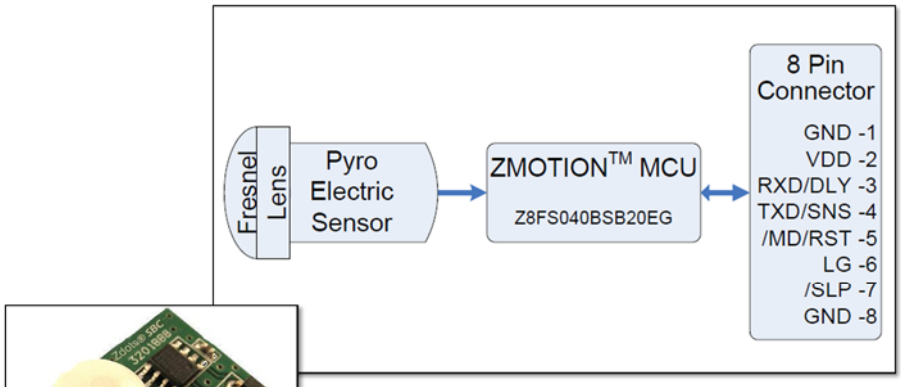
Passive Infrared Motion Sensing

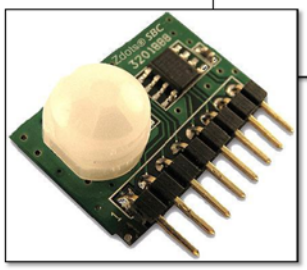


$6

Zilog's ZMOTIONTM Detection Module is a complete and fully functional motion detection solution ideal for lighting control and other occupancy and proximity detection applications. It is a board level module that combines the unique features of Zilog's Z8FS040 Motion Detection Microcontroller with a Pyroelectric Sensor and a low profile Fresnel lens

Passive Infrared Motion Sensing





Some Project Examples …

Shipping Tilt Meter

- Interface a microcontroller to a tilt sensor and a real-time clock (RTC). When the tilt sensor indicates a tilt, interrogate the RCT and log the tilt event in EEPROM. The device has an RS232 interface that allows users to connect to a terminal emulator on a PC.
- Through this interface users can set the clock, download and clear the data in EEPROM. The device is low power and small so that user can attach it to packages.
- An application for the device is in the shipping industry where some items must be shipped the right side up, and tilting can damage contents. The device described here can log if/when a container was titled.

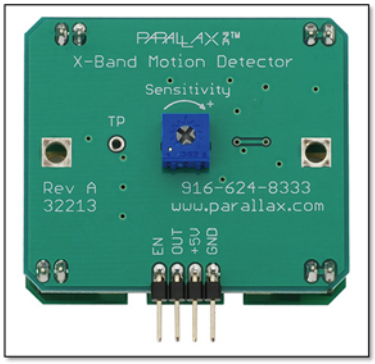
Digital Filter

- Build a digital filter using an ATtiny45V microcontroller. The filter samples in input signal using the ATTiny45's internal A/D converter and then filters the signal using an IIR filter. The filtered signal is output to a D/A converter.
- Resources
  - There are many resources available for designing digital filters, including Matlab

X-Band Heartbeat Monitor I

- **Build a device that uses a commercially-available X-band microwave motion detector module to monitor a human's heartbeat. It may be necessary to use some simple amplifier/level shifter (using op-amps) to interface the device to a microcontroller.**
- **The microcontroller will measure the Doppler shift caused by the heart's beating. The microcontroller has a serial (RS232) interface that allows connection to a PC. The microcontroller will stream the data a PC over the serial link. The PC will capture the software using terminal-emulation software. Simple Matlab code will display the data offline.**
- **Resources**
  - **Online Information: www.parallax.com**
  - **One can easily configure and use terminal emulation software such as SecureCRT (available on the lab computers) to capture the data that the microcontroller streams**

X-Band Heartbeat Monitor I



X-band Module from Parallax

Line Frequency Meter I

- **Build a device that will measure and the mains line frequency. The device will have a transformer that plugs into a 110 V outlet. Simple electronics will convert the 6.3 V secondary voltage to a nominally 60-Hz square wave with amplitude 0–5 V.**
- **A microcontroller makes highly-accurate measurements of the frequency, which it displays on an LCD. The microcontroller also has a serial (RS232) interface that allows connection to a PC.**
- **The microcontroller will stream the measured line frequency to the PC over the serial link.**

Line Frequency Meter II

- **The microcontroller will asynchronously accept a few configuration commands over the serial link:**

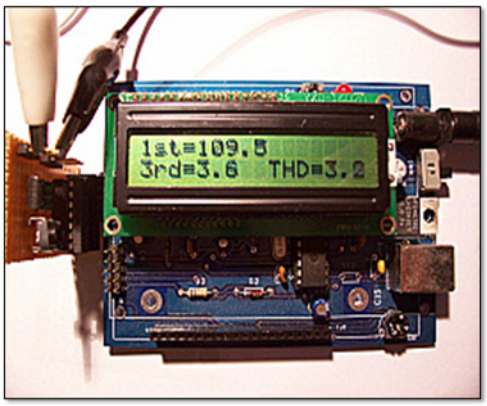
Command	Meaning
`I XXXX`	Set the report interval to XXXX where XXXX represent 100 ms. Thus the command `I 10` means "Report a value every 1,000 ms"

Power Line 3rd Harmonic Meter with LCD Display I

- **Build a device that will measure and display amplitude of fundamental and the 3rd harmonic of the mains line frequency, along with the total harmonic distortion (THD) on an LCD.**
- **The device will have a transformer that one plugs into a 110 V outlet. Simple electronics (op-amp based) will shift 6.3 V secondary voltage to a nominally 60-Hz sine wave with amplitude 0–5 V. The microcontroller will sample, using its built-in A/D converter, the sine wave and embedded software will perform the required calculations.**
- **The software performs DFT calculation finding the amplitude of the fundamental frequency and the 3rd harmonic. The distortion is computed by the ratio of the amplitude of the 3rd harmonic to the fundamental frequency.**

Power Line 3rd Harmonic Meter with LCD Display II

- **Resources**
  - **Example of distortion meter built around a PIC microcontroller**
    www.kmitl.ac.th/~kswichit/PICTHD/picthd.htm



Ultrasonic Rangefinder

- Build an ultrasonic rangefinder that displays the distance on an LCD or seven segment display
- Since the speed of sound is a function of temperature, measure the temperature and compensate as needed
- Allow user to select English or metric units
- Resources
  - www.best-microcontroller-projects.com/pic-sonar.html

Computerized Etch-A-Sketch

Computerized Etch-A-Sketch

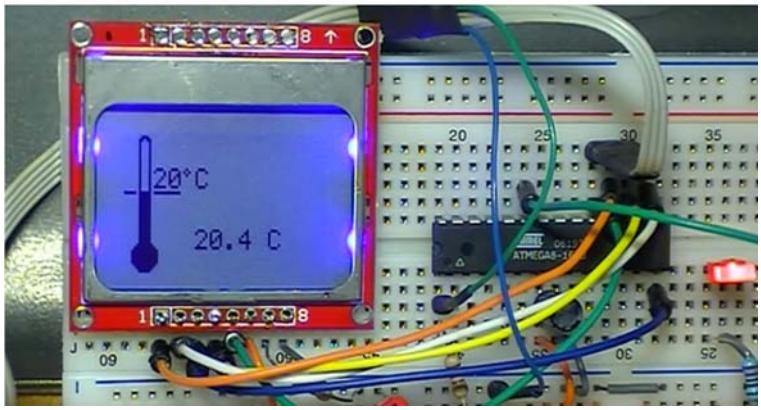
- **Use a microcontroller and two motors to control an Etch-A-Sketch**
- **Provide a serial interface through which one can download text**
- **Resources**
  - **This is a fairly popular project and there are several projects documented on the web as well as on YouTube**
  - **The instructor may be able to provide the motors**
- **Challenges**
  - **Since this is a popular project, you must convince the instructor that the work presented is really your own**
  - **Don't underestimate the challenges mechanically modifying an Etch-A-Sketch**

Capture and Display RC5 Codes

http://avr-mcu.dxp.pl/rc5+remote+control+infrared+assembly.html

Enhanced User Interface

Example - Graphical LCD:



The device could also have a Bluetooth communication interface …

… EOL