# The University of Texas at Arlington

# Lecture 1
# Class Introduction


CSE@UTA

## CSE 3442/5442

Embedded Systems 1 – Fall 2018

Tues/Thurs 12:30pm – 2pm WH 221

N. Brent Burns

# Instructor and Webpage

- **Nicholas “Brent” Burns**
  - nburns@mavs.uta.edu
  - Office Hours
    - Thursday 2pm – 5pm in ERB 548
- Web Page: http://omega.uta.edu/~nbb0130/CSE3442.html
  - For lecture slides, homework, and reference materials
- BlackBoard: https://elearn.uta.edu/
  - To submit lab work, homework, and view grades
  - If multiple sections show up, use the “-001”

# TA & Lab Instructor

- **Peter Dang**
  - petervdang@mavs.uta.edu
  - Office Hours
    - Friday 1pm – 3pm in ERB 126 (Lab)

- **Labs are in <u>ERB 126</u>**
  - Mondays 9am – Noon

    or…
  - Wednesdays 9am – Noon

# Pre-reqs.

- You need to know the information covered in these courses.
  - CSE 2441 (Digital Logic)
  - CSE 2312 (Computer Organization and Assembly Language)

# Text Book

- PIC Microcontroller and Embedded Systems - Mazidi, Mckinlay, and Causey
  - ISBN-13: 978-0131194045
  - ISBN-10: 0131194046
- Reference materials and files will be available on the lab computers and the class webpage

# Class Attendance Policy

- No required attendance for normal lectures, but..
- Grades are typically directly related to class attendance
- It’s better to come to class late than miss

# Grading

- Two Exams – 40%
  - 20% each
- Homework – 20%
- Lab – 40%
  - Labs 1-6: 4% each
  - Lab 7: 16%

- A: 90-100; B: 75-89; C: 60-74; F: <60

# Exams

- **Exam 1 – Thurs. Oct. 4th, 2018 (20%)**
- **Exam 2 – Tues. Nov. 20th, 2018 (20%)**

- No exam during Finals Week instead you will demo your Lab 7 (ABET)
- **A grade of zero will be recorded on any absence from an exam.**

# HW & Lab Assignments

- Assignments must be turned in by due date or will considered late
- 20 points (on a 100 point assignment) per day will be deducted from all late home work starting sharp at the deadline

# Lab Assignments

- When do Labs start?
  - **Monday Labs: Sept. 10th**
  - **Wednesday Labs: Sept. 12th**
- Lab descriptions will be available beforehand on BlackBoard and on lab computers
  - Lab 1: Introduction to QwikFlash Board and PIC
  - Lab 2: LCD Control
  - Lab 3: GPIO Circuit Basics
  - Lab 4: ADC – Analog to Digital Conversion
  - Lab 5: DAC – Digital to Analog Conversion
  - Lab 6: Timers and Interrupts (Building a Watch)
  - Lab 7: Standalone Alarm System with EUSART Communication (ABET)

# Labs cont.

- What you will submit…
  - Single .C file for each lab (except for Lab 1)
  - All .C files **and** extensive lab report for the final Lab 7
- You will demo your code/circuit's functionality during lab time and have **one week** to submit files via BlackBoard
- You will be graded on…
  - whether it works 100% correctly (demo in lab)
  - the "quality" and efficiency of your code
  - overall structure of your .C file
  - your comments' detail and understandability
    - Could a competent stranger understand what you are trying to accomplish?

# Ethics

- **Policy on cheating** --- students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and dismissal from the University. Since dishonesty harms the individual, all students, and the integrity of the University, policies on scholastic dishonesty will be strictly enforced.


# Course Topics

1. Course Introduction
2. Embedded System Concepts & Microcontroller Features
3. Lab Introduction and Programming
4. PIC Programming in C
5. PIC18F Hardware Connections
6. PIC Timers & Serial I/O
7. Interrupt Concepts
8. ADC, DAC, and Sensor Interfacing
9. Other concepts and applications

# Rest of the Syllabus

- Taking Attendance in MyMav
- Accepted file formats
- Grievance
- Drop
- Title IX
- Integrity
- ADA
- Mav mail
- Support
- Feedback
- Final Review Week
- Emergency Procedures

# Questions

?

# Embedded systems overview

- Computing systems are everywhere
- Most of us think of “desktop” computers
  - PC’s
  - Laptops
  - Mainframes
  - Servers
- But there’s another type of computing system
  - Far more common...

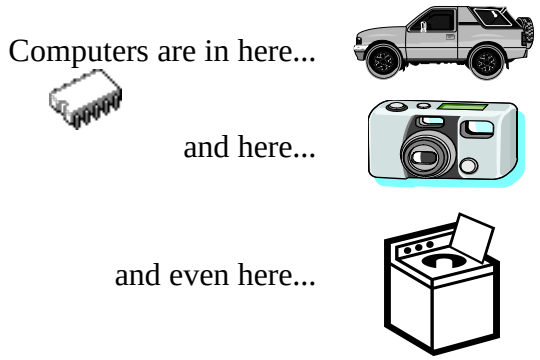
# The Embedded System (Wikipedia Definition)

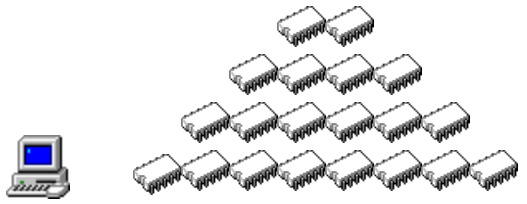
http://en.wikipedia.org/wiki/Embedded_system_overview

- An **embedded system** is a special-purpose system in which the computer is completely encapsulated by the device it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few pre-defined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, so the cost savings may be multiplied by millions of items.
- Handheld computers or PDAs are generally considered embedded devices because of the nature of their hardware design, even though they are more expandable in software terms. **This line of definition continues to blur as devices expand.**
- Physically, embedded systems range from portable devices such as MP3 players, to large stationary installations like traffic lights or factory controllers.

# Embedded systems overview

- Embedded computing systems
  - Computing systems embedded within electronic devices.
  - General - Computing systems embedded in a specific application.
  - **Billions** of units produced yearly, versus millions of desktop units
  - Many-many per household and/or automobile



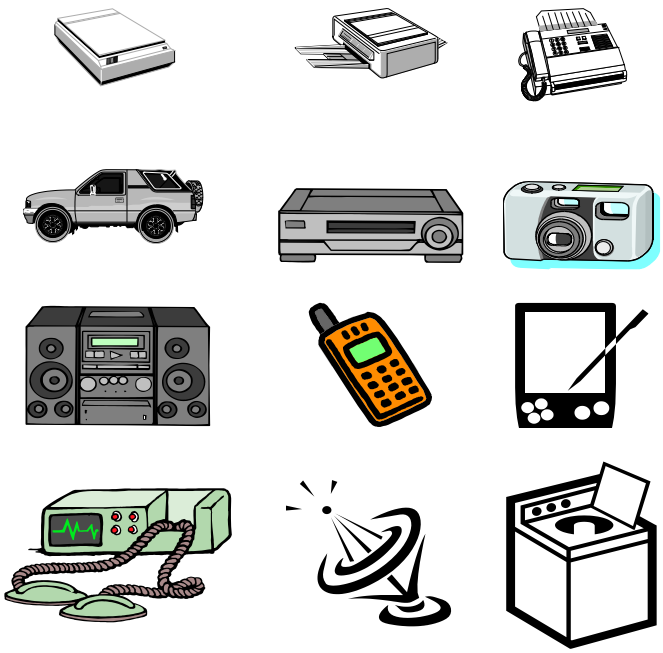



Lots more of these, though they cost a lot less each.

# A “short list” of embedded systems

Anti-lock brakes
Auto-focus cameras
Automatic teller machines
Automatic toll systems
Automatic transmission
Avionic systems
Battery chargers
Camcorders
Cell phones
Cell-phone base stations
Cordless phones
Cruise control
Curbside check-in systems
Digital cameras
Disk drives
Electronic card readers
Electronic instruments
Electronic toys/games
Factory control
Fax machines
Fingerprint identifiers
Home security systems
Life-support systems
Medical testing systems

Modems
MPEG decoders
Network cards
Network switches/routers
On-board navigation
Pagers
Photocopiers
Point-of-sale systems
Portable video games
Printers
Satellite phones
Scanners
Smart ovens/dishwashers
Speech recognizers
Stereo systems
Teleconferencing systems
Televisions
Temperature controllers
Theft tracking systems
TV set-top boxes
VCR’s, DVD players
Video game consoles
Video phones
Washers and dryers




# Some common characteristics of embedded systems

- **Single-functioned**
  - Executes a single program, repeatedly
- **Tightly-constrained**
  - Low cost, low power, small, fast, etc.
- **Reactive and real-time**
  - Continually reacts to changes in the system's environment
  - Must compute certain results in real-time without delay


# Embedded Systems - Processors

Different types of embedded processors

- **General Purpose**
  - Pentium, Athelon, (Intel, AMD)
- **Micro-controllers**
  - PIC (Microchip), MSP430 (TI), ARM, ATMEL
- **Special Processors**
  - TMS320 Series DSP (TI)
- **Application Specific** Instruction-Set Processors (ASIPs)

# Microcontroller

- Microcontroller features
  - On-chip peripherals
    - Timers, analog-digital converters, serial communication, etc.
    - Tightly integrated for programmer, typically part of register space
  - On-chip program and data memory
  - Direct programmer access to many of the chip's pins
  - Specialized instructions for bit-manipulation and other low-level operations
- For embedded control applications
  - Reading sensors, setting actuators
  - Mostly dealing with events (bits): data is present, but not in huge amounts
  - e.g., VCR, disk drive, digital camera (assuming SPP for image compression), washing machine, microwave oven

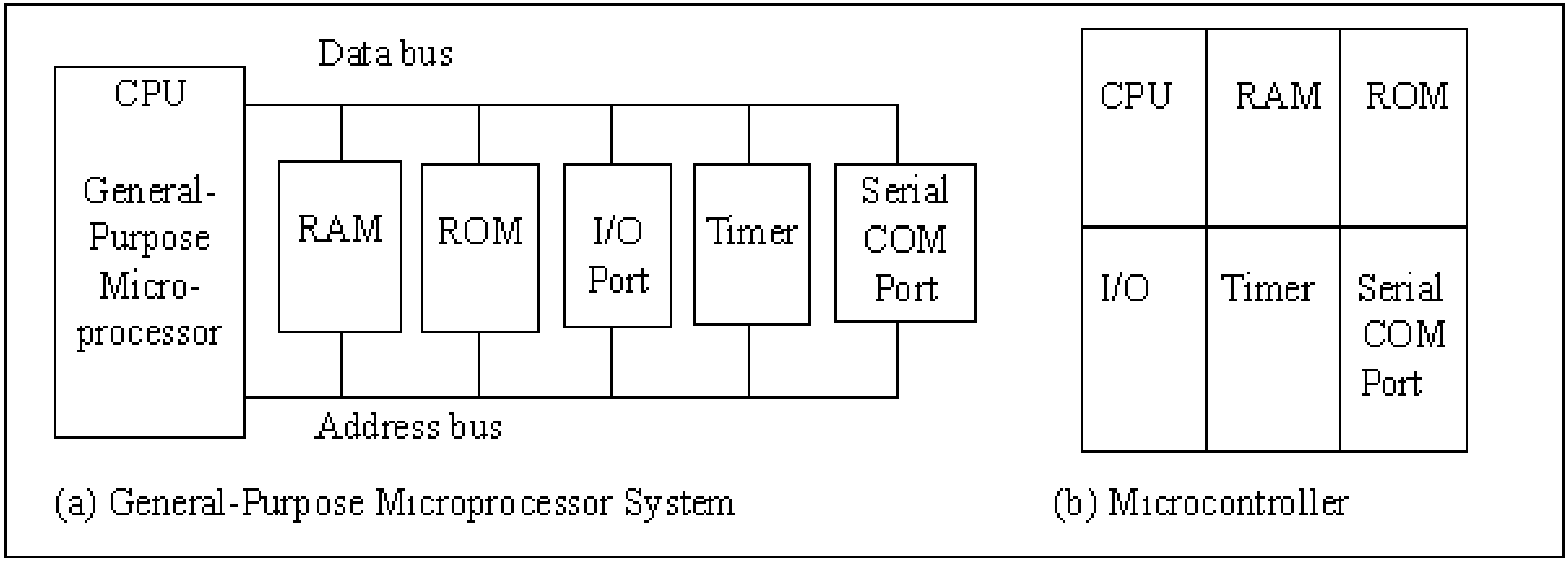
# Digital Signal Processors (DSP)

- For signal processing applications
  - Large amounts of digitized data
  - Data transformations must be applied fast
  - e.g., cell-phone voice filter ordecoder, digital TV, music synthesizer
- DSP features
  - Several instruction execution units
  - Efficient vector operations – e.g., add two arrays
    - Vector ALUs, loop buffers, etc.

# Application-specific processors

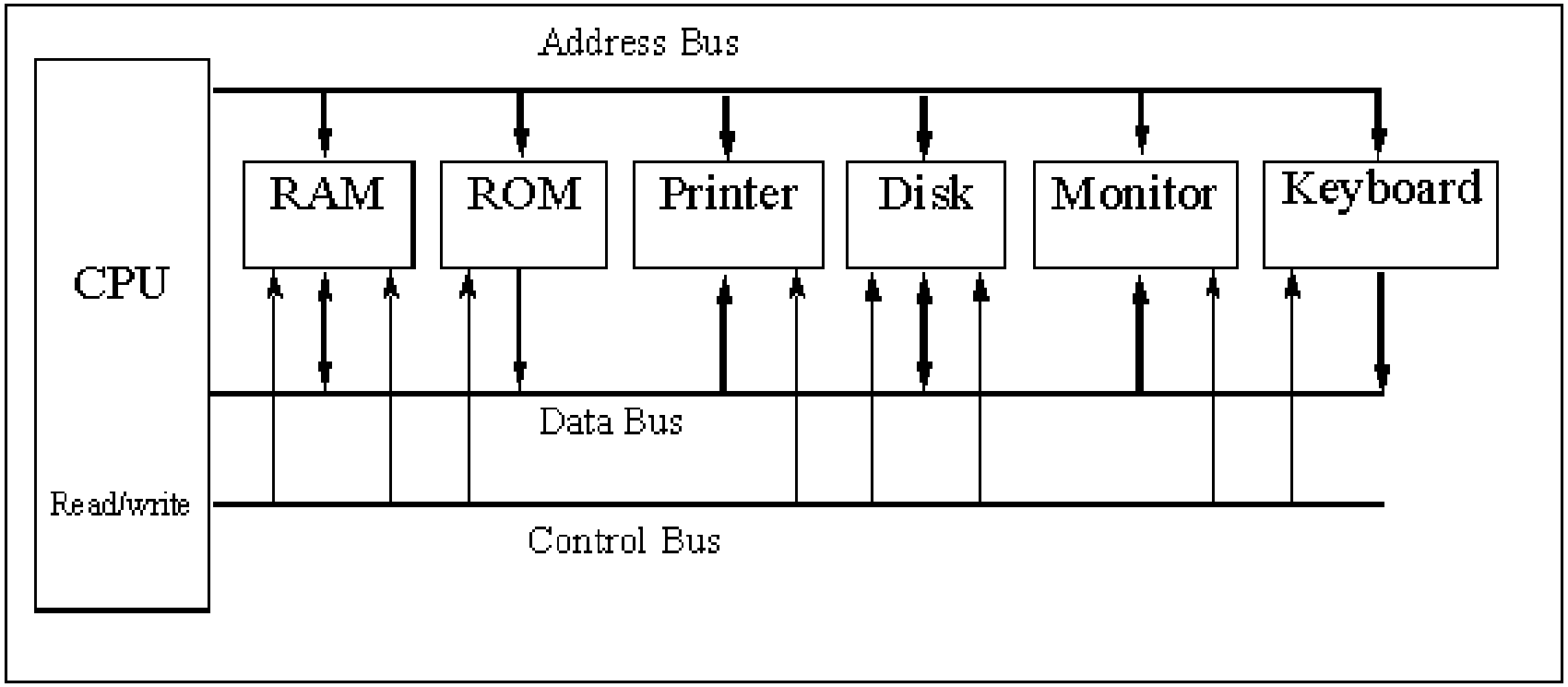
- Programmable processor optimized for a particular class of applications having common characteristics
  - smaller and simpler than their general-purpose counterparts, are able to run at higher clock frequencies, and are more energy efficient.

# Microprocessor System vs. Microcontroller System

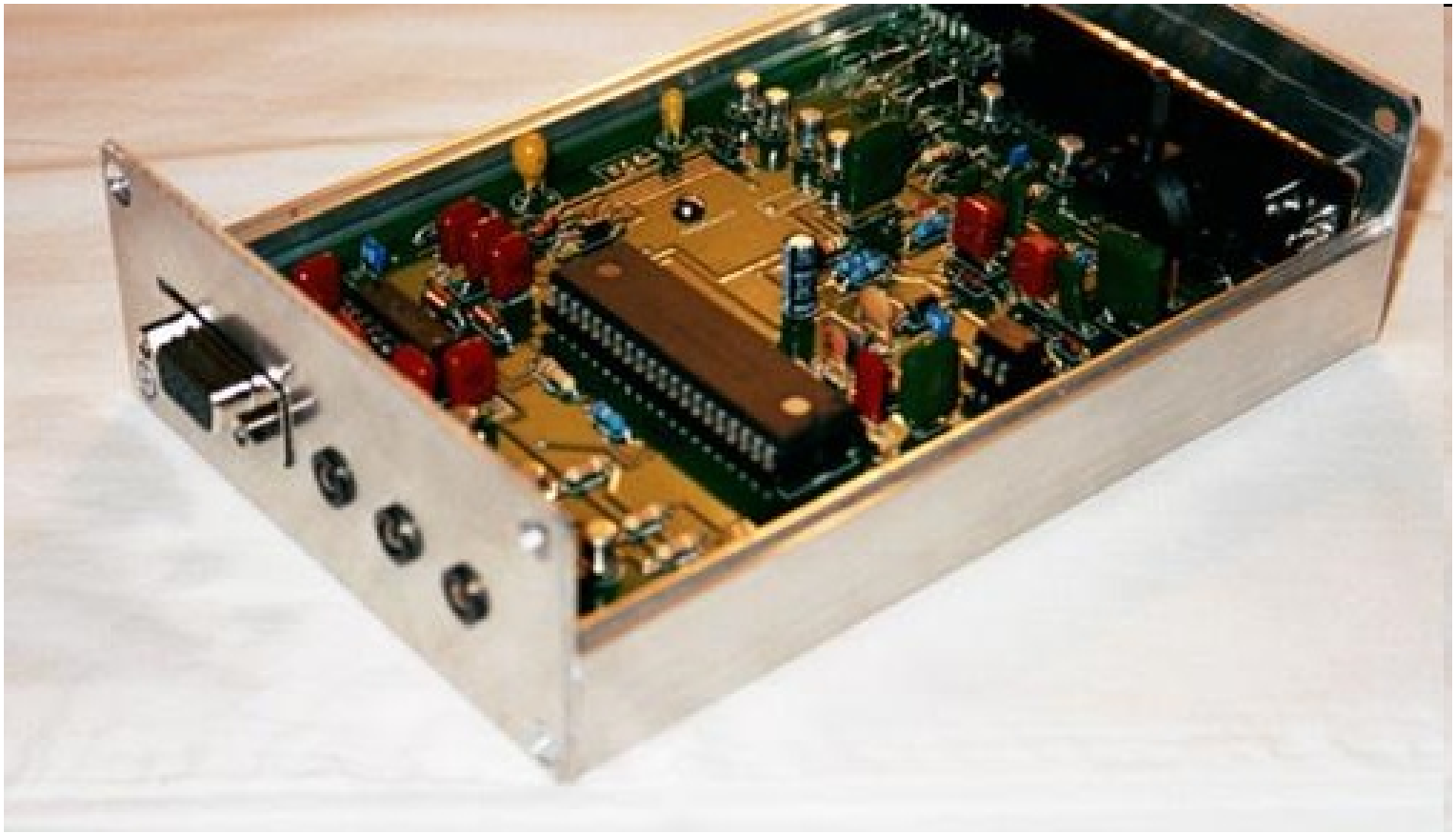



But, microcontrollers can also have external peripherals.

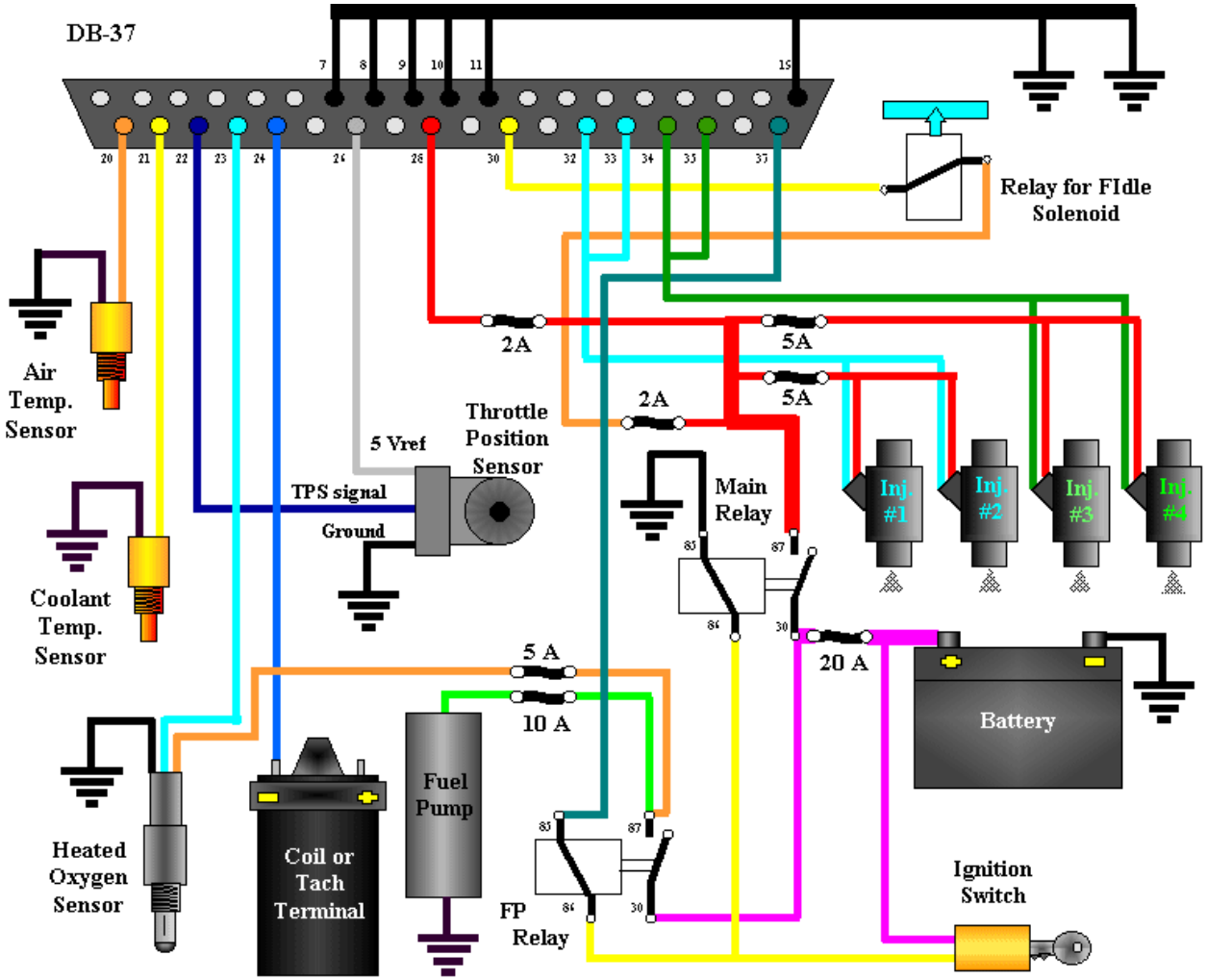
# Micro-Computer



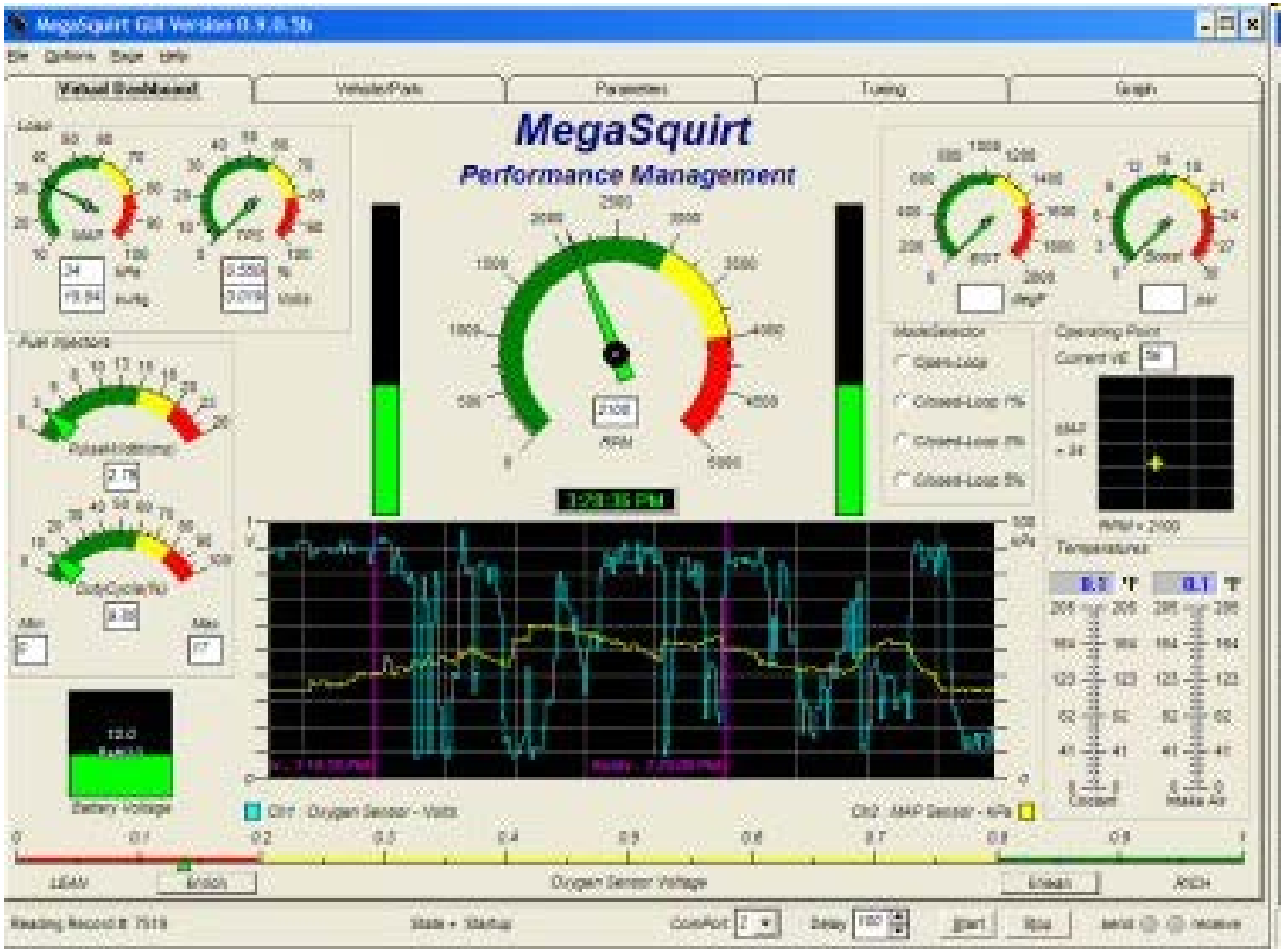
# Embedded System – Example
# DIY Megasquirt car ECU



# What does Megasquirt do?



# Tuning your car



# Embedded PC

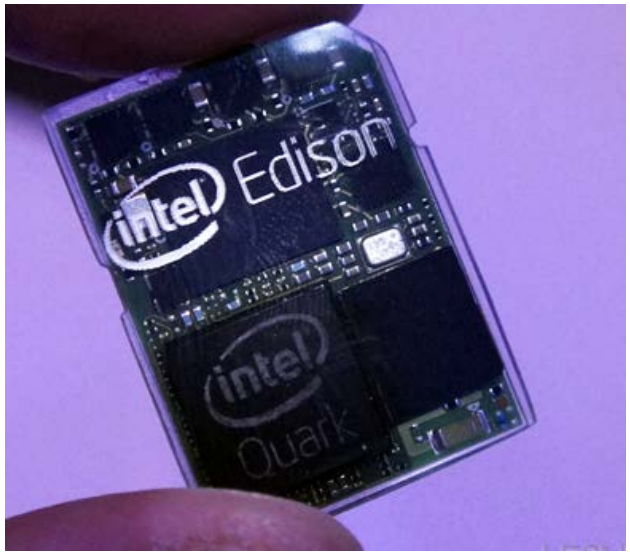
- E.g., Beaglebone Black (similar to Raspberry PI)
  - Processor: AM335x 1GHz ARM® Cortex-A8
  - 512MB DDR3 RAM
  - 2GB 8-bit eMMC (on-board flash storage)
  - 3D graphics accelerator
  - NEON floating-point acce
  - 2x PRU 32-bit microcontr

# Embedded PC

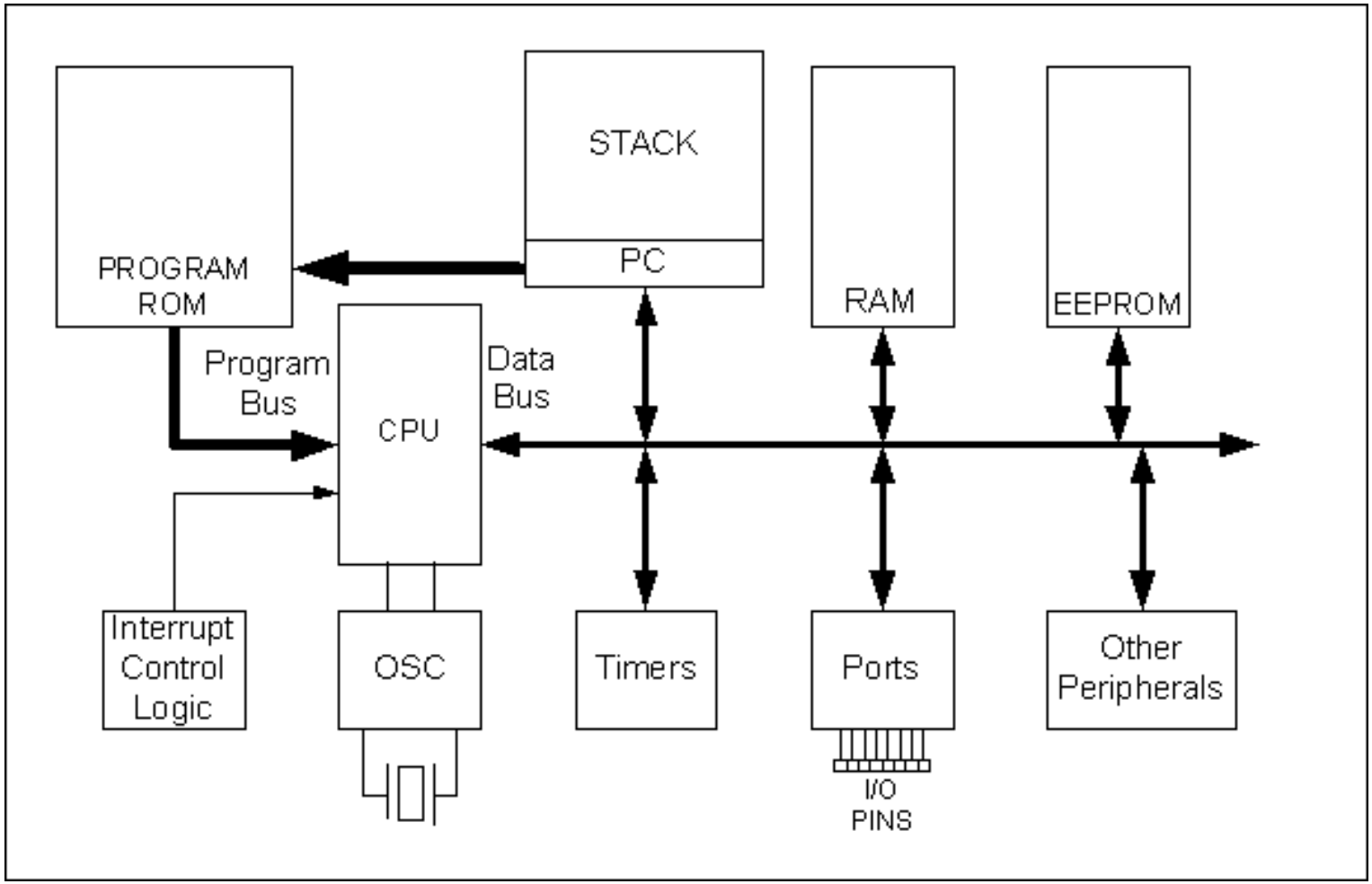
- E.g., Advantech PCM-9562
  - Embedded Intel® Atom™ processor N450 Single Core/D510 Dual Core 1.66 GHz +
  - Supports up to 3 Intel GbE, 6 COM, and 2 Watchdog timer
  - Essentially a full-PC

# Embedded PC

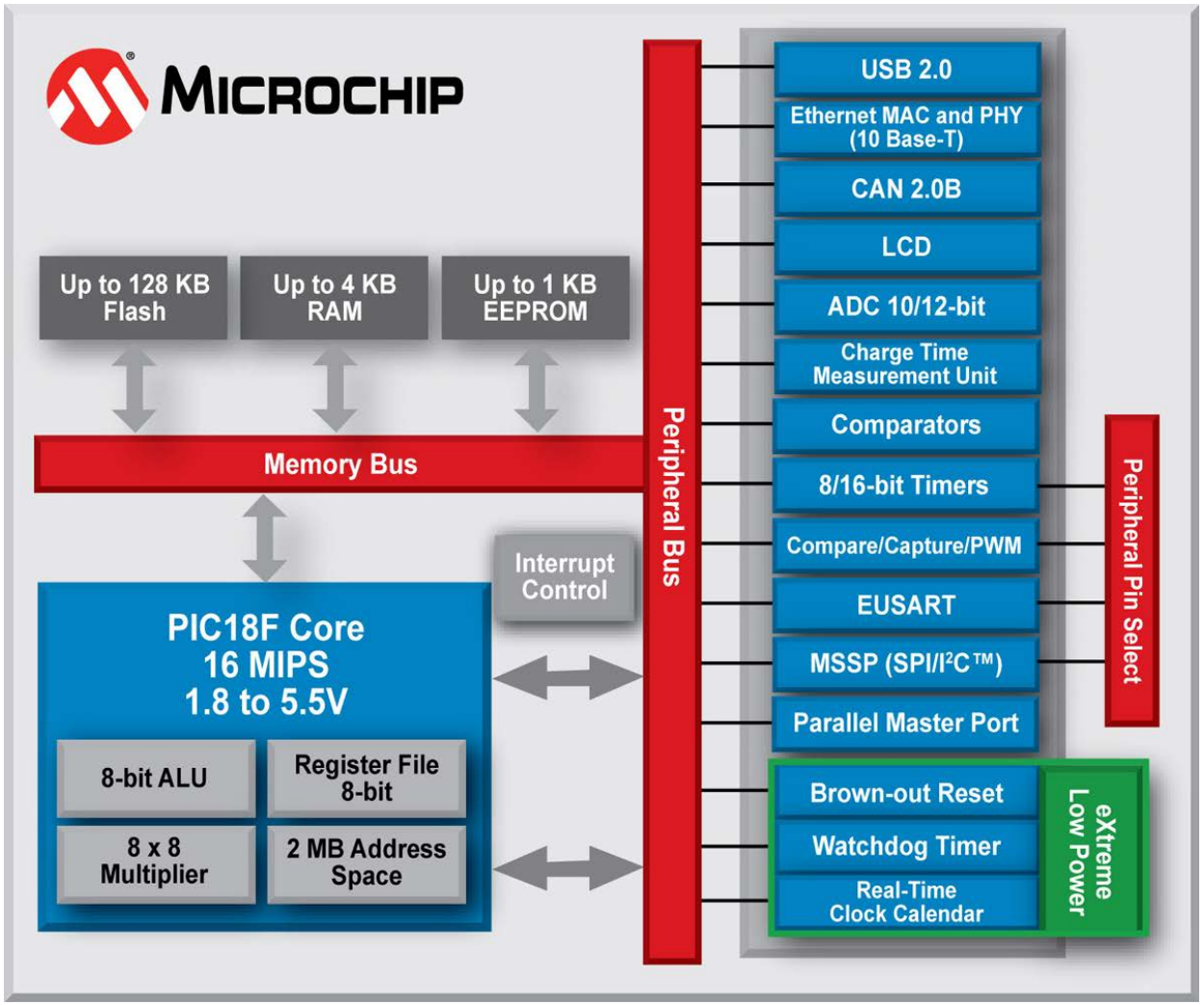
- E.g., Intel Edison (SD card sized)
  - 22nm Quark dual-core processor (32-bit x86 system-on-chip with extra-low power consumption)
  - Wi-Fi module and Bluetooth 4.0.
  - runs on Linux and has its own app store



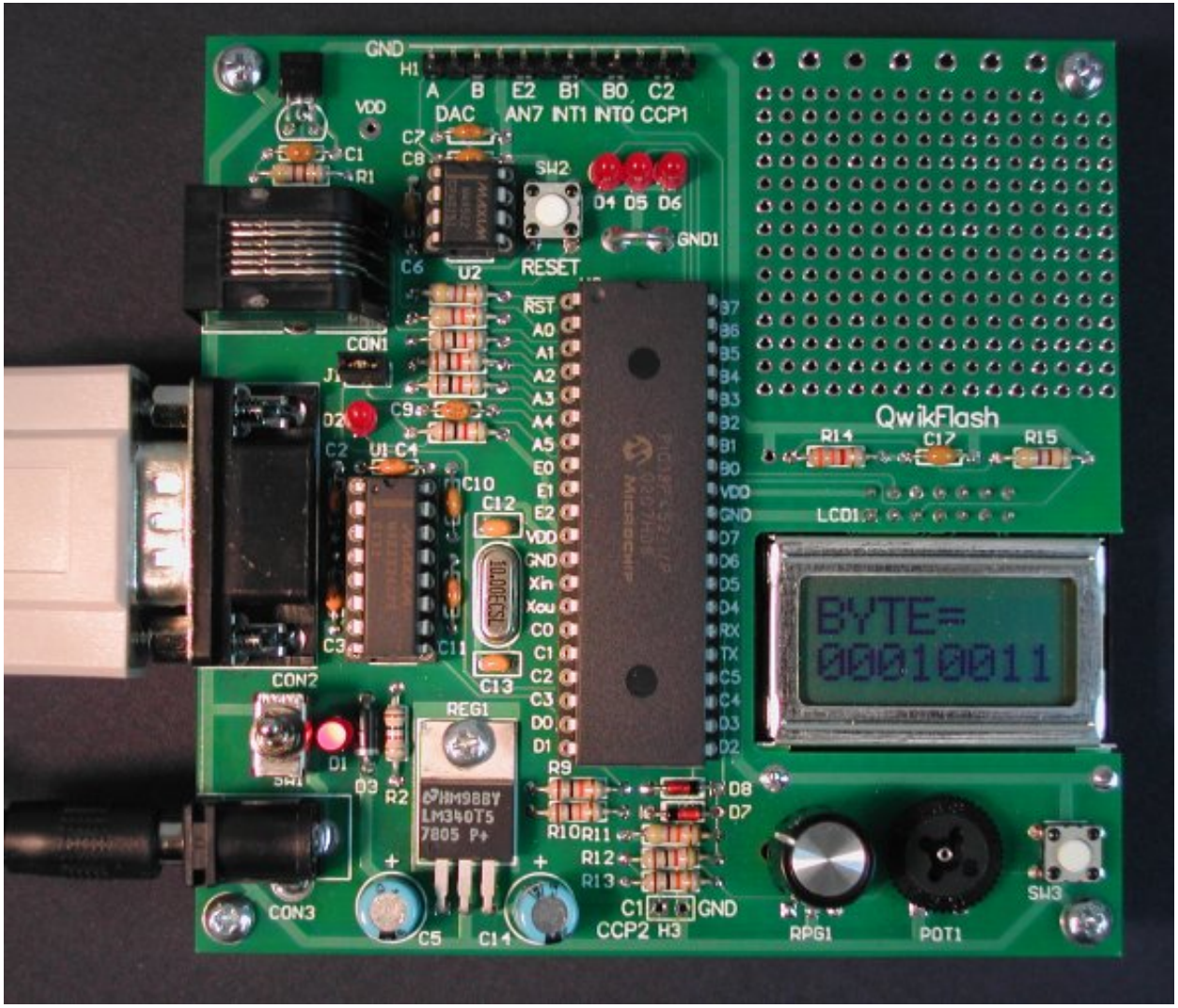
# PIC Microcontroller



# PIC18F


MICROCHIP
Up to 128 KB Flash
Up to 4 KB RAM
Up to 1 KB EEPROM
Memory Bus
Interrupt Control
PIC18F Core
16 MIPS
1.8 to 5.5V
8-bit ALU
Register File 8-bit
8 x 8 Multiplier
2 MB Address Space
Peripheral Bus
USB 2.0
Ethernet MAC and PHY (10 Base-T)
CAN 2.0B
LCD
ADC 10/12-bit
Charge Time Measurement Unit
Comparators
8/16-bit Timers
Compare/Capture/PWM
EUSART
MSSP (SPI/I²C™)
Parallel Master Port
Brown-out Reset
Watchdog Timer
Real-Time Clock Calendar
eXtreme Low Power
Peripheral Pin Select

# QwikFlash


GND
H1
A B E2 B1 B0 C2
DAC AN7 INT1 INT0 CCP1
VDD
C1
R1
C7
C8
SW2
D4 D5 D6
GND1
C6
U2
RESET
CON1
J1
D2
C9
C2
U1
C4
C10
C12
C3
C11
C13
CON2
SW1
D1
D3
R2
REG1
LM340T5
7805 P+
CON3
C5
C14
RST
A0
A1
A2
A3
A4
A5
E0
E1
E2
VDD
GND
Xin
Xou
C0
C1
C2
C3
D0
D1
R9
R10
R11
R12
R13
C1
CCP2
H3
GND
D8
D7
RPG1
POT1
SW3
QwikFlash
R14
C17
R15
LCD1
BYTE=
00010011
B7
B6
B5
B4
B3
B2
B1
B0
VDD
GND
D7
D6
D5
D4
RX
TX
C5
C4
D3
D2


# Questions?

- Look over Lecture 2: PIC Overview
- Will cover chapters 1 and 2 of the textbook in next few classes