

MICROPROCESSORS A (17.383)

Fall 2010

Lecture Outline

Class # 01

September 07, 2010

Dohn Bowden

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Today's Lecture

- Administrative
- General Course Overview
- Microcontroller Hardware and/or Interface
- Programming/Software
- Lab
- Homework

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Course Admin

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Administrative

- Admin for tonight ...
 - Attendance/Introductions/Backgrounds
 - Syllabus
 - Textbook
 - 17.383 Web Site
 - Email List creation
 - Course Objectives

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Attendance / Introductions / Backgrounds

- Attendance ...
 - When called ... please introduce yourself
 - Include the following
 - Knowledge of “C” programming
 - Education
 - Work Experience
 - Other notable work/engineering/hobbies
 - Future Plans

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My Background

- Education
- Work Experience
- Other notable work/engineering/hobbies
- Future Plans

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Syllabus

- Syllabus
 - Hard copies available
 - Electronic copy available on the class website
- Web Address on syllabus

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Syllabus Review

<i>Week</i>	<i>Date</i>	<i>Topics</i>	<i>Lab</i>	<i>Lab Report Due</i>
1	09/07/10	Intro, Course & Lab Overview, Microcontroller Basics	1	
2	09/14/10	PIC16F684 Overview and General Input/Output	1 con't	
3	09/21/10	Switches	2	1
4	09/28/10	Seven Segment LEDs		
5	10/05/10	Examination 1	2 con't	
X	10/12/10	No Class – Monday Schedule		
6	10/19/10	Analog to Digital Conversion	3	2
7	10/26/10	Analog to Digital Conversion con't	3 con't	
8	11/02/10	LCD Interface and Assembly Language	4	
9	11/09/10	Comparators	4 con't	3
10	11/16/10	Timers and Pulse Width Modulation (PWM)	5	
11	11/23/10	Mixed C & Assembly Programming/Course Project	Project	4
12	11/30/10	Examination 2		
13	12/07/10	Course Project	Project	5
14	12/14/10	Final Exam/Course Project Brief and Demonstration	Demo	

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Grading Policy

- Located at the bottom of syllabus
- Exam # 1 (20%) Exam #2 (20%)
- Laboratory ... including lab reports (30%)
- Final Exam/Course Project (30%)

A	93-100	A-	90-92		
B+	87-89	B	83-86	B-	80-82
C+	77-79	C	73-76	C-	70-72
D+	67-69	D	60-66		
F	Below 60				

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Class Hours

- Tuesdays evenings ... 6 – 9 PM in BL-407
 - See next slide for access to BL-407
 - See syllabus for schedule of classes
- Call/email if you will not be in class ...
- I am available for extra help **Before / After** class
 - If possible ... please schedule in advance so I will ensure that I am available
- Labs – start to pick-up at approximately 8:45 PM

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Access to Labs

- To gain access to BL-407
 - You will need to have an access cards
 - Access cards are given out on the South Campus at Access Services
 - Arrangements are done through the Continuing Education Office
 - Then I will need your UMS# (will be on your Access Card)
 - I will then send your name and UMS# to the Room POC

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Textbooks

- We will be using material that is available from the web
 - The course website will have a link to the material
- OPTIONAL TEXT ...
 - Stephen G. Kochan, *Programming in C*, Sams Publishing, 2005
 - An excellent book for those less familiar with C

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Course Web Site

- The Course Homepage is at:
<http://faculty.uml.edu/dbowden>
- This website will contain the following:
 - Syllabus
 - Lab material
 - Labs procedures
 - Datasheets
 - Reference documents
 - Such as the textbook material
 - Links
 - **Portions** of Class lectures (will be placed on the web site **AFTER** the lecture)
 - Homework

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Email Distribution List

- I will be creating a class email list
-  Email me at:

Dohn_Bowden@uml.edu
- This will ensure that your correct email address or addresses are included
- The email list will allow me to provide information to each of you

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Text Messages

- **NEW** --- Any interest in having text message capability?

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Course Objectives

- What do you want to get out of this class?
- My goals for the course ...

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Course Evaluations

- How they are used

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Questions?

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General Course Overview

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General Overview

- This is a “Hands-on” course ...
 - The best way to learn is by doing!
- Similar to learning how to drive a car
 - Proficiency through experience
- Experience with the microcontroller by ...
 - Applying the microcontroller to multiple hardware and software configurations

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Course Expectations
Slide 1 of 2

- Introduction to programming and interfacing the PIC microcontroller
 - Programming the PIC microcontroller in both ...
 - “C” and ...
 - Assembly language
 - Interfacing the microcontroller with ...
 - LEDs
 - LCDs
 - And other commonly used electronic interfaces
 - Such as switches and Sensors

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Course Expectations
Slide 2 of 2

- Learn the basics behind the microcontroller
 - Understanding the datasheet specifications
 - Differences between various microcontrollers
- Learn how to interface with devices
 - Understanding the electronics
- Course Project ...
 - Applying the techniques and information covered during the course

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Course Overview

- What is a microcontroller?
 - We will lay the foundation of ...
 - Using and ...
 - Programming the PIC microcontroller
- This foundation will enable the expansion to other PIC microcontroller families (and other manufacturers)

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Embedded Systems

- An *embedded system* is a combination of computer hardware and software, designed to perform a dedicated function
 - Examples ... microwave oven, digital watch, video game player
- The design of an embedded system to perform a dedicated function is in direct contrast to that of the personal computer
 - A personal computer is not designed to perform a specific function, rather it is able to do many things

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Embedded Developer

- The embedded developer needs to understand ...
 - Hardware
 - Code
 - Peripheral interfaces

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Embedded Language

- C programming language is the current language of choice
- C advantages ...
 - Small and fairly simple to learn
 - Compilers available for almost every processor
 - Large population of C programmers
 - Processor independence
 - Allows the programmer to concentrate on algorithms and applications rather than the processor architecture

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Getting to Know the Hardware

- Before writing software for an embedded system ...
 - You must be familiar with the hardware on which it runs
- Understand ...
 - General operation of the system
 - What the inputs are
 - What the outputs are
 - etc
- Initially you don't need all the details of the hardware, but it is helpful

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Hardware Basics

- Understanding the hardware by reviewing ...
 - The Schematics
 - Which give details of the hardware
 - Datasheets
 - Complete specifications for a specific component

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The Processor

- Review the datasheets
- What internal functions does the processor have?
 - ADC?
 - Comparators?
 - Etc.
- What is connected to it?
- How does it communicate with those interfaces?
- Memory Mapping
- Initializing the processor

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General Course Overview

- Typical Lecture/Class Structure
 - Microcontroller Hardware and/or Interface
 - Programming/Software
 - Programming Basics
 - “C” and/or Assembly Language Commands
 - PIC commands
 - Lab
 - Overview
 - Lab Conduct
 - Homework

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Microcontroller Hardware and / or Interfaces

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Basic Microcontroller facts ...

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Basic Microcontroller facts

- What is a Microcontroller?
 - An inexpensive single chip computer
 - Single chip means ... that the entire computer lies within the confines of the integrated circuit
 - The microcontroller is capable of storing and running a program (its most important feature)

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Basic Microcontroller facts

- Unlike ordinary microprocessors, microcontrollers have built-in features that make them operate almost independent of additional circuitry
- This is possible because microcontrollers contain things like
 - memory (ROM, EPROM, RAM, etc)
 - input and output ports
 - timers
 - serial and parallel communication capability
 - analog-to-digital converters

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Basic Microcontroller facts

- What is the difference between a microprocessor and a microcontroller?
 - A microcontroller is a specialized form of microprocessor ...
 - Designed to be self-sufficient and cost-effective
 - A microprocessor is typically designed to be general purpose (the kind used in a PC)
 - Microcontrollers are frequently found in automobiles, office machines, toys, and appliances

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Basic Microcontroller facts

- Why use a Microcontroller?
 - Its ability to store and run unique programs makes it extremely versatile
 - A microcontroller can be programmed to make decisions and perform functions based on predetermined situations (I/O line logic) and selections
 - Its ability to perform math and logic functions allows it to mimic sophisticated logic and electronic circuits
 - Microcontrollers are responsible for intelligence in most smart devices on the consumer market

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Basic Microcontroller facts

- The PIC Chip
 - Microchip's microcontrollers are commonly called PIC chips
 - Microchip uses PIC to describe its series of PIC microcontrollers
 - The PIC microcontroller was originally designed as a Peripheral Interface Controller (PIC) for a 16 bit microprocessor
 - It was essentially an I/O controller and was designed to be very fast
 - It had a small micro-coded instruction set
 - This design became the basis for the Microchip Technology's PIC family of microcontrollers

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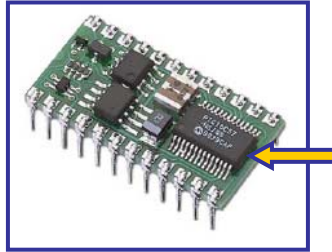
Basic Microcontroller facts

- Better than any Stamp
 - Faster speed
 - Lower Cost
 - PIC chips save you 75% of the cost of the Basic Stamp
 - Application dependant ... cost may be less

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Basic Microcontroller facts

- The BASIC Stamp 2 embeds a microcontroller, the PIC16C57, on a module to make programming and use very simple, yet very powerful



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Some examples of microcontroller applications include ...

- Automotive
 - Anti-lock brakes
 - Keyless entries
 - Air bags
 - Burglar alarm systems
 - Sun roof
 - Ignition
 - Other engine functions
- Communications
- Office automation
- Industrial control
- Etc
- Consumer
 - Cell phone
 - Pager
 - Answering machines
 - Home appliances
 - Washing machines
 - Clothes dryer
 - Furnace
 - Air Conditioner
 - Security system
 - Refrigerators
 - Watches
 - Sprinkler systems
 - Microwave Ovens
 - Toys
 - Toaster
 - Hair Dryer
 - Radio
 - TV
 - VCR
 - Calculator
 - Electronic games
 - Clocks
 - Garage door openers
 - Smoke detectors



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How does the Microcontroller compare to the typical of a personal computer?

- A PC contains ...
 - Main Memory
 - Disk Memory
 - Operating System
 - Serial I/O
 - Parallel I/O
 - Real-time clock
 - Keyboard
 - Video Display
 - Sound Card
 - Mouse
 - Network Interface Card
 - USB ports
 - etc.
- A Microcontroller ...
 - All necessary resources are available on the chip including:
 - Central Processor
 - Memory
 - I/O
 - Etc.
 - External requirements include:
 - Power
 - Clocking

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How does the Microcontroller compare to the typical of a personal computer?



- PC can run many programs
- PC has generalized CPU



- Embedded System Does One Task
- Embedded System has specialized microcontroller

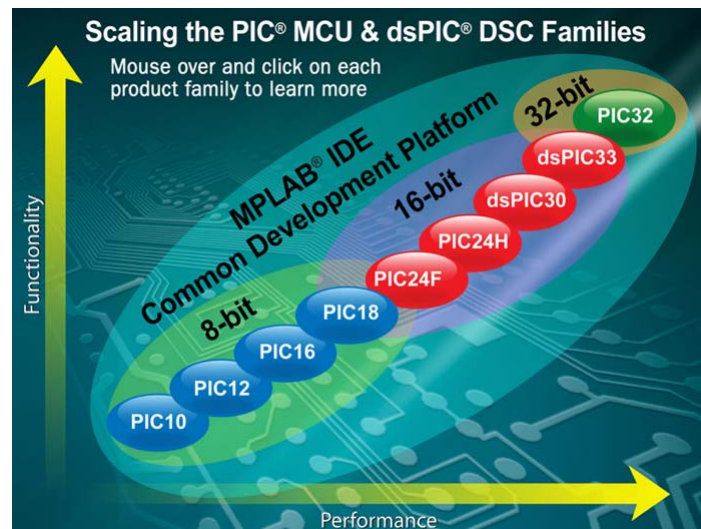
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Microcontroller and Microprocessor For This Course

- We will be centering our studies the Microchip PIC16F684 microcontroller
- The PIC16F684 is ...
 - A fourteen-pin microcontroller
- Other PIC microcontrollers will be available (for your course project)
- Rabbit S ... Rabbit® 5000 Microprocessors



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<http://www.microchip.com/stellent/images/mchpsiteimages/en537986.jpg>

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MiniCore™ RCM5700



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How do I select the best microcontroller for my application?

- PIC® Microcontroller Product Architectures
 - Baseline Product Architecture
 - Mid-range Product Architecture
 - High Performance Product Architecture

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Baseline Product Architecture

- Comprised of the PIC10F family and portions of the PIC12 and PIC16 families
 - These devices utilize a 12-bit program word architecture with 6 to 28-pin package options
 - A concisely defined feature set
 - A range of low operating voltages makes this family ideal for battery-operated applications
- Baseline Features:
 - Low pin-count and small form factor
 - Flexible Flash program memory
 - Low power capability
 - Cost sensitive
 - Ease-of-use

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Mid-range Product Architecture

- Comprised of portions of the PIC12 and PIC16 families
 - These devices feature a 14-bit program word architecture with 8 to 64-pin options
- Mid-range Features
 - Expansive package offerings ... 8 to 64 pins
 - Flexible Flash program memory
 - Low power capability
 - Rich peripheral set
 - 5 MIPS operating performance
 - Optimal cost to performance ratio

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High Performance Product Architecture

- Features the PIC18 family of devices
 - These MCUs utilize a 16-bit program word architecture with 18 to 80-pin package options
- High Performance Features
 - Expansive package offerings--18 to 80 pins
 - Flexible Flash program memory
 - Low power capability
 - Linear program memory space up to 2Mbytes
 - 10 MIPS operating performance
 - Hardware 8x8 multiplier
 - Advanced communication peripherals and protocols (CAN, USB and TCP/IP)

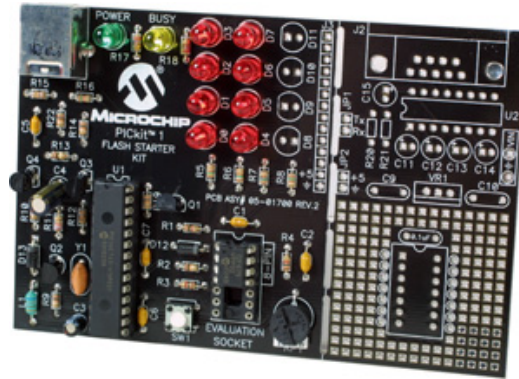
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PICKit™ 1 Flash Starter Kit

- PICKit™ 1 Flash Starter Kit is a Microcontroller Programmer Development Kit
- A complete development system
- The PICKit™ 1 Provides ...
 - Programming
 - Evaluation
 - And development

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PICKit™ 1 Flash Starter Kit



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PICKit™ 1 Flash Starter Kit

- The PICKit™ 1 Flash Starter Kit includes the following:
 - Circuit and Prototype Board
 - (2) PIC MCU's ...
 - PIC12F675 (we will not use this processor)
 - PIC16F684
 - USB cable Software
- The PICKit™ 1 Flash Starter Kit is for your use during the semester ... the kit **needs to be returned at the end of the semester** ...
 - If it is not returned, you will receive an “INC” until it is returned!

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PICDEM Lab Development Kit

- Recently the school purchased the PICDEM Lab Development Kit
- The Kit is designed to provide a comprehensive development and learning platform for Microchip's FLASH-based 6-, 8-, 14-, 18- and 20-pin 8-bit PIC® microcontrollers
- Geared toward first-time PIC® microcontroller users and students
 - Supplied with five of the most popular 8-bit PIC® microcontrollers
 - A host of discrete components to create instructive applications
- Expansion headers provide complete access/connectivity to all pins on the connected PIC® microcontrollers and all mounted components

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PICDEM Lab Development Kit



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PICDEM Lab Development Kit

- The PIC® Microcontrollers included with the kits are:
 - PIC16F690 (20-pin)
 - PIC16F88 (18-pin)
 - PIC16F616 (14-pin)
 - PIC12F615 (8-pin)
 - PIC10F206 (6-pin) in 8-pin PDIP package for debugging

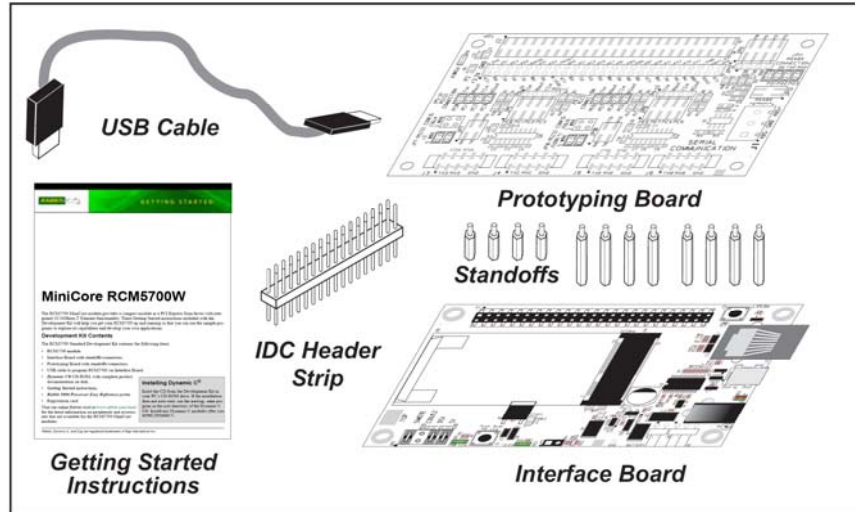
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PICDEM Lab Development Kit

- Kit Contents:
 - PICDEM™ Lab Development Board
 - Component kit
 - PICkit™ 2 Programmer/ Debugger
 - CD containing a comprehensive user guide, labs, application examples and a number of additional tutorials

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Rabbit - RCM5700 Standard Development Kit



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Questions?

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Programming / Software

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Course Software

- Microchip's MPLAB IDE (integrated development environment)
 - Current Version is 8.43 (copy on class web site)
- PIC MCU Assembly Language Programming
 - PIC MCU Assembler ... known as MPASM® assembler
- "C" programming language (a third party compiler)
 - HT-Soft's Hi-Tech C Pro (Lite Mode) C compiler
 - Current Version is 9.70 PL5 (included with MPLAB IDE)

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Course Software

- Recommend ...
 - If you have a laptop ...
 - Install
 - Use during Labs
- Lab computers do have the software available

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Typical Tasks for developing an embedded controller application

- The four steps in developing an application ...
 - First ... Create the high level design
 - Second ... Compile, assemble, and link the software
 - Third ... Test your code
 - Fourth ... “Burn” the code into a microcontroller

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A Question ...

- How many have been exposed to ...
 - To computer programming?
 - “C” programming?
 - Assembly language programming?
- Do you remember the details of the above?

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Microchip's MPLAB IDE

- MPLAB IDE ... (Integrated Development Environment)
- MPLAB IDE is a “wrapper” that ...
 - Coordinates all the tools from a single Graphical User Interface (GUI)
 - Usually automatically

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Microchip's MPLAB IDE

- MPLAB IDE ...
 - Once code is written using the MPLAB IDE Editor ...
 - It can be converted to executable instructions ... and ...
 - Downloaded into a microcontroller
 - In this process multiple tools are needed:
 - An editor ... to write the code
 - A project manager ... to organize files and settings
 - A compiler or assembler to ... convert the source code to machine code
 - And ... some sort of hardware or software that either connects to a target microcontroller or simulates the operation of a microcontroller

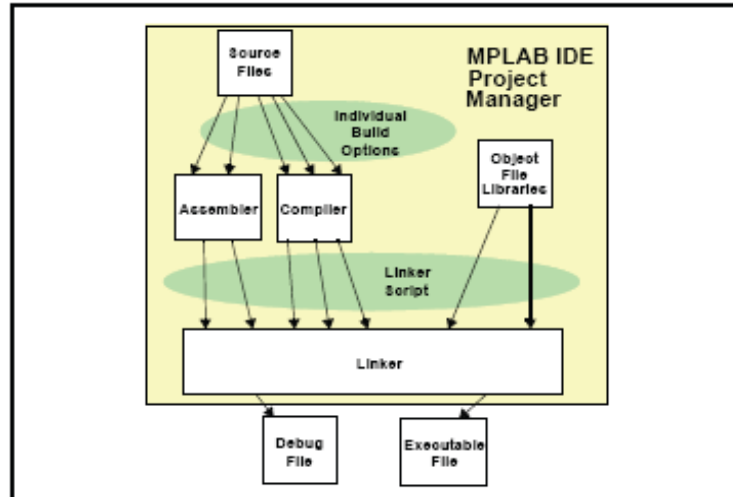
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Components of MPLAB IDE

- Built-In components
 - Project Manager
 - Editor
 - Assembler/Linker and Language Tools
 - Debugger
 - Execution engines
- Optional Components
 - Compiler Language tools
 - Programmers
 - In-Circuit Emulators
 - In-Circuit Debugger

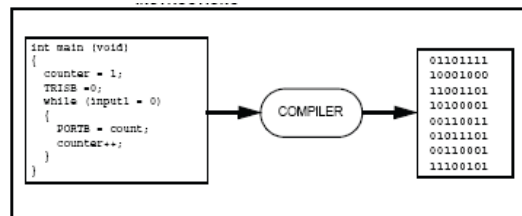
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MPLAB IDE Project Manager



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A Compiler Converts Source Code Into Machine Instructions



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Questions?

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Lab

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LAB OVERVIEW

- Simulation using software is not an acceptable alternative to breadboarding
- Benefits of hands-on labs/breadboarding ...
 - Use of ...
 - Components
 - Test equipment
 - Knowledge of Test equipment is a foundation for hardware troubleshooting
 - ** Learn troubleshooting techniques
 - ** Will greatly enhance the class material
 - Solving Lab Problems will enforce the course material

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LAB OVERVIEW

- Basic lab knowledge/techniques
 - Use of a breadboard
 - Learn the identification systems for components
 - Resistors
 - Capacitors
 - Integrated circuits
 - Application of data sheets

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LAB OVERVIEW

- **Problems encountered during lab performance ...**
 - Knowledge gained from troubleshooting

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LAB OVERVIEW

- Lab grade ...
 - Lab proficiency 20 points
 - Lab Report Format 20 points
 - Lab Notebook 20 points
 - Technical adequacy 40 points
- Explanation on why a lab could not be completed
- Lab preparation
 - Need to work through the lab prior to class
- Lab Results ...
 - Record in your lab notebook events/results
 - Write on what you did during the class ...
 - Not what you did after the lab

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LAB OVERVIEW

- Things you should bring to the lab ...
 - Laptop (if available)
 - Flash drive
 - PICkit™ 1 Flash Starter Kit
 - A container for your board, parts, tools, etc.
 - Tools
 - Wire strippers
 - Wire cutters
 - Jeweler's screwdrivers
 - Screwdriver
 - A copy of the lab (available on the web)

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LAB OVERVIEW

- Lab Reports
 - Report form for each lab is available on the course web pages
 - Electronic report submission is an alternative to hard copies ...
 - PDF format only
 - Sent via email NLT than the due date
 - Send your programs to me via email
- Lab results will usually be due 2 weeks after completion of the lab (as indicated on the syllabus)
- Labs will be available for downloading from the website NLT Monday evening

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Lab #1– Overview and Basic Steps

- The first lab will be an introduction to the MPLAB software
- An introduction to the PICKit™ 1 Flash Starter Kit
- The “code” used may be unfamiliar to some/all of you ...
- Future classes will provide details on ...
 - Hardware
 - Programming (software)

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The Lab – Basic Steps and the Lab #1 Overview

- MPLAB projects have the same basic steps ... they are:
 - Select Device
 - Create Project
 - Select Language Tools
 - Put Files in Project
 - Create Code
 - Build Project
 - Test Code with the Simulator
 - Burn Code into the microcontroller
 - One additional step may be to remove the microcontroller from the PICKit and install in another circuit ... future labs

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Lab # 1

- Provides more detail than most
 - Is helpful for the first encounter to this material
- The lab will extend into next week
 - Ideally you will finish Part 1 tonight
 - Lab 1, Experiments 2 and 3 will complete next week
 - » This allows time to work on the software prior to class
- Homework is to work on the labs at home

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Lab # 1

- Download the software from ...
 - The class web site ... to maintain the same version
 - Alternatively you can download from
 - <http://www.microchip.com> (MPLAB IDE)
- This will enable you to work on your labs on your own computer
- You may want to order your own PICKIT™ 1 Flash Starter Kit

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Questions?

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Next Week ...

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Next Week Topics

- PIC16F684 Features
- C commands
 - » C program structure
 - » Comments
 - » # include
 - » Integer variables
 - » for
 - » While
- Configuration Word
- Finish Lab #1

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HomeWork

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Homework

1. Send an email with your email address or addresses (for class distribution list)
2. Send me your UMS# (will be on your Access Card) so I can get access to BL-407
3. Review the PIC16F684 Datasheet
4. Review MPLAB IDE User Guide
5. Review the Hi-Tech C Pro Manual
6. Prepare for the remainder of Lab #1

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Time To ...
Start the Lab ...

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