UNIVERSITY OF SASKATCHEWAN

College of Engineering

Laboratory: Introduction to Mechatronics

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Lab 1. Introduction

Lab Sessions

- Lab 1. Introduction to the equipment and tools to be used in the lab, which include the development board (PICDEM 2 Plus),the microcontroller (PIC 16F1937), and the USB Oscilloscope (Analog Discovery).
- Lab 2. Experiment 2: Transistor Operation, Experiment 3: Passive filters, and an Op Amp circuit experiment.
- Lab 3. Experiment 7: LED Control and Interruptions.
- Lab 4. Experiment 10: Stepper Motor Motion Control.
- Lab 5. Experiment 11: DC Motor Speed Control Using PWM.
- Lab 6. Experiment 12: Closed Loop DC Motor Position Control.

Lab 1. Outline

- Objective.
- Lecture
  - Development board (PICDEM 2 Plus) and microcontroller (PIC 16F1937).
  - USB Oscilloscope (Analog Discovery).
- Analog Discovery Practice.
- Time for the experimental question in assignment 1

Objective

- **General Lab Objective:** To test and learn some functions of a PIC microcontroller to observe its potential uses in embedded applications which are typical in Mechatronic applications.

- **Lab 1 Objective:** To learn the general characteristics of the PIC 16F1937 and the board PICDEM 2 Plus, and to develop an understanding of the Analog Discovery tool (USB Oscilloscope)

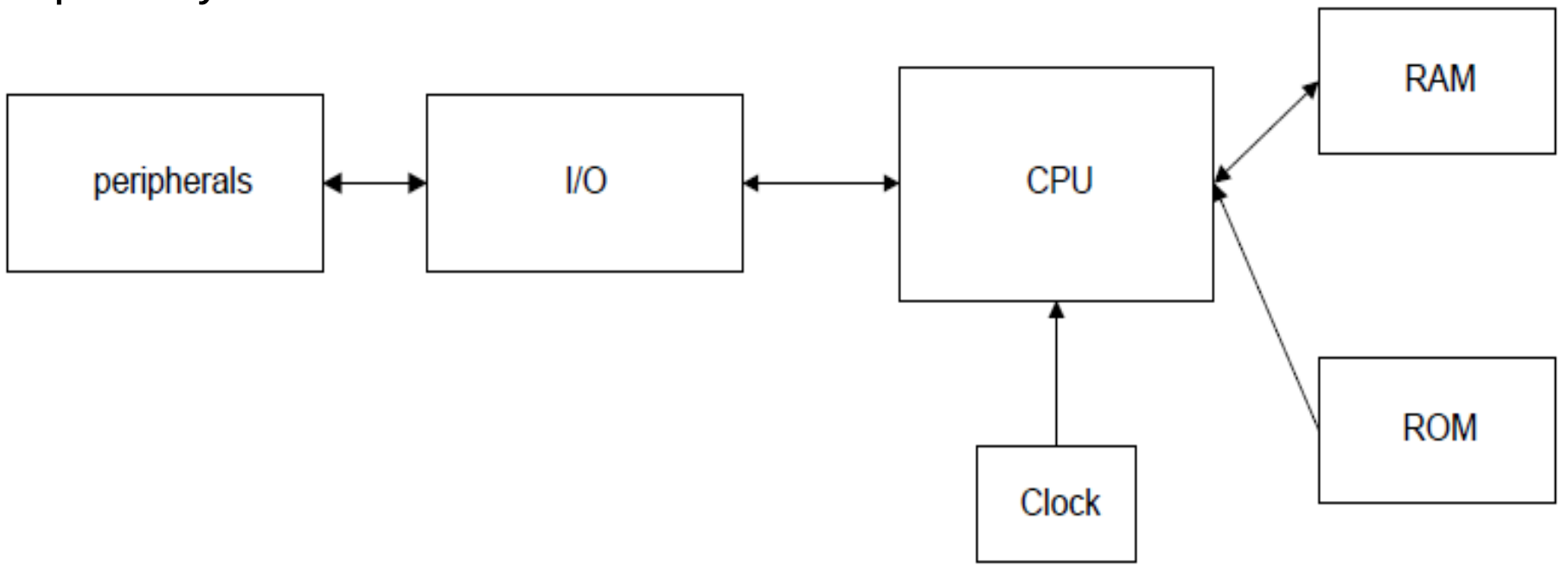
Logistics of the Labs

- **Groups:** The labs will be divided into 9 groups of 3. Selected by the students.

- **Equipment:**
  - There are 9 sets of equipment, one set for each group.
  - Components are placed in bins that are labelled.
  - When doing experiments, take only the components necessary for the labs.
  - Take apart circuits at the end of the lab and put the components back in their proper location.

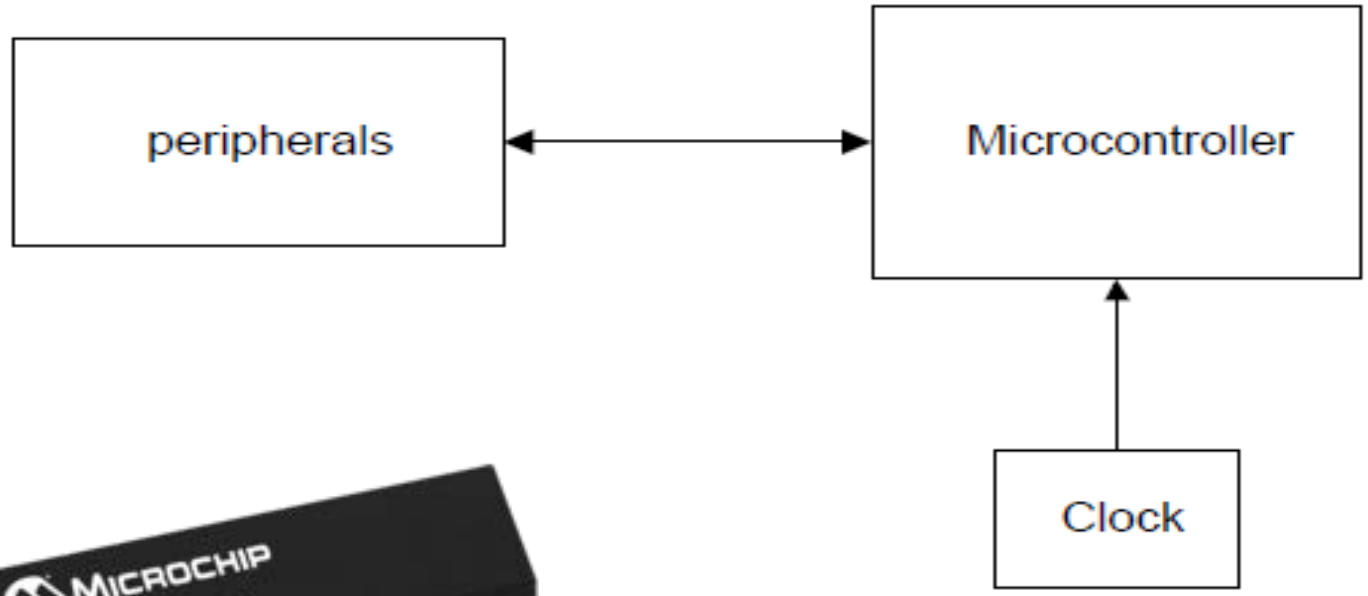
Introduction

Microcomputer systems



- Every computer, no matter how simple or complex, has at its heart two things: a **CPU and some memory**. Together, these two things are what make it possible for your computer to run programs.

- A microcontroller is a simplified version of a similar architecture, placed on one chip.



Microcontroller (PIC 16F1937)

- Operating speed: 32 MHz oscillator/clock input (125 ns instruction cycle)
- Wide Operating Voltage Range: 1.8V-5.5V
- 8K x 14 words of Flash Program Memory.
- 512 Bytes of Data Memory.
- Interrupt capability with automatic context saving.
- 5 bidirectional I/O ports.
- 5 PWM Modules.
- Analog to digital converter module.
- LCD Driver.
- Programing language: C++using MPLAB (Microchip Resources)

- Data Sheet available online at Microchip's web site.

Block Diagram

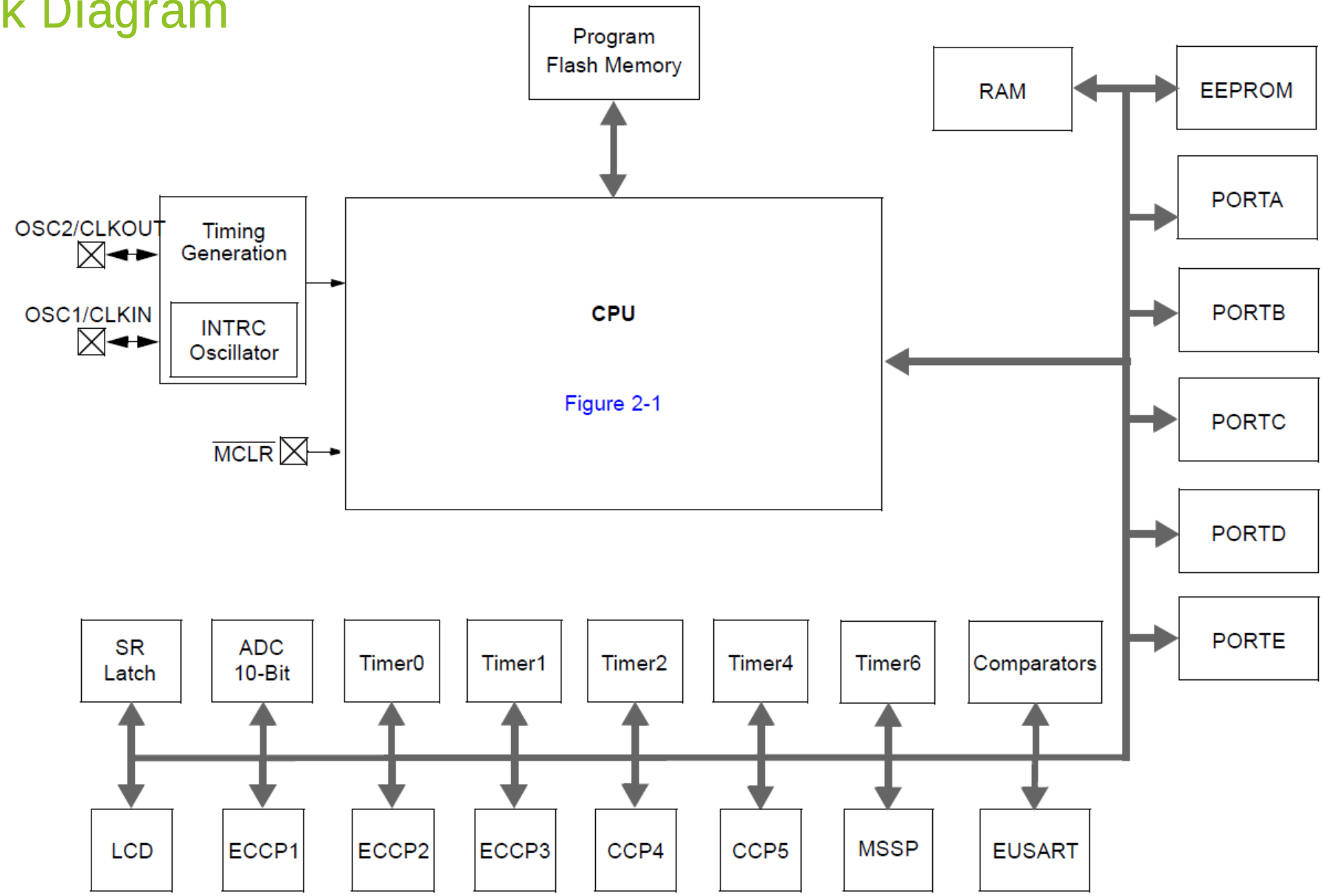
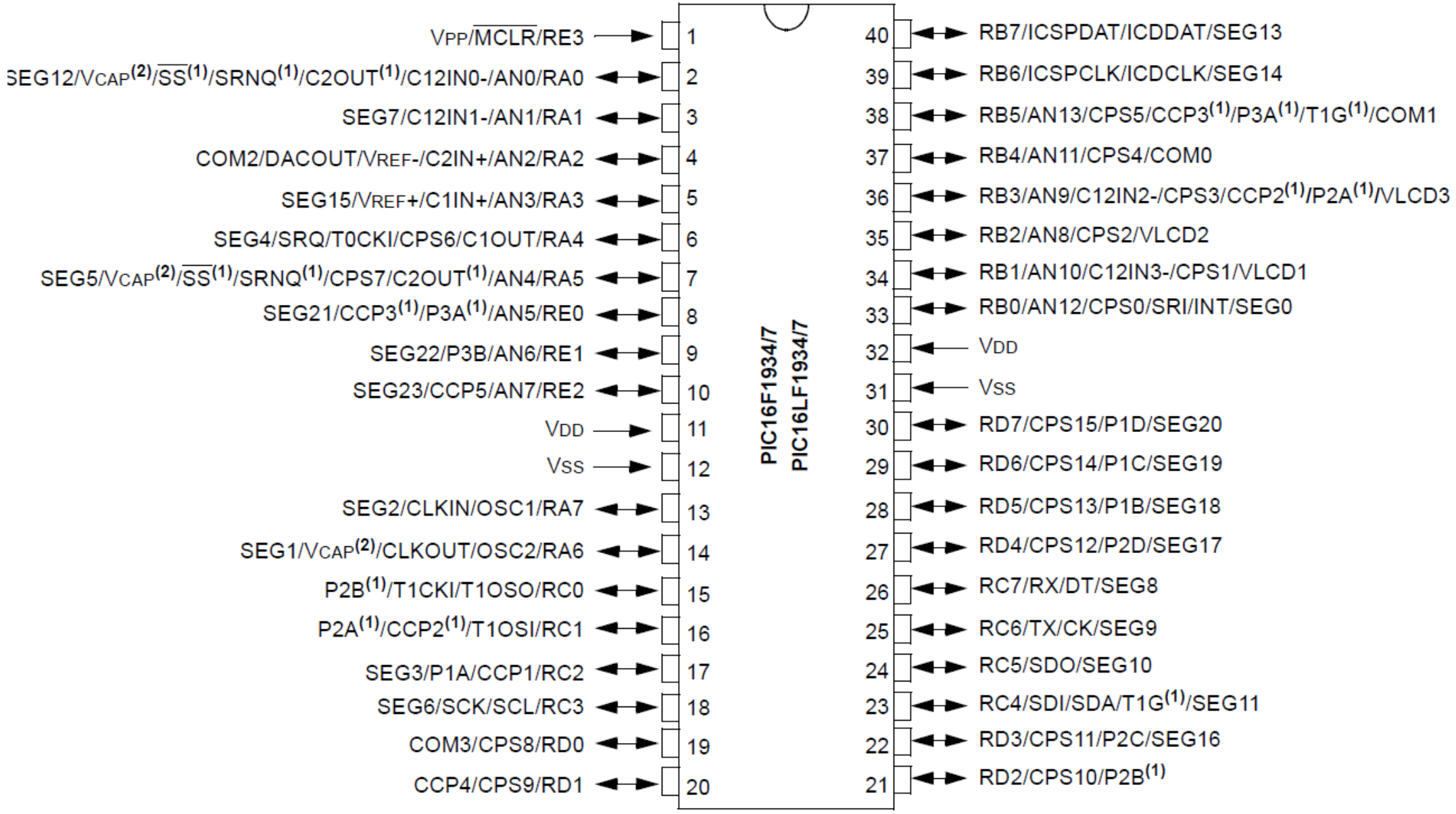


Figure 2-1

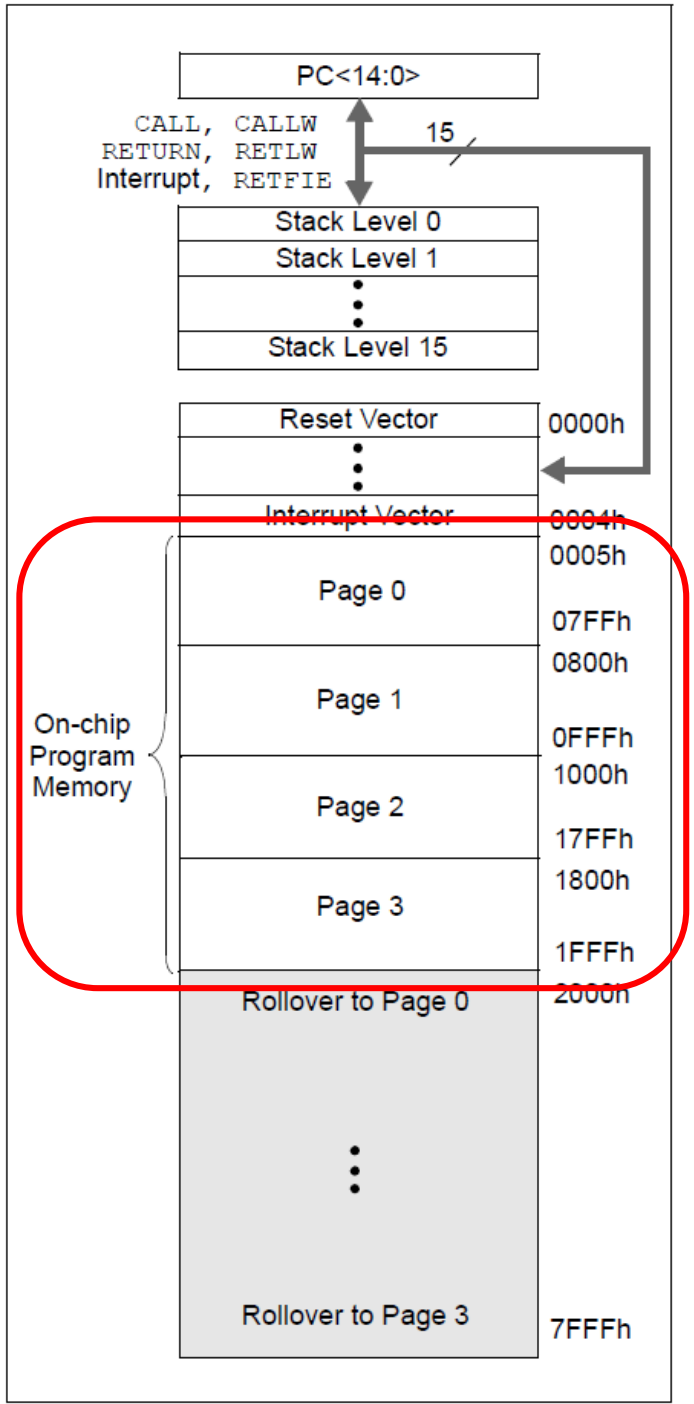
Pin Diagram


PIC16F1934/7
PIC16LF1934/7
1 VPP/MCLR/RE3
2 SEG12/VCAP(2)/SS(1)/SRNQ(1)/C2OUT(1)/C12IN0-/AN0/RA0
3 SEG7/C12IN1-/AN1/RA1
4 COM2/DACOUT/VREF-/C2IN+/AN2/RA2
5 SEG15/VREF+/C1IN+/AN3/RA3
6 SEG4/SRQ/T0CKI/CPS6/C1OUT/RA4
7 SEG5/VCAP(2)/SS(1)/SRNQ(1)/CPS7/C2OUT(1)/AN4/RA5
8 SEG21/CCP3(1)/P3A(1)/AN5/RE0
9 SEG22/P3B/AN6/RE1
10 SEG23/CCP5/AN7/RE2
11 VDD
12 VSS
13 SEG2/CLKIN/OSC1/RA7
14 SEG1/VCAP(2)/CLKOUT/OSC2/RA6
15 P2B(1)/T1CKI/T1OSO/RC0
16 P2A(1)/CCP2(1)/T1OSI/RC1
17 SEG3/P1A/CCP1/RC2
18 SEG6/SCK/SCL/RC3
19 COM3/CPS8/RD0
20 CCP4/CPS9/RD1
40 RB7/ICSPDAT/ICDDAT/SEG13
39 RB6/ICSPCLK/ICDCLK/SEG14
38 RB5/AN13/CPS5/CCP3(1)/P3A(1)/T1G(1)/COM1
37 RB4/AN11/CPS4/COM0
36 RB3/AN9/C12IN2-/CPS3/CCP2(1)/P2A(1)/VLCD3
35 RB2/AN8/CPS2/VLCD2
34 RB1/AN10/C12IN3-/CPS1/VLCD1
33 RB0/AN12/CPS0/SRI/INT/SEG0
32 VDD
31 VSS
30 RD7/CPS15/P1D/SEG20
29 RD6/CPS14/P1C/SEG19
28 RD5/CPS13/P1B/SEG18
27 RD4/CPS12/P2D/SEG17
26 RC7/RX/DT/SEG8
25 RC6/TX/CK/SEG9
24 RC5/SDO/SEG10
23 RC4/SDI/SDA/T1G(1)/SEG11
22 RD3/CPS11/P2C/SEG16
21 RD2/CPS10/P2B(1)

Memory Organization

- Flash Program Memory (ROM):
  - Size: 8K Words
  - Word size = 14 bits.
- Data Memory (RAM):
  - Size: 512 bytes
  - Word size = 1byte (1 byte = 8 bits)
- Data EEPROM (256 bytes)

Program Memory (ROM)



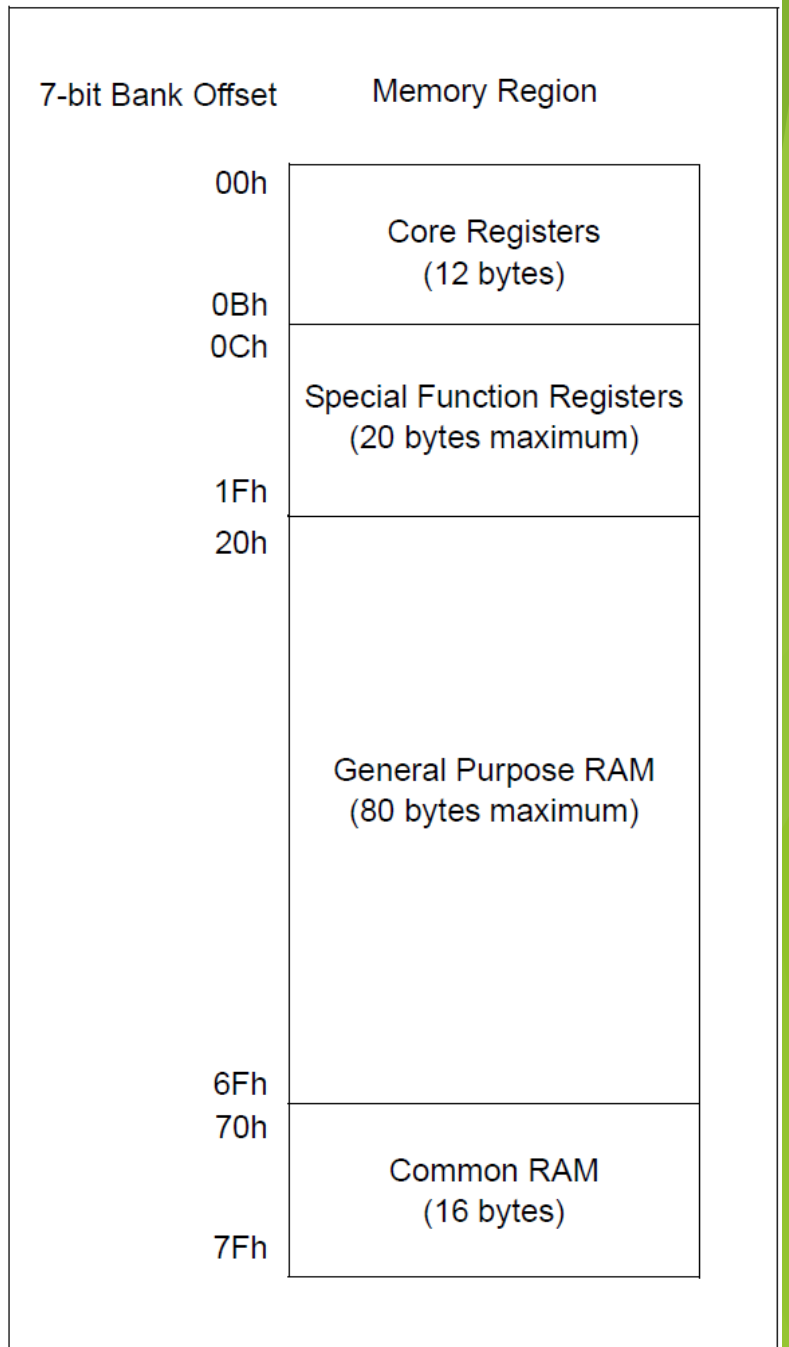
- Program memory and EEPROM are not directly mapped in the register file space. Instead, they are indirectly addressed through the Special Function Registers (SFRs).

8K x 14 bits

Data Memory (RAM)

- Memory: $512\ bytes$
  - Divided in 32 banks with 128 bytes in a bank.
    - 12 core registers
    - 20 Special Function Registers (SFR)
    - Up to 80 bytes of General Purpose RAM (GPR)
    - 16 bytes of common RAM

FIGURE 3-3: BANKED MEMORY PARTITIONING



Special Function Registers (SFR)

- Control the **“core" operation** of the microcontroller.
- Specific name, STATUS, FSR, PORTA, TRISA…

- No name but address number or direction. DATA MEMORY space.

Likewise access.

Ports

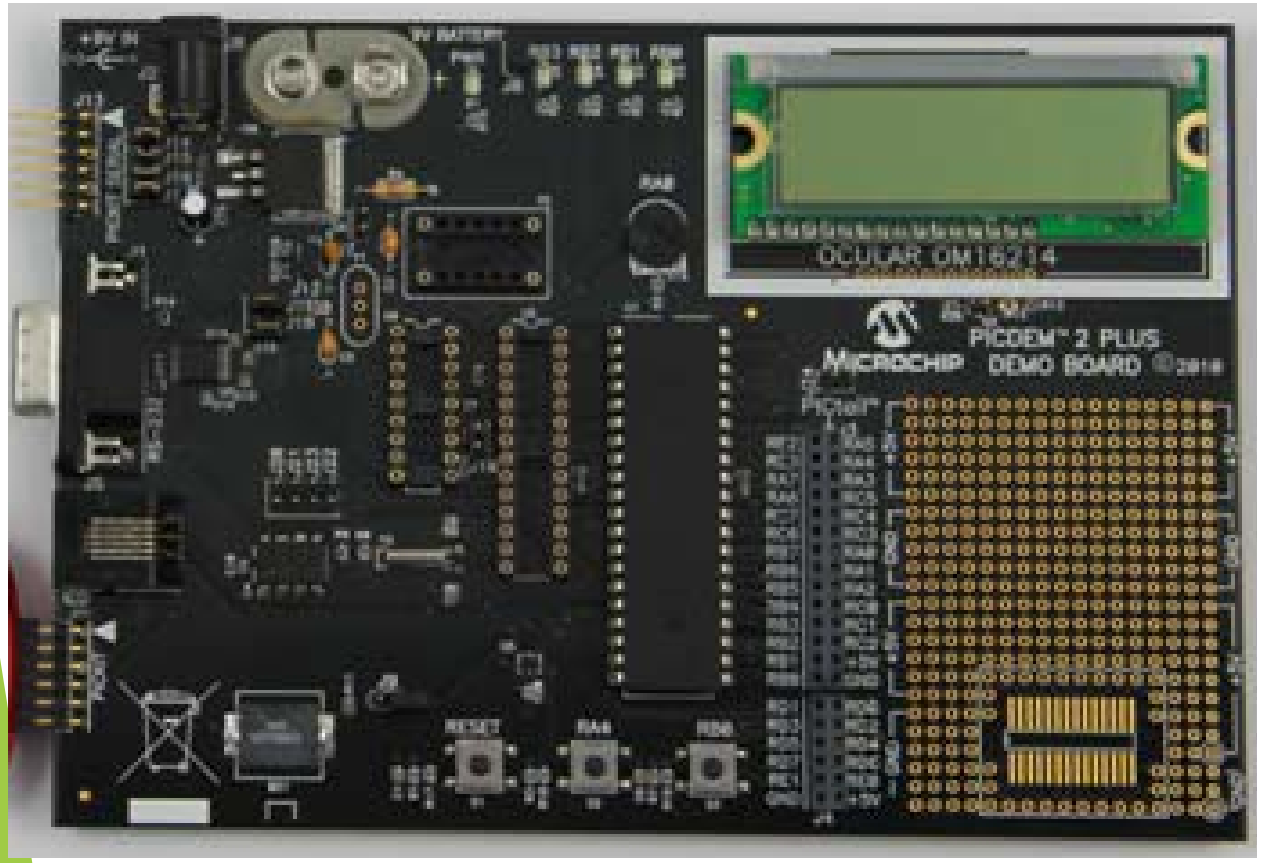
- 5 ports (A,B,C,D, and E). Each port has different characteristics and number of pins.
- Ports are bidirectional (Input/Output).
- Multi-functional. Some pins are multiplexed with an alternate function. When a peripheral is enable, that pin may not work as a general input/output.

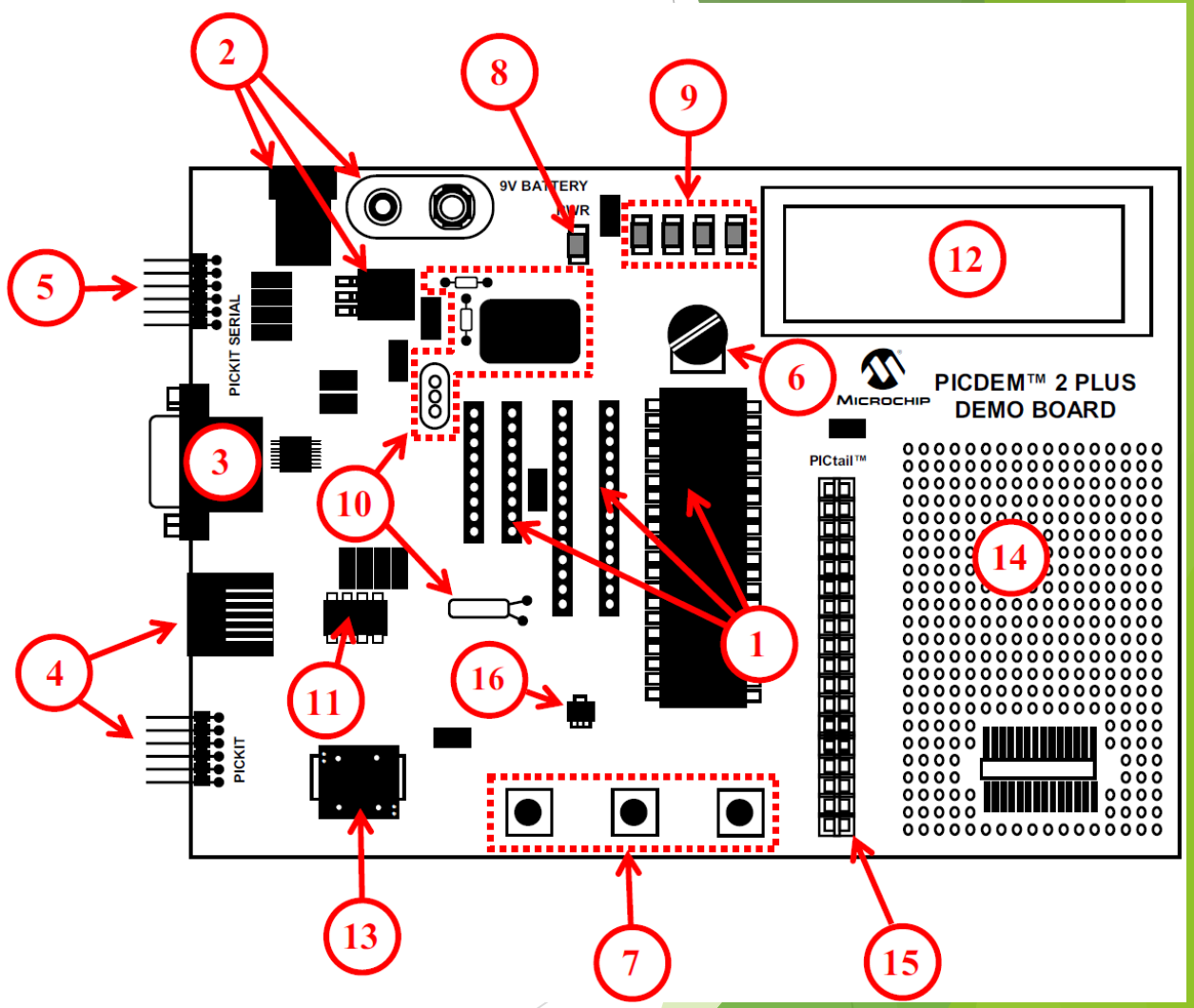
Development Board (PICDEM 2 Plus)

- The PICDEM 2 Plus is a demonstration board that can be used to test and debug programs loaded into a PIC such as the PIC 16F1937.

- The board has several components including LEDs, push buttons, PIC kit serial connector, LCD display, access to external pins. which allow the user to test several applications that

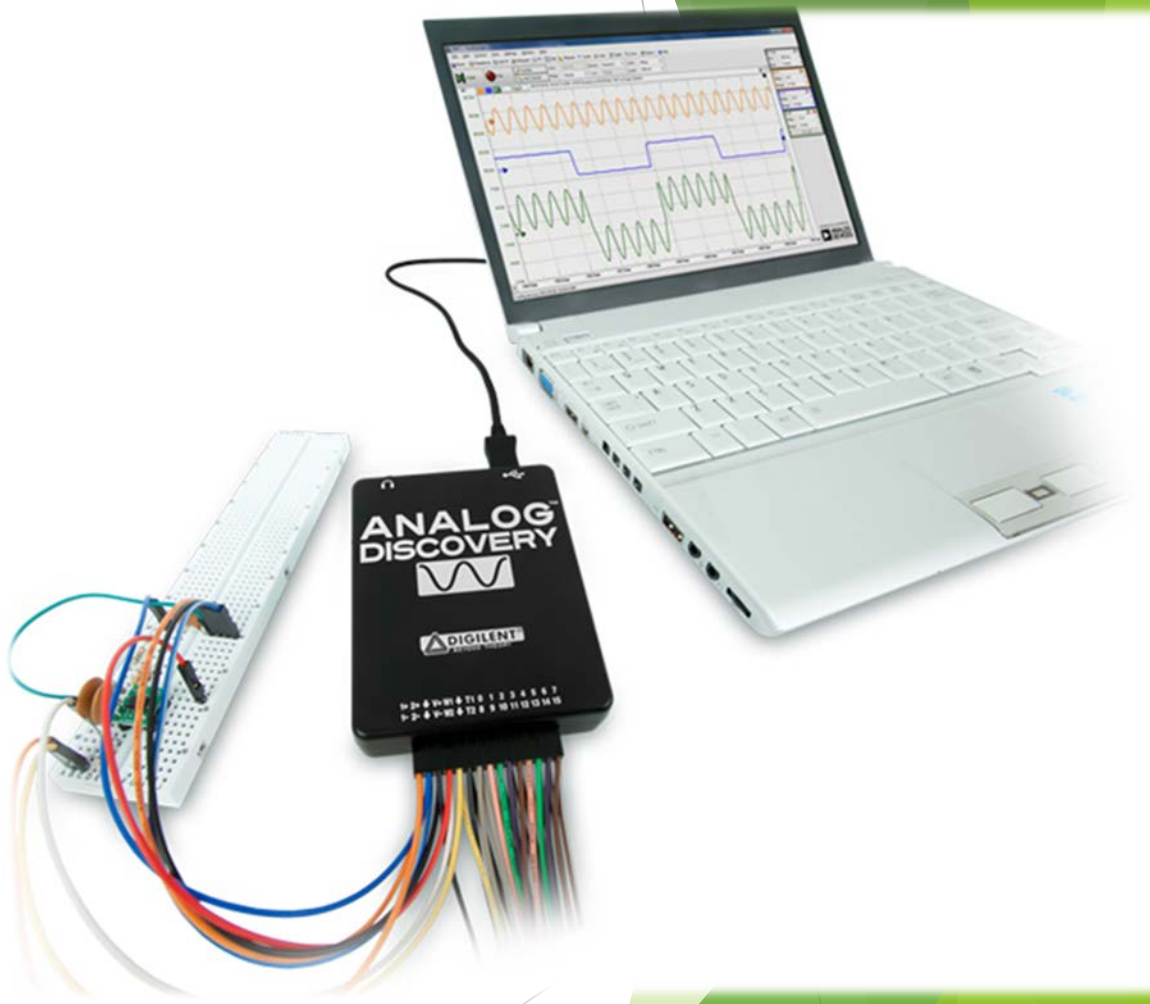
PICDEM 2 Plus



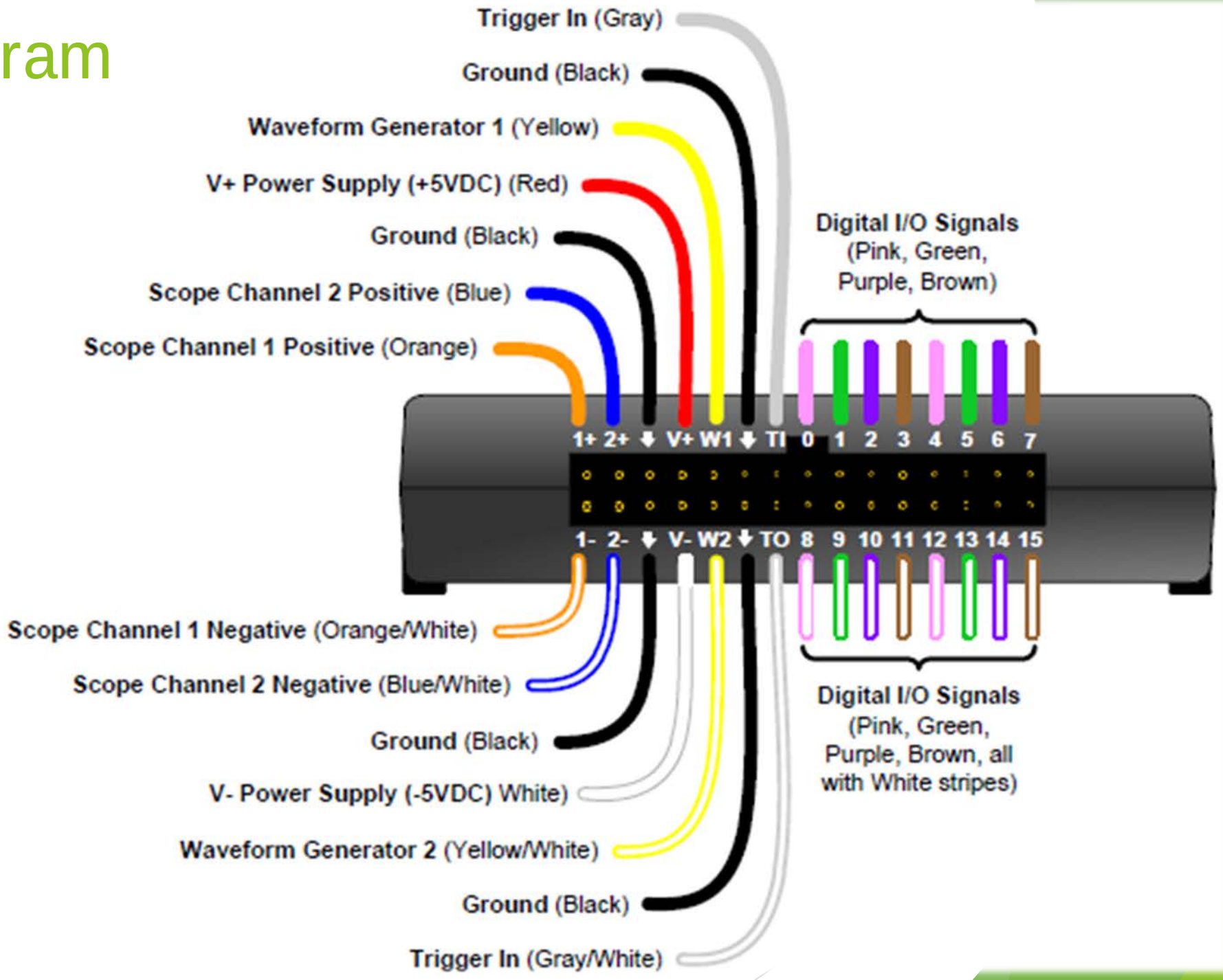


Analog Discovery (USB Oscilloscope)

- 2-Channel Oscilloscope
- 2-Channel Waveform Generator
- 16-Channel Logic Analyzer
- 16-Channel Digital Pattern Generator
- ±5VDC Power Supplies
- Spectrum Analyzer
- Network Analyzer
- Voltmeter
- Digital I/O
- Supported by MATLAB / MATLAB student edition



Pin Diagram


Trigger In (Gray)
Ground (Black)
Waveform Generator 1 (Yellow)
V+ Power Supply (+5VDC) (Red)
Ground (Black)
Scope Channel 2 Positive (Blue)
Scope Channel 1 Positive (Orange)
Digital I/O Signals (Pink, Green, Purple, Brown)
1+ 2+ V+ W1 TI 0 1 2 3 4 5 6 7
1- 2- V- W2 TO 8 9 10 11 12 13 14 15
Scope Channel 1 Negative (Orange/White)
Scope Channel 2 Negative (Blue/White)
Ground (Black)
V- Power Supply (-5VDC) White)
Waveform Generator 2 (Yellow/White)
Ground (Black)
Trigger In (Gray/White)
Digital I/O Signals (Pink, Green, Purple, Brown, all with White stripes)

Assignment for today

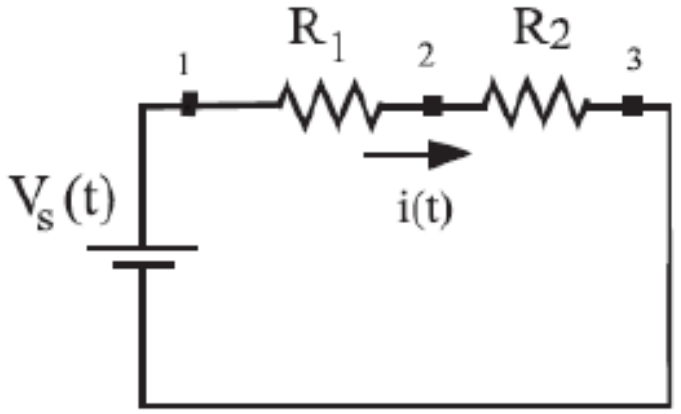
- Watch 5 YouTube videos on the operation of the Digilent scope. (45 min. duration)
  - Directory created for you C:ME475_2017. Open the Word file ***Analog Discovery Lab Intro***
- Perform the experiments suggested in the videos.
- Complete Question 6 from the Mechatronics Lab Manual posted on the ME475 website.

Question 6 [Marks: 25]. Use part of the time set for Lab Session 1 to complete the following experiments (Before the experiments, students should familiarize themselves with the tools and components used in building and debugging electronic circuits by reading Mechatronics Lab Manual, Sabri Cetinkunt, which is posted in the ME475 website).

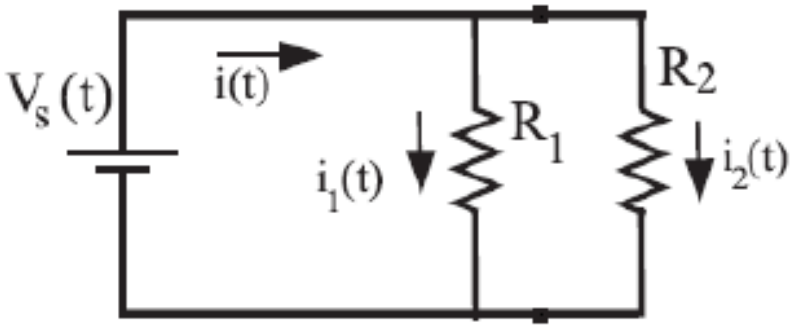
(1) Design and build a voltage divider circuit shown in the following figure (a) and confirm the Kirchoff's voltage law.

(2) Design and build a current divider circuit shown in the following figure (b) and confirm the Kirchoff's current law.

(3) Measure the values of $V_s(t)$, R_1 and R_2 in these two circuits, and then use them to calculate the voltage drops V_{12} and V_{23} in Circuit (a) and $i_1(t)$ and $i_2(t)$ in Circuit (b), respectively. Compare the calculated values with the measured values.



(a)



(b)

Thanks