Microcontroller Architecture PIC18F Family

ELEC 330

Digital Systems Engineering

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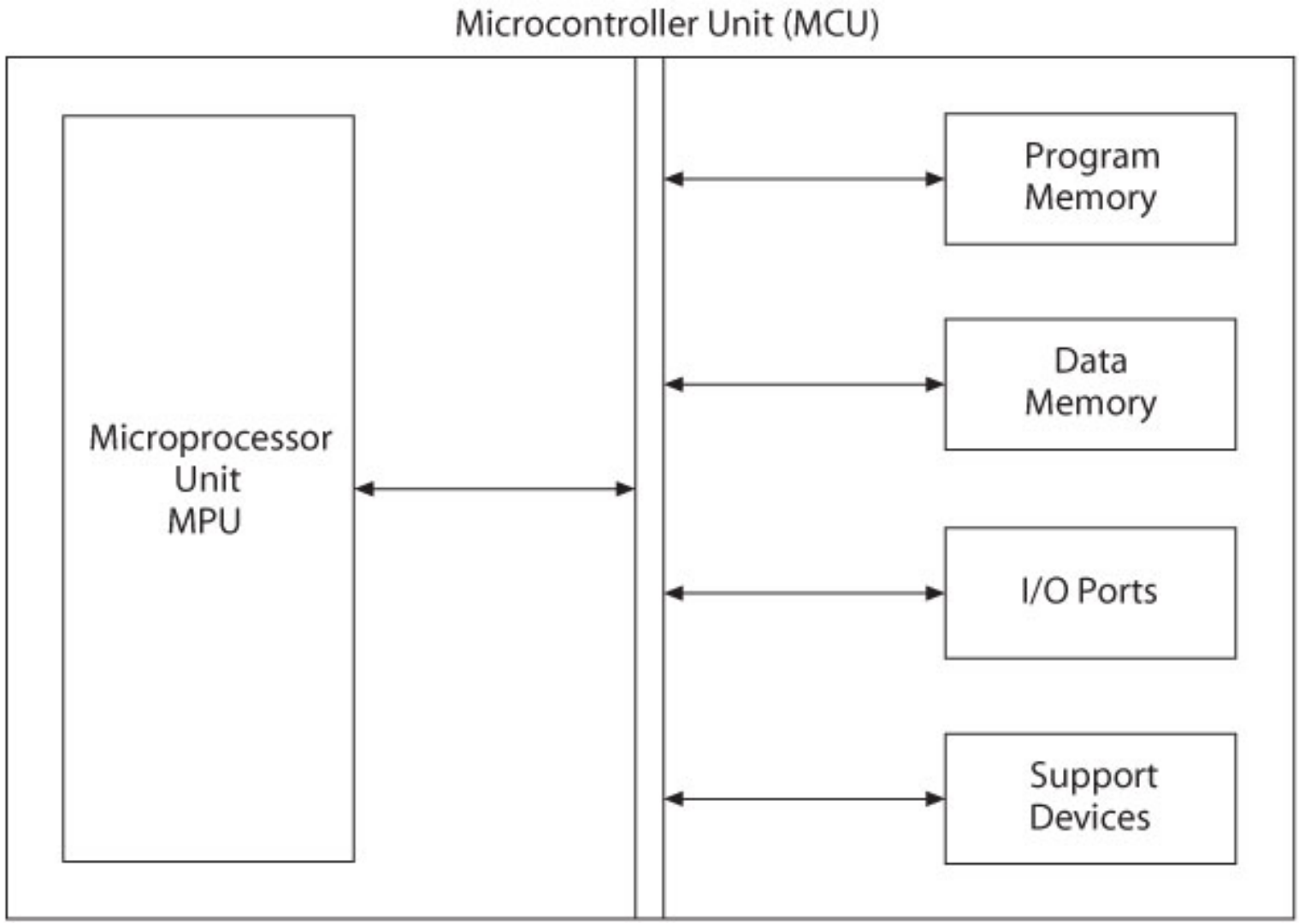
Images Courtesy of Ramesh Gaonkar and Delmar Learning

THE CITADEL
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

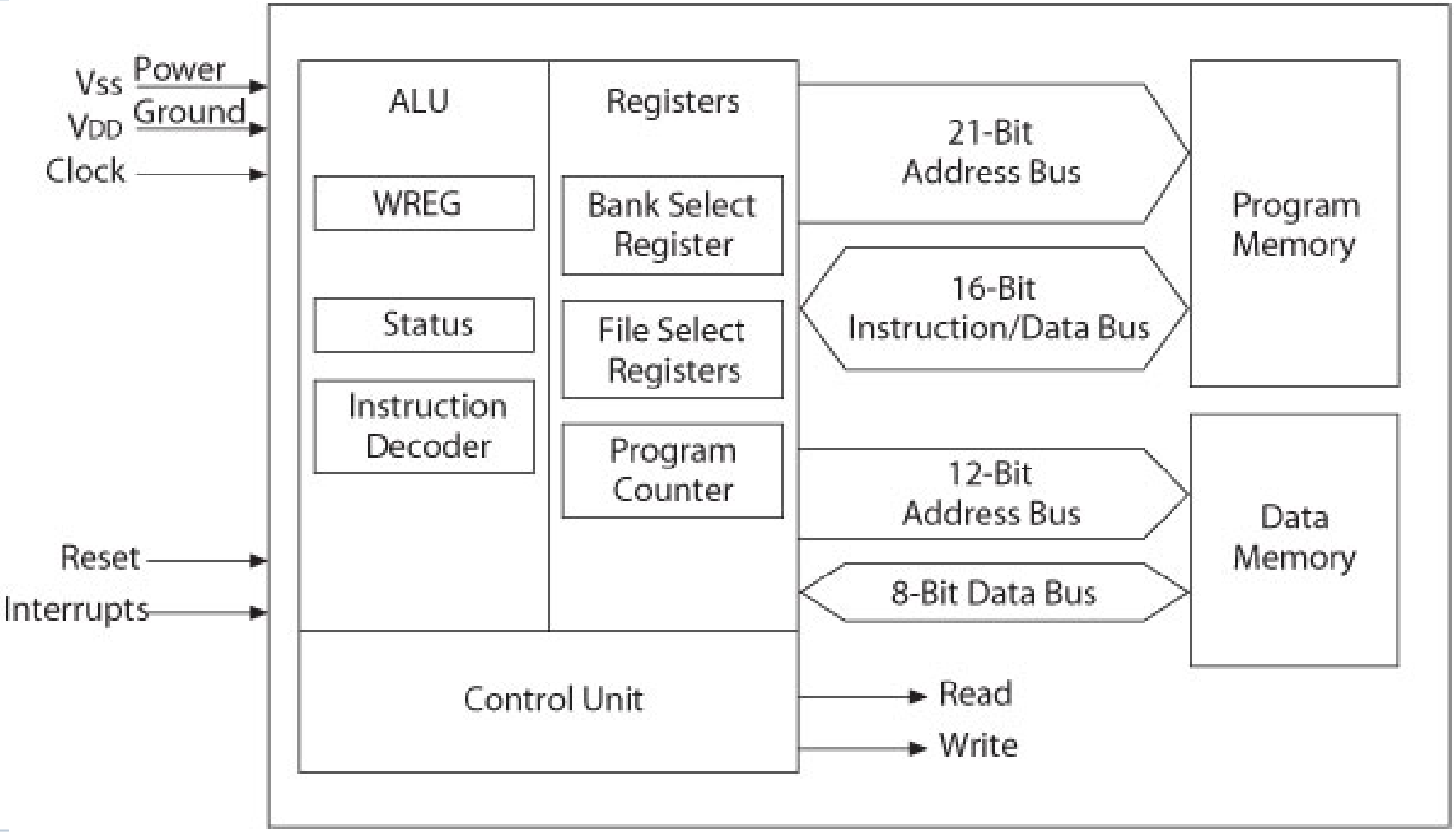
PIC18F Microcontrollers

- Microcontroller Unit (MCU)
  - Microprocessor unit (MPU)
  - Harvard Architecture
    - Program memory for instructions
    - Data memory for data
  - I/O ports
  - Support devices such as timers

Microcontroller Unit



PIC18F – MPU and Memory



Microprocessor Unit

- Includes Arithmetic Logic Unit (ALU), Registers, and Control Unit
  - Arithmetic Logic Unit (ALU)
    - Instruction decoder
      - 16-bit instructions
    - Status register that stores flags
      - 5-bits
    - WREG – working register
      - 8-bit accumulator

Microprocessor Unit

- Registers
  - Program Counter (PC)
    - 21-bit register that holds the Program Memory address
  - Bank Select Register (BSR)
    - 4-bit register used in direct addressing the Data Memory
  - File Select Registers (FSRs)
    - 12-bit registers used as memory pointers in indirect addressing Data Memory
- Control unit
  - Provides timing and control signals
    - Read and Write operations

PIC18F - Address Buses

- Address bus
  - 21-bit address bus for Program Memory
    - Addressing capacity: 2 MB
  - 12-bit address bus for Data Memory
    - Addressing capacity: 4 KB

Data Bus and Control Signals

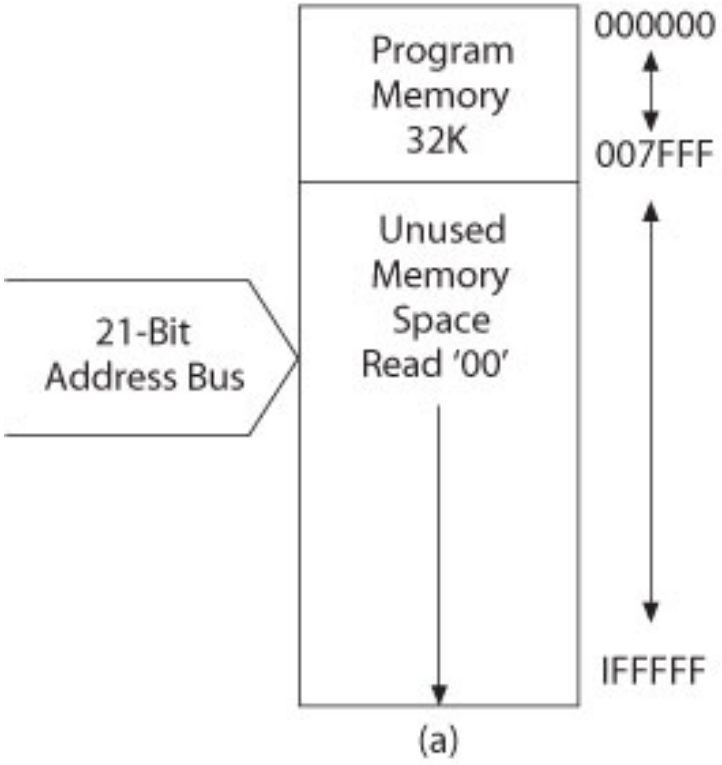
- Data bus
  - 16-bit instruction/data bus for Program Memory
  - 8-bit data bus for Data Memory
- Control signals
  - Read and Write

PIC18F452/4520 Memory

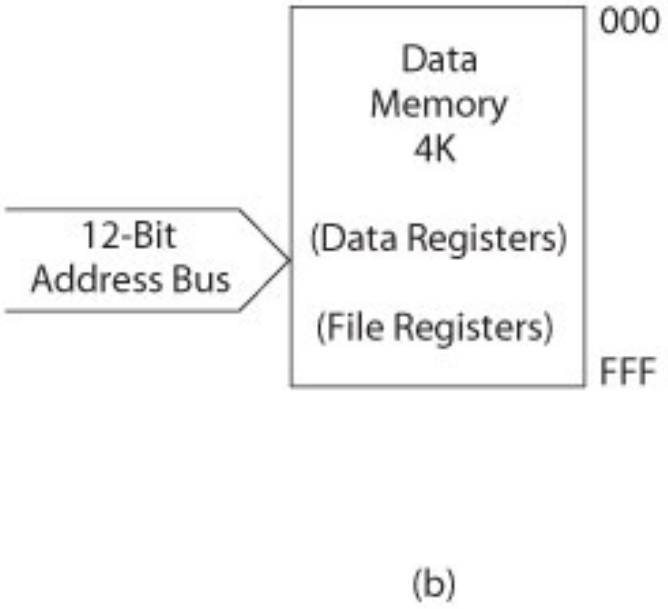
- Program Memory: 32 K
  - Address range: 000000 to $007FFF_H$
- Data Memory: 4 K
  - Address range: 000 to FFF_H
- Data EEPROM
  - Not part of the data memory space
  - Addressed through special function registers

PIC18F452/4520 Memory

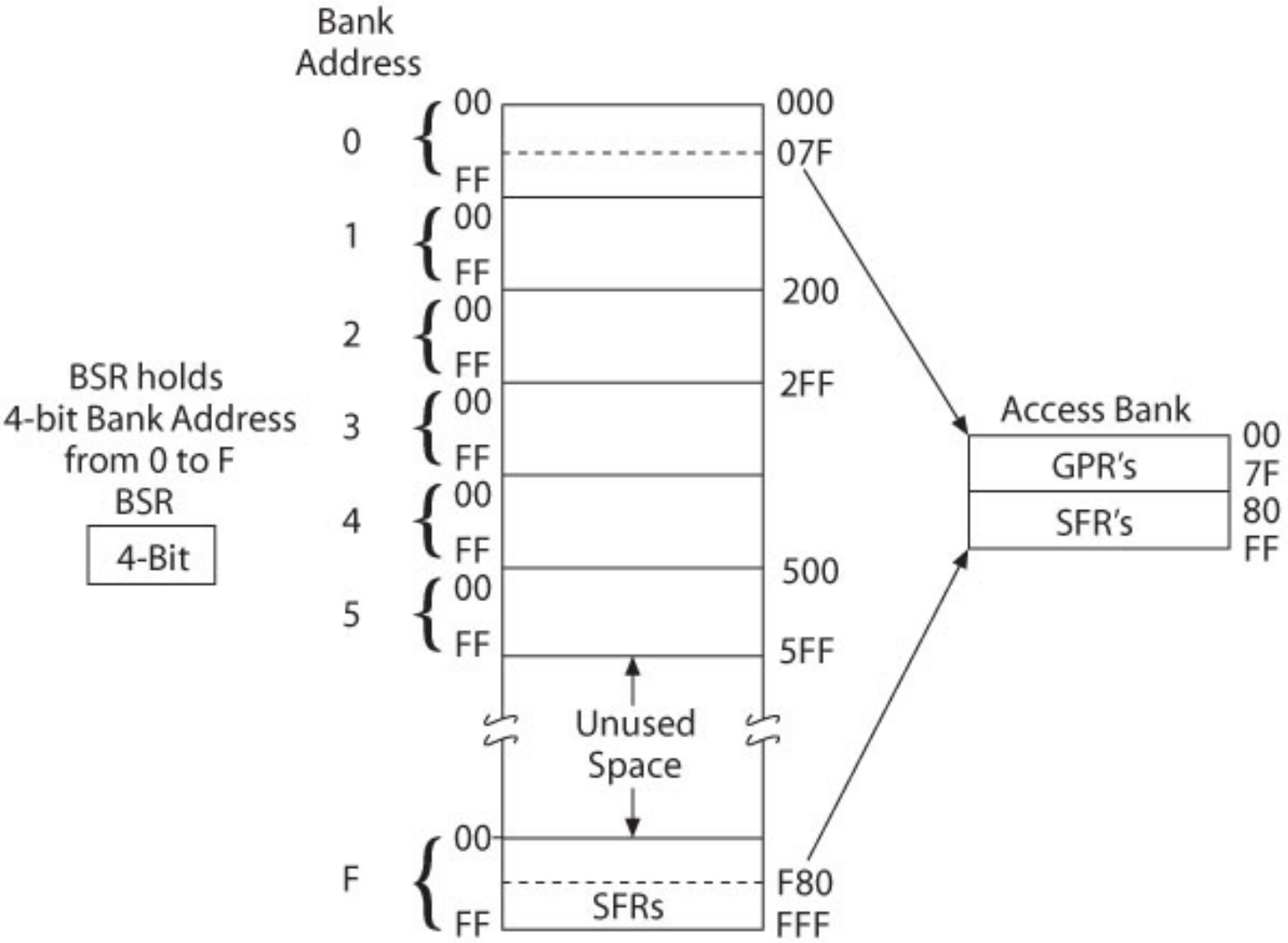
- Program Memory



- Data Memory



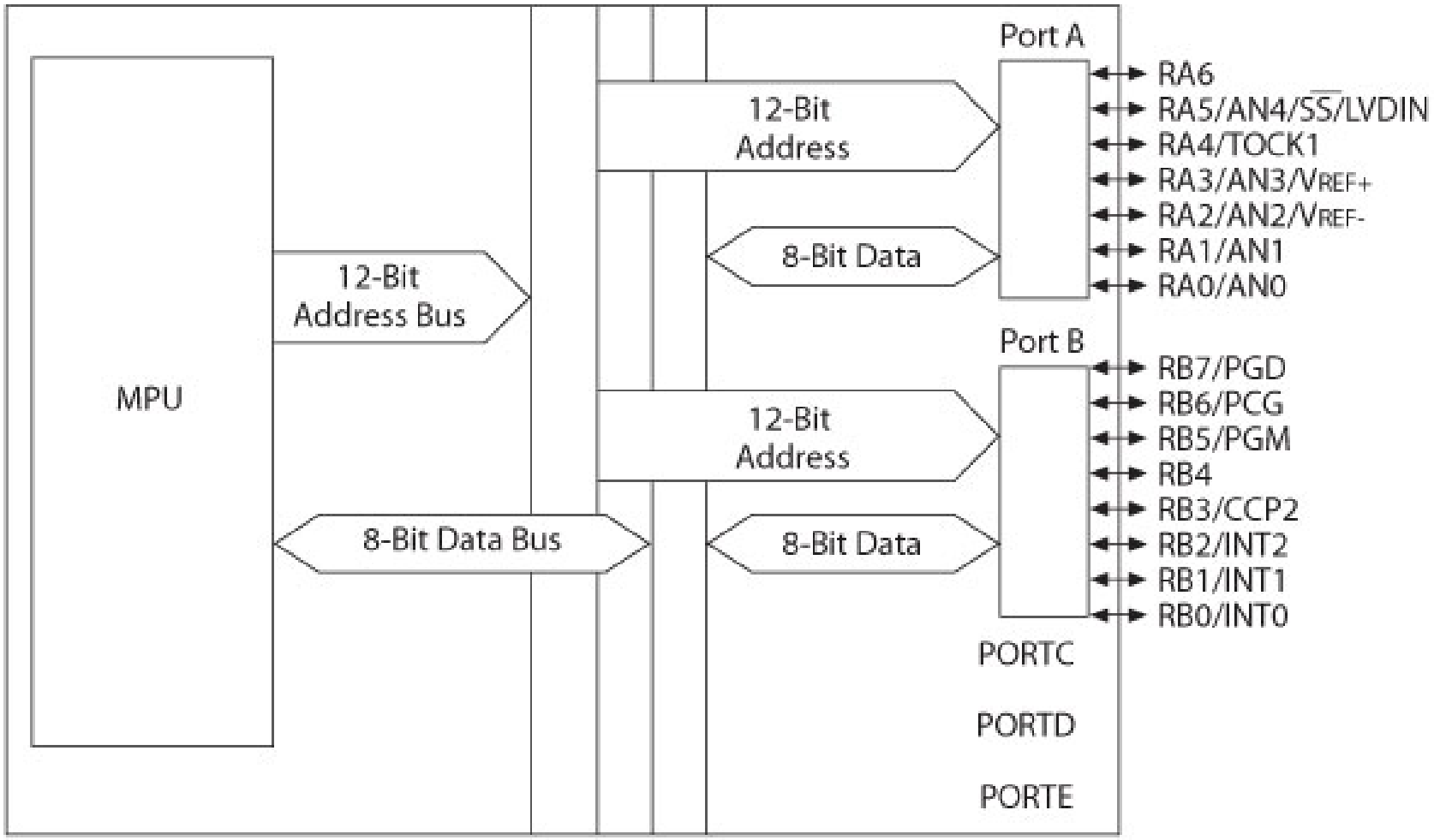
Data Memory Banks



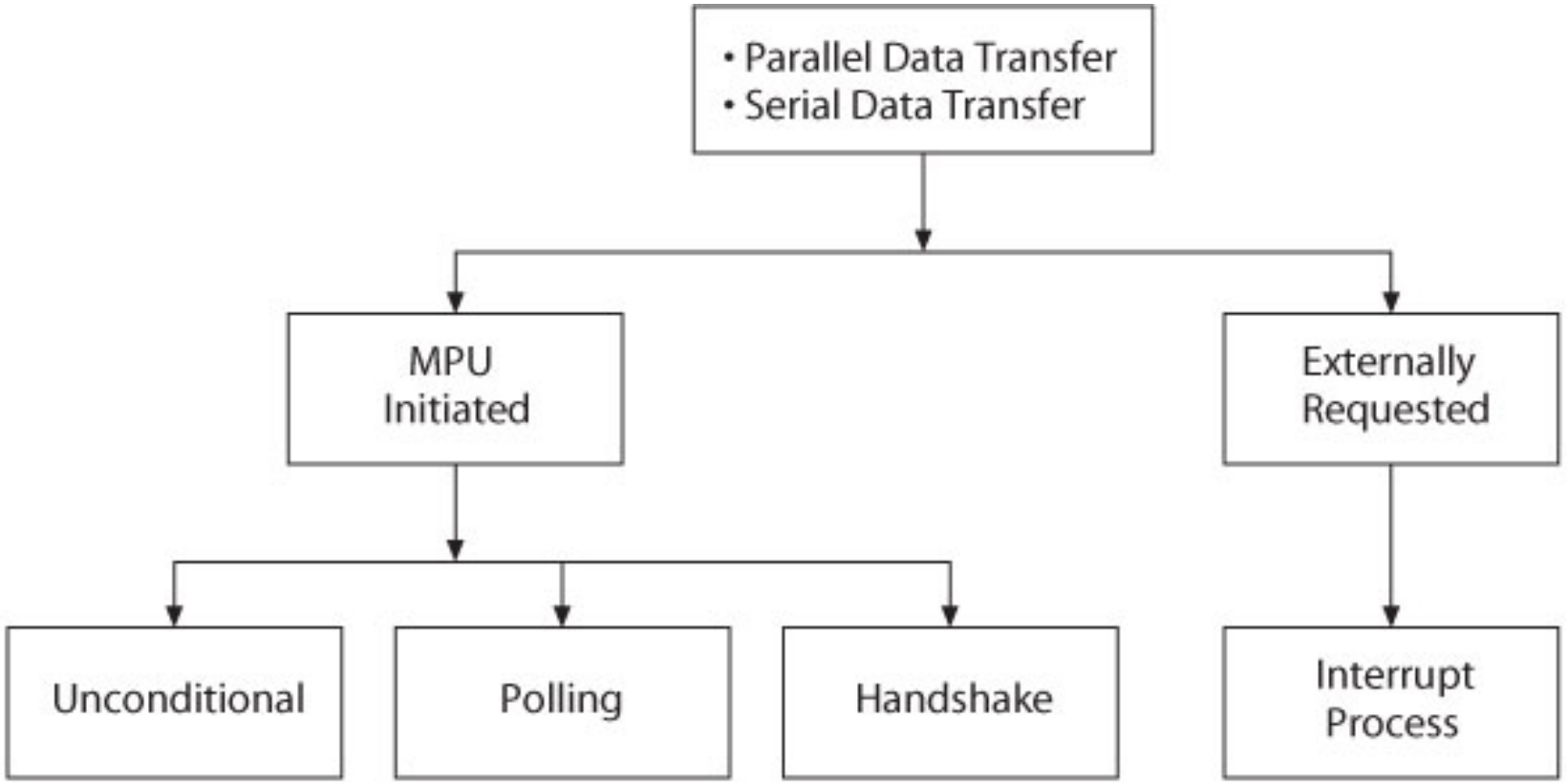
PIC18F452 I/O Ports

- Five I/O ports
  - PORT A through PORT E
  - Most I/O pins are multiplexed
  - Generally have eight I/O pins
  - Addresses already assigned to these ports
  - Each port is identified by its assigned SFR

I/O Ports A and B



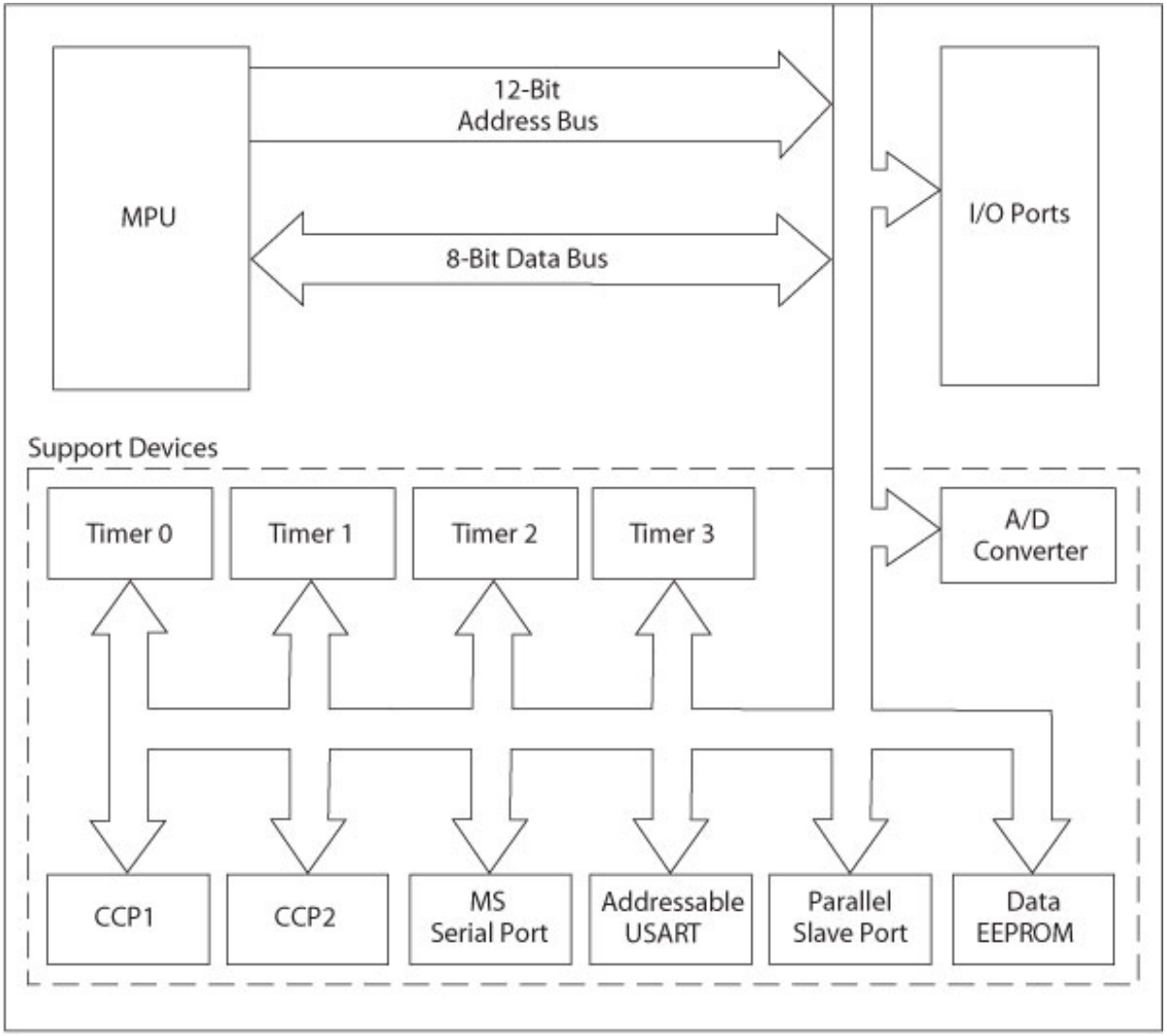
Data Transfer



MCU Support Devices

- Timers
  - Capture, Compare and PWM (CCP Modules)
- Serial Communications
  - Master Synchronous Serial Port (MSSP)
  - Addressable USART
- A/D converter
- Parallel Slave Port (PSP)
- Data EEPROM

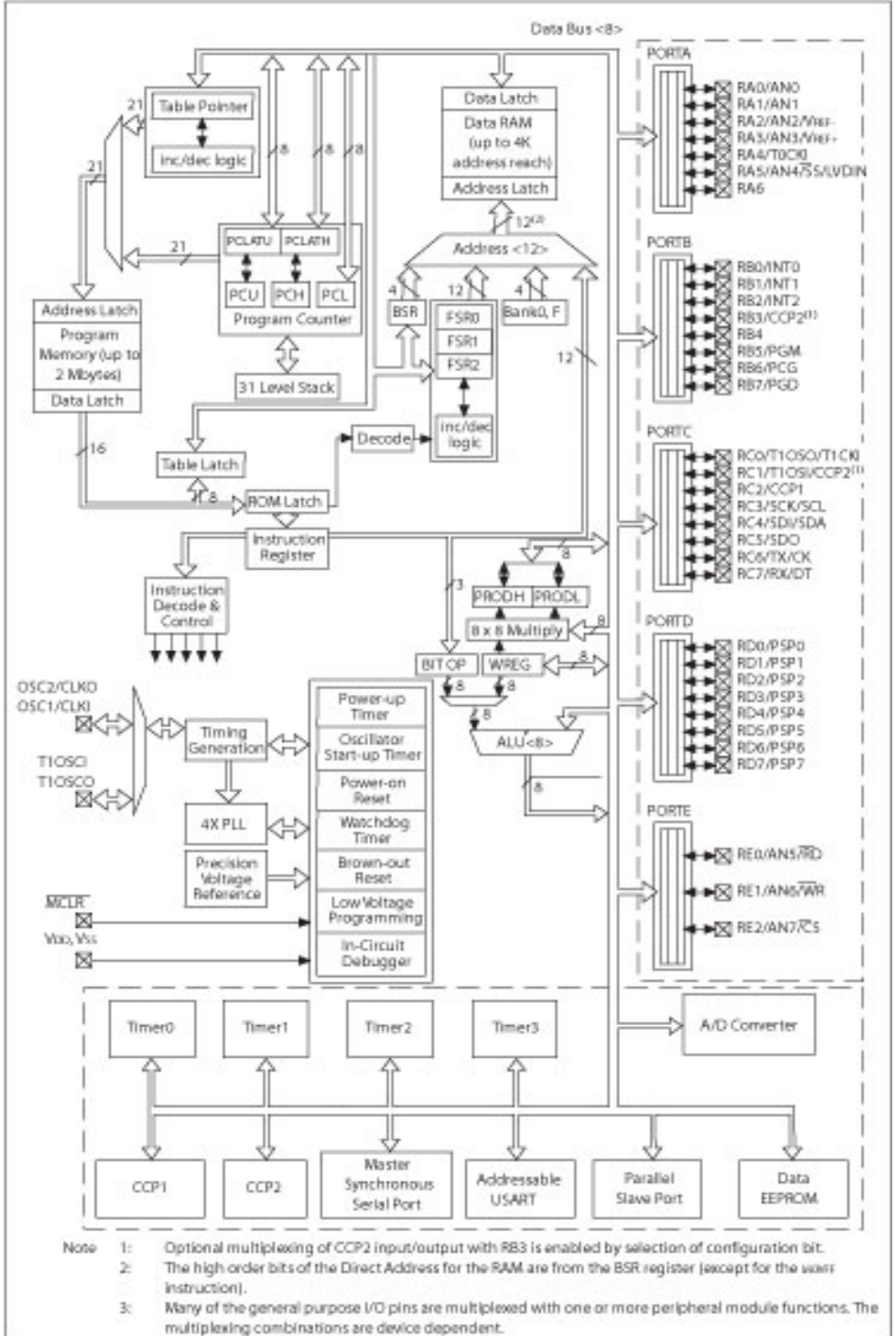
MCU Support Devices



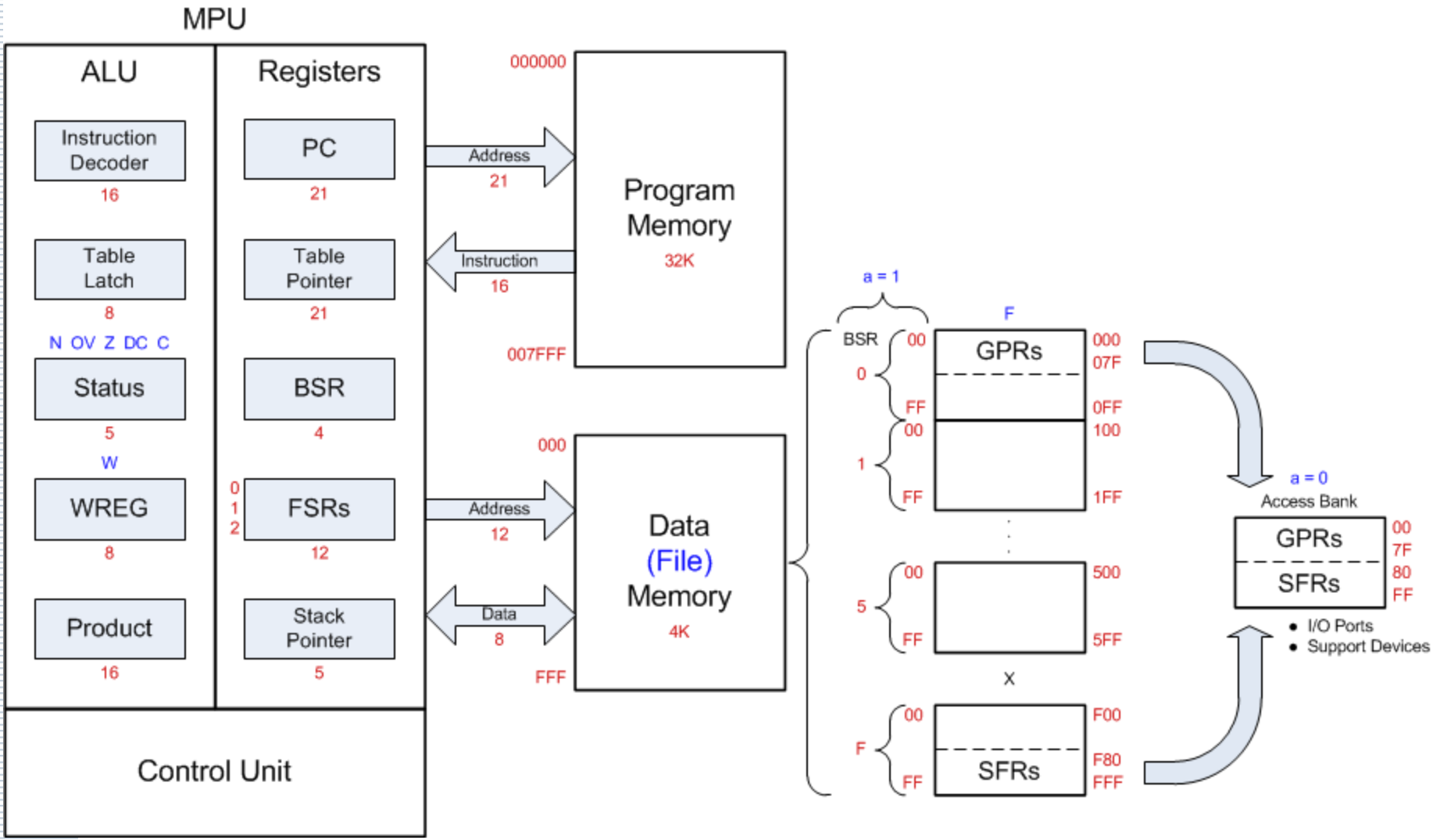
PIC18F Special Features

- Sleep mode
- Watchdog timer (WDT)
- Code protection
- In-circuit serial programming
- In-circuit debugger

- PIC18F4X2 Architecture Block Diagram



PIC18F452 Programming Model



List of Selected Microcontroller Families from Microchip

Part No.	Program OTP/Flash	EE PROM	RAM	Total Pins	I/O Pins	Analog ADC	Analog Comp.	Digital Timers/ WDT	Digital Serial I/O	CCP/ ECCP	Max Speed MHz	Instruc-tion Size	Total Instruc-tions
10F200	256x12 Flash		16	8	4			1-8 bit, 1-WDT			4	12-bit	33
10F220	256x12 Flash		16	8	4	2x8-bit		1-8 bit, 1-WDT			8	12-bit	33
12F510	1536x12 Flash		38	8	6	3x8-bit	1	1-8 bit 1-WDT			8	12-bit	33
16F506	1536x12 Flash		67	14	12	3x8-bit	2	1-8 bit 1-WDT			20	12-bit	33
16C55A	768x12 OTP		24	28	20			1-8 bit 1-WDT			40	12-bit	33
16CR58B	3072x12 ROM		73	18	12			1-8 bit 1-WDT			20	12-bit	33
12F683	2048x14 Flash	256	128	8	6	4x10-bit	1	1-16 bit, 2-8 bit, 1-WDT			20	14-bit	35
16F687	2048x14 Flash	256	128	20	18	12x10-bit	2	1-16 bit, 1-8 bit, 1-WDT	EU/I^{2}C/ SPI		20	14-bit	35
18F1230	2048x16 Enh Flash	128	256	18-28	16	4x10-bit	3	2-16 bit 1-WDT	EU		40	16-bit	77
18F4520	16384x16 Enh Flash	256	1536	40-44	36	13x10-bit	2	1-8 bit, 3-16 bit, 1-WDT	EU/ MI^{2}C /SPI	1/1	40	16-bit	77
18F6527	24576x16 Enh Flash	1024	3936	64	54	12x10-bit	2	2-8 bit, 3-16 bit, 1-WDT	2EU/ 2 - MI^{2}C /SPI	2/3	40	16-bit	77
18F8622	32768x16 Enh Flash	1024	3936	80	70	16x10-bit	2	2-8 bit, 3-16 bit, 1-WDT	2EU/ 2 - MI^{2}C /SPI	2/3	40	16-bit	77
18F96J60	32768x16 Flash		2048	100	72	16x10-bit	2	2-8 bit, 3-16 bit, 1-WDT	2EU/ 2 - MI^{2}C /SPI	2/3	42	16-bit	77
24FJ128GA-010	65536x16 Flash		8192	100-128	86	16x10-bit	2	5-16 bit, 1-WDT	2 –UART 2-I^{2}C/ SPI	5	32	16-bit	77

Abbreviations: 1) ADC: Analog-Digital Converter, 2) AUSART: Addressable USART, 3) CCP: Capture/Compare/PWM, 4) ECCP: Enhanced CCP, 5) EU: Enhanced USART, 6))Enh Flash: Enhanced Flash, 7) I^{2}C: Inter-integrated Circuit Bus, 8) MI^{2}C/SPI: Master I^{2}C /SPI, 9) OTP: One-Time Programmable, 10) SPI: Serial Peripheral Interface, 11) USART: Universal Synchronous/Asynchronous Receiver/Transmitter, 11) WDT: Watchdog Timer

PIC18F Instructions

- 77 assembly language instructions
  - Earlier PIC families have 33 or 35 instructions
- PIC18F instruction set
  - Most instructions are 16-bit word length
  - Four instructions are 32-bit length

Instruction Descriptions

- Copy (Move) 8-bit number (Literal) into W register
  - Mnemonics: MOVLW 8-bit
  - Binary format:

  0000 1110 XXXX XXXX (any 8-bit number)
- Copy (Move) contents of W register into PORTC (File)
  - Mnemonics: MOVWF PORTC, a
    - ('a' indicates that PORTC is in the Access Bank)
  - Binary format:

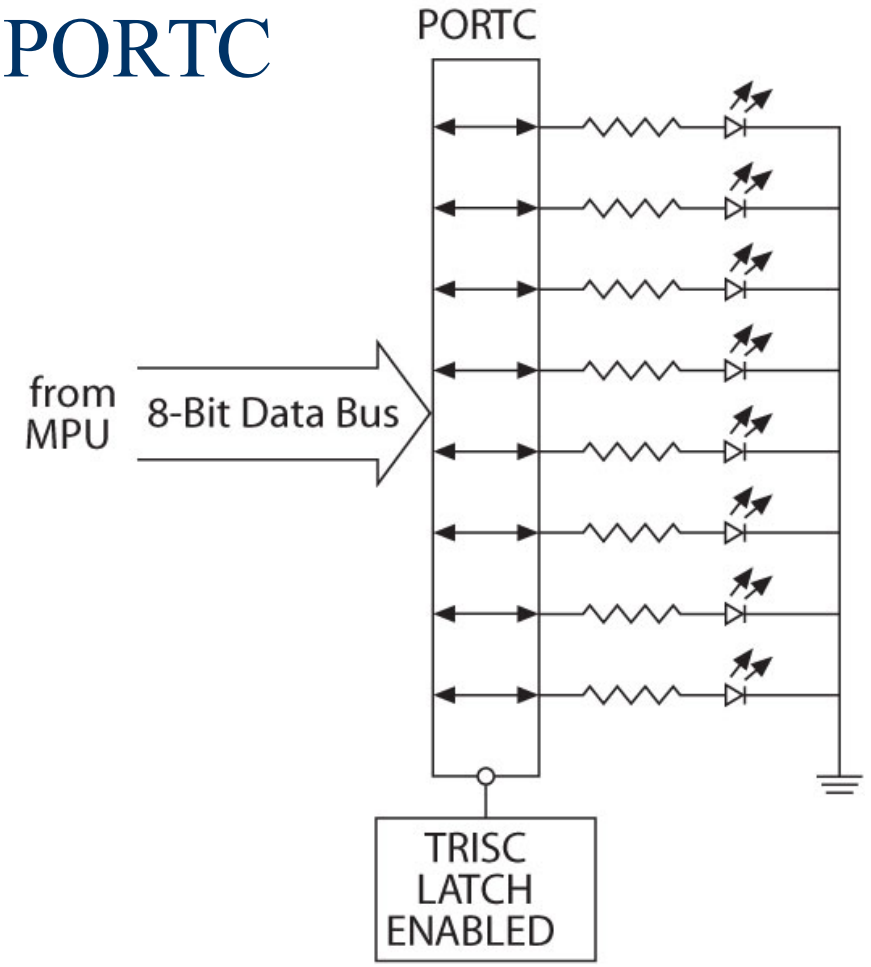
  0110 1110 1000 0010 (82_H is PORTC address)

Illustrative Program

- Problem statement:
  - Write instructions to light up alternate LEDs at PORTC
- Hardware:
  - PORTC
    - Bidirectional (input or output) port
    - Setup as output port for display
  - Logic 1 will turn on an LED

Illustration

- Interfacing LEDs to PORTC



Illustration

- Program (software)
  - Logic 0 to TRISC sets up PORTC as an output port
  - Byte 55_H turns on alternate LEDs

```
MOVLW   00      ;Load W register with 0
MOVWF   TRISC   ;Set up PORTC as output
MOVLW   0x55    ;Byte 55H to turn on LEDS
MOVWF   PORTC   ;Turn on LEDs
SLEEP           ;Power down
```

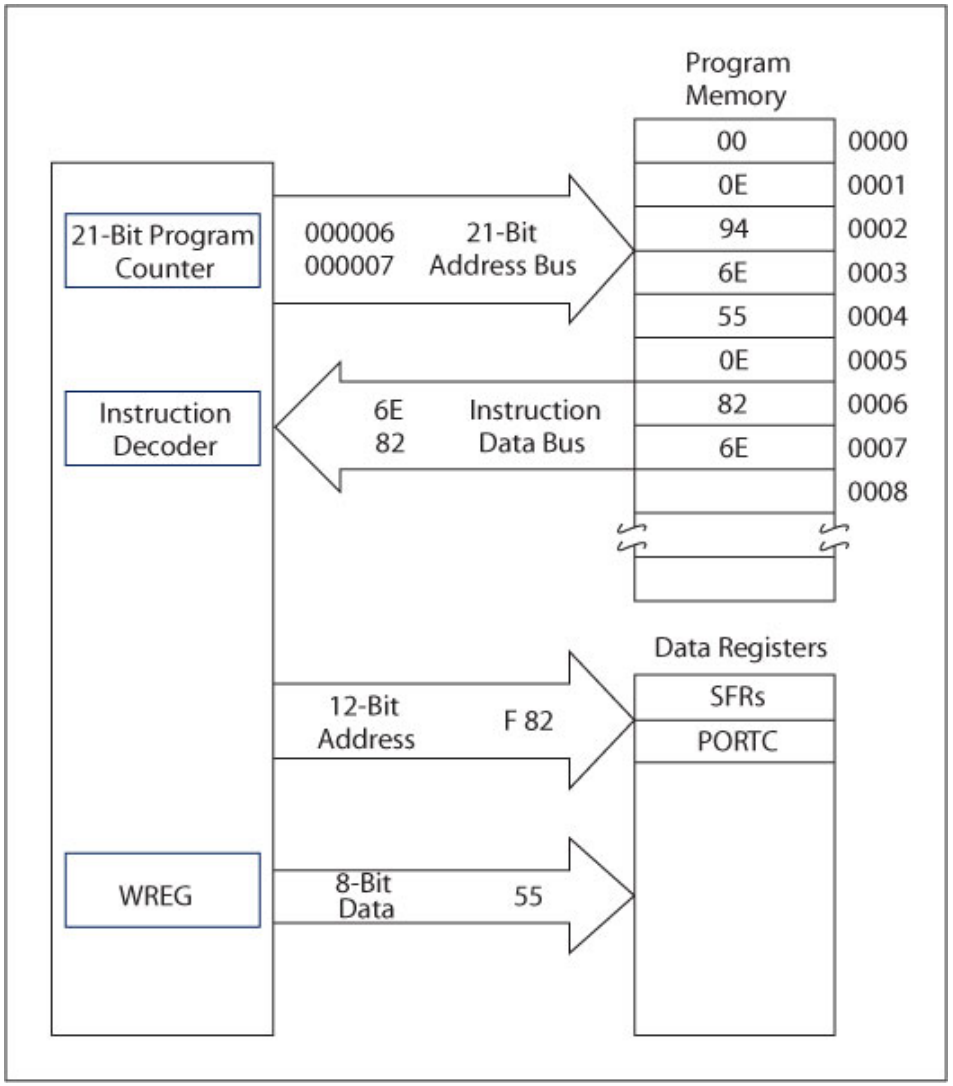
Illustration

Address	Hex	Mnemonics	Comments
000000	0E00	MOVLW 00	;Load W with 0s
000002	6E94	MOVWF TRISC	;Set PORTC as output
000004	0E55	MOVLW 0x55	;Load 55 to turn on LEDs
000006	6E82	MOVWF PORTC	;Turn on LEDs
000008	0003	SLEEP	;Power Down

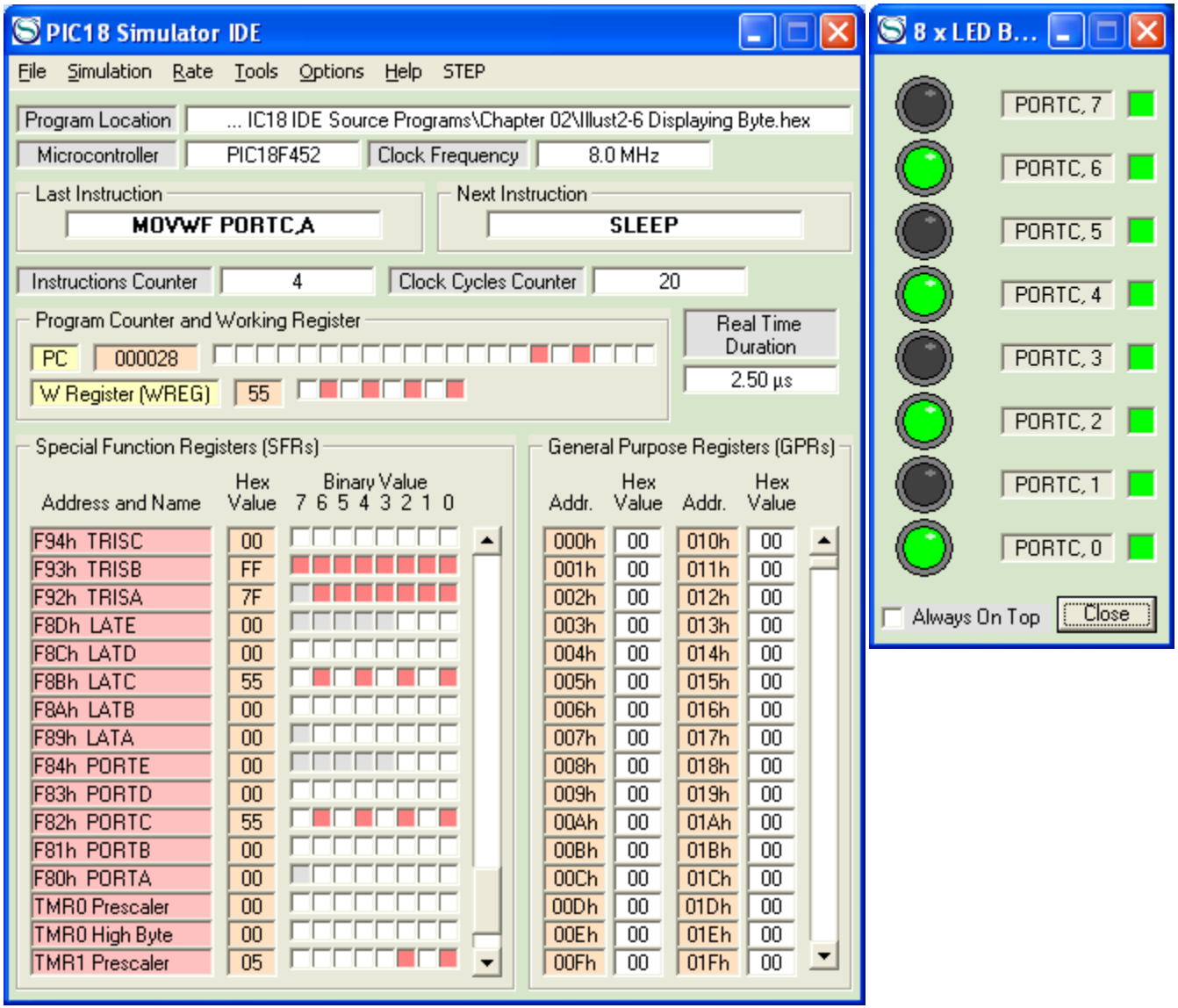
Illustration

- Execution of the instruction:

  MOVWF PORTC



PIC18 Simulator IDE



Embedded System

- MCU-based System