

# Microcontroller Architecture PIC18F Family

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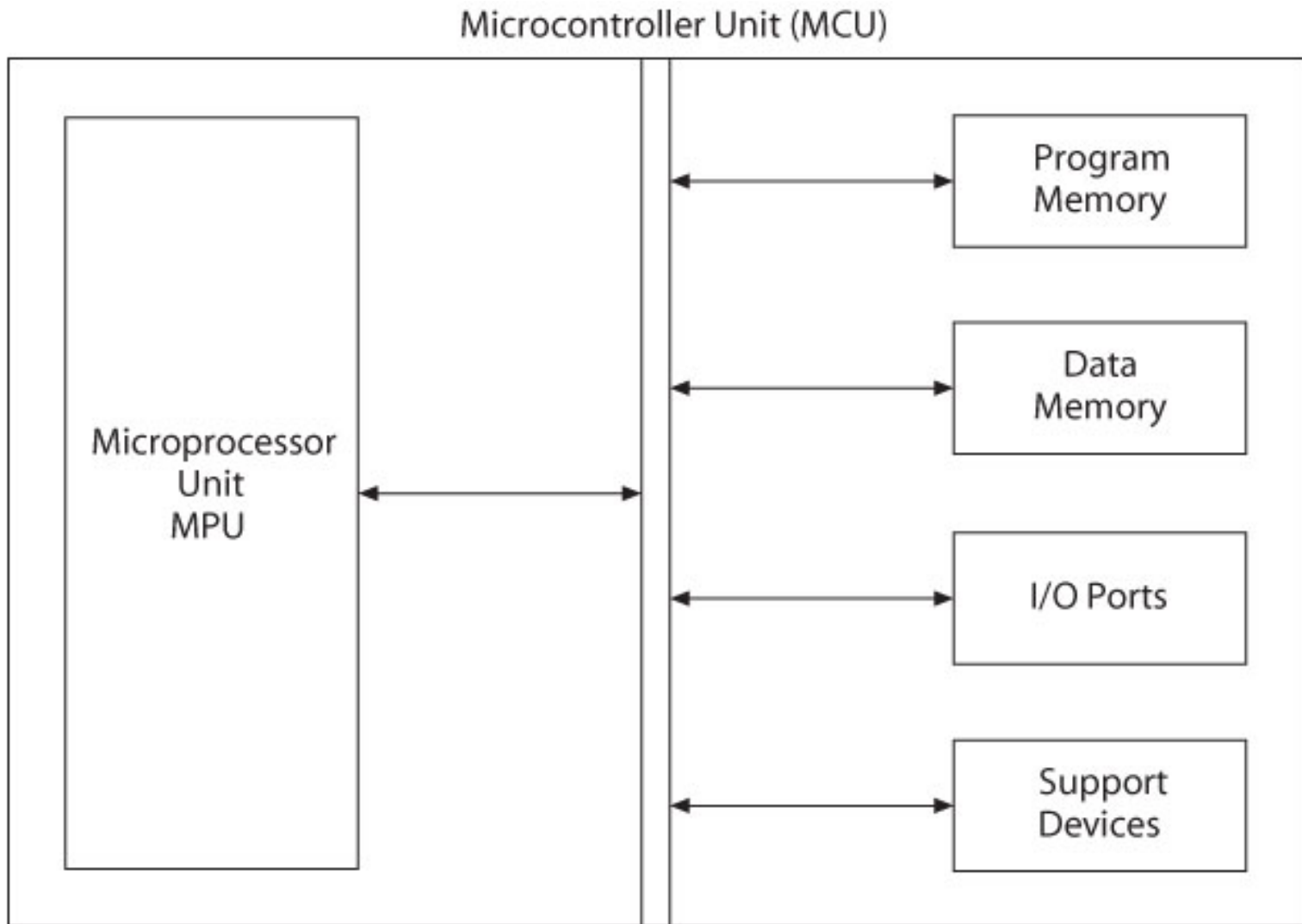
*Images Courtesy of Ramesh Gaonkar and Delmar Learning*



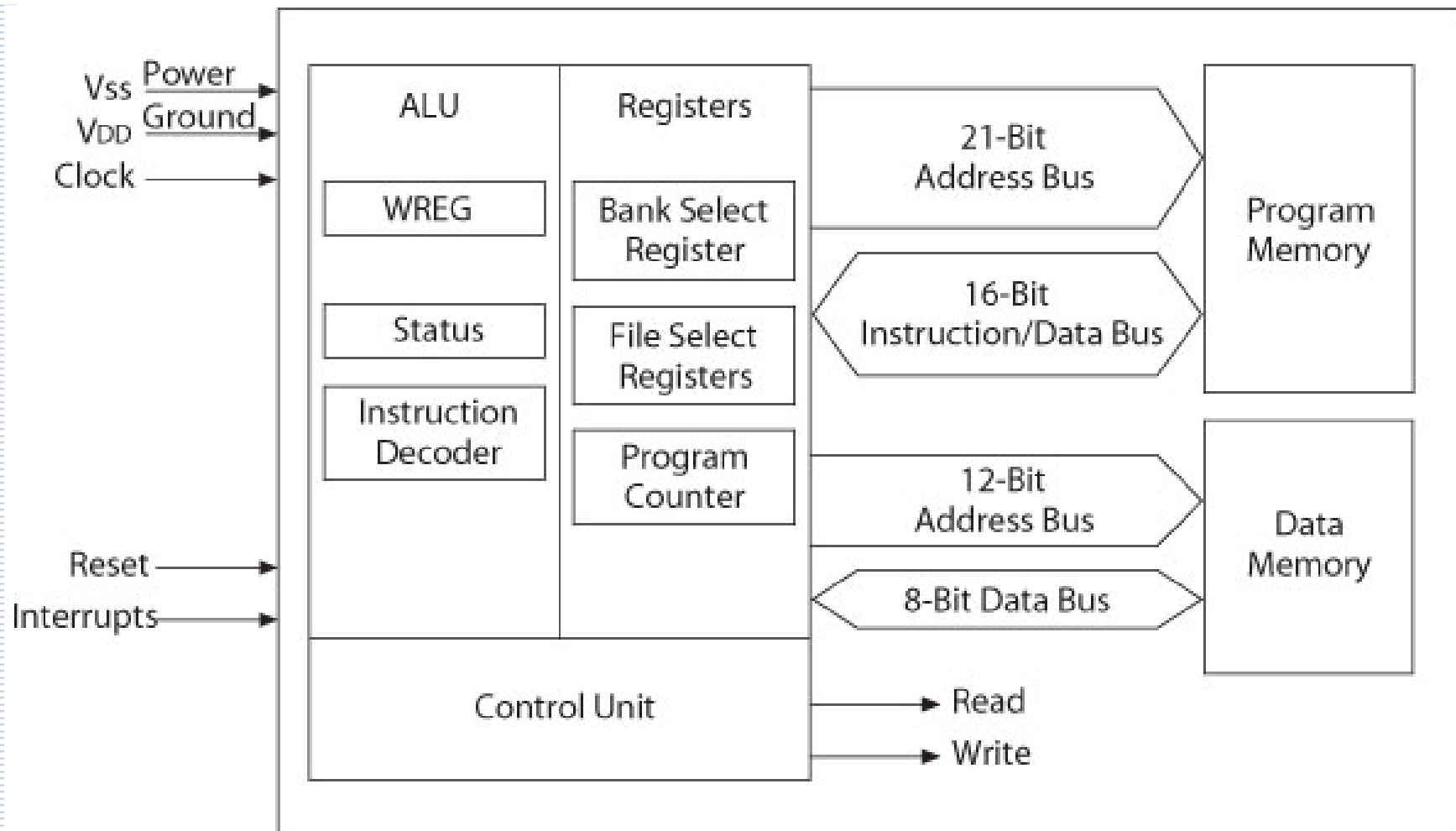
# PIC18F Microcontrollers

- ◆ 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

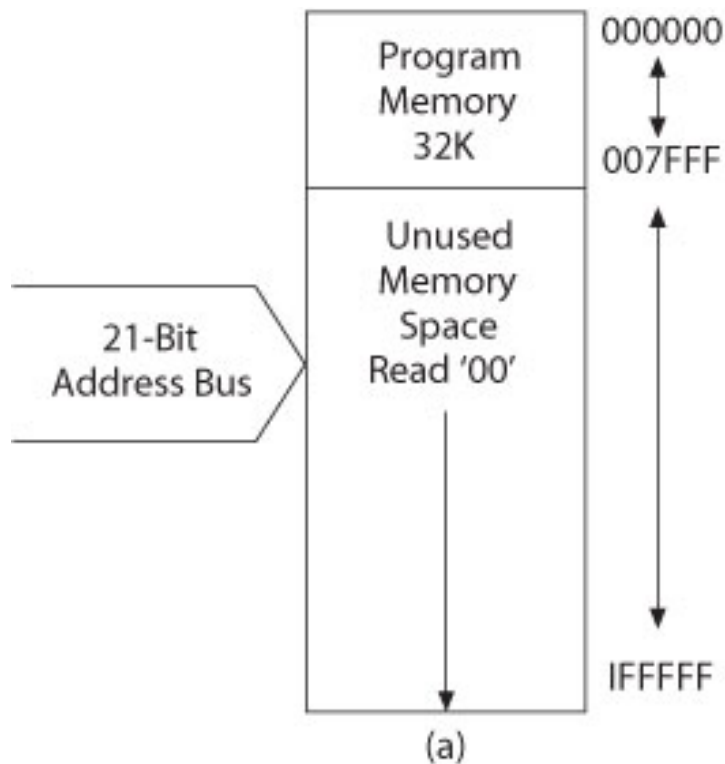


# PIC18F452/4520 Memory

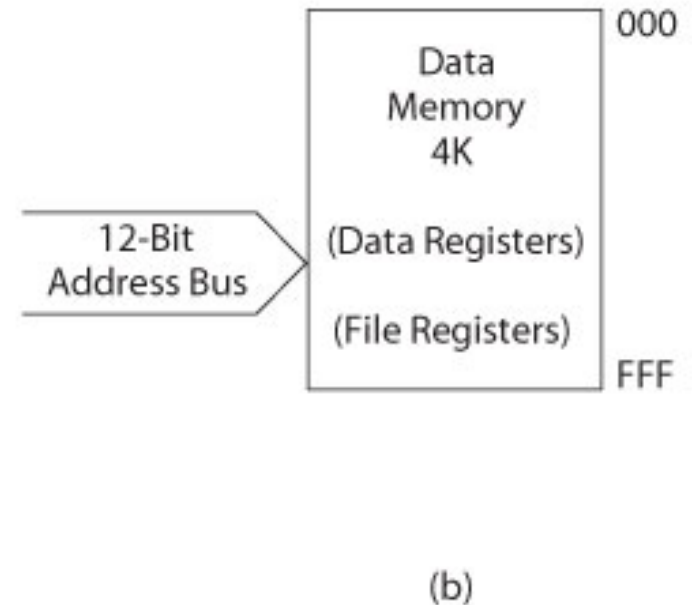
- ◆ Program Memory: 32 K
  - Address range: 000000 to 007FFF<sub>H</sub>
- ◆ Data Memory: 4 K
  - Address range: 000 to FFF<sub>H</sub>
- ◆ Data EEPROM
  - Not part of the data memory space
  - Addressed through special function registers

# PIC18F452/4520 Memory

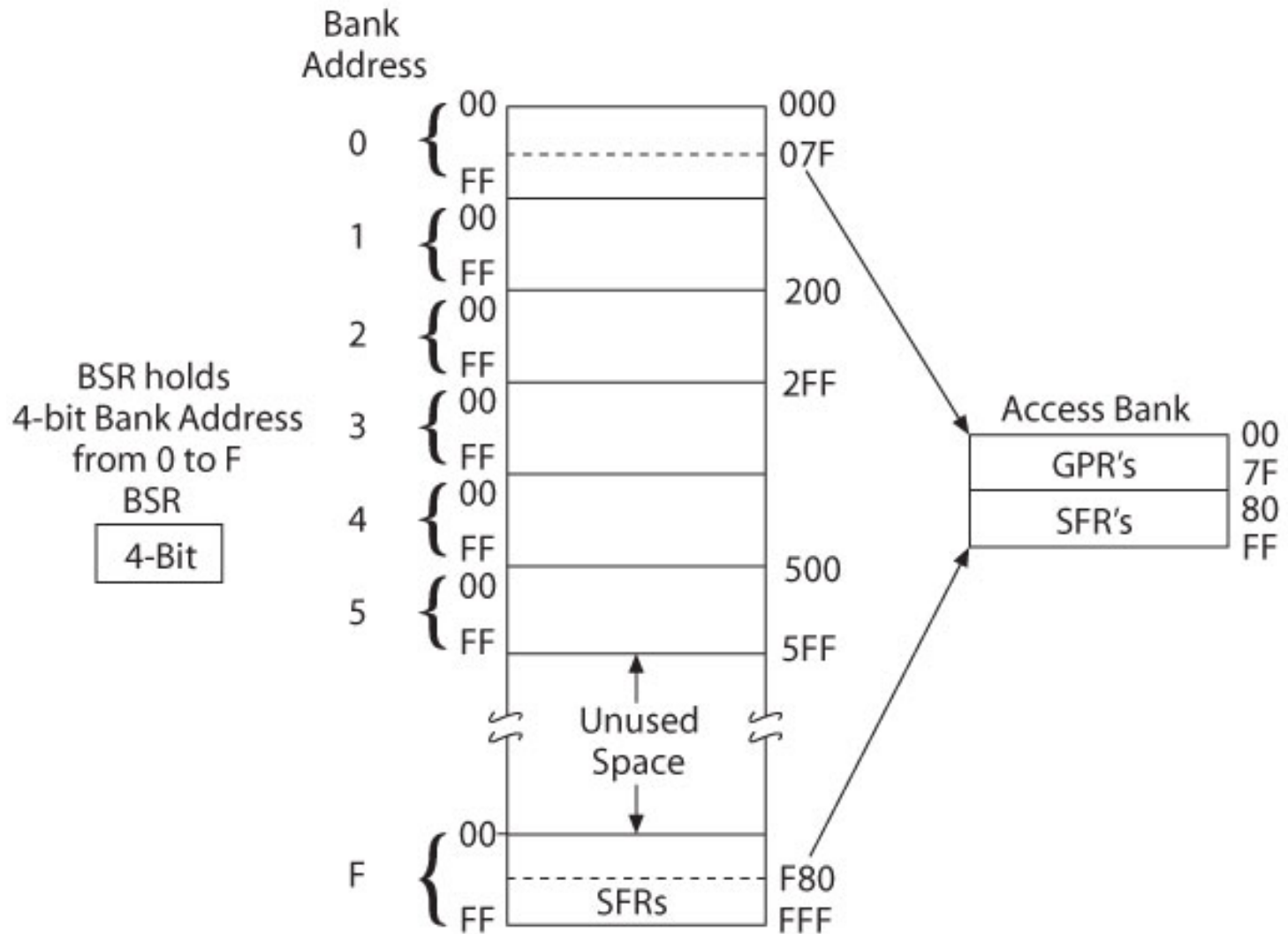
## ◆ Program Memory



## ◆ Data Memory



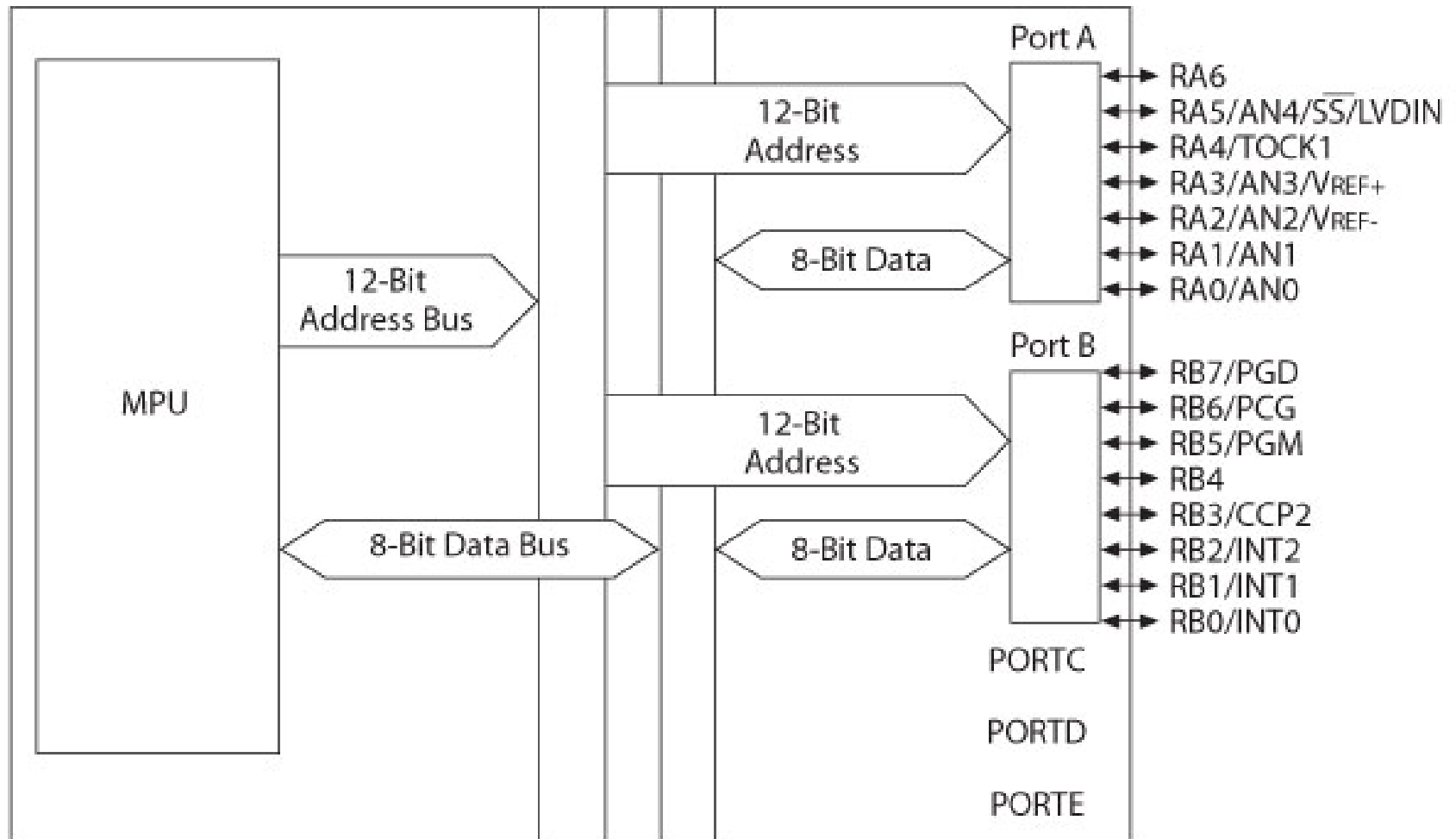
# Data Memory Banks



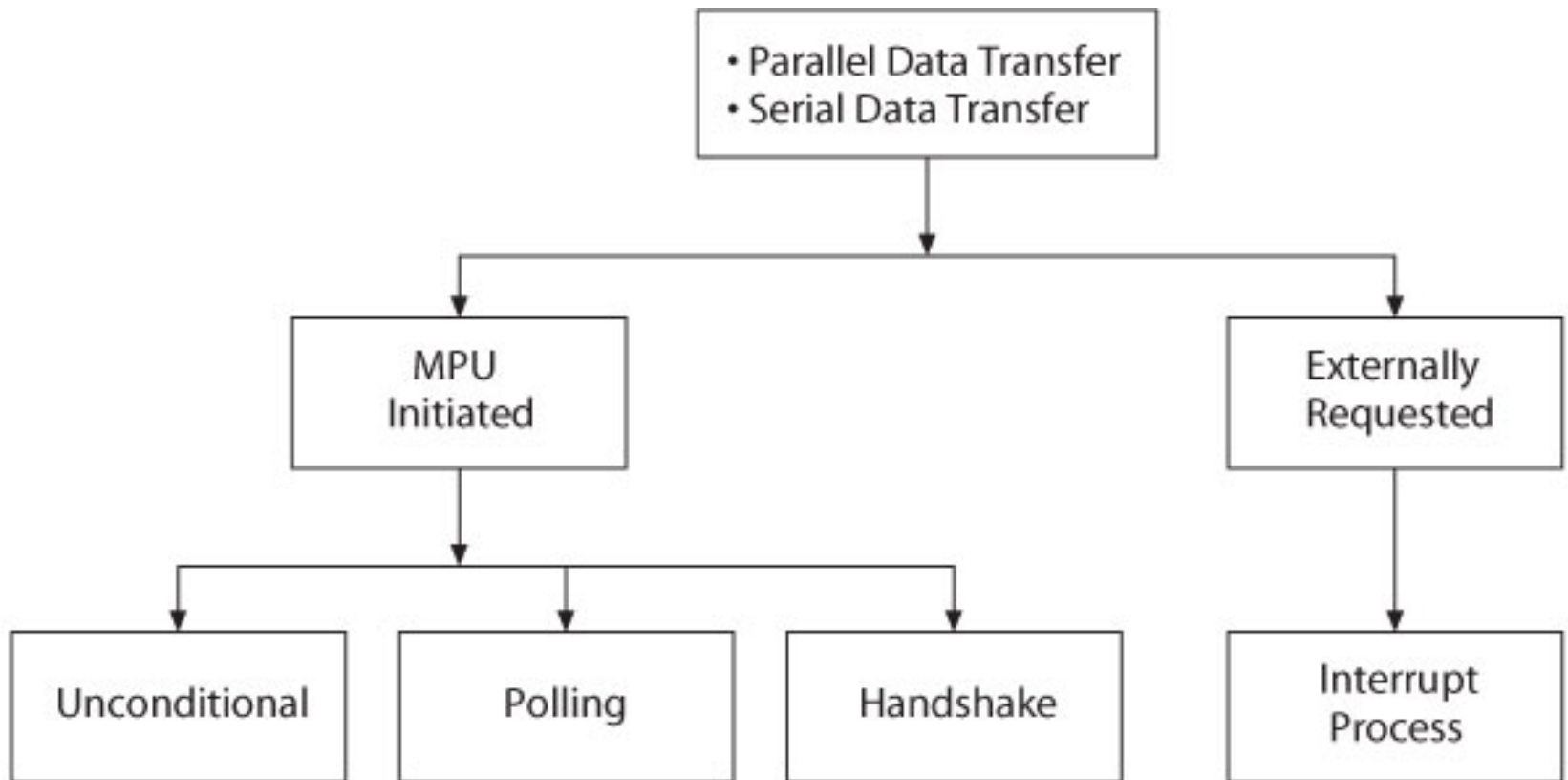
# PIC18F452 I/O Ports

- ◆ 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



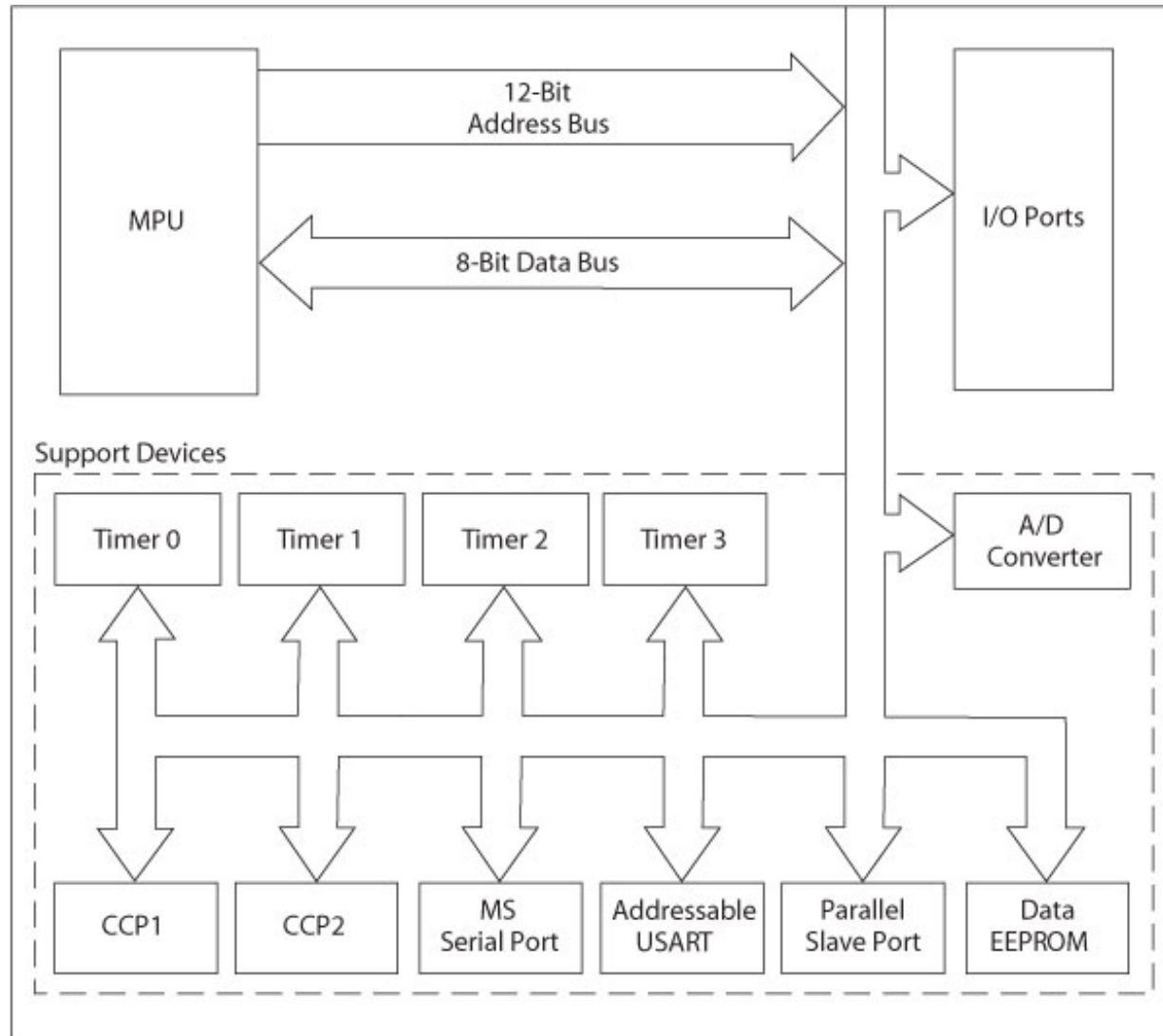
# Data Transfer



# 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

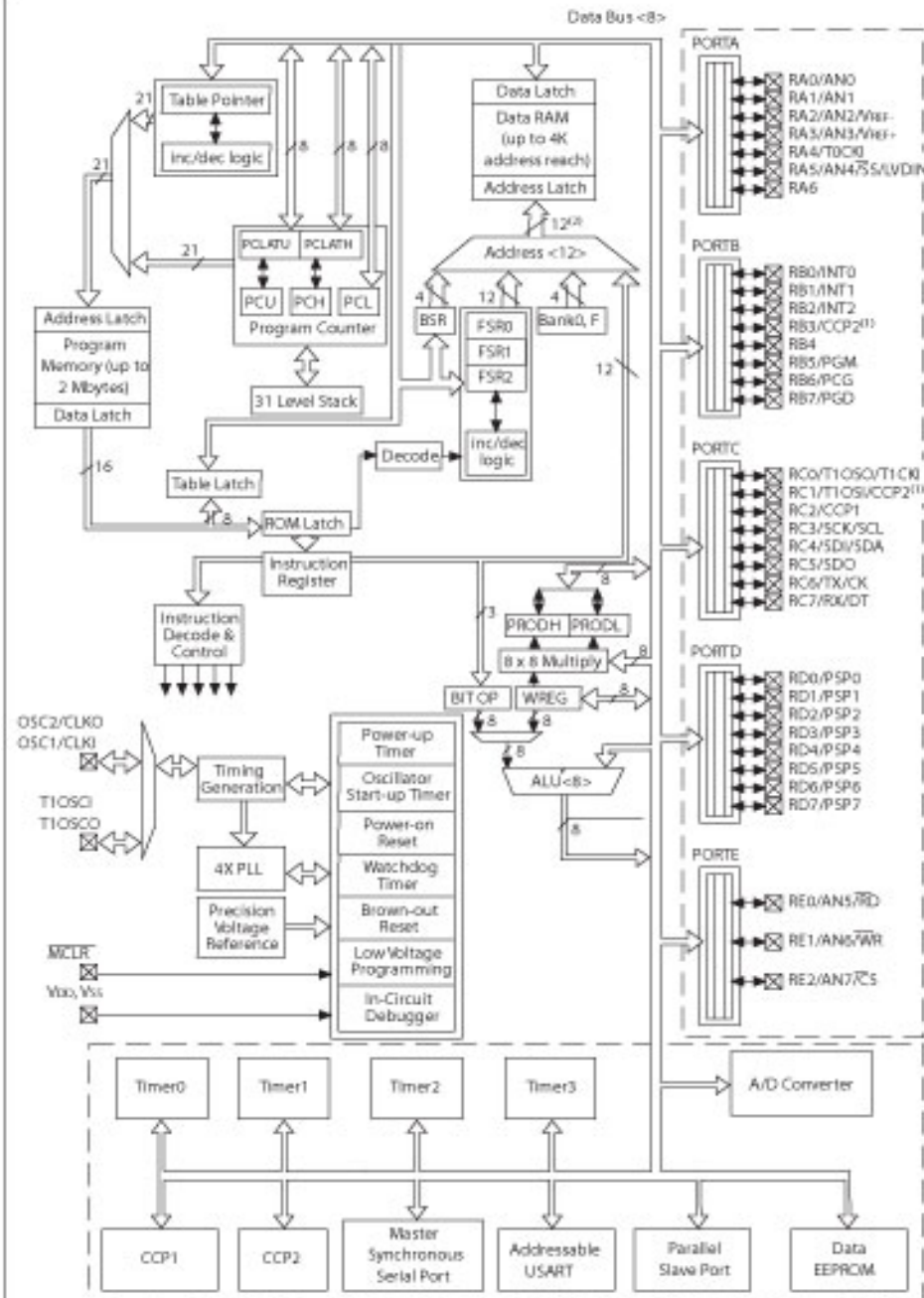




# PIC18F Special Features

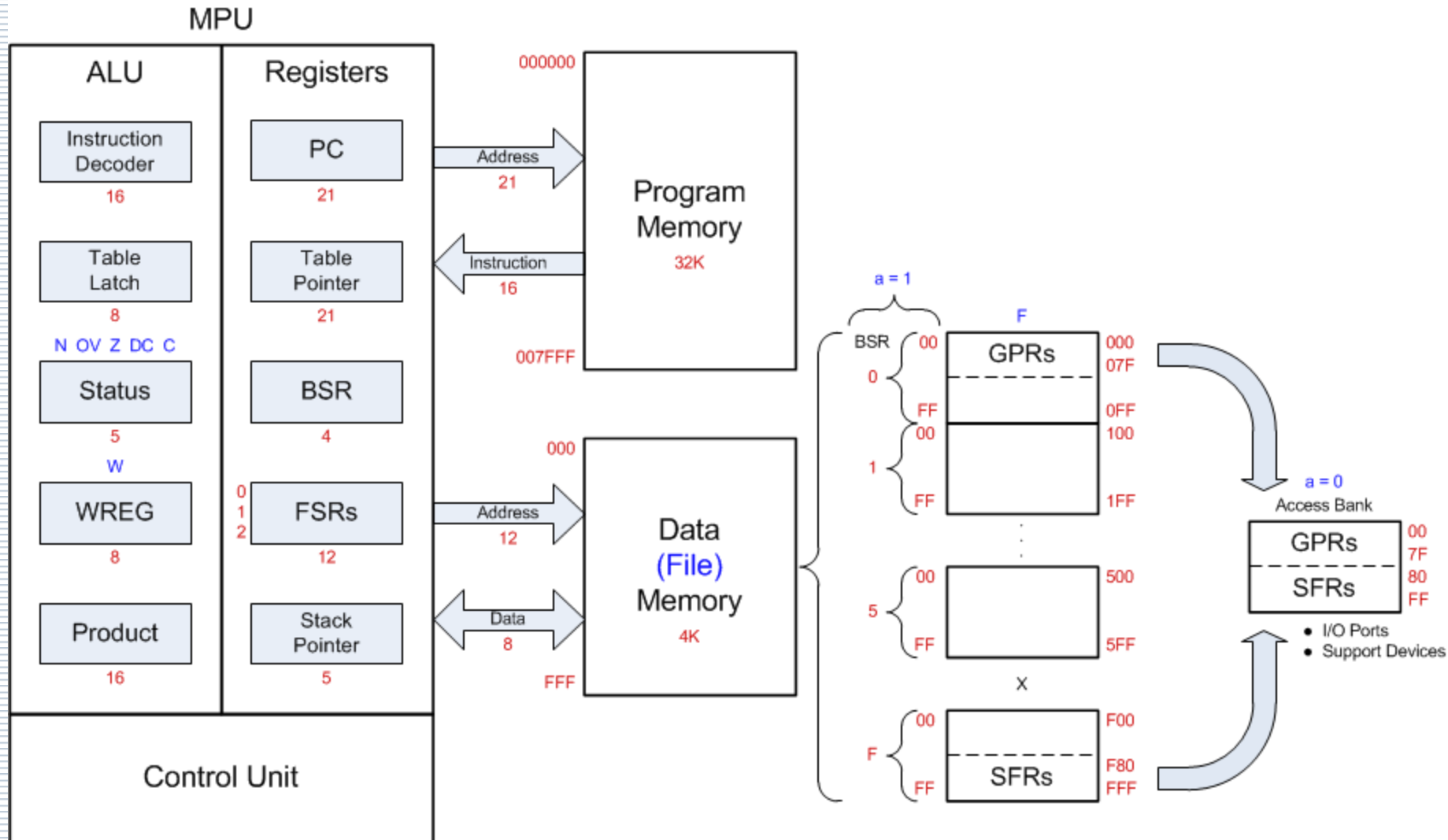
- ◆ Sleep mode
- ◆ Watchdog timer (WDT)
- ◆ Code protection
- ◆ In-circuit serial programming
- ◆ In-circuit debugger

# ◆ PIC18F4X2 Architecture Block Diagram



- Note 1: Optional multiplexing of CCP2 input/output with RB3 is enabled by selection of configuration bit.
- Note 2: The high order bits of the Direct Address for the RAM are from the BSR register (except for the `wrrn` instruction).
- Note 3: Many of the general purpose I/O pins are multiplexed with one or more peripheral module functions. The multiplexing combinations are device dependent.

# PIC18F452 Programming Model



## List of Selected Microcontroller Families from Microchip

Part No.	Program OTP/Flash	EE PROM	RAM	Total Pins	I/O Pins	ADC	Analog Comp.	Digital Timers/ WDT	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 <sup>2</sup> 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 <sup>2</sup> 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 <sup>2</sup> 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 <sup>2</sup> 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 <sup>2</sup> 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 <sup>2</sup> 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<sup>2</sup>C: Inter-integrated Circuit Bus, 8) MI<sup>2</sup>C/SPI: Master I<sup>2</sup>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

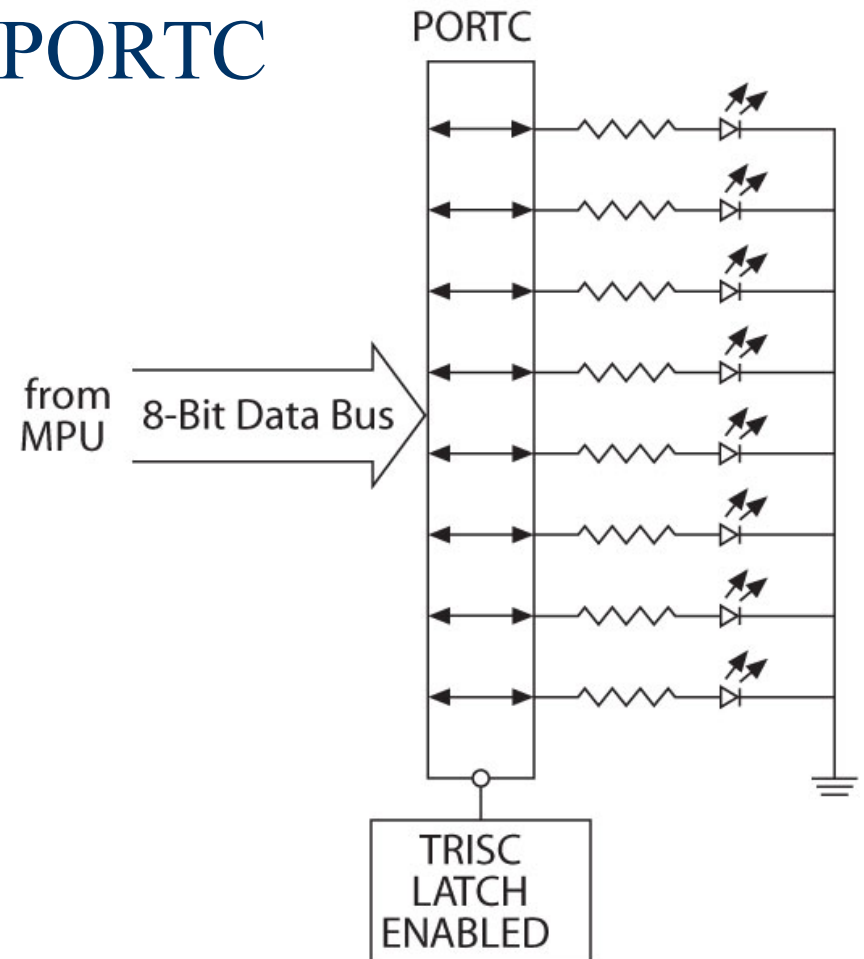
- ◆ Copy (Move) 8-bit number (Literal) into W register
  - Mnemonics: MOVLW 8-bit
  - Binary format:  
0000 1110 XXXX XXXX (any 8-bit number)
- ◆ Copy (Move) contents of W register into PORTC (File)
  - Mnemonics: MOVWF PORTC, a
    - ('a' indicates that PORTC is in the Access Bank)
  - Binary format:  
0110 1110 1000 0010 (82<sub>H</sub> 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<sub>H</sub> turns on alternate LEDs

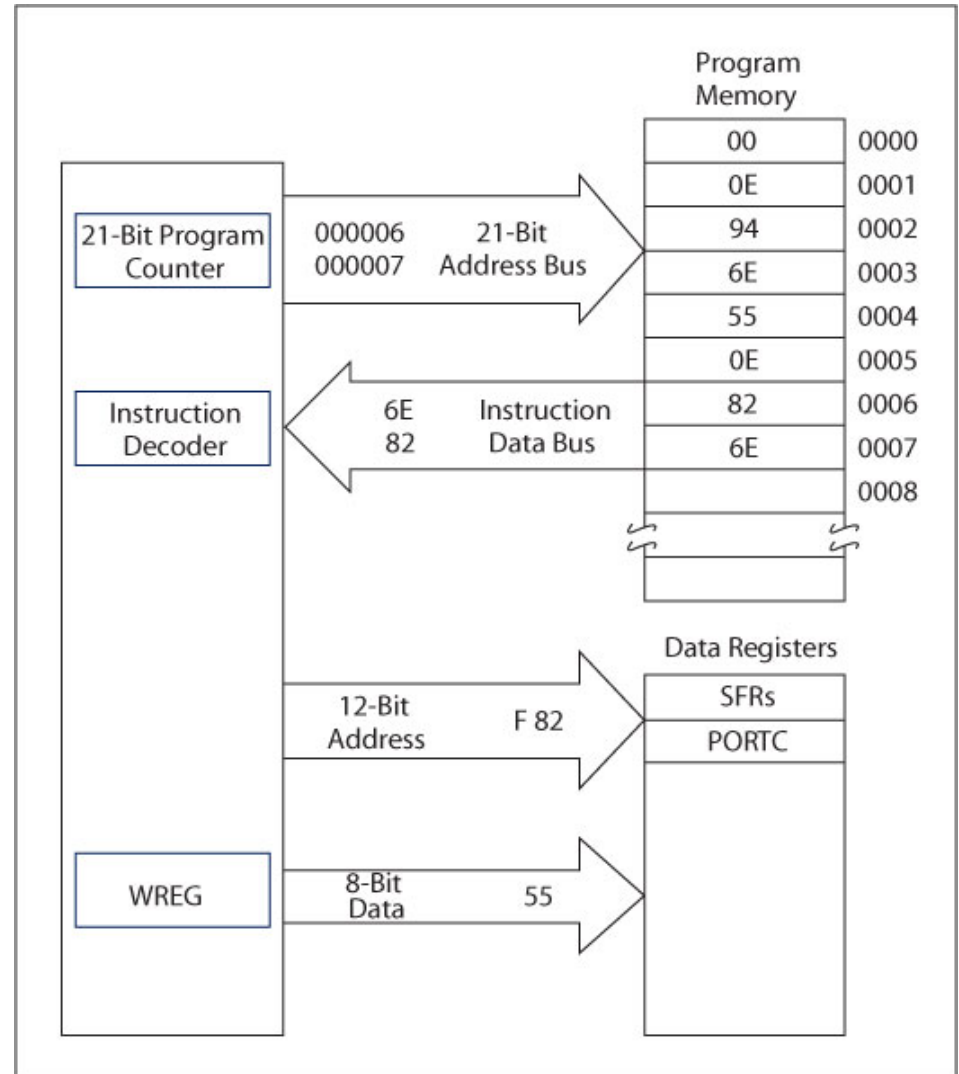
• MOVLW	00	;Load W register with 0
• MOVWF	TRISC	;Set up PORTC as output
• MOVLW	0x55	;Byte 55 <sub>H</sub> to turn on LEDS
• MOVWF	PORTC	;Turn on LEDs
• SLEEP		;Power down

# 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

The screenshot displays the PIC18 Simulator IDE window and an 8 x LED B... window.

**PIC18 Simulator IDE Window:**

- File Simulation Rate Tools Options Help STEP**
- Program Location:** ... IC18 IDE Source Programs\Chapter 02\Illust2-6 Displaying Byte.hex
- Microcontroller:** PIC18F452 **Clock Frequency:** 8.0 MHz
- Last Instruction:** MOVWF PORTC,A **Next Instruction:** SLEEP
- Instructions Counter:** 4 **Clock Cycles Counter:** 20
- Program Counter and Working Register:**
  - PC:** 000028
  - W Register (WREG):** 55
- Real Time Duration:** 2.50  $\mu$ s
- Special Function Registers (SFRs):**

Address and Name	Hex Value	Binary Value (7 6 5 4 3 2 1 0)
F94h TRISC	00	00000000
F93h TRISB	FF	11111111
F92h TRISA	7F	01111111
F8Dh LATE	00	00000000
F8Ch LATD	00	00000000
F8Bh LATC	55	01010101
F8Ah LATB	00	00000000
F89h LATA	00	00000000
F84h PORTE	00	00000000
F83h PORTD	00	00000000
F82h PORTC	55	01010101
F81h PORTB	00	00000000
F80h PORTA	00	00000000
TMR0 Prescaler	00	00000000
TMR0 High Byte	00	00000000
TMR1 Prescaler	05	00000101
- General Purpose Registers (GPRs):**

Addr.	Hex Value	Addr.	Hex Value
000h	00	010h	00
001h	00	011h	00
002h	00	012h	00
003h	00	013h	00
004h	00	014h	00
005h	00	015h	00
006h	00	016h	00
007h	00	017h	00
008h	00	018h	00
009h	00	019h	00
00Ah	00	01Ah	00
00Bh	00	01Bh	00
00Ch	00	01Ch	00
00Dh	00	01Dh	00
00Eh	00	01Eh	00
00Fh	00	01Fh	00

**8 x LED B... Window:**

- Displays 8 LEDs corresponding to PORTC, 7 through PORTC, 0.
- Each LED is currently lit (green).
- Buttons: ☐ Always On Top, Close

# Embedded System

- ◆ MCU-based System

