Chapter 13
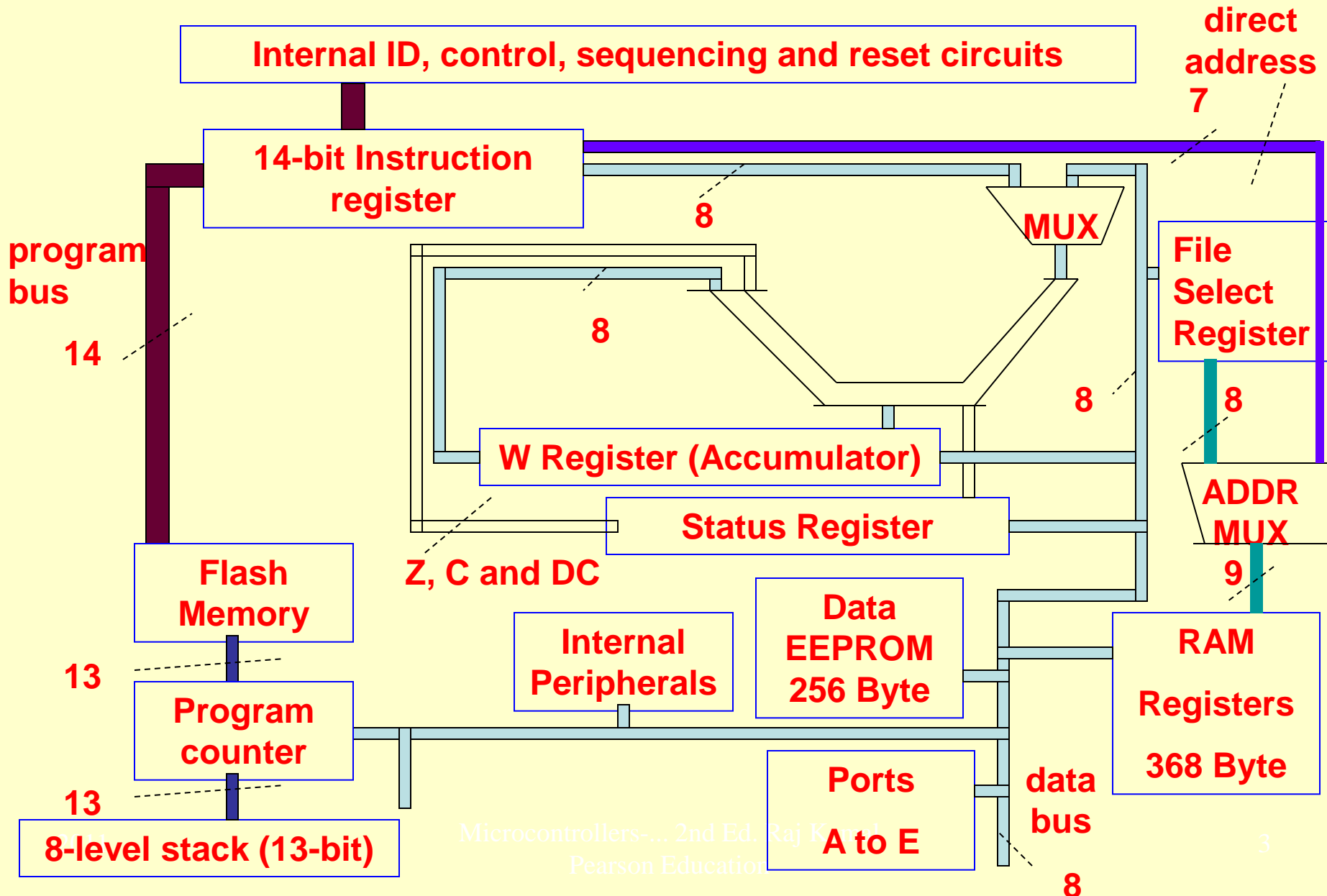
PIC Family Microcontroller

Lesson 02

Architecture of PIC 16F877

Internal hardware for the operations in a PIC family MCU

Internal ID, control, sequencing and reset circuits

14-bit Instruction register

direct address 7

program bus

14

MUX

8

8

File Select Register

8

8

W Register (Accumulator)

Status Register

Z, C and DC

ADDR MUX

9

Flash Memory

13

Program counter

13

8-level stack (13-bit)

Internal Peripherals

Data EEPROM 256 Byte

RAM Registers 368 Byte

Ports A to E

data bus

8

ALU Features

- Supports 8-bit operations

- Internal data bus is of 8-bits

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

ALU Features

- ALU operations between the Working (W) register (accumulator) and register (or internal RAM) from a register-file

- ALU operations can also be between the W and 8-bits operand from instruction register (IR)

- The operations also use three flags Z, C and DC/borrow. [Zero flag, Carry flag and digit (nibble) carry flag]

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

ALU features

- The destination of result from ALU operations can be either W or register (f) in file

- The flags save at status register (STATUS)

- PIC CPU is a one-address machine (one operand specified in the instruction for ALU)

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

ALU features

- Two operands are used in an arithmetic or logic operations

- One is source operand from one a register file/RAM (or operand from instruction) and another is W-register

- Advantage—ALU directly operates on a register or memory similar to 8086 CPU

Harvard architecture

- Separate address spaces for the program
- Separate address spaces for data

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Data

(i) data memory for special function registers (SFR), registers, internal RAM,

(ii) data memory EEPROM, and

(iii) separate address spaces for program memory, interrupt vectors, constant data and text (flash memory)

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Separate internal buses

- Address of 13-bit A0-A12 for the program address in 16F877

- Program code-bus of 14-bit

- Data D0-D7 of 8-bit

- Flash memory retention period is more than 40 years

Program Memory

- Program memory 8 k × 14. Program address fetch bus is of 13-bit. There are thus 8192 program instruction addresses.

- Program counter is thus of 13-bit word pointing to one of the 8 k (8192) addresses in program memory (flash).

- Total are 8192 addresses (2^{13}) in flash in PIC 16F877 as Program counter is of 13 bit)

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Instruction

- Instruction length 14-bit

- Program-code bus 14-bit.

- Flash saves 14-bits at each address

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Program Counter

- Program Counter starts from a value, which is pre-programmed at the reset vector address

Reset vector address

- Reset vector address is 0x0000 in program memory

- Reset vector means the memory location from where the processor will find the address of the program codes to be executed after the reset or on-power-up

Stack

- 8-level stack with 13-bit stacked at an instance (13-bit Program counter)

Data bus

- Data bus width 8-bit

- Interconnects the registers

- RAM

- Internal peripherals and ports A to E

Register File/RAM

- 368 B in PIC 16F877

- 9-bits are required to access the RAM

- Therefore the register file/RAM divides in four banks

- Each bank has 128 addresses

- Each bank register/RAM therefore accesses by 7-bit address

RAM/File Register Select Register FSR

- Register of 8-bits

- Provides the 8-bit address of RAM/register in register file

- hat address is in which bank-pair, this is as per IRP bit in the STATUS

- FSR used for indirect addressing in the instruction

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Status Register

- **8-bits**

- **Bit 0, 1, 2 — C, DC/borrow and Z**

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Multiplexers

- **MUX**
- **ADDRMUX**

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Peripherals

- 8-input channel 10-bit ADC

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Peripherals

- The synchronous serial port configured as 3-wire Serial Peripheral Interface (SPI™) option 1

- Option 2 is 2-wire Inter-Integrated Circuit (I²C™) bus and a Universal Asynchronous Receiver Transmitter. (USART).

Peripherals

- Two data communication peripherals are 1-A/E/USART (universal synchronous asynchronous receiver and transmitter) and 1-MSSP (SPI/I2C). [MSSP (master synchronous serial port) operate in master SPI mode or master/slave mode I2 C.

Timers

- There are two 8-bit timers, TMR0 and TMR2 $2 \times$ 8-bit. (Section 13.5)

- There is one 16-bit timer, TMR1 $1\times$ 16-bit. (Section 13.5)

- There is CCP1, 2. CCP1, 2 has two capture/compare/PWM peripherals for input capture, out-compare and pulse width modulation functions].

Operations

- MCU operates at 2.0 V to 5.5V and has 40-pins.

- The clock circuit (oscillator circuit) and reset circuits are the internal circuits.

- A XTAL is attached at two pins OSC1 and OSC2. 20 MHz Oscillator. It connects the OSC1 and OSC2 pins. OSC circuit has four options (Table 13.2):

- Reset Circuit, which connects to MCLR pin. MCLR = 0 for the reset.

Peripherals

- MCLR pin is also used as Vpp (Programming voltage). The Vpp is also applied at this pin when programming the MCU. [Programming means writing the program codes to internal flash memory.]

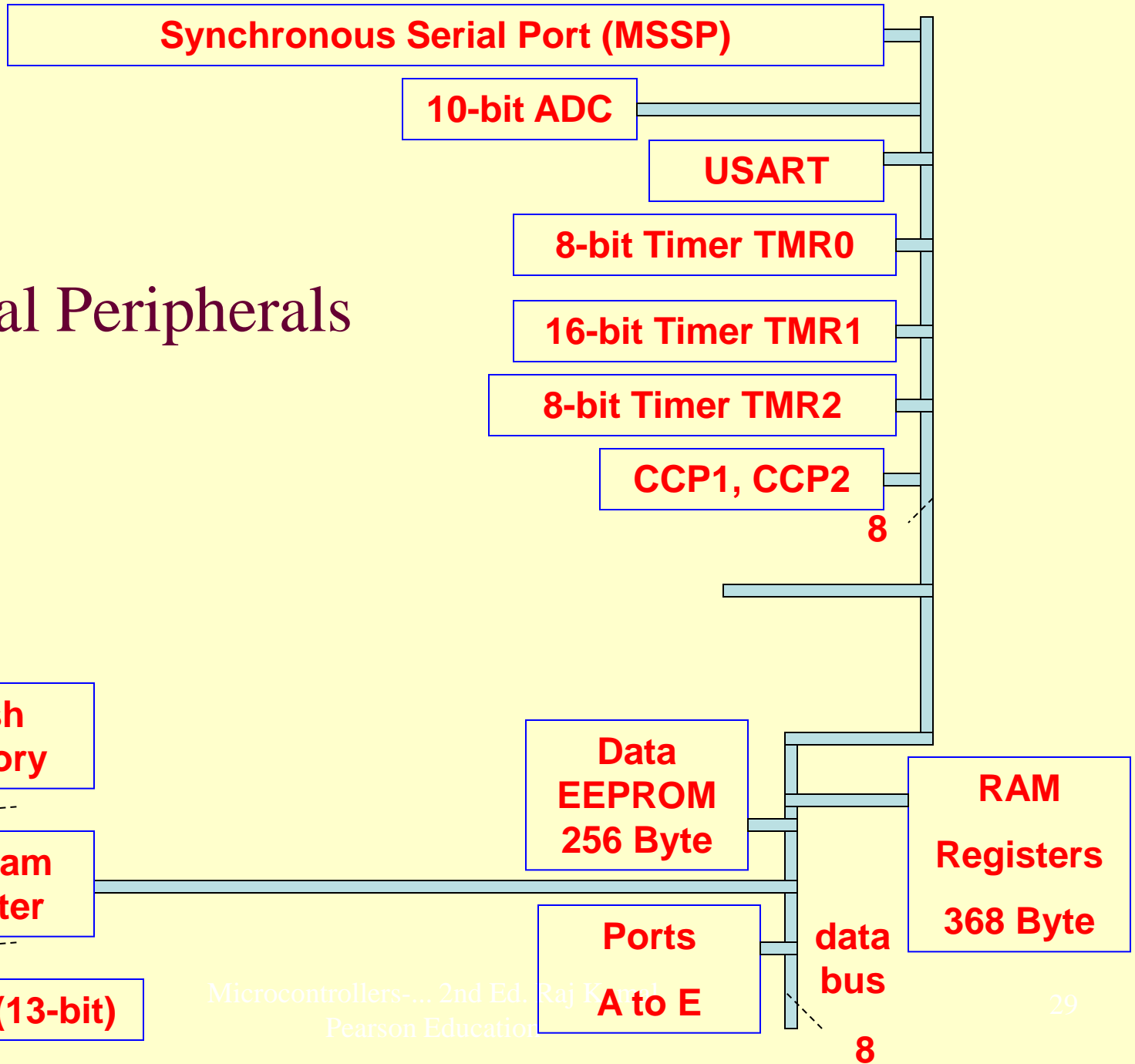- One external interrupt is provided. It occurs through PORTB RB0 pin.

Brown-out Reset

- There are power-up timer, oscillator start-up timer, power-on reset, brown out reset, in-circuit debugger and low V programming. [Brown-out circuit means a circuit, which detects the voltage VDD falling below a threshold then it resets the MCU] Programming means writing the program codes to internal flash memory/EPROM.

Watchdog timer

- Can be set to reset the processor after watched-time for finishing a task is over

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Internal Peripherals

Synchronous Serial Port (MSSP)

10-bit ADC

USART

8-bit Timer TMR0

16-bit Timer TMR1

8-bit Timer TMR2

CCP1, CCP2

8

Flash Memory

13

Program counter

13

8-level stack (13-bit)

Data EEPROM 256 Byte

RAM Registers 368 Byte

Ports A to E

data bus
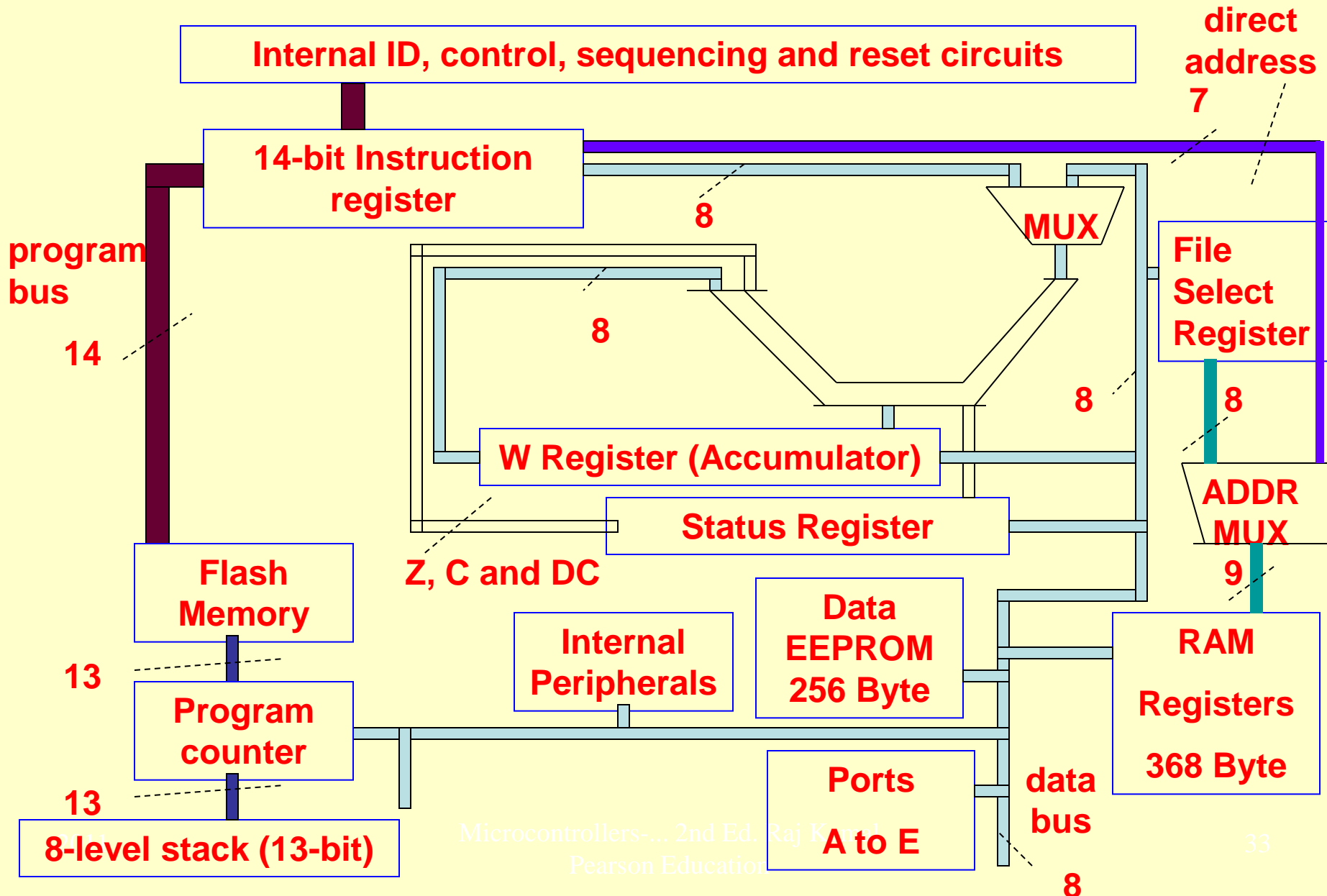
8

Summary

We learnt

- 13-bit program counter

- 14-bit instructions

- ALU features

- 8-bit Data bus

- 14-bit Program code bus

- 13-bit Address bus

- 8-bit Status Register

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

We learnt

- 8-level stack 13-bit
- RAM
- EEPROM
- Flash
- Ports
- Timers
- ADC
- Serial Communication Ports

Microcontrollers-... 2nd Ed. Raj Kamal
Pearson Education

Internal hardware for the operations in a PIC family MCU

Internal ID, control, sequencing and reset circuits

direct address 7

14-bit Instruction register

8

program bus

14

8

MUX

File Select Register

8   8

W Register (Accumulator)

Status Register

Z, C and DC

ADDR MUX

9

Flash Memory

13

Program counter

Internal Peripherals

Data EEPROM 256 Byte

RAM Registers 368 Byte

13

8-level stack (13-bit)

Ports A to E

data bus

8

End of Lesson 02 on

Architecture of PIC 16F877