Today: Introduction to the PIC Architecture I

- Review of digital electronics
- Begin the tour of the primary components of the PIC 16F628 (the 876 is very similar)

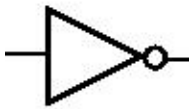
Administrivia

- Please make sure that your EdLab accounts are set to go (we will need them next week). See CSCF if you are having troubles
- PIC hardware manuals have made it to the lab
  - Many single-page copies of the 628 and 876 pinouts (feel free to take these and use them as you wish)
  - C compiler manual will be there soon
  - Electronic copies are available from the Wiki

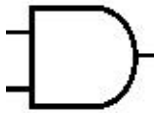
A Bit of Context

- We will be doing our programming in C
- However it is important to:
  - Be able to reason about the components of the PIC chip
  - Understand the assembly instruction set (at least in the abstract)

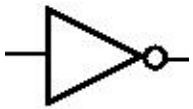
Logic Gates



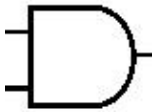
What logic operations do these symbols implement?



Logic Gates



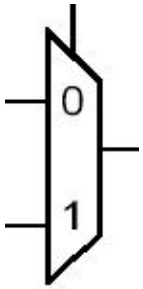
NOT



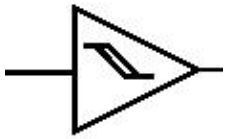
AND

OR

Logic Modules (sort of)

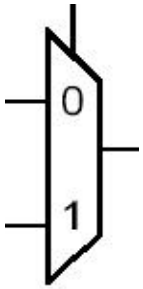


How about these symbols?

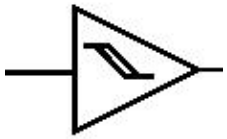


Logic Modules (sort of)

XOR



MUX



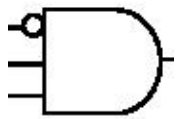
Schmidt Trigger

Schmidt Triggers

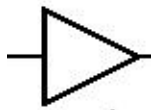
- Signal conditioning circuitry:
  - Conversion of an analog signal (typically between the digital ranges; e.g., 0 to 5 volts) into a “binary” signal (either 0 or 5 volts, but nothing in between)
  - Often includes some hysteresis: does not switch too quickly

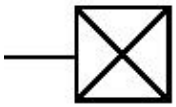
More on this later...

A Few More Symbols



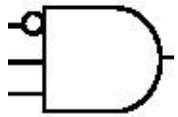
... and these?



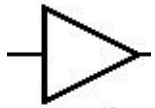


RB4/PGM

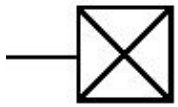
A Few More Symbols



AND with an inverted input

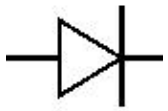


Buffer

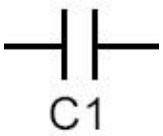


A pin

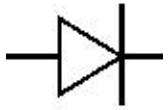
Electronic Components



How about these symbols?

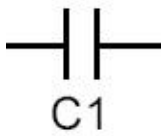


Electronic Components



Diode: allows current to flow in one direction

Crystal: used for generating clock signals

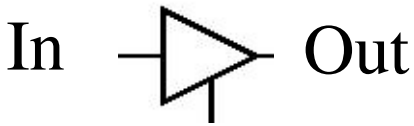


Capacitor: a charge storage element

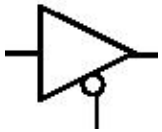
Resistor: restricts flow of current

More on these later...

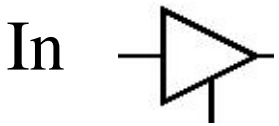
Tristate Buffers



What is the function of a tristate buffer?



Tristate Buffers

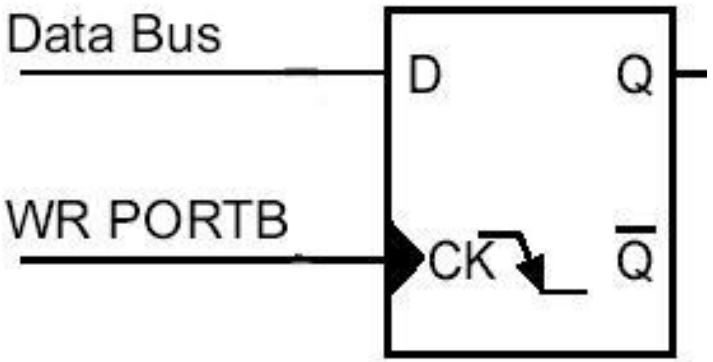


When select = 1, out reflects in

Otherwise: the out voltage is undetermined

Active low tristate buffer

Latch



- Bit storage device
- When the clock (CK) transitions from high to low, the signal on D is copied
- Q is the value that has been stored
- $\overline{Q}$ is the inverse

And Finally...

What are:

- VSS
- VDD

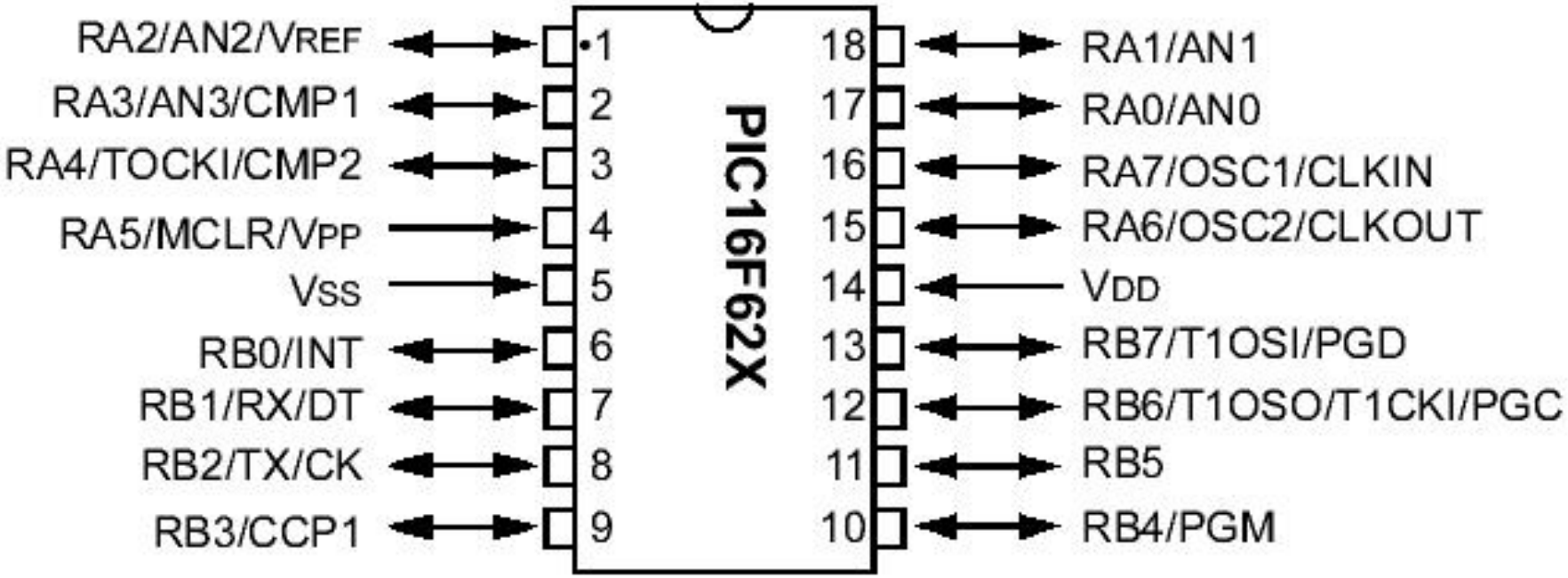
And Finally...

What are:

- VSS: ground (0 volts)

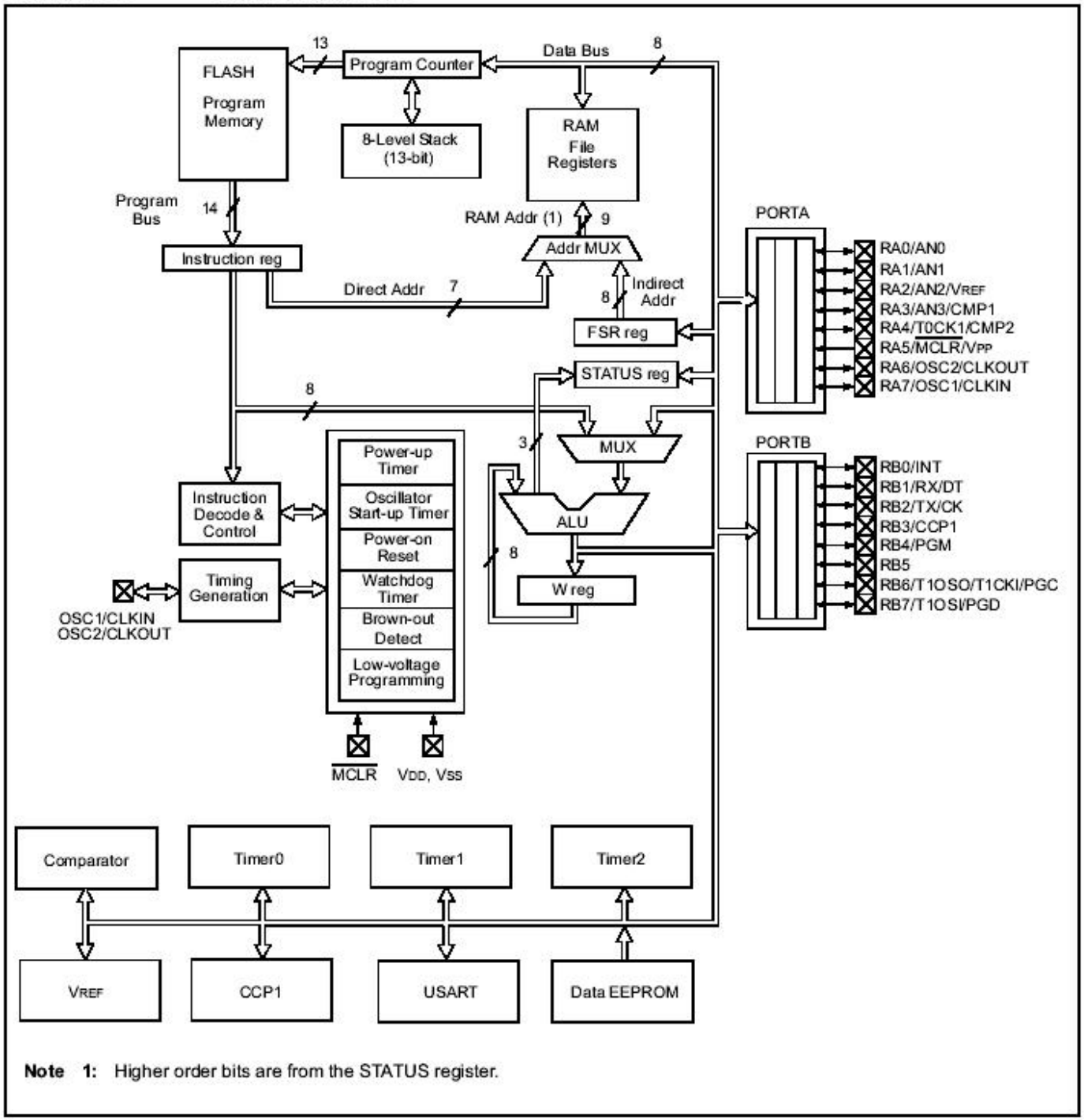
- VDD: power (+5 volts for our purposes)

The 16F628



- Most pins serve multiple purposes
  - Use is configured through register settings
  - When designing a new (complicated) application, we must plan component use carefully

FIGURE 2-1: BLOCK DIAGRAM



Note 1: Higher order bits are from the STATUS register.

Memory Organization

- Harvard Architecture
  - Which means ... ?
  - Why do we take this approach?

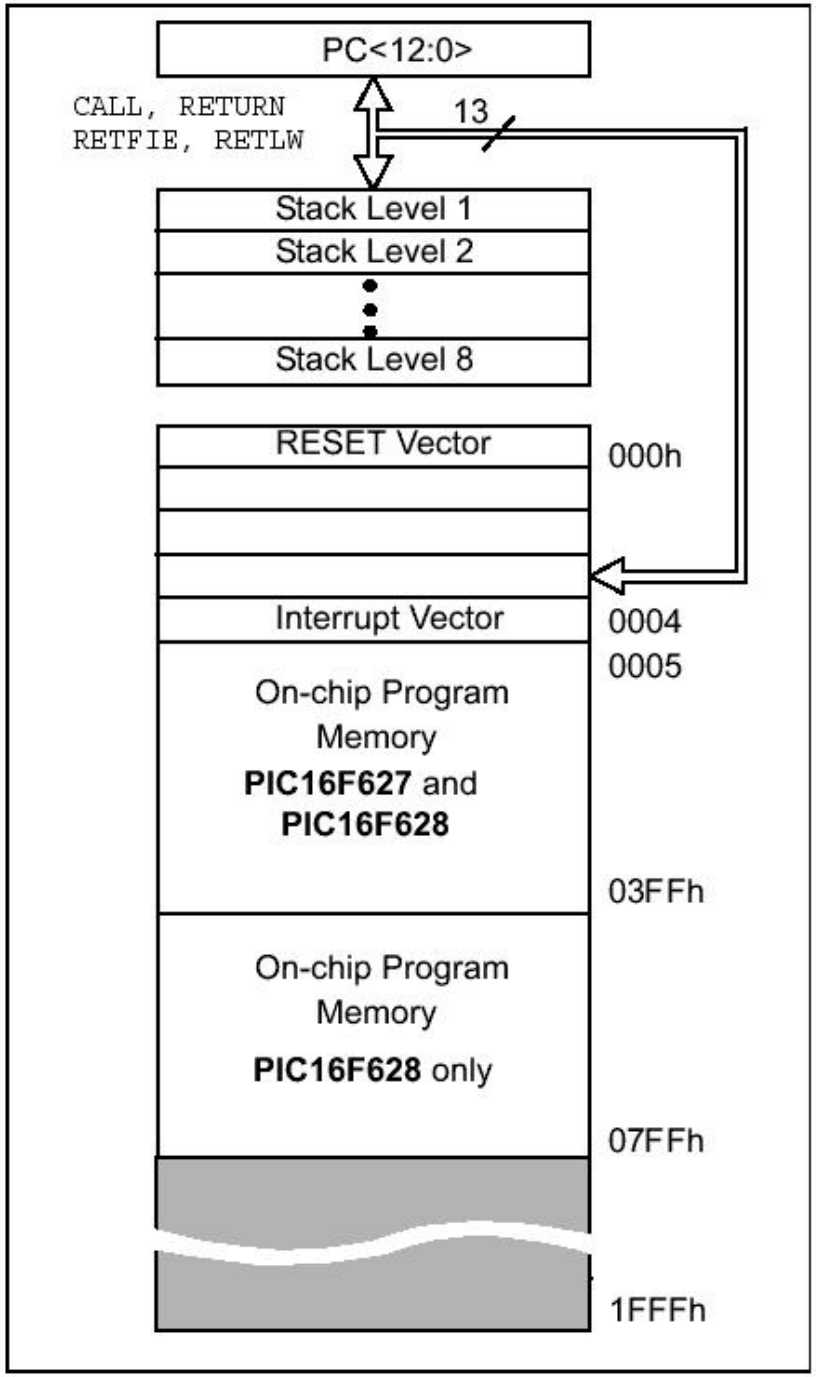
Memory Organization

- Harvard architecture:
  - Separate program and data memory spaces
  - Data paths are most naturally widths that are factors of 8
  - Program space is constrained by the number of instructions, their different forms, the addressing modes, and the size of the addresses
    - In the PIC, this requires more than 8 bits, but less than 16
    - Storing program words in data memory would necessarily waste space

Separate Register Sets

- Program counter (PC)
- Stack
- Program memory

FIGURE 3-1: PROGRAM MEMORY MAP AND STACK



Stack

- 8 x 13 memory space (separate from data and program space)
- Used for storing return addresses (interrupts and call instructions)
- Circular buffer: once you reach the end, you wrap around (so you must plan carefully)

Data Memory

- 8 bits x 224 (for the 628)
  - These are all registers (so no distinction between registers and memory at this level)
- One working register (W)

Memory Is Split into Four Banks

	RP1	RP0
Bank0	0	0
Bank1	0	1
Bank2	1	0
Bank3	1	1

Addresses F0h-FFh, 170h-17Fh and 1F0h-1FFh are implemented as common RAM and mapped back to addresses 70h-7Fh.

- Allows for more compressed addressing
  - This will largely be invisible to us
- Registers RP0 and RP1 select the bank

Data EEPROM

- 128 bytes of permanent storage
- Can be configured at time of programming or the PIC itself can use it as a storage device
- Writing a single byte takes a significant amount of time (~10ms)

Processor Clock

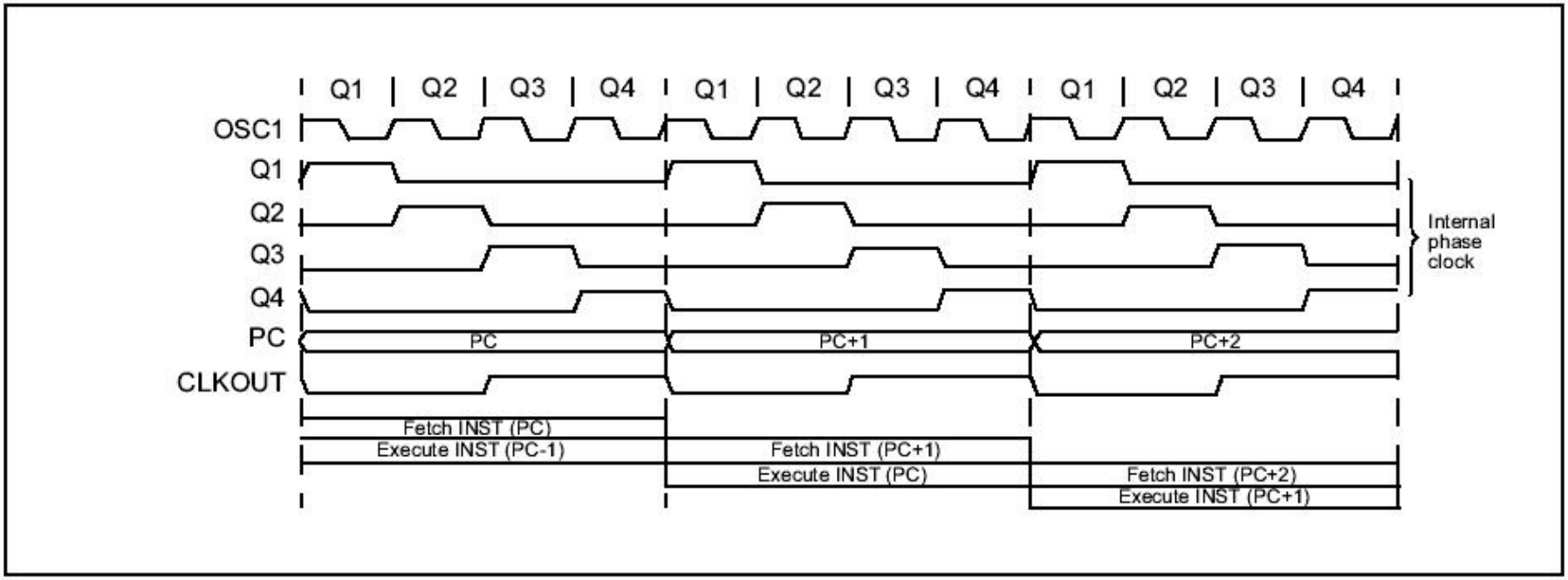
The clock can be produced from any one of several sources:

- Internal circuitry (in some varieties of PIC)
- Resistive-capacitive (RC) circuit
- Crystal: can achieve the highest and most accurate clock rates

More on these details later...

Processor Clock

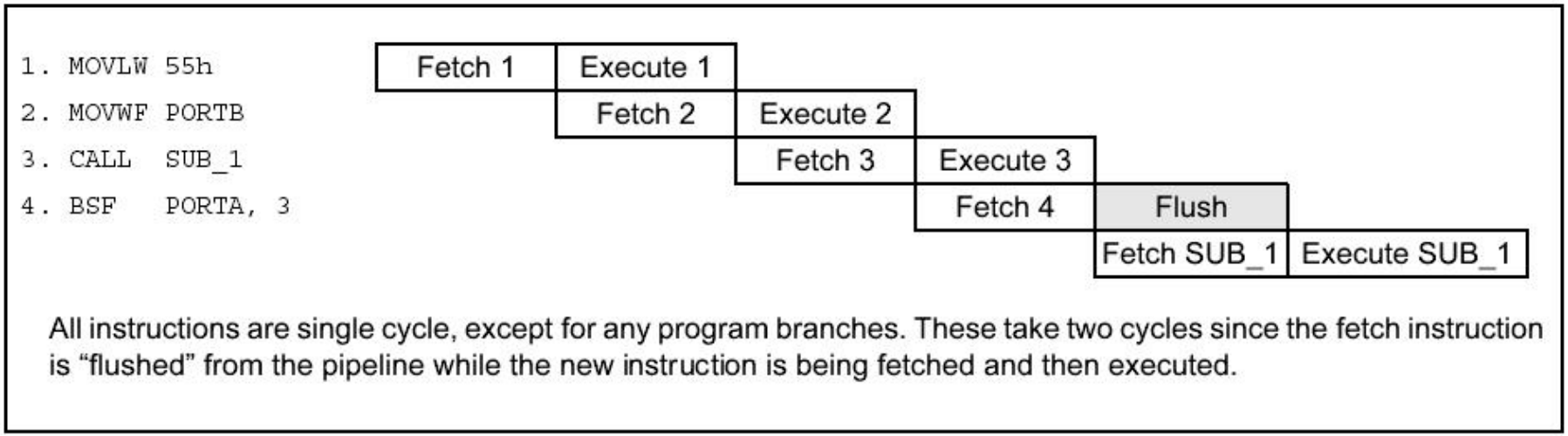
FIGURE 2-2: CLOCK/INSTRUCTION CYCLE



- System clock (OSC1) is divided by 4 to determine the instruction clock (CLKOUT)

Instruction Fetch/Execution Cycle

EXAMPLE 2-1: INSTRUCTION PIPELINE FLOW

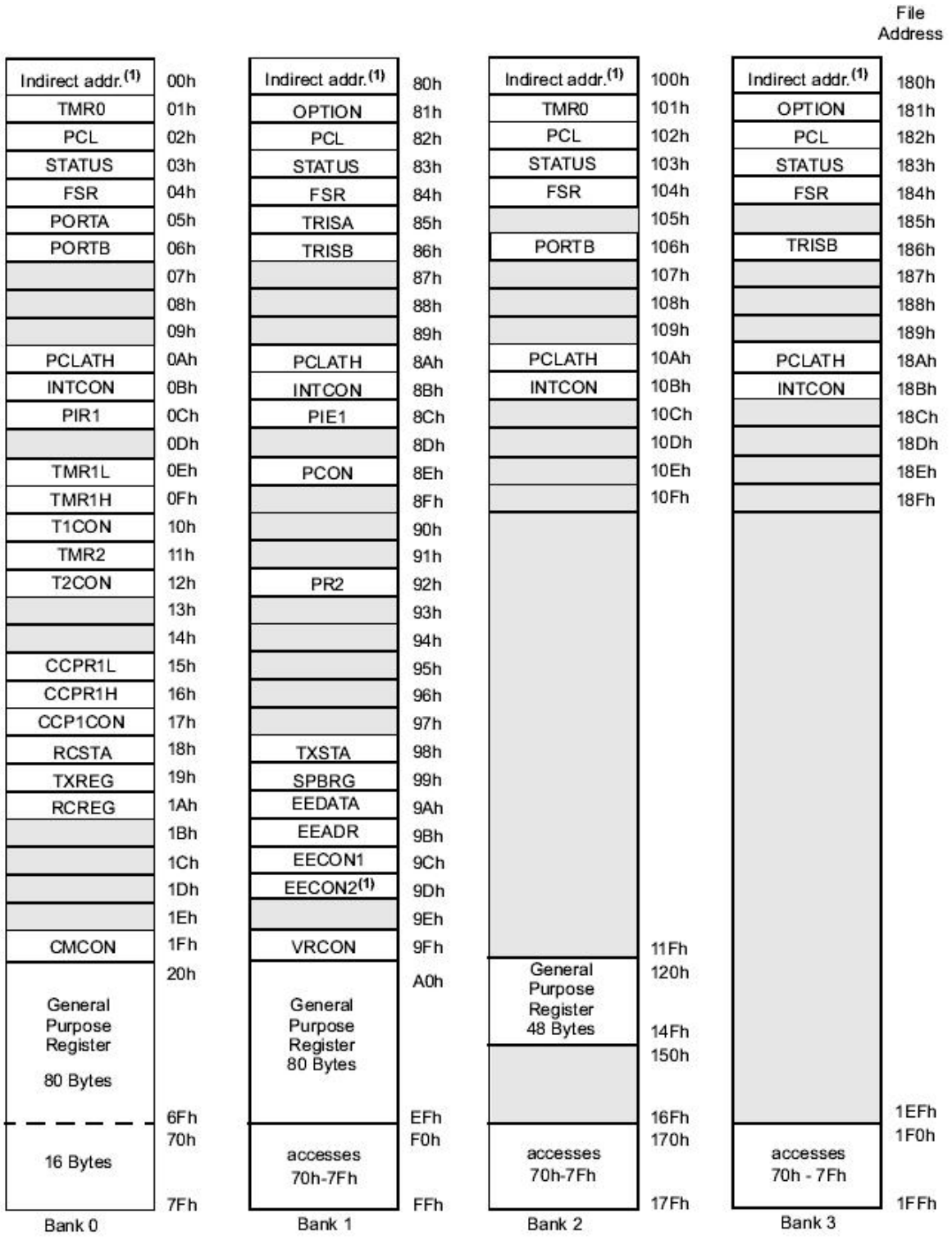


All instructions are single cycle, except for any program branches. These take two cycles since the fetch instruction is "flushed" from the pipeline while the new instruction is being fetched and then executed.

- Instructions are prefetched on the cycle prior to their execution
- On branches: the fetched instruction must be flushed and replaced with the instruction at the branch destination
  - Requires one extra cycle

Data Memory

- The names of the specialized registers are shown
- In many cases (but not all), a program may read or write to these registers directly



The Status Register

STATUS REGISTER (ADDRESS: 03h, 83h, 103h, 183h)

R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x
IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C
bit 7							bit 0

- Different bits have different functions (this is the case for most specialized registers)
- In the case of the SR, most bits are set as a result of executing an instruction

Next Time

Practical issues in PIC programming

- C (and our variant)
- Using the compiler
- Blanking and programming of the PIC chips
- Example circuits and programs

Reading:

- None

Remember: lab is closed on Monday