MPLAB8 and Flow Charts

One of the challenges you face with any microcontroller is how to get the program onto the chip.

One way to program a PIC chip is to use an external programmer, such as PICStart-Plus

PICStart Plys from www.Digikey.com

Once you compile your program with MPLAB (coming next), you place your PIC chip into the programmer and select *program.* That easy. (This is how the boot-loader on your PIC chips was programmed if you're curious.)

The problem with external programmers is you have to remove yor PIC chip from the board, program it, and put it back into your board. This is inconvenient, breaks pins, takes time, etc.

A boot-loader is a small program resident on your PIC chip which runs on reset. This program waits to see if you are trying to download a new program.

- If so, it takes data sent on the serial port and writes it to program memory.
- If not, it runs whatever program is in program ROM

The boot-loader on your PIC chip takes up the lower 0x300 words of program memory. On reset, it sends the message

```
    3 2 1 0 >
```

to the serial port at 9600 baud.

- If it gets to zero before you hit the return button on the PC keyboard (ascii 13), it then executes whatever program is in memory, starting at address 0x800
- If you hit the return key, however (ascii 13), the boot loader clears program memory and waits to receive a new program on the serial port at 9600 baud.

Note that this means you need to start your programs at 0x800

MPLAB8 and Assembler Programming

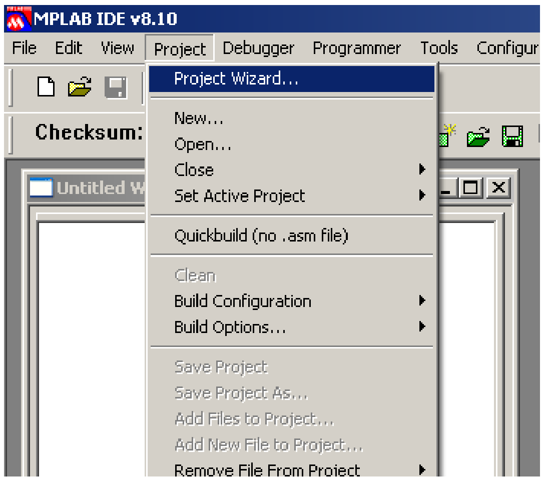
To write a program in assembler in MPLAB8

Step 1. Create a new directory. I prefer using your Z: drive with a folder Z:\ECE376\ASM\Count

Step 2. Start MPLAB8

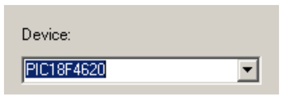
Step 3. Click on File New Project

Project Wizard if this is a new project



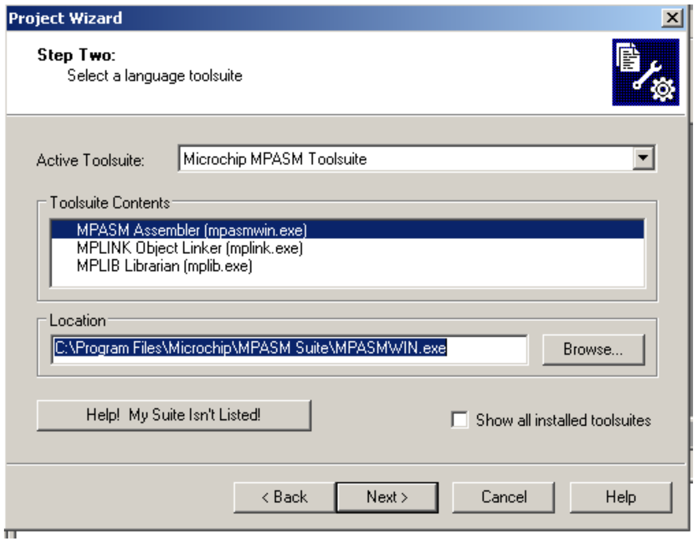
This takes you through the process of starting a new project (i.e. a new program). Click OK

Device = PIC18F4620 (next)



Device: PIC18F4620

Program Language is MPASM


Project Wizard

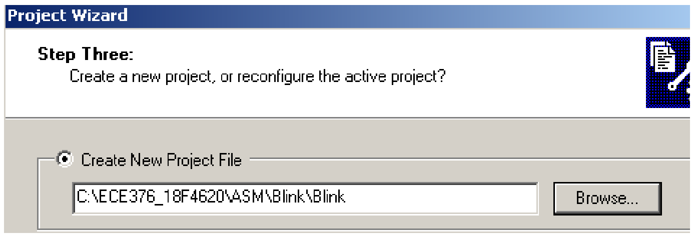
Step Two:
Select a language toolsuite

Active Toolsuite: Microchip MPASM Toolsuite

Toolsuite Contents
- MPASM Assembler (mpasmwin.exe)
- MPLINK Object Linker (mplink.exe)
- MPLIB Librarian (mplib.exe)

Location: C:\Program Files\Microchip\MPASM Suite\MPASMWIN.exe

Directory for Files: Select the directory on your Z-drive (I don't have a Z-drive so I'm using my C drive.)

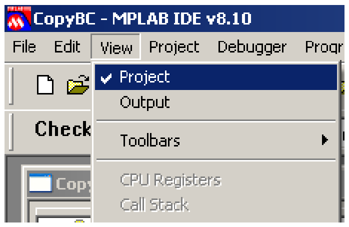

Project Wizard

Step Three:
Create a new project, or reconfigure the active project?

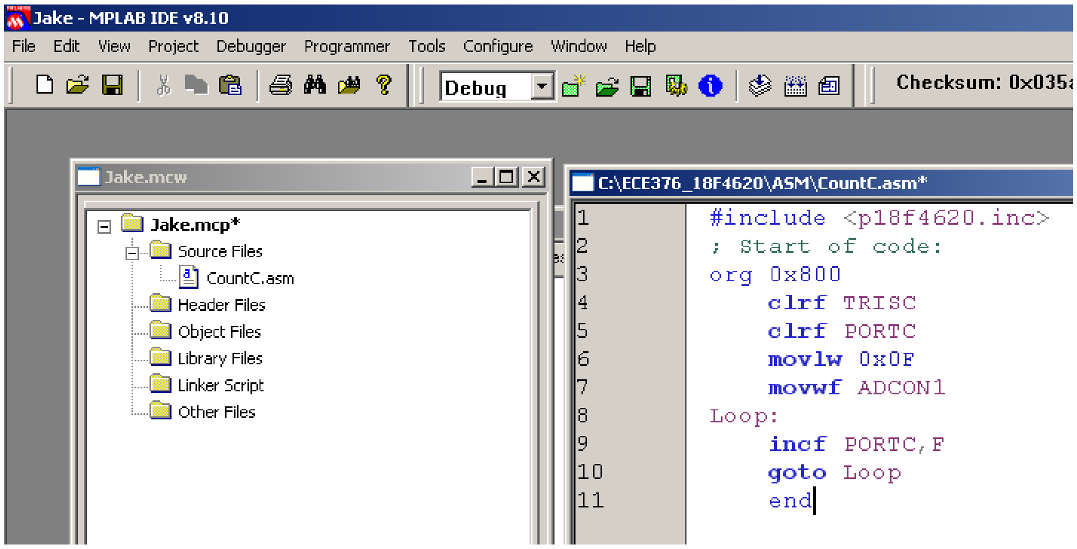
Create New Project File: C:\ECE376_18F4620\ASM\Blink\Blink

If you have an ASM file, select that file. If not, leave the file name blank and continue.

Click on View Project

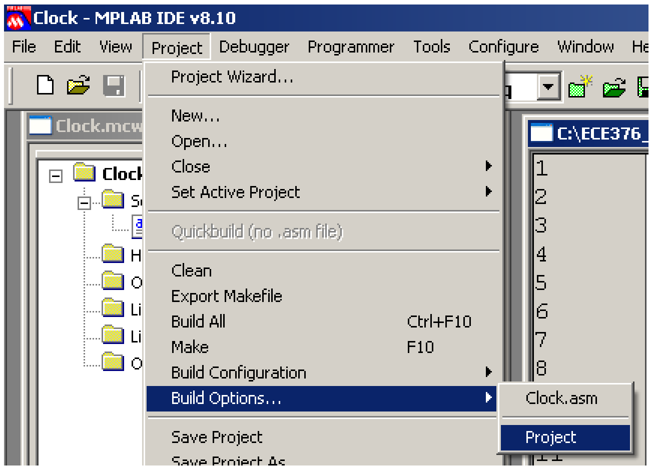

CopyBC - MPLAB IDE v8.10

You should see the following:

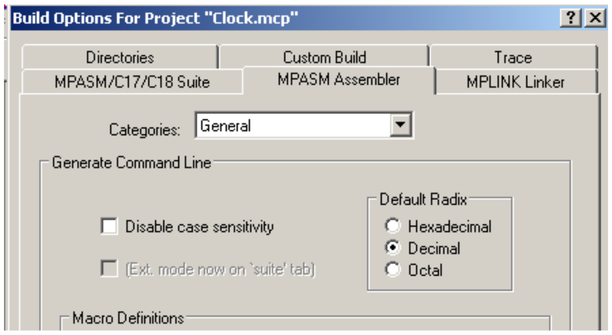


```
#include <p18f4620.inc>
; Start of code:
org 0x800
     clrf TRISC
     clrf PORTC
     movlw 0x0F
     movwf ADCON1
Loop:
     incf PORTC,F
     goto Loop
     end
```

Change the default to decimal. Click on Project Build Options Project



Click on MPASM anc select Decimal. This results in numbers like 100 representing 100 base 10.

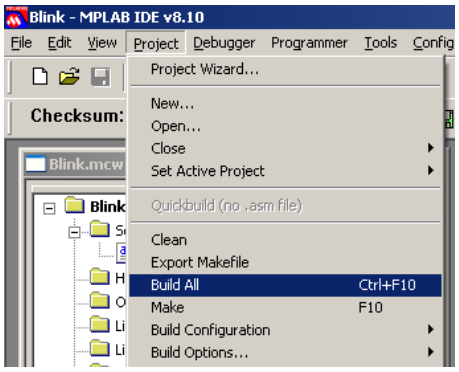


Default Radix: Hexadecimal [✓ Decimal] Octal

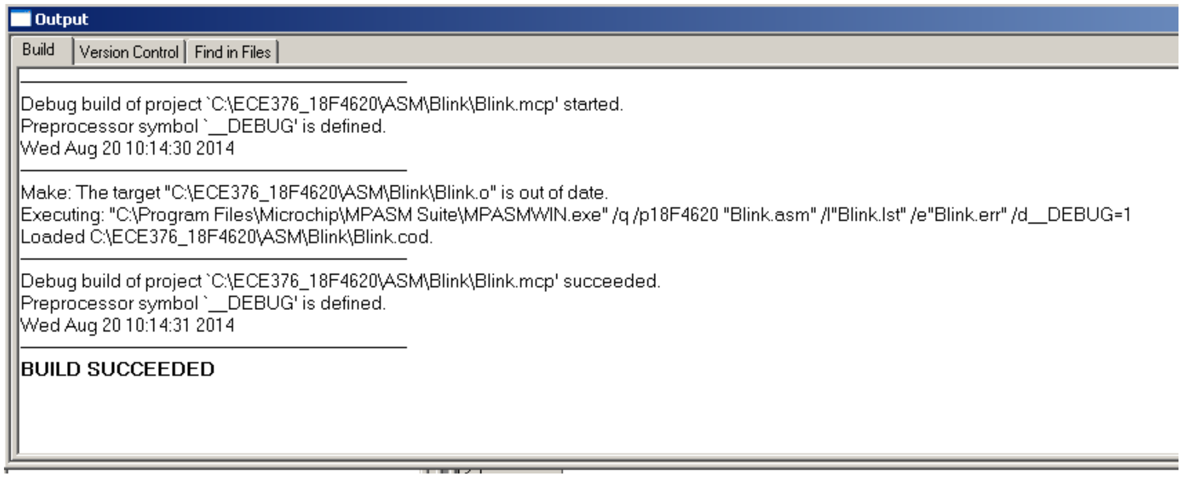
The source file is what you compile.

- If this is blank, right click on Source File and select the ASM file you wish to compile.
- If you don't have an ASM file yet, select File New edit a file, and save it as .ASM

To compile your code, click on Project Bulid All (or hit key F10)

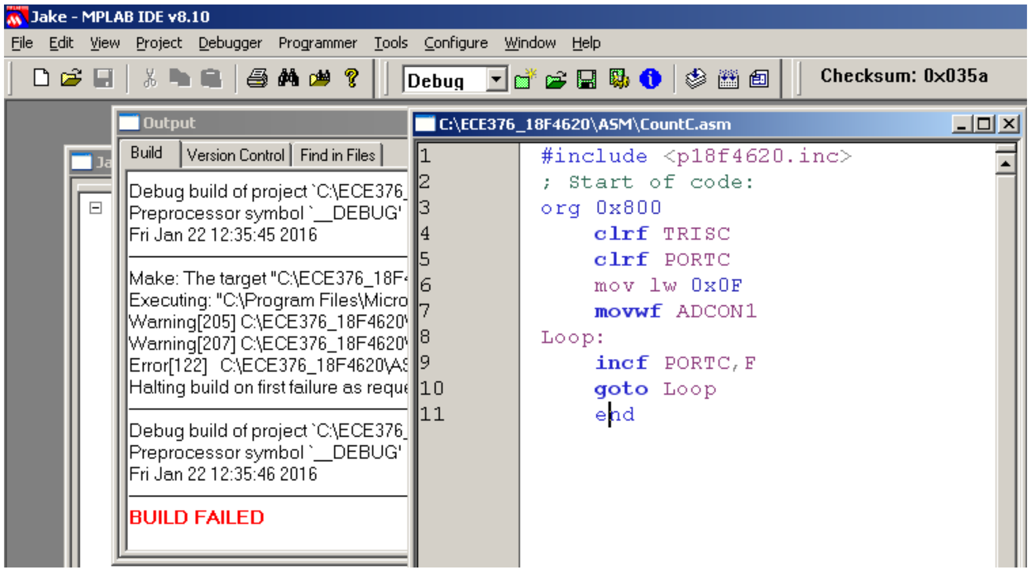


If your program compiles correctly, you get the message 'Succeed'



```
----------------------------------------------------------------------
Debug build of project `C:\ECE376_18F4620\ASM\Blink\Blink.mcp' started.
Preprocessor symbol `__DEBUG' is defined.
Wed Aug 20 10:14:30 2014
----------------------------------------------------------------------
Make: The target "C:\ECE376_18F4620\ASM\Blink\Blink.o" is out of date.
Executing: "C:\Program Files\Microchip\MPASM Suite\MPASMWIN.exe" /q /p18F4620 "Blink.asm" /l"Blink.lst" /e"Blink.err" /d__DEBUG=1
Loaded C:\ECE376_18F4620\ASM\Blink\Blink.cod.
----------------------------------------------------------------------
Debug build of project `C:\ECE376_18F4620\ASM\Blink\Blink.mcp' succeeded.
Preprocessor symbol `__DEBUG' is defined.
Wed Aug 20 10:14:31 2014
----------------------------------------------------------------------
BUILD SUCCEEDED
```

If there is an error in your code (such as a space in line 13 below), you will get an error message along with a notice which line has a problem

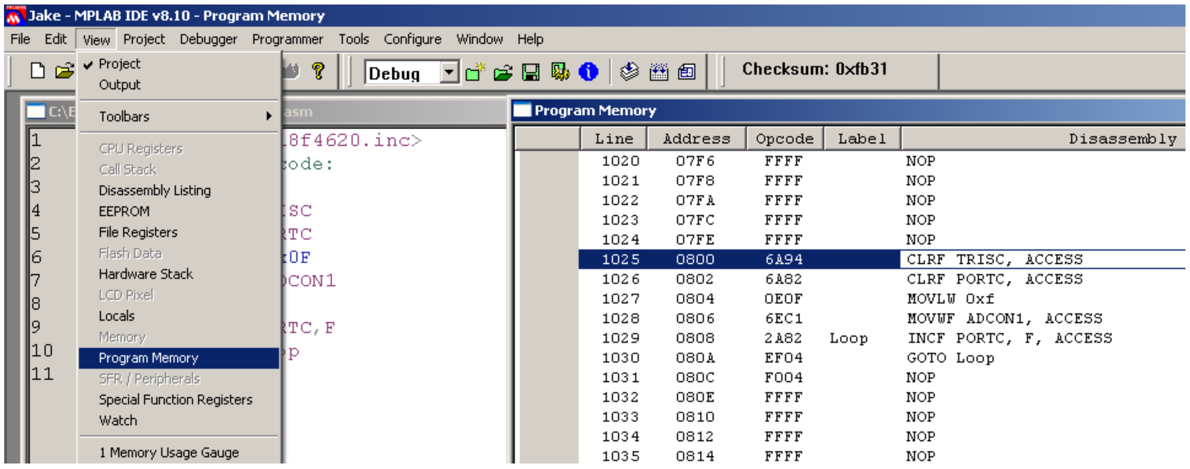

Jake - MPLAB IDE v8.10
File Edit View Project Debugger Programmer Tools Configure Window Help
Debug
Checksum: 0x035a
Output
Build
Version Control
Find in Files
C:\ECE376_18F4620\ASM\CountC.asm

```
Debug build of project `C:\ECE376_
Preprocessor symbol `__DEBUG'
Fri Jan 22 12:35:45 2016

Make: The target "C:\ECE376_18F4
Executing: "C:\Program Files\Micro
Warning[205] C:\ECE376_18F4620\
Warning[207] C:\ECE376_18F4620\
Error[122]   C:\ECE376_18F4620\AS
Halting build on first failure as reque

Debug build of project `C:\ECE376_
Preprocessor symbol `__DEBUG'
Fri Jan 22 12:35:46 2016

BUILD FAILED
```

```
#include <p18f4620.inc>
; Start of code:
org 0x800
    clrf TRISC
    clrf PORTC
    mov lw 0x0F
    movwf ADCON1
Loop:
    incf PORTC,F
    goto Loop
    end
```

Note that compiling doesn't mean your code is correct - it only means the compiler could understand it.

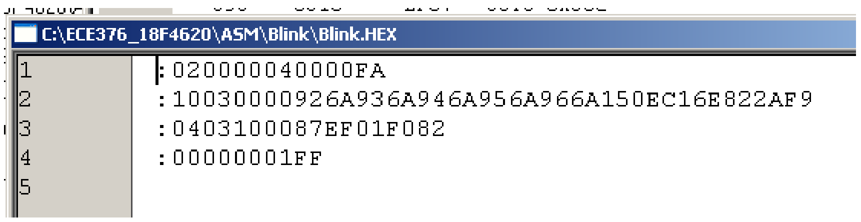
If you want to see what your program looks like, click on View Program Memory



```
Line  Address  Opcode  Label   Disassembly
1020  07F6     FFFF            NOP
1021  07F8     FFFF            NOP
1022  07FA     FFFF            NOP
1023  07FC     FFFF            NOP
1024  07FE     FFFF            NOP
1025  0800     6A94            CLRF TRISC, ACCESS
1026  0802     6A82            CLRF PORTC, ACCESS
1027  0804     0E0F            MOVLW 0xf
1028  0806     6EC1            MOVWF ADCON1, ACCESS
1029  0808     2A82    Loop    INCF PORTC, F, ACCESS
1030  080A     EF04            GOTO Loop
1031  080C     F004            NOP
1032  080E     FFFF            NOP
1033  0810     FFFF            NOP
1034  0812     FFFF            NOP
1035  0814     FFFF            NOP
```

Note that your program starts at address 0x800 (due to the ORG statement. This keeps it away from the boot-loader). Also note that this is a very small program: it takes 8 lines of code (out of 32,000). A PIC can do more.

The program is stored in the file .HEX This is a text files that contains the program in machine language (the OP-Code above)



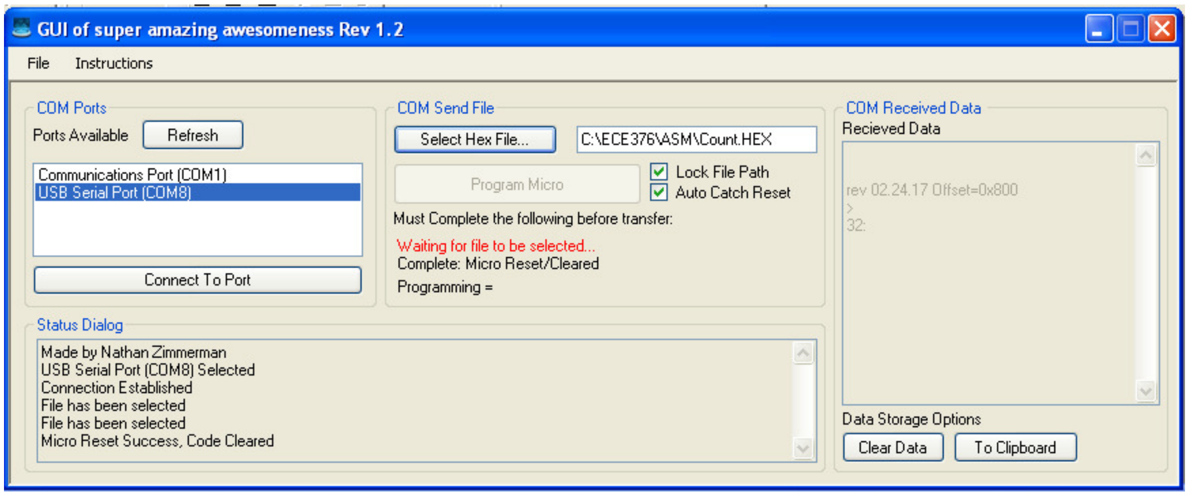
C:\ECE376_18F4620\ASM\Blink\Blink.HEX

```
:020000040000FA
:10030000926A936A946A956A966A150EC16E822AF9
:0403100087EF01F082
:00000001FF
```

To download your code to your PIC board,

- Power up your PIC board (i.e. plug it in)
- Connect the serial cable to a PC
- Run a terminal program, such as Hyperterminal or PIC_Flash_Tool (you might have to download the PIC Flash Tool. It's on the ECE 376 Resources page)

  http://www.bisonacademy.com/ECE376/Resources.htm



GUI of super amazing awesomeness Rev 1.2

Communications Port (COM1)
USB Serial Port (COM8)

C:\ECE376\ASM\Count.HEX

Lock File Path ✓
Auto Catch Reset ✓

Must Complete the following before transfer:
Waiting for file to be selected...
Complete: Micro Reset/Cleared
Programming =

Recieved Data

```
rev 02.24.17 Offset=0x800
>
32:
```

```
Made by Nathan Zimmerman
USB Serial Port (COM8) Selected
Connection Established
File has been selected
File has been selected
Micro Reset Success, Code Cleared
```

- Select the USB Serial Port (COM number varies)
- Select the HEX file to download.
  - Note: PIC_Flash only recognizes capital .HEX You might have to rename your file if the compiler used lower case letters
- Hit RESET on your PIC board. This should results in a 321 message onthe COM Received Data window.
- When the count gets to 2, this program should send a carriage return - which clears out the old program and waits for a new one. At that point, Program Micro lights up.
- Press Program Micro. You will see the LED on RA4 blink a few times (each blink is one line in the .HEX file) then your program is running.

Flow Charts and Assembler Programs

Flow Charts:

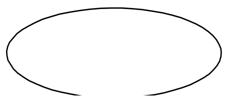
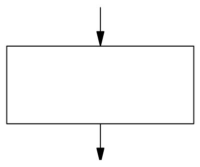
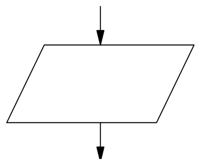
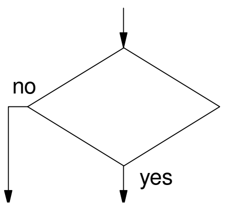
A flow chart is a graphical way to display how a program works (i.e. the algorithm). The purpose of a flow chart is to make the program easier to understand. Likewise, when you make a flow chart, try to

- Keep it simple (less than 20 blocks), but
- Keep it informative (more than one block)

It also helps if you follow a few rules:

- Flow charts should start at the top of the page
- The program execution should move down towards the bottom of the page
- There should be a single exit point

The main symbols for flow charts are as follows:

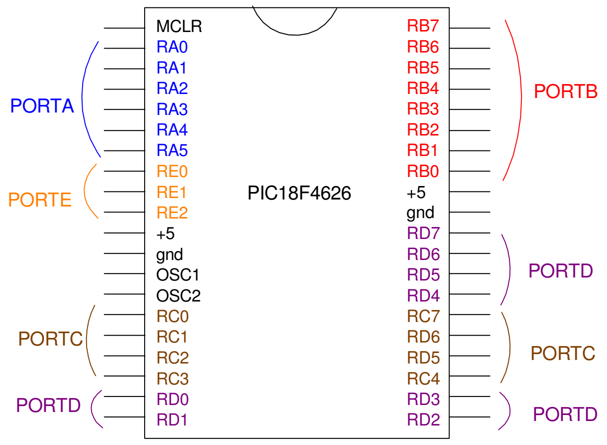
Symbol	Image	Meaning
Oval		Start / End of routine or program
Rectangle		Function or operation
Parallelogram		Input / Output
Diamond		Decision

Ideally, your program should match up with the flow chart. Sort of like how your English term paper should match up with the outline.

For complicated routines, it helps to write the flow chart first. For smaller programs, you can just write the program first then draw the corresponding flow chart. This again is sort of like how you write your English papers and the corresponding outline.

PIC I/O

To illustrate some programs, it will help to use some of the I/O pins on the PIC. These are pins which allow you to detect when a button is pressed (input) or turn an LED on and off (output). We'll talk more about this later - but for now, understand that the PIC has five I/O ports: PORTA..PORTE. These are physically connected to the pins on your PIC chip as follows:



The PIC18f4620 chip has 33 I/O lines split into five ports:

	PORTA	PORTB	PORTC	PORTD	PORTE
Pins	2..7	33..40	15..18, 24..26	19..22, 27..30	3
Binary Input	5	8	8	8	3
Binary Output	5	8	8	8	3
Analog Input	5	5	-	-	3

Setting Up I/O Ports for Binary I/O

Three registers are associated with each port

- PORTx: Defines whether the pin is 0V (0) or 5V (1)
- TRISx: Defines whether the pin is input (1) or output (0)
- LATx: I don't understand what the latch does. The data sheets say "Read-modify-write operations on the LATC register read and write the latched output value for PORTC." To this, I say "huh?" So far, ignoring the LAT registers hasn't caused any problems for me. They're probably good for something though.

In addition, you need to initialize ADCON1 to 15

```
movlw    15          load the number 15 to W
movwf    ADCON1      write W to ADCON1
```

This sets all I/O pins to binary. Some can be analog inputs as well - we'll cover this later when we get to A/D converters.

TRISx are 8-bit registers. Each bit defines whether a given pin is input (1) or output (0). You can write to all 8 bits at once or set and clear each bit one at a time. For example, the command

```
    movlw   0x0F         binary 0000 1111
    movwf   TRISB
```

sets RB0..3 to input (1) and RB4..7 to output (0). The commands

```
    bsf      TRISC,1
    bcf      TRISD,2
```

sets PORTC pin 1 (making RC1 input) and clears PORTD pin 2 (making RD2 output)

PORTx defines the value on each pin:

- logic 0 is 0V
- logic 1 is 5V.

When a pin is input, the logic level is defined by the external voltage applied to the pin. Writing to an input has no affect.

When a pin is output, the logic level is defined by your program. Writing a 1 outputs 5V, writing a 0 outputs 0V.

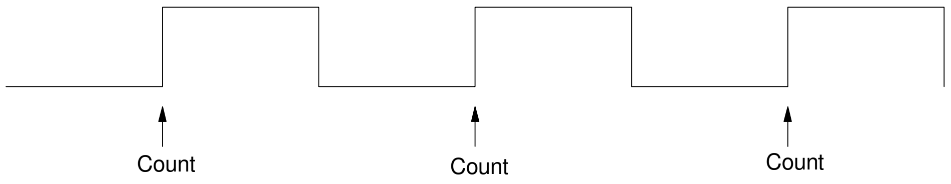
note: Each I/O pin can source or sink up to 25mA. If you want to tie an I/O pin to 0V or 5V, you should use a 200+ Ohm resistor rather than a wire. (Your evaluation boards use 1k resistors). If you accidently set that I/O pin to an output opposite of the connection, the 1k resistor limits the current to 5mA, saving the PIC. If you set the pin to input, the current should be zero (inputs have high impedance) and the 1k resistor has no effect.

Example 1: Write a program which counts how many times you press RB0. Display this count on PORTC.

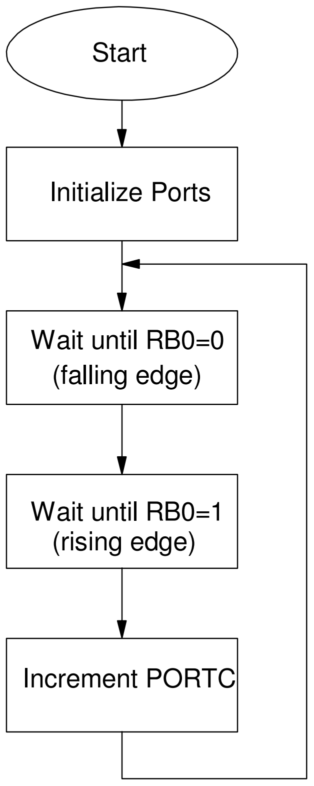
Software: To count one time each button press, you need to

- Keep checking RB0 until it goes high, then
- Keep checking RB0 until it goes low, and
- Repeat

If all you do is wait for RB0 to go high, you'll count really fast while RB0 is high rather than just once.

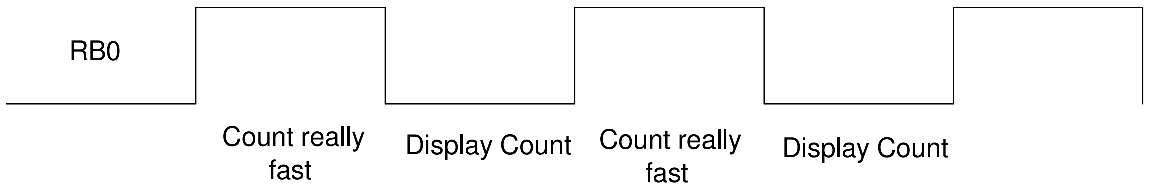


```
#include <p18f4620.inc>

; ---  COUNT_RB0.ASM ----
; This program counts how many times
; RB0 is pressed and displays the result
; on PORTC

; Program

    org 0x800

    clrf  TRISA
    movlw 0xFF
    movwf TRISB
    clrf  TRISC
    clrf  TRISD
    clrf  TRISE
    movlw 0x0F
    movwf ADCON1
    clrf  PORTC


Loop1:
   btfsc PORTB,0
   goto  Loop1
Loop2:
   btfss PORTB,0
   goto  Loop2
   incf  PORTC,F
   goto  Loop1
   end
```

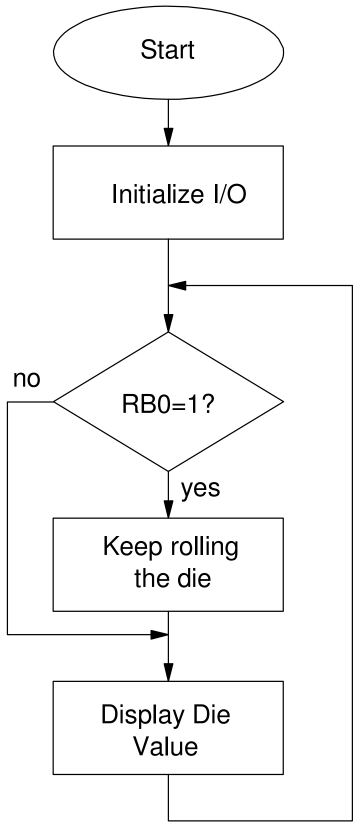

Start
Initialize Ports
Wait until RB0=0 (falling edge)
Wait until RB0=1 (rising edge)
Increment PORTC

Example 2: Design a circuit which displays a random number from 0..7 every time RB0 is pressed and relased.

Solution: One way to do this is to use the above program but count really fast while RB0 = 1. When you release, the resulting value will look like a random number.



```
; ---  RANDOM.ASM ----
; This program generates a random number 0..7 every time RB0 is pressed
; and sends the result to PORTC

#include <p18f4620.inc>

; Variables
DIE   EQU   0

; Program

   org 0x800

   clrf  TRISA
   movlw 0xFF
   movwf TRISB
   clrf  TRISC
   clrf  TRISD
   clrf  TRISE
   movlw 0x0F
   movwf ADCON1

Main:
   btfsc PORTB,0
   incf   DIE,W
   andlw  0x07
   movwf  DIE
   movwf  PORTC
   goto   Main

end
```

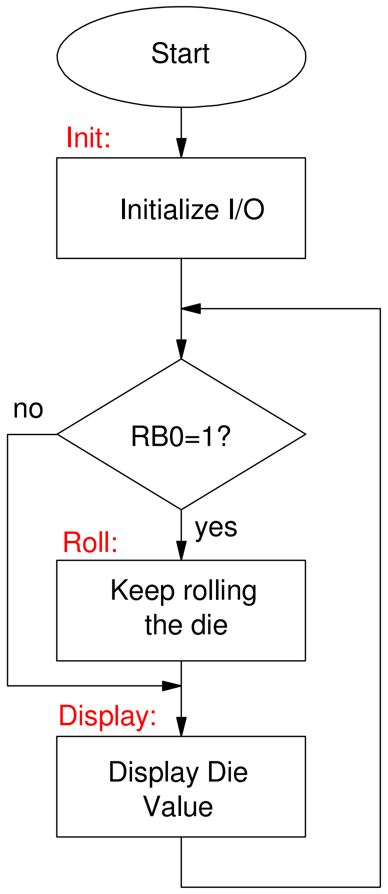


Top Down Programming:

A better way to write this program uses subroutines and top-down programming. The idea is to identify the main functions you need to do to make the program work and make each of these a subroutine. You then fill in each subroutine one by one to get the program to work.

For example, the previous program could be

```
; ---  RANDOM.ASM ----
; This program generates a random number 0..7 every time RB0 is pressed
; and sends the result to PORTC

#include <p18f4620.inc>

; Variables
DIE   EQU   0                     ; random number located at address 0

; --- Main Routine ---

         org 0x800
         call  Init
Main:
         btfsc PORTB,0
         call  Roll
         call  Display
         goto  Main

; ---  Subroutines ---

Init:
         clrf  TRISA
         movlw 0xFF
         movwf TRISB
         clrf  TRISC
         clrf  TRISD
         clrf  TRISE
         movlw 0x0F
         movwf ADCON1
         return

Roll:
         incf   DIE,W
         andlw  0x07
         movwf  DIE
         return

Display:
         movf   DIE,W
         movwf  PORTC
         return

         end
```



Note that, with top-down programming,

- The main routine is much easier to understand
- Modifications can be made by changing one subroutine