Microcontroller: A Practical Approach

What is a Microcontroller?

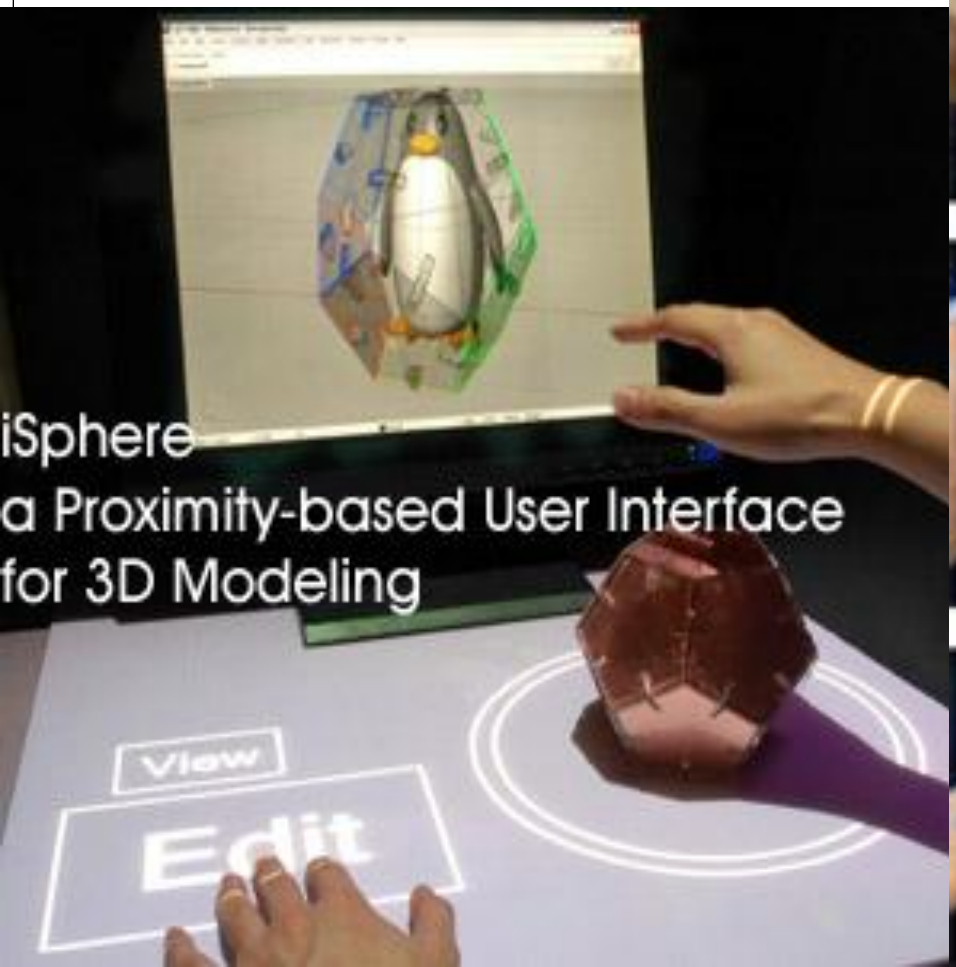
- Mini-Computer
  - Microprocessor
    - The Brains
    - Arithmetic Logic Unit (ALU)
    - Control Unit
- Program/ Data Storage
- Peripherals (Input/Output)

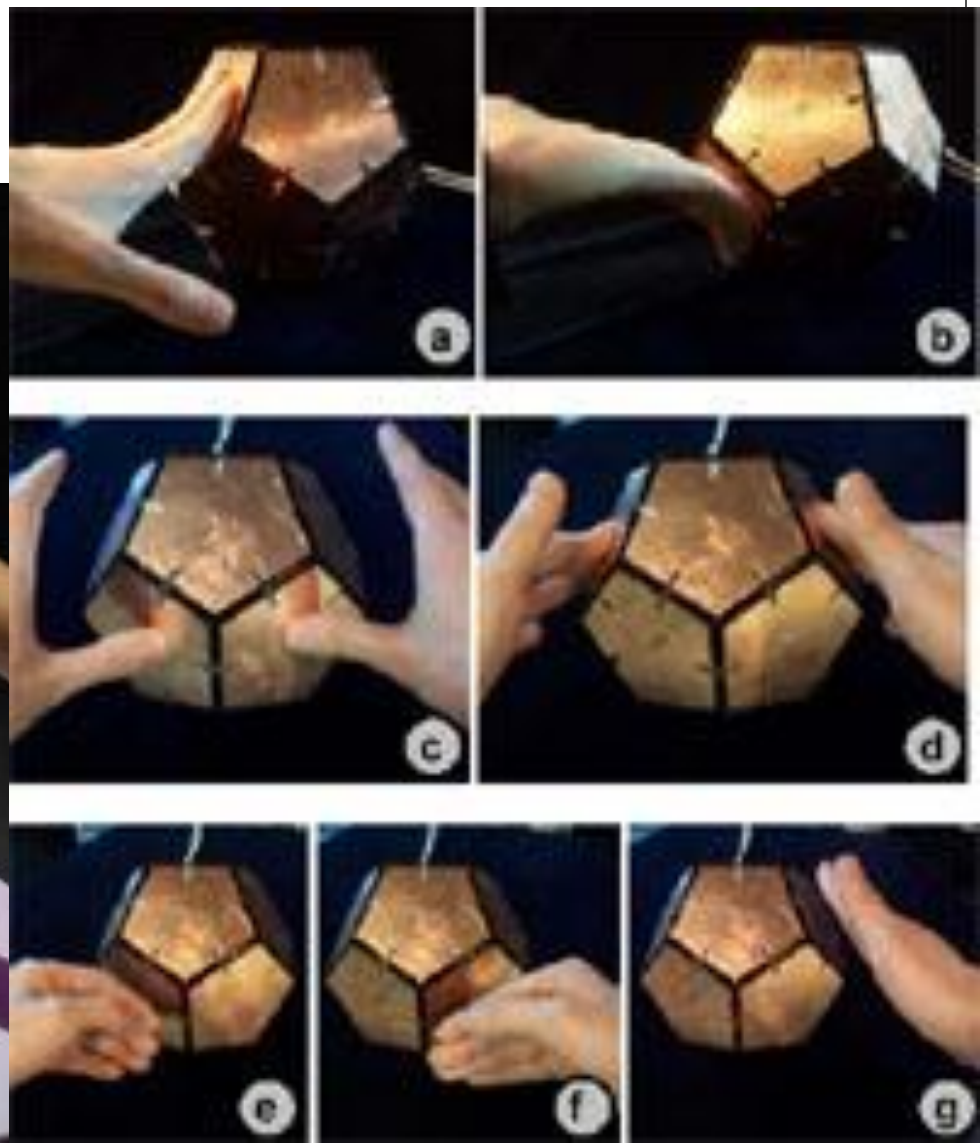
Low-Cost

Why Important?

- Embedded Inside:
  - Automotive systems
  - Airplanes
  - Toys
  - Medical Devices
  - Furniture
- Billions of units

iSphere

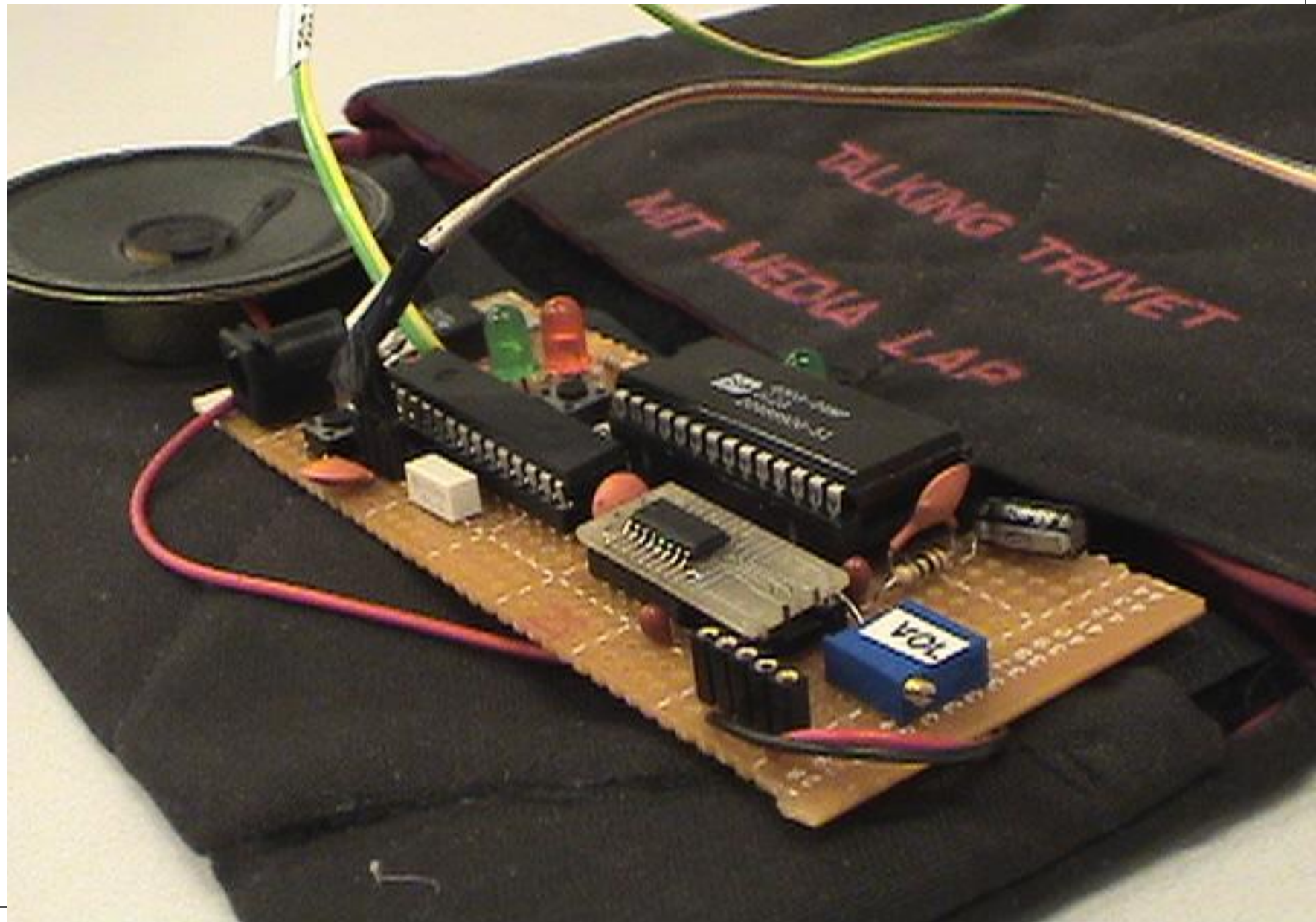

iSphere
a Proximity-based User Interface
for 3D Modeling
View
Edit


a
b
c
d
e
f
g

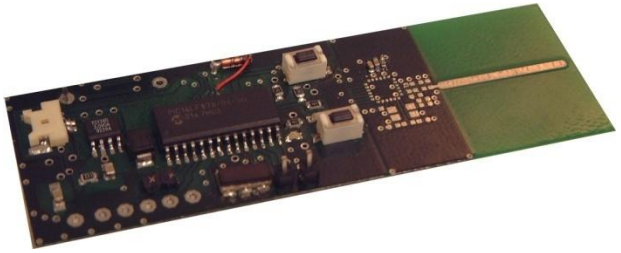
Augmented Reality Kitchen

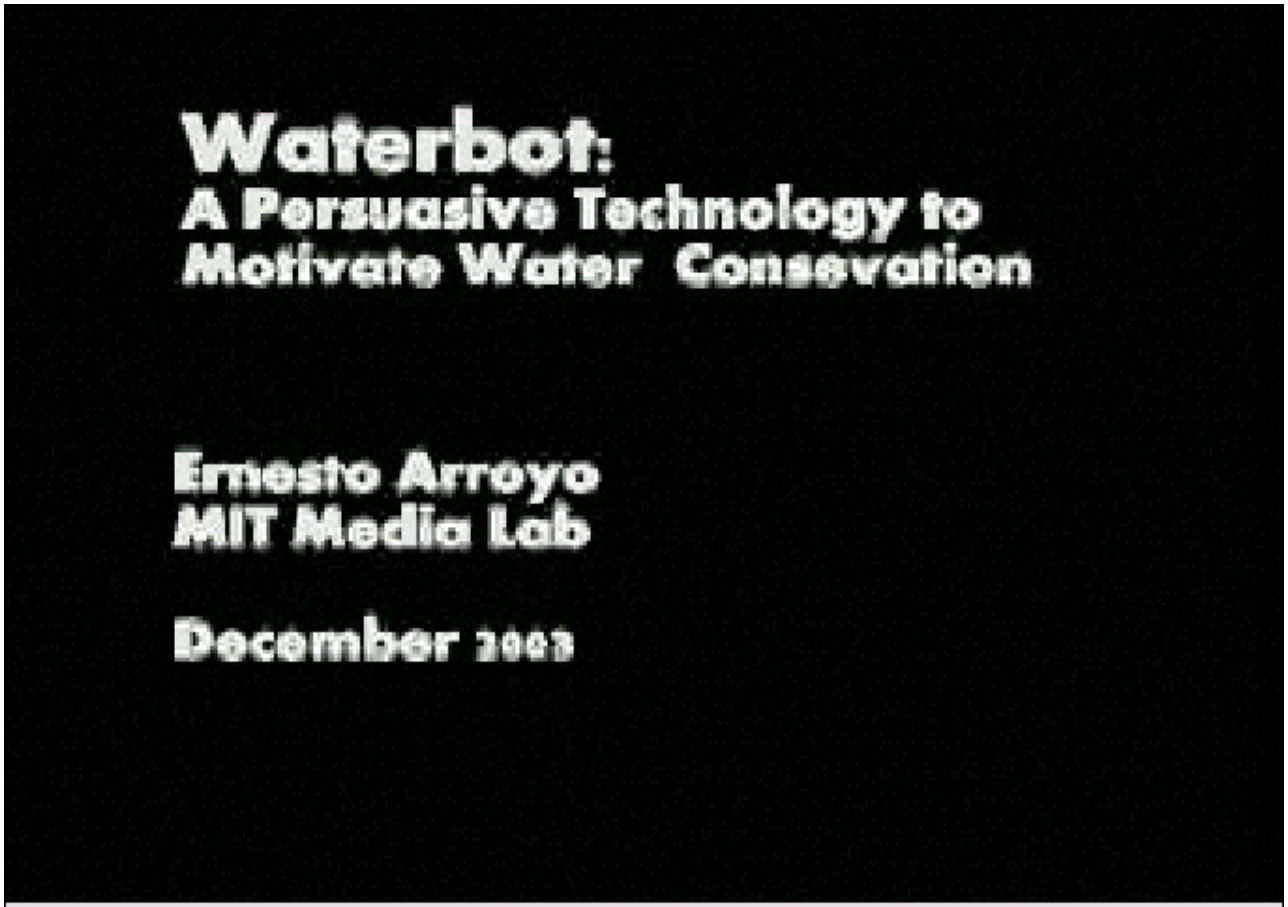
Augmented Reality Kitchen

Talking Trivet



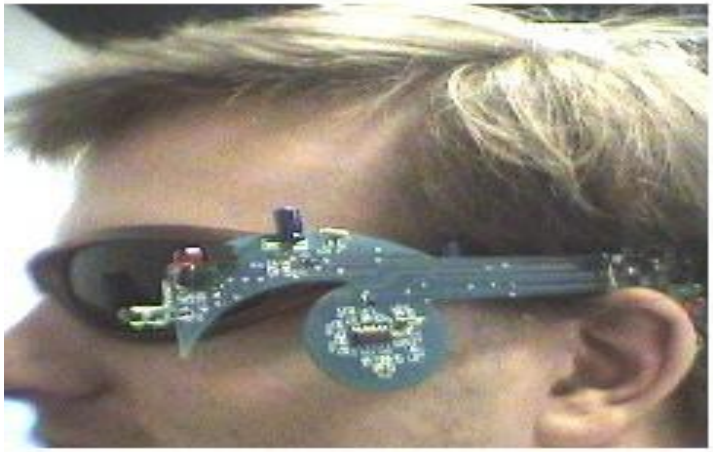
WaterBot

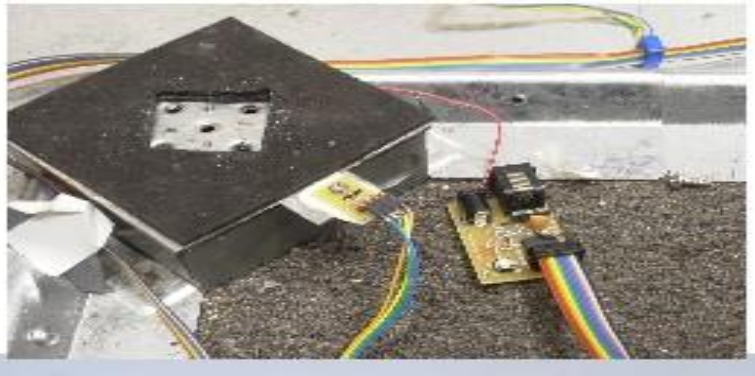




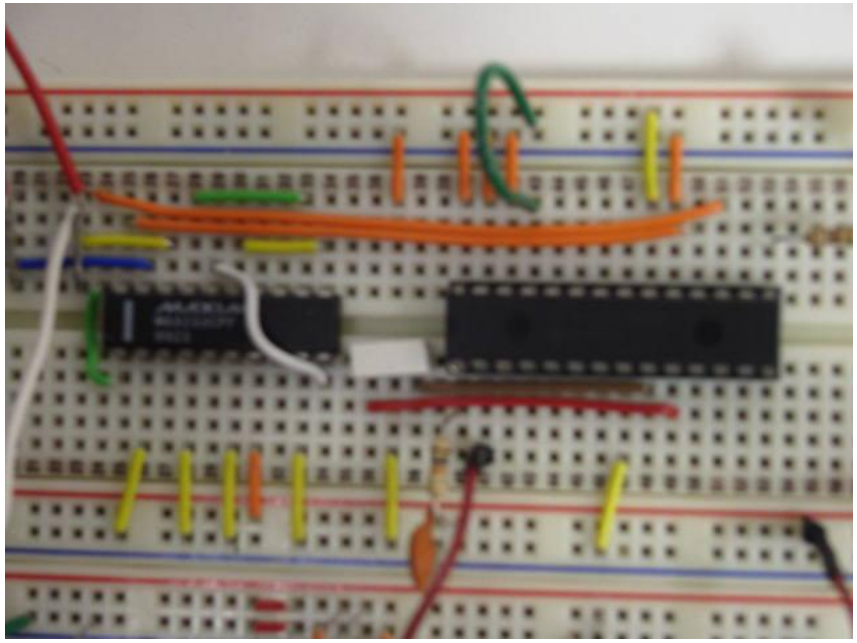
waterbotvirtualdub.avi

EyeR

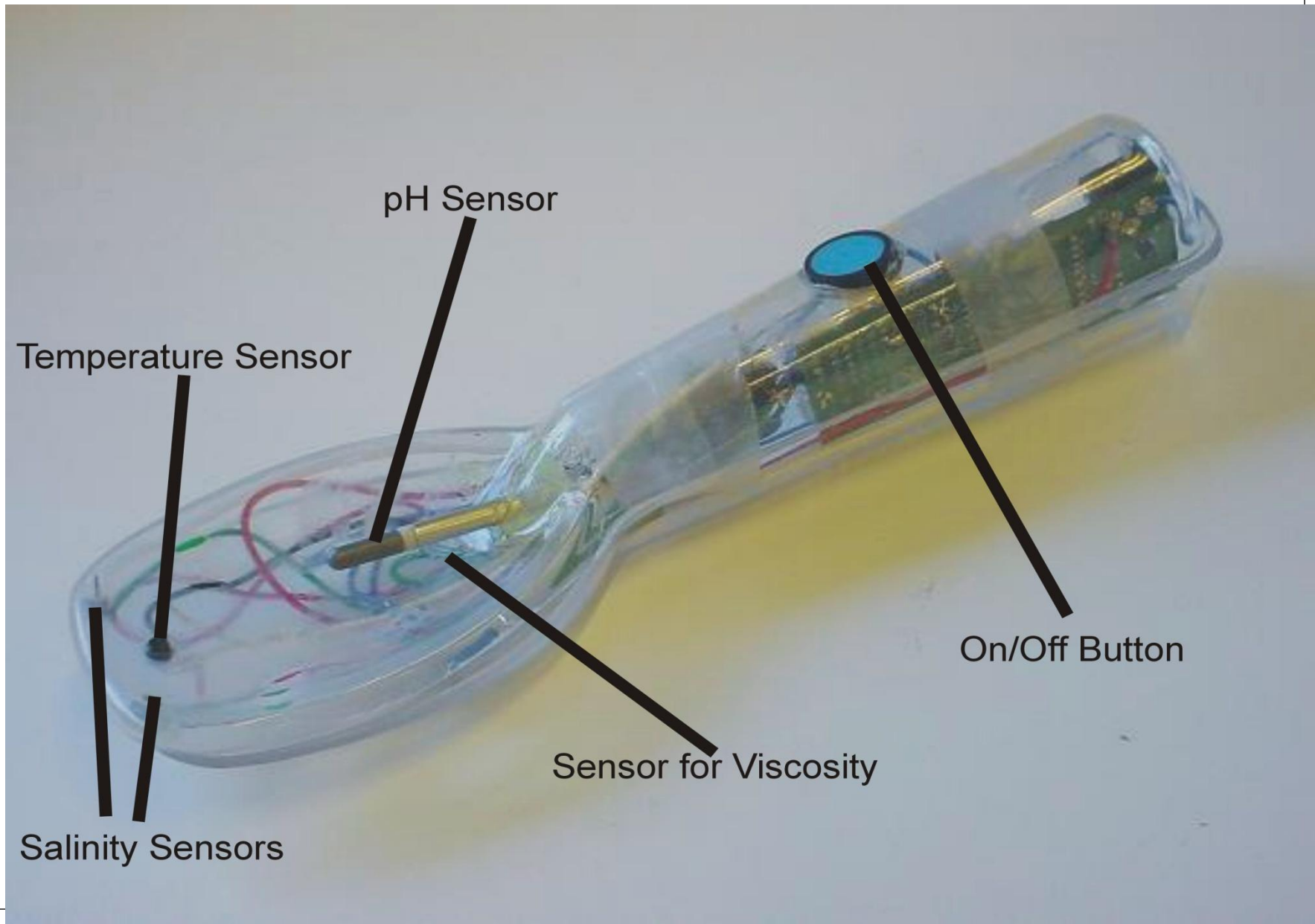




Thermo Mouse Pad



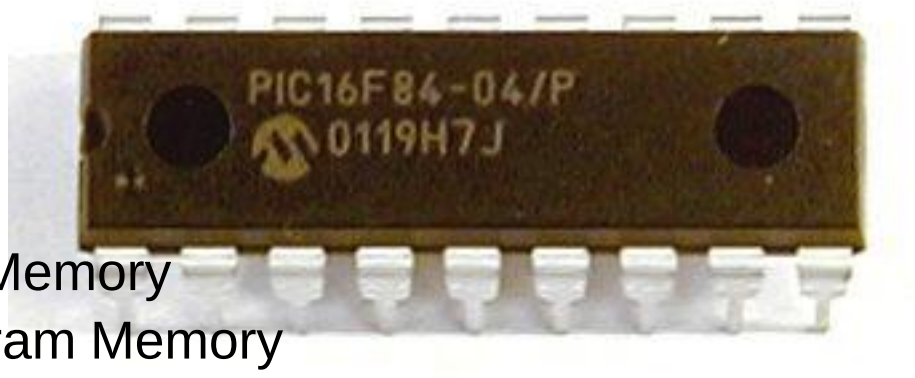
Spatula


pH Sensor
Temperature Sensor
On/Off Button
Sensor for Viscosity
Salinity Sensors

Spatula

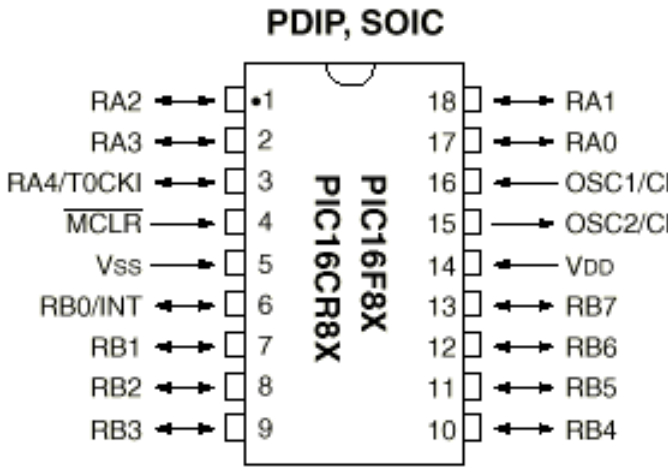
PIC16F88

- Microchip
- 8 bit
- Memory
  - 68 bytes of RAM Execution Memory
  - 68 bytes of EEPROM Program Memory
    - Retention > 40 years
- 2-5.5v
- 18 Pins
  - 13 I/O pins



www.microchip.com

I/O



PIC16F84A

TABLE 1-1: PIC16F84A PINOUT DESCRIPTION

Pin Name	PDIP No.	SOIC No.	SSOP No.	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	16	16	18	I	ST/CMOS(3)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	15	15	19	O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. In RC mode, OSC2 pin outputs CLKOUT, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$	4	4	4	I/P	ST	Master Clear (Reset) input/programming voltage input. This pin is an active low RESET to the device.
						PORTA is a bi-directional I/O port.
RA0	17	17	19	I/O	TTL	
RA1	18	18	20	I/O	TTL	
RA2	1	1	1	I/O	TTL	
RA3	2	2	2	I/O	TTL	
RA4/T0CKI	3	3	3	I/O	ST	Can also be selected to be the clock input to the TMR0 timer/counter. Output is open drain type.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	6	6	7	I/O	TTL/ST(1)	RB0/INT can also be selected as an external interrupt pin.
RB1	7	7	8	I/O	TTL	
RB2	8	8	9	I/O	TTL	
RB3	9	9	10	I/O	TTL	
RB4	10	10	11	I/O	TTL	Interrupt-on-change pin.
RB5	11	11	12	I/O	TTL	Interrupt-on-change pin.
RB6	12	12	13	I/O	TTL/ST(2)	Interrupt-on-change pin. Serial programming clock.
RB7	13	13	14	I/O	TTL/ST(2)	Interrupt-on-change pin. Serial programming data.
VSS	5	5	5,6	P	—	Ground reference for logic and I/O pins.
VDD	14	14	15,16	P	—	Positive supply for logic and I/O pins.

Legend: I= input O = Output I/O = Input/Output P = Power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Programming Languages

- ASM
  - Low level
  - Full Control
- BASIC, Forth, LOGO
  - Interpreted
  - Easy to use
  - Slow
- C
  - Most used
  - HiTech C
  - Microchip C
  - CCS PIC C
    - We will this

Program Example: Loop

```
/* pulses pin PORTB<3>
eight times */

pulse:
movlw 0x08
movwf counter

pulse_lp0:
bsf     PORTB, 3
bcf     PORTB, 3
decfsz counter, F
goto    pulse_lp0
return
```

ASM Code

```
/* pulses pin PORTB<3>
 eight times */

void pulse()
{
   int i;
   for (i=0; i<8; i++)
     { output_high(PIN_B3);
        output_low(PIN_B3);
        }
  return;
}
```

C Code

Compilers' Inefficiency

```
/* pulses pin PORTB<3>
eight times */


0000: movlw  0x8
0001: movwf  0x20
0002: bsf    0x6,0x3
0003: bcf    0x6,0x3
0004: decfsz 0x20
```

Our Code

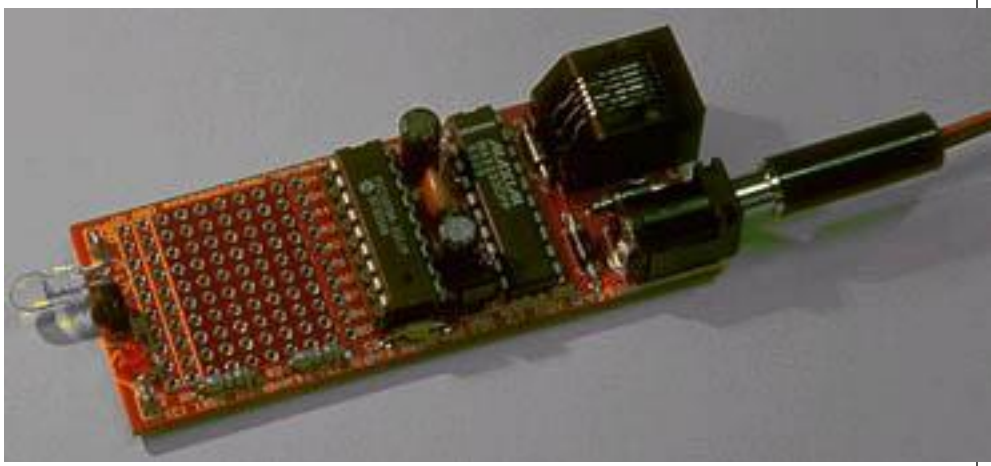
```
/* pulses pin PORTB<3> eight
   times */
   0005:  CLRF   21
   0006:  MOVF   21,W
   0007:  SUBLW  07
   0008:  BTFSS  03,0
   0009:  GOTO   014
   000A:  BSF    03,5
   000B:  BCF    06,3
   000C:  BCF    03,5
   000D:  BSF    06,3
   000E:  BSF    03,5
   000F:  BCF    06,3
   0010:  BCF    03,5
   0011:  BCF    06,3
   0012:  INCF   21,F
   0013:  GOTO   006
```

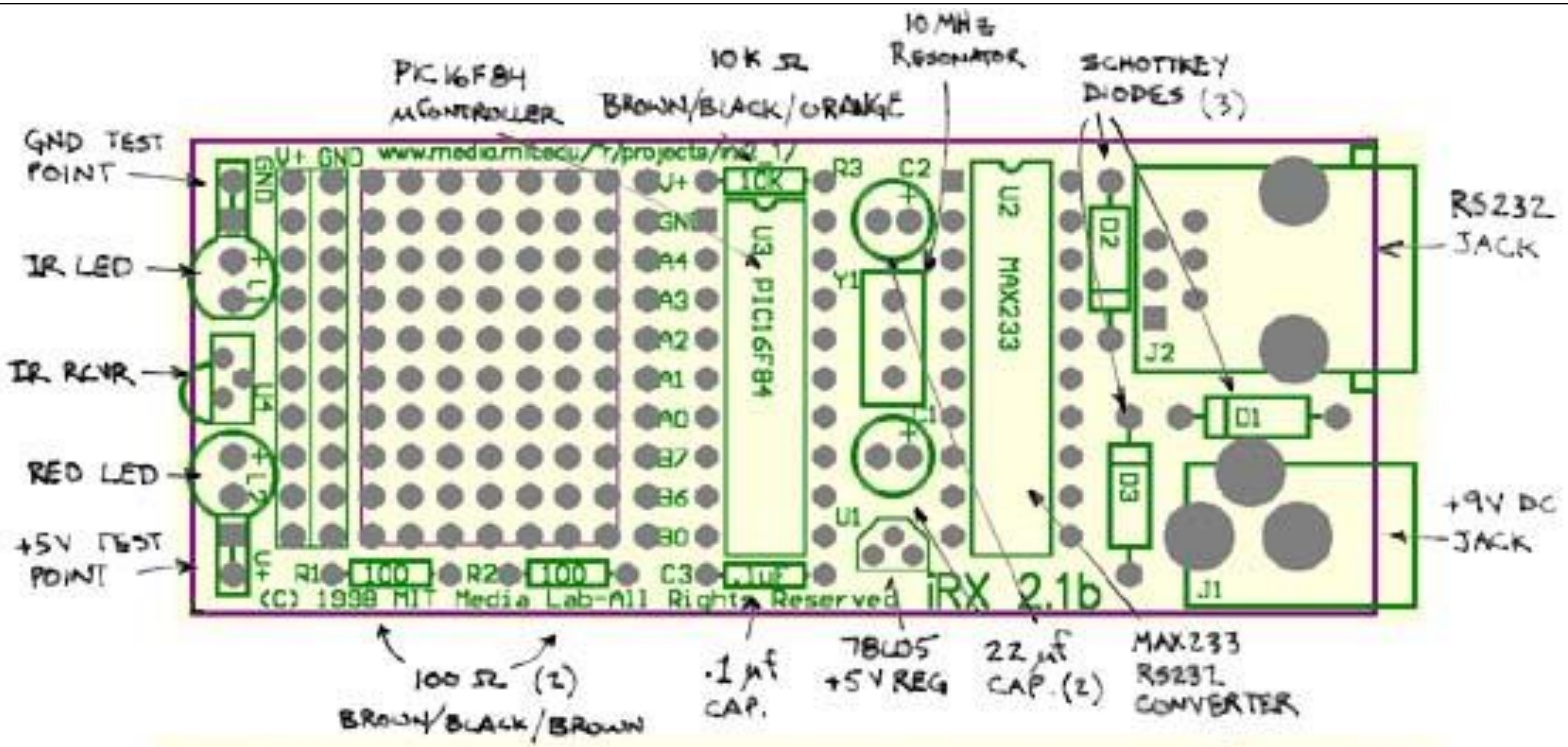
Compiler's ASM Code

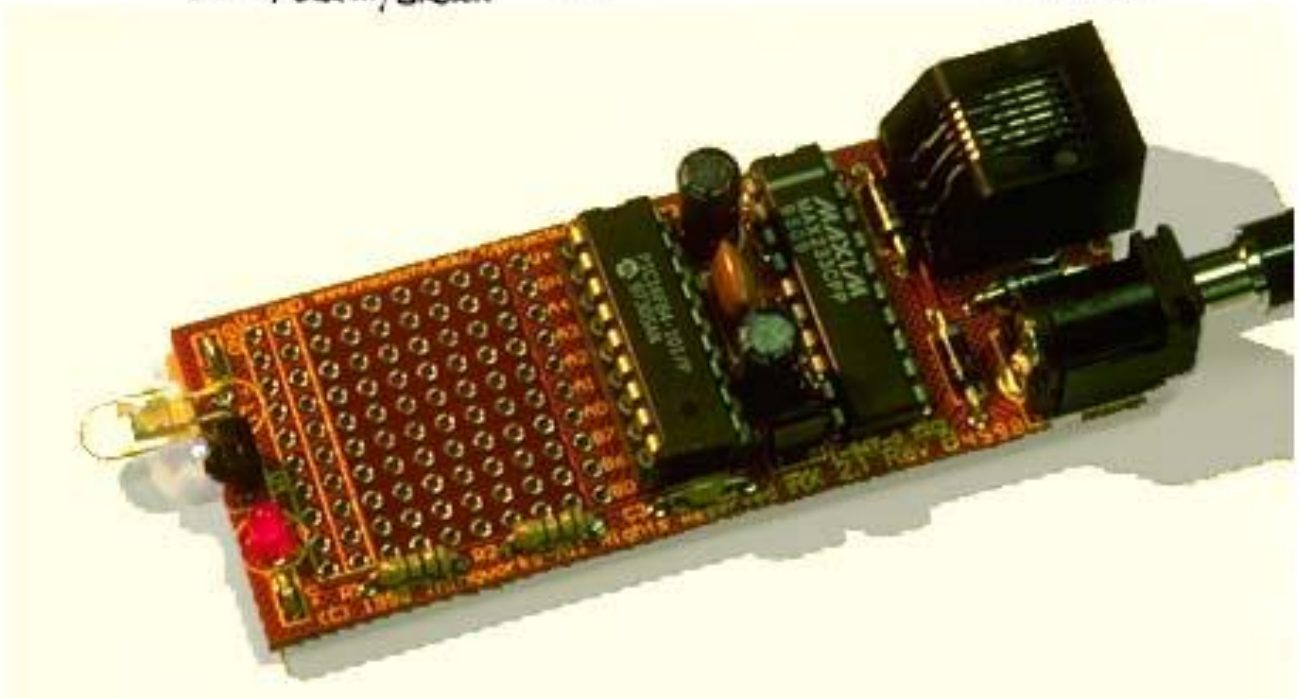
See http://www.ccsinfo.com/picc.shtml for compiler's info

IRX Board

- PIC16F84
- RS-232 Serial Port
- Visible LED
- Infrared LED
- Infrared Detector
- 8 I/O Available
- Prototyping Area




PIC16F84
μCONTROLLER
10K Ω
BROWN/BLACK/ORANGE
10 MHz
RESONATOR
SCHOTTKEY
DIODES (3)
GND TEST
POINT
IR LED
IR RCVR
RED LED
+5V TEST
POINT
RS232
JACK
+9V DC
JACK
www.media.mit.edu/~r/projects/mir
U3 PIC16F84
U2 MAX233
J2
J1
D1
D2
D3
Y1
U1
R1
R2
R3
C2
C3
(C) 1998 MIT Media Lab-All Rights Reserved
iRX 2.1b
100 Ω (2)
BROWN/BLACK/BROWN
.1 μf
CAP.
78L05
+5V REG
22 μf
CAP. (2)
MAX233
RS232
CONVERTER



What you need

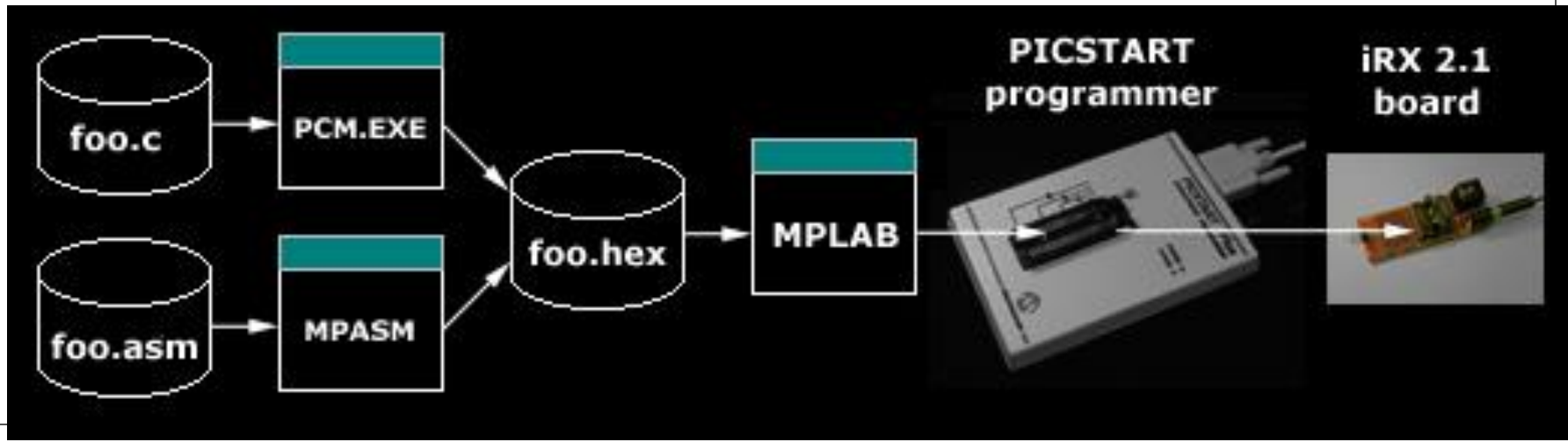
- PIC C/ASM Compiler
- PIC Programmer
- MPLAB IDE
  - Free

http://www.ccsinfo.com/

http://www.microchip.com

What is the Process ?

1. Write you program
   - MPLAB
   - C or ASM
2. Compile your program
   - CCS PCM
3. Transfer your program
   - Puts HEX file into the PIC
   - Use PICSTART and MPLAB
   - “Burns your app into the PIC”
4. Insert your PIC
   - Face pin 1 to resistor
5. Power it Up
   - Connect 9V Battery
6. Debug your program
   - Never works a the first time
7. Repeat step 1



Tips

Programming

- Flash LED at start up for 500 mSec or longer
- Program all unused I/O pins to be outputs

Debugging

- Make sure the PIC is inserted properly and pin 1 facing the resistor
- Verify you have power
- Check the oscillator

Hands on