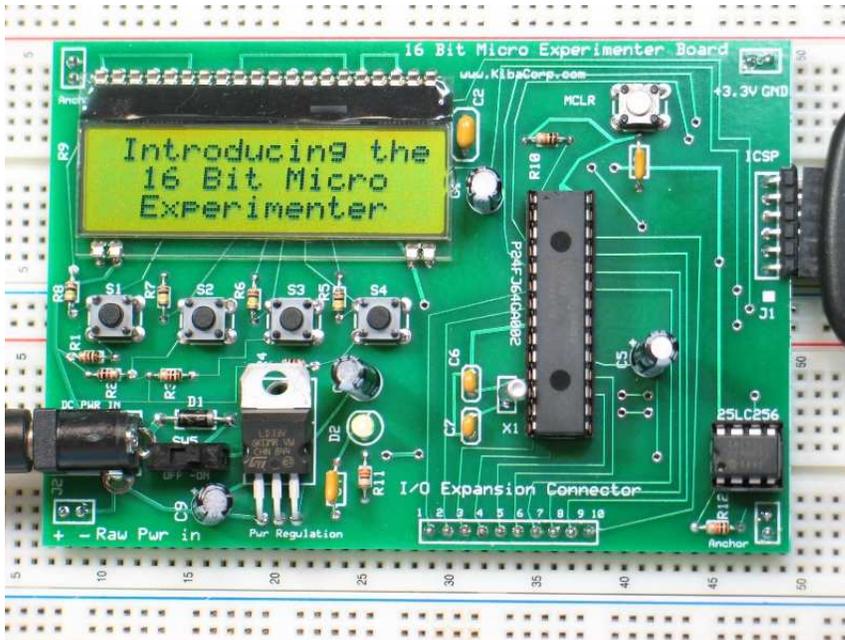


# Product Overview -A 16 bit Micro Experimenter for Solderless Breadboards

## 1.0 Introduction

The 16 Bit Micro Experimenter is an innovative solderless breadboard kit solution developed by a Microchip Academic Partner for the Practicing Engineer, Hobbyist or Student and is offered through KibaCorp [www.KibaCorp.com](http://www.KibaCorp.com)

The Experimenter facilitates prototype exploration and testing of Microchip 16 bit PIC24F Microcontroller with other electronics using the convenience of a solderless bread board environment



## Features

- Plug in Module Format with built in 3.3V regulator for use with larger solderless breadboards.
- 16x3 low profile LCD display and 4 user defined pushbuttons
- ICSP interface for in circuit programming and debug
- Standard I/O Expansion Bus for breadboard access to PIC24F peripheral set
- On board 32KHz timing crystal for accurate timekeeping
- On board 32KB EEPROM
- Uses PIC24FJ64GA002
  - +3.3 V Operation 16 MIPS with +5 Volt logic compatibility
  - 64K Flash 8K RAM
  - Host of on chip peripherals: ADC, Programmable I/O, Dual UART, Dual SPI, I2C, Analog Comparators, Capture/Compare Modules

- On/off switch with power on LED indicator-- power by wall transformer or direct connection. +3.3V out can be used for breadboard as well.
- Comes in kit format using full compliment of thru-hole parts for ease of assembly
- Demonstration Code to check board operation and facilitate experimentation

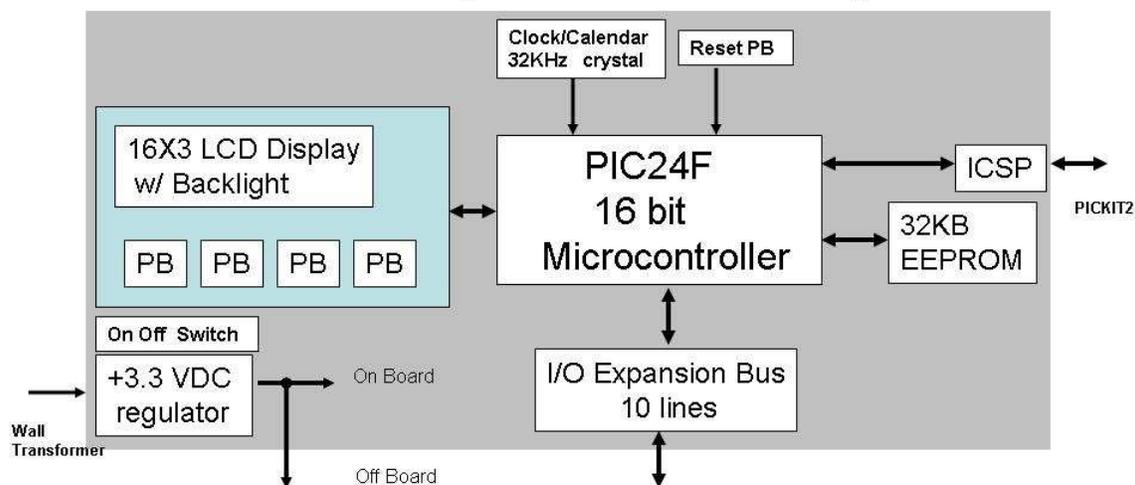
## 2.0 Applications

- Large application set for home laboratory or school use
  - Allows use of Microchip extensive support libraries
- Example Apps:
  - HTTP Web Server
  - FAT16 SD-Card Storage and retrieval
  - 100 year Date/Time Calendar
  - RGB Color palette
  - Thermometer
  - RTOS Multi-task experiments (FREE RTOS, (<http://www.freertos.org/> ) )
  - Assortment of other applications (user defined)
    - Accelerometer, Ranger Finder, RFID, PIR experiments
    - Elementary intro exercises for PIC24F ADC, CCP, UART and Digital ports

## 3.0 Experimenter Overview

The block diagram captures all the major functionality of the Experimenter.

### 16 bit Micro Experimenter Block Diagram



The center piece is Microchip PIC24FJ64GA002 Microcontroller. This member of the PIC24F is the lowest cost 16 MIPS (Million Instructions per Second) microcontroller available from Microchip, and is their advertised entry point from 8 bit microcontrollers.

The technology uses 3.3 Volts for operation. Its skinny dip is ideal for hands- on assembly.

Companion to the PIC24F is a 32KB Serial EEPROM (25LC256) that allows for flexible non-volatile storage as required during program operation to store those necessary items for some applications like calibration data, password or even miniature web page content. The Experimenter is also equipped with a clock crystal to insure accurate time keeping with the PIC24F internal Real Time Clock Calendar peripheral (RTCC).

The Experimenter also provides an I/O expansion bus that is driven by 10 different chip lines originating from the PIC24F. These I/O lines provide ample selection and access to the majority of the PIC24FJ64GA002 on chip peripherals, but more on this later.

All inputs are +5V volt tolerant, and all the digital only outputs can be configurable as Open Drain (open ended CMOS outputs), that can be tied to external pull up resistor to +5V to achieve +5 volt levels on output. This whole scheme allows easily transition when interfacing the 16 bit Experimenter with +5V logic families.

The Experimenter also provides a good measure of user Interface needs with a low profile 16x3 character based LCD display and 4 user configured pushbuttons

The whole assembly (4.25" x 3") is a two layer PC board constructed out of FR4 material. As shown it fits very well onto a large solderless breadboard configuration and consumes about a third of the space that would have been consumed had you elected to build the same configuration using point to point wiring. . On flip side of the module is a number of .100 in headers that are installed from the bottom and used for mechanical stability as well as functional I/O and power integration into the Solderless breadboard. The unit as a whole is easily removed and re-inserted.

Power can be applied to a DC barrel jack by a 9.1mm positive +6V to +9V wall transformer or optionally through a pin set designated as raw power located in lower left of the module. Incoming power is switch on/off to an on board +3V linear regulator. Power on condition is indicated by a green led. The Regulator +3.3V can also be made available to the Solderless breadboard through the upper board right Pin set. The development tool set to use with the Experimenter is Microchip's Inexpensive Integrated Development Environment (IDE) and the Microchip PICKIT 2 debugger and programmer kit. Visit Microchip's web site:

[http://www.microchip.com/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodeId=1406&dDocName=en023805](http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en023805)

The PICKIT2 requires an In Circuit Serial programmer interface (ICSP). Within the Experimenter the ICSP is conveniently located to the module's far right for easy insertion.

### ***3.0 Overview of Built –in Demo***

The Experimenter is equipped with a built-in demo. The demo was written using Microchip free MPLAB and PIC24F C code. The PIC24 C Compiler, MPLAB C30

v3.11b (or later), Student Edition is free and was used for this demo. Click the link below to download and see a full description of the compiler.

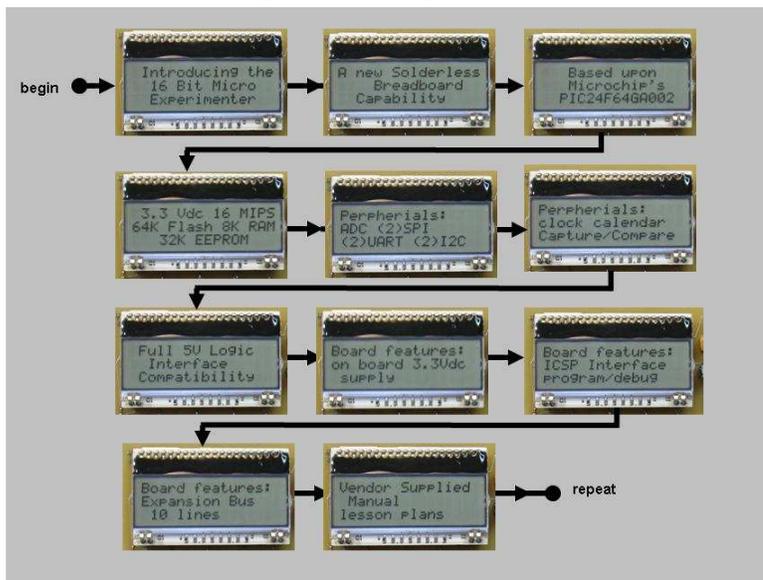
[http://www.microchip.com/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodeId=1406&dDocName=en010065&part=SW006012](http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en010065&part=SW006012)

The demo starts as a revolving series of eleven different flash screens, each lasting about 4 seconds. The user invokes a specific functional demo by pushing one of the pushbuttons.

Two of the introductory functional demos that come with the kit require some additional hardware and hook-up as shown. A third functional demo does not rely on any additional hardware. These functional demos are intended to allow user to gain familiarity with the Experimenter and insure its proper operation. As mentioned earlier, they can be invoked using the pushbuttons anytime during the flash screen displays and then can return to Flash Displays by simply pressing pushbutton S4.

### 3.1 Demo Flash Screen Sequence

16 Bit Micro Experimenter Start up Auto Flash Screens



## 3.2 Thermometer Functional Demo

### Thermometer

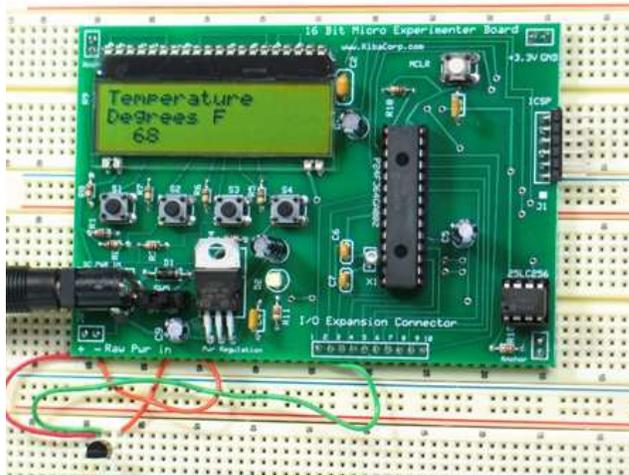


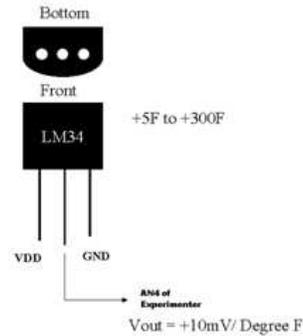
Figure 1 Thermometer Demo

Depressing Push Button S1 initializes Thermometer demo. This configures pin 1 of I/O expansion bus to be an analog input and then continuously digitizing this input using the PIC24F internal 10 bit ADC. The results are displayed in degrees Fahrenheit. You need to connect a LM34Z sensor as shown. Please use a raw input of +5VDC for input power to power the sensor. This can be done simply by applying power to the board through the RAW + and - inputs rather than using a wall transformer.

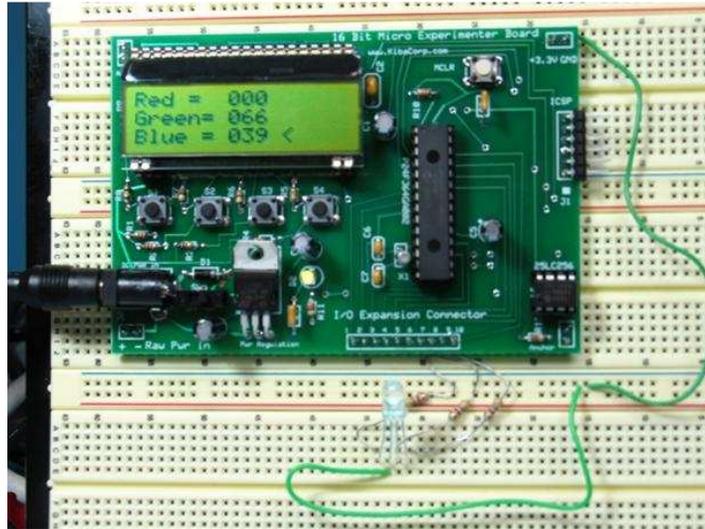
## 3.3 RGB Functional Demo

### Thermal sensor LM34Z

Sensor VDD -> RAW + (+5VDC)  
Sensor GND -> RAW - (GND)  
Sensor Out -> I/O bus pin 1

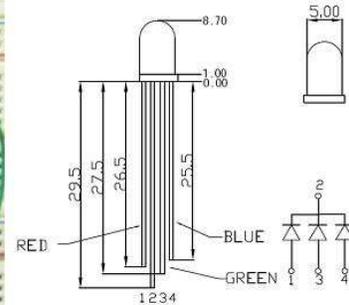


## RGB 16M Color Palette



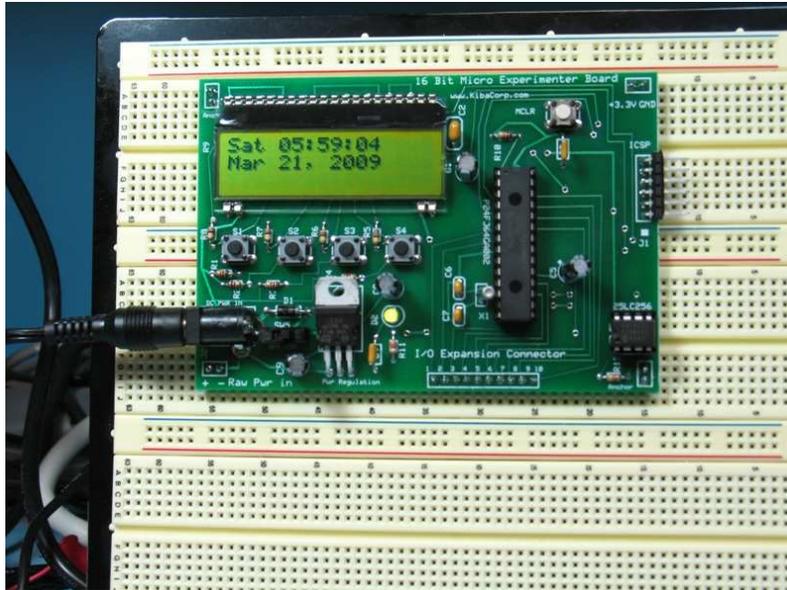
### RGB LED

LED Pin 1 -> 470 Ohm resistor -> I/O bus pin 7  
LED Pin 2 -> GND  
LED Pin 3 -> 470 Ohm resistor -> I/O bus pin 8  
LED Pin 4 -> 470 Ohm resistor -> I/O bus pin 10



Depressing Push Button S2 initializes RGB Color Generator. This Demo configures pins 7, 8, 10 to be independent Pulse Generators (using the PIC24F Output Compare Modules) to PWM separately each of the three LEDs (Red, Green and Blue) of an RGB LED. Each PWM output has a setting of 0-255 which can be set via the LCD and pushbuttons so that you can get 255x255x255 or 16M different colors under this arrangement. You need to connect a RGB LED as indicated, using 470 ohm resistors in series with each LED anode, and common cathode to ground. My RGB LED source was SPARKFUN ([www.sparkfun.com](http://www.sparkfun.com)) Enjoy the show! To exit and go back to the flash screens simply press S4.

## 3.4 One Hundred Year Clock/Calendar Functional Demo



Depressing pushbutton S3 initializes Clock demo. This demo enters a mode where pushbuttons assume clock setting and control operations for internal 100 year real time clock calendar. User options are: change mode from clock display to clock setting and enter clock changes, stay in clock mode to simply display clock, or exit clock mode back to “Flash Screens”. Designated button functions are as follows:

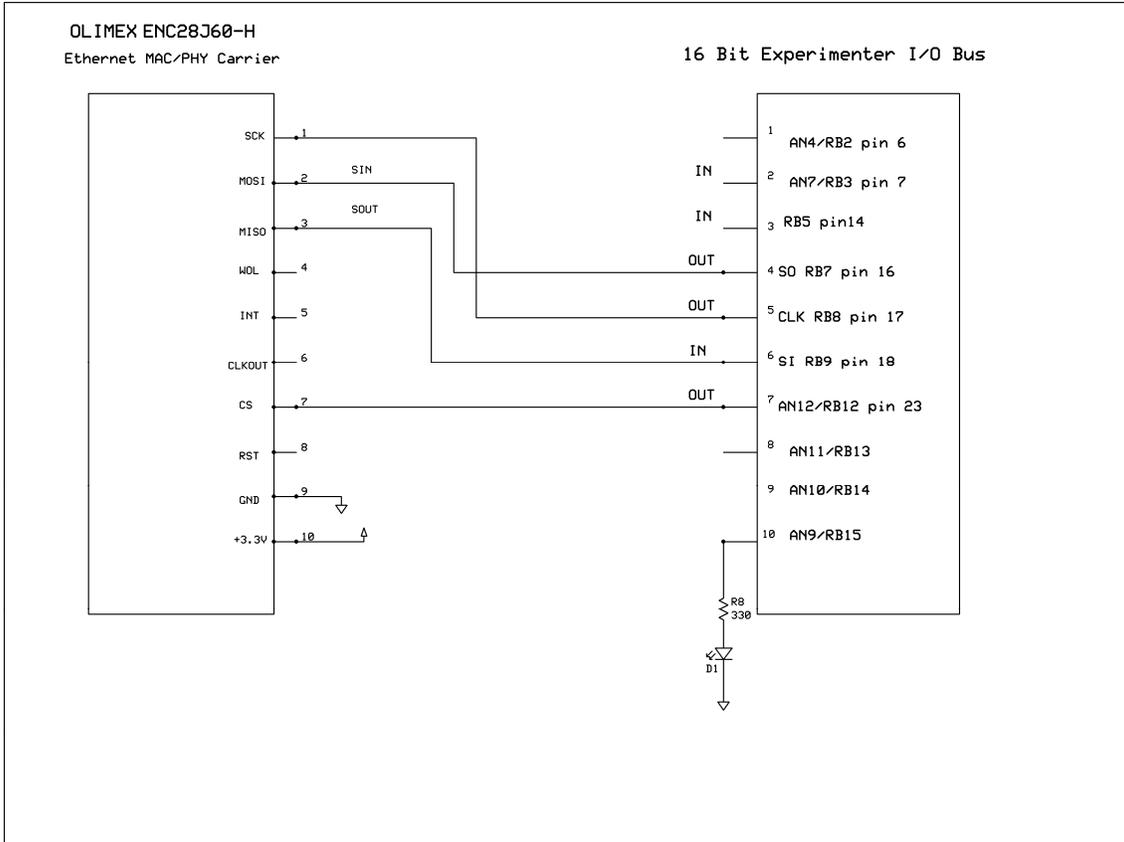
- Push Button S1 toggle between clock run mode and clock setting mode
- Push Button S2 if in clock setting mode increment current data field
- Push Button S3 if in clock setting mode decrement current data field
- Push Button S4 advance to next allowable data field if in clock setting mode or if pressed in clock run mode exit to “Flash Screens”

#### **4.0 A Standalone Application- HTTP Web Server**

The Experimenter with the right hardware/software can function as a HTTP web server as one of its stated applications. Microchip originally supplied the stack version 3.75.6 and HTTP server code, but an important additional resource for PIC24FJ64GA002 web code, tools and interfaces modules is LJCV Electronics Web site

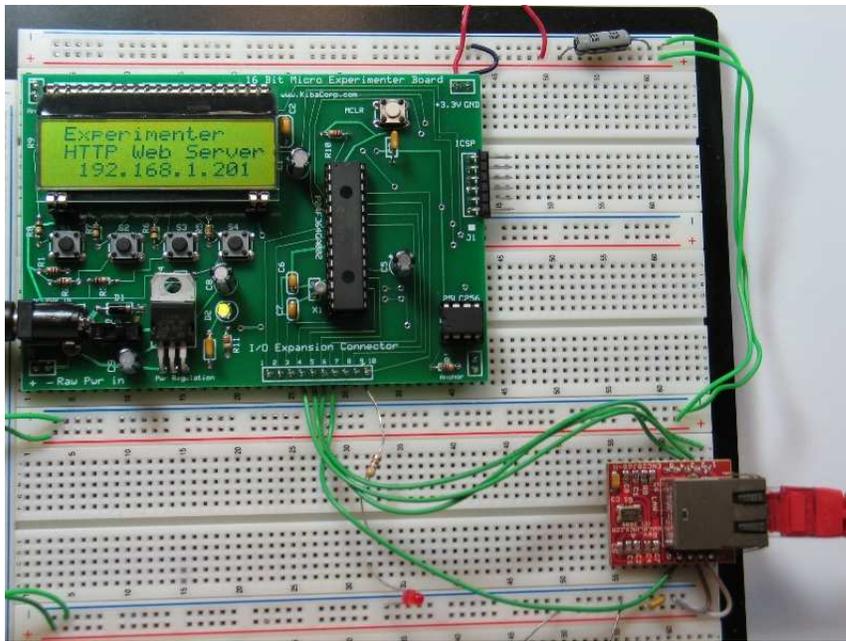
<http://www.ljcv.net/projects/pic24fj64/index.html>

A schematic for other electronics is shown using the OLIMEX ENC28J60-H is shown. See OLIMEX web site [www.olimex.com](http://www.olimex.com), an alternate module is LJVC nic28 module, see LJVC product listings at <http://www.ljcv.net/netdev1.html> ).



**Figure 2 Web Hook-up Schematic**

The schematic shows the Experimenter I/O connected to an OLIMEX Ethernet module. The photo below shows everything on a large solderless breadboard.



**Figure 3 Experimenter Web Server**

This application shows a static web page when an internet browser is opened to the Experimenter Server's IP address on your home local network. The Web page HTML data is stored on the Experimenter 25LC256 EEPROM.

The IP address of the Experimenter is fixed at 192.168.1.201. The Experimenter web server supports ping, so using the PING command under windows command prompt, you can verify the reply response from the Experimenter.

The Experimenter 25LC256 EEPROM needs to be programmed with the HTML information. This info is coded in Microchip web page image format. Since the web server supports FTP protocol, we can use this to download load of a web image to Experimenter. Use the command prompt and start an FTP session using `ftp 192.168.1.201`. For user prompt use **ftp** and for password prompt use **microchip**. Execute the **put** command to transfer the web image file into the Experimenter board remotely. Exit the FTP session by typing **bye**.

Once this is process is completed, bring up an internet browser to 192.168.1.201 and you should see the Experimenter web site.

### PING Command

```
C:\EXJORGE>ping 192.168.1.201
Pinging 192.168.1.201 with 32 bytes of data:
Reply from 192.168.1.201: bytes=32 time=2ms TTL=100

Ping statistics for 192.168.1.201:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 2ms, Average = 2ms
```

### FTP Command

```
C:\EXJORGE>ftp 192.168.1.201
Connected to 192.168.1.201.
220 Ready
User (192.168.1.201:(none)): ftp
331 Password required
Password:
230 Logged in
ftp> put mpfsimg_3.bin
200 Ok
150 Transferring data...
###
226 Transfer Complete
ftp: 2526 bytes sent in 0.00Seconds 2526000.00Kbytes/sec.
ftp> bye
221 Bye
```

Figure 4 Commanding the Experimenter over Web

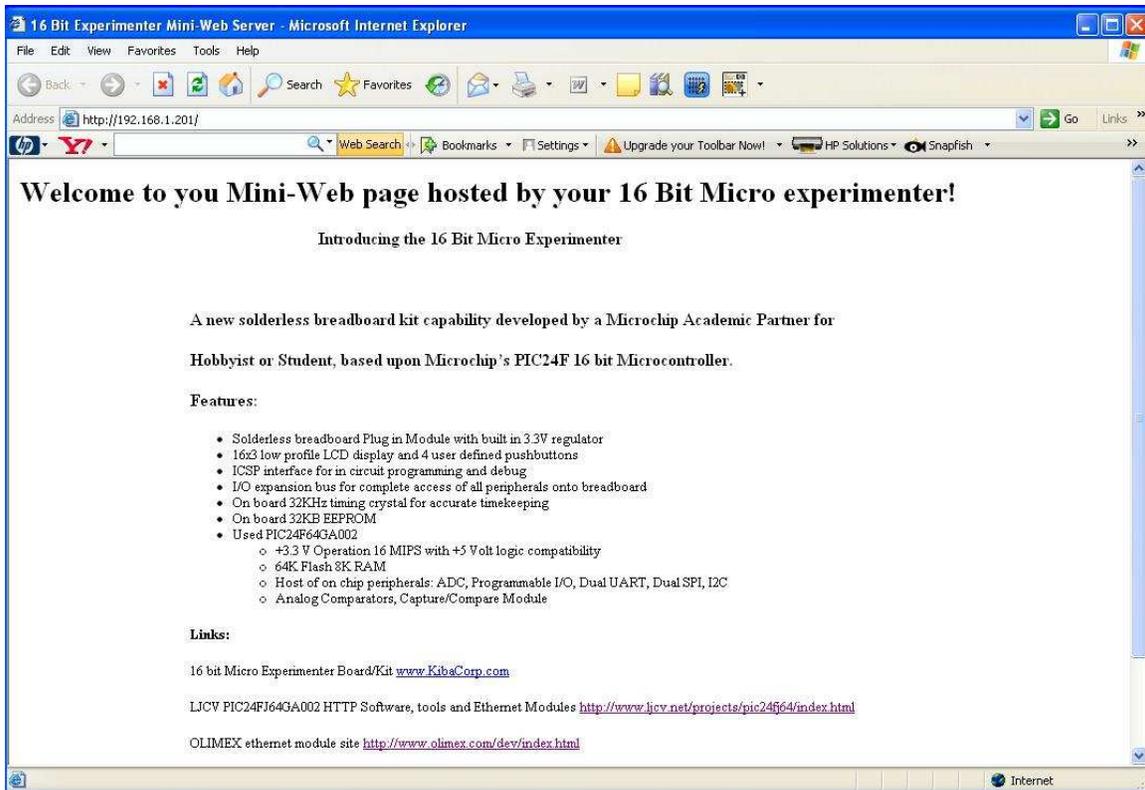


Figure 5 Experimenter Built-in Web page

## 5.0 Overview of Experimenter I/O expansion Bus

### I/O Expansion Bus

The I/O bus is a convenient way of accessing the ports and built-in peripherals of the PIC24F on the Experimenter Module. The pin assignments for the I/O bus are shown. PIN 7 for instance can be fixed to either analog Input Channel #11 (AN11), or digital change notification #14 (CN14) or simply a digital I/O pin #13 for Port B (RB13). Note that this pin also can be used as RP12, in which case it can be configured by code to be any in or out from any of the major on-chip peripherals (i.e. UART, SPI, Capture Compare to name a few). The makes the I/O expansion bus for the Experimenter a pretty powerful resource for Solderless prototyping. A number of these I/O are used in the demo code.

J3 I/O Expansion Bus

J3 I/O bus PIN	Normal Assigned PIN	Programmable PIN
<b>PIN 1</b>	AN4,C11IN-,SDA2,CN6,RB2	RP2
<b>PIN 2</b>	AN5,CIN+,SCL2,CN7,RB3	RP3
<b>PIN 3</b>	SDA1,CN27,RB5	RP5
<b>PIN 4</b>	INT0,CN23,RB7	RP7
<b>PIN 5</b>	SCL1/CN22/RB8	RP8

<b>PIN 6</b>	SDA1/CN21/RB9	RP9
<b>PIN 7</b>	AN12/CN14,RB12	RP12
<b>PIN 8</b>	AN11/CN13,RB13	RP13
<b>PIN 9</b>	AN10,CVREF,RTCC,CN12,RB14	RP14
<b>PIN 10</b>	AN9,CN11,RB15	RP15

## **6.0 Installing Tools**

You are going to want to install your own development tools to program the Experimenter on your own. Recommend you purchase from Microchip their PICKIT2 development kit.

You need to install a copy of Microchip MPLAB IDE to be able to use it. It will exist on the CD-ROM associated with the PICKIT2 kit you purchased. Install software as directed. Our demo is written in C code. We therefore need to install a copy of the PIC24 C Compiler. The MPLAB® C30 compiler is a full-featured ANSI compliant C compiler for the Microchip 16-bit PIC24 Microcontroller. MPLAB C30 v3.11b (or later) Student Edition is free and thus this is used for this demo. Click the link below to download and see a full description of the compiler.

[http://www.microchip.com/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodeId=1406&dDocName=en010065&part=SW006012](http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en010065&part=SW006012)

Finally we need to install PICKIT2 kit programmer and debugger software. Once MPLAB, PIC24 C compiler, and PICKIT2 installs are complete you will have a fully integrated 16 bit PIC24 Microcontroller development system at your disposal. A good way to start is to program the Demo yourself onto the Experimenter. Let's discuss this in the next section.

## **7.0 Programming the Experimenter First Time**

The Demo application code for this project is downloadable from KibaCorp [www.KibaCorp.com](http://www.KibaCorp.com) and also exists on the CD-ROM supplied with the kit under Software Directory.

Please load, unzip, and place the project folder Demo on your desktop, also download exp16\_web.hex and mpfsimg\_3.bin and put these as well in a convenient location on your computer.

Now connect the PICKIT2 to USB of you computer and the other end to the ICSP Bridge on the Experimenter. Switch on power to the Experimenter. Open the folder containing our application code, and double click project file Demo.mcp. You should see the following screen shot (see figure 6). The demo project directory is visible, C code for Main function is open, and the output window should display PICKIT2 ready, PIC24FJ64GA002 found, and show that target power is applied.

If a reconnection to PICKIT2 is required, simply click on the PICKIT2 ICON in the tool bar and watch for the above messages in the output window.

We are almost there. On the IDE toolbar click the Build button, and watch IDE and PIC 24 C Compiler compile the program. The output window should indicate no compile error. Use Program option pull down list and select program. The PICKIT2 will then actively program the PIC24F flash on your breadboard through ICSP.

At the completion of this your Experimenter ought to automatically come up and display an automatic flash screen on LCD Display as it did before. You should use the button to activate demo. You can now either remove the PICKIT2 from the ICSP or leave it connected. The Experimenter will now work independently on each power up cycle.

To program the exp16\_web.hex just open the Microchip IDE directly without a project. Select the PIC24J64GA002 from device configuration and under file operation import the web object code. Use the PICKIT2 to program the Experimenter.

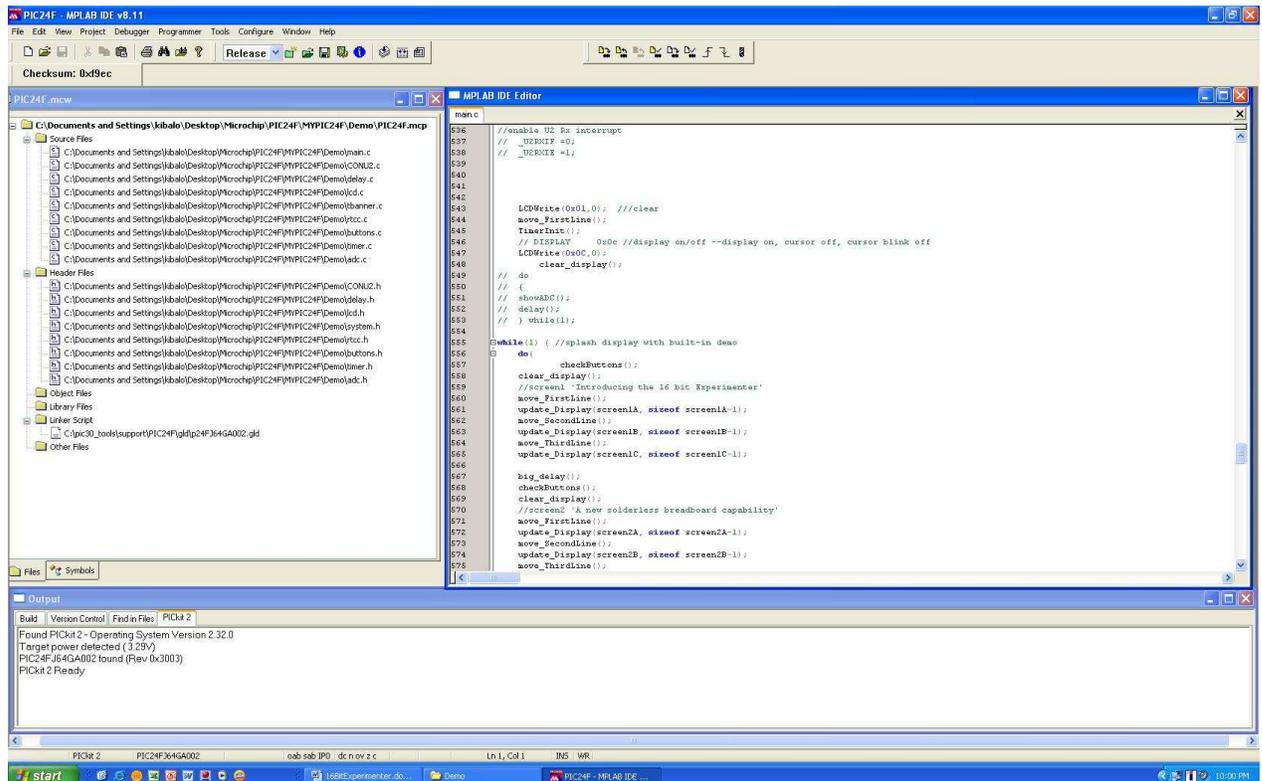


Figure 6 Demo Project open using IDE