.NET & Internet of Things

The fun and easy way,

the **FEZ** way...

Connecting the world, one "thing" at a time!

Brought to you by

GHI electronics

with the

Microsoft .NET Micro Framework

April 27, 2011

www.ghielectronics.com

Table of Contents

Document Information

Information	Description
Abstract	This document provides several fun projects on how to connect things to the cloud.

1. Introduction

While the internet is becoming an essential part of our daily life, it is also becoming an important part of the devices (things) we depend on. If devices can communicate then they can probably preform better. This concept is called “The internet of things”. See wikipedia for more details http://en.wikipedia.org/wiki/Internet_of_Things and don't forget to watch this video as well http://www.youtube.com/watch?v=sfEbMV295Kk

But how do we connect to the internet? We would need hardware with Ethernet or WiFi interface. We also need the low level software that carries out the low level communication over the internet. Neither of these is usually simple to accomplish, but thanks to .NET Micro Framework from Microsoft and the devices and libraries from GHI Electronics, connecting devices to the internet is a simple task.

2. Prerequisite

This book expects you to have basic knowledge of C# and visual studio. Not to worry, if you don't, there is another beginner guide to get you through it all.

This page is a compilation of key resources and tutorials http://www.tinyclr.com/support

Not to forget about the very friendly and active community available at

http://www.tinyclr.com/forum/ and the hundreds of code examples found at http://code.tinyclr.com

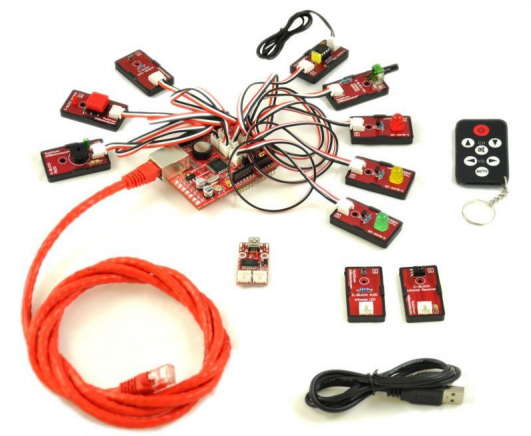
3. Complete Kits

This book is aimed towards the FEZ Internet of Things Kit and FEZ Ultimate Kit

3.1. Internet of things Kit

With over ten years of experience working on little embedded devices and with the help of the www.TinyCLR.com community, GHI is combining the most popular sensors along with plenty of projects to bring the “internet of things” right to your desk. Complete projects with detailed explanations are included in this book to complete many internet-connected device, all for under $100.

On the hardware side, all of the components are plug-and-play. No soldering or any special skill is required. Also, on the software side, all open-source drivers are included. Use the provided drivers as-is or modify to fit your needs.



The kit doesn't come with a processor board giving the user further flexibly selecting a device. FEZ Domino, FEZ Panda or FEZ Panda II are ideal mates for the Internet of Things Kit. The kit even works with Arduino and its derivatives, keeping in mind that all open-source code samples are this book are aimed to using C# for FEZ and .NET Micro Framework.

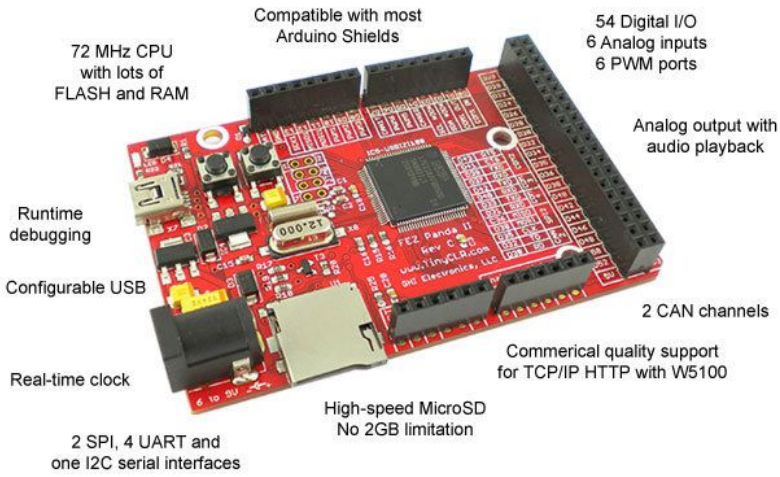
3.2. FEZ Ultimate Kit

Expanding on the Fez Internet of Things Kit, FEZ Ultimate kit takes the same kit and adds FEZ Panda II with FEZ Touch at only $149.95.

4. FEZ Ultimate Kit Contents

4.1. FEZ Panda II

The second generation of FEZ Panda is a state-of-the-art processor board, capable of hosting complete commercial applications.



The Panda Hardware

- 72Mhz 32-bit processor with 512KB of FLASH and 96KB of RAM
- 148KB of FLASH and 62KB of RAM are available for your application
- Micro SD socket capable of hosting any size memory card, drop in a 16GB memory card and you have near unlimited embedded storage
- Real Time Clock (RTC). By adding a little 3V watch battery, FEZ Panda can keep track of time for years even if FEZ Panda is powered off
- Over 60 digital inputs and outputs
- 6x Analog inputs
- One analog output which is also capable of audio playback

- 6x PWM channels
- 2x CAN channels
- 4x UART (serial ports)
- 2x SPI
- I2C
- USB Client
- USB Host (requires minor hardware modifications)

The Panda Software

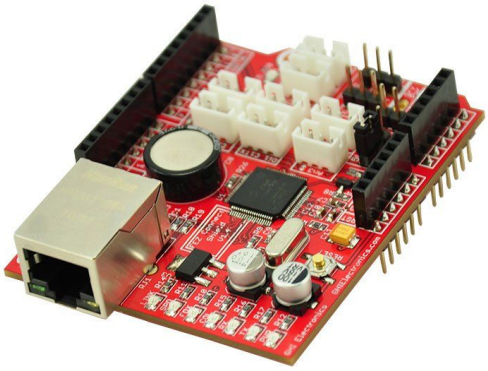
FEZ Panda packs loads of libraries ready for you to use. Some of these libraries are from the core of NETMF and some are GHI exclusive. Here is some of the main libraries

- Threading
- Memory management
- Visual Studio Debugging
- SPI
- UART, serial COM ports
- I2C
- CAN
- OneWire
- In Field Update
- Wiznet networking
- CAN
- USB Client Customization, USB Card reader simulation, USB mouse/keyboard simulation, USB virtual serial port.
- USB Debugging + Virtual Serial port

4.2. FEZ Internet of Things Kit Contents

FEZ Connect Shield

This shield plugs right into FEZ Panda and “connects” you to the outside world. It has the circuitry needed to connect to Ethernet and also has eight JST connectors, where eblocks can plug right in. There are also 2 headers to connect servo motors.



eblocks are electronics building blocks where each has a specific feature allowing electronics to connect to our physical world. From measuring temperature to outputting light. The following eblocks come standard with the “FEZ Internet of Things” kit but note that there are plenty of other sensors for you to add to your project, these sensors can be purchased at http://www.ghielectronics.com/catalog/category/3/

LED

There are 3 LEDs included with the kit, Red, Yellow and Green.

Switch

An easy way to read an input from a user.

Temperature sensor

This component provides an analog value representing the temperature at the tip of the NTC water resistant thermistor (included). Temperature measured can be ranging between -20 to 54 degree Celsius. This sensor works with any pin with Analog input feature on FEZ.

38Khz Infrared Receiver

This component is used to detect infrared signals of 38kHz carrier. The sensor output is logical high when it detects 38kHz frequency, otherwise the output is low. It can be used to detect the signal sent by the ER-4 Easy Remote (not included) or most TV remotes.

IRLED Transmitter

Pair this simple IR LED Transmitter with the Infrared Receiver.

Light Sensor

Use with any analog pin to measure light's intensity.

Piezo (speaker)

Piezo can be used to generate all kinds of tones. Use it as an alarm clock or to play simple melodies!

Variable Resistor (POT)

Potentiometers (POT for short) are variable resistors that change their resistance when the knob is rotated. This is similar to the volume control you see on many devices. Works with any pin with Analog input feature on a FEZ.

Serial-to-USB

This eblock instantly converts any COM (serial) port into a USB connection. Windows sees this eblock as a virtual serial port so, for Windows applications, this is simply a serial port on the system.

Cables

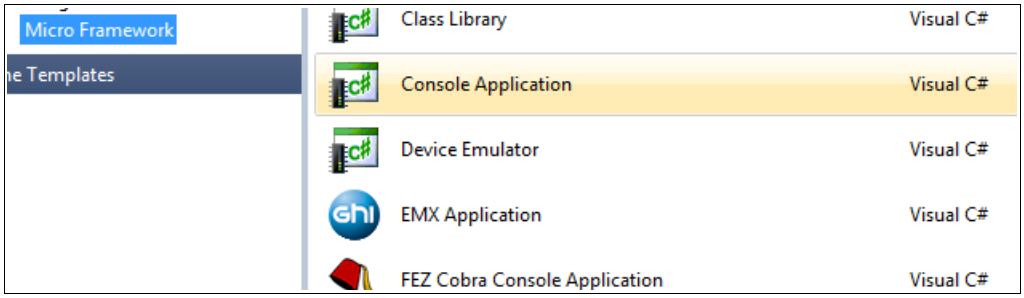
The kit also includes a mini USB Cable for the Serial-to-USB eblock and an Ethernet Cable.

5. Going On A Test Drive

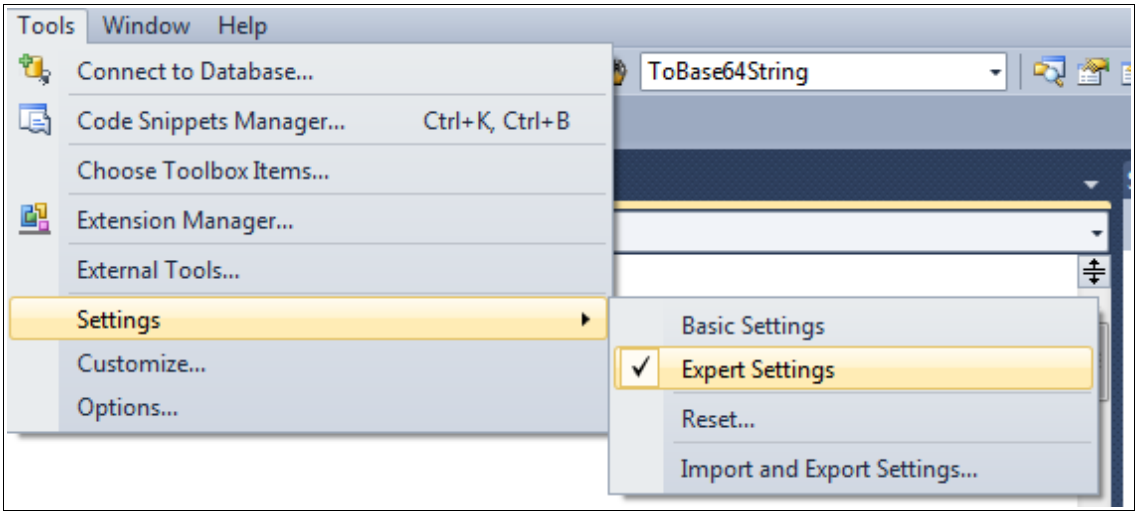
Note 1: If you are already using GHI's NETMF devices then you can skip this chapter. If this is the first time you use GHI NETMF devices then start with this tutorial http://wiki.tinyclr.com/index.php?title=First_Project

5.1. Testing the Emulator

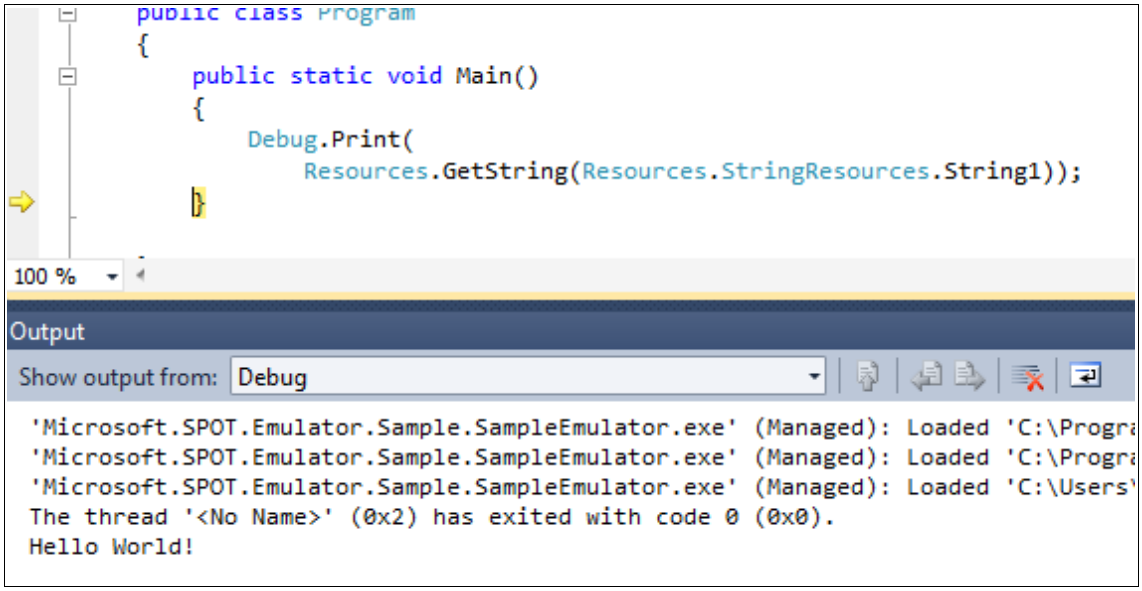
Create a new “Micro Framework” C# console project



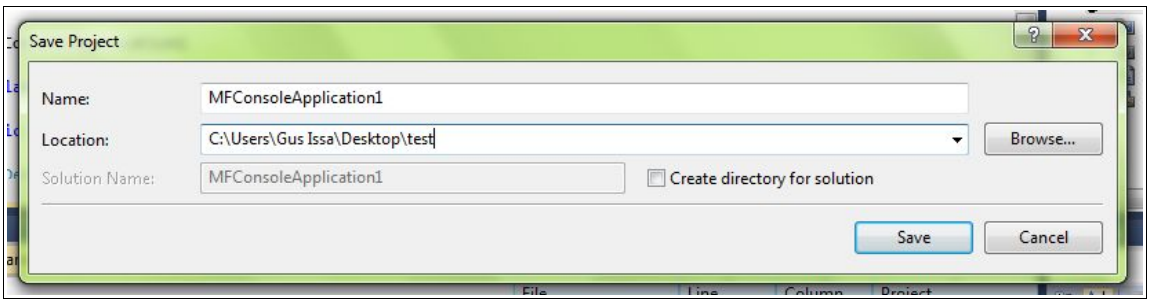
Leave the code unchanged and press F10 (once) to step in the code. This is a shortcut for “Debug → Step Over”. Now, open the output window. Note that you need to enable “expert settings” if you haven't done so already.



Step more in the code using F10 till you go over the line with “Debug.Print” and you will see “Hello World” in the output window.



Stop debugging using “shift+F5”. Save your project as we will be adding to it shortly.



5.2. Check the Firmware Version (very important)

Before using your FEZ, it is **very important** to check that your PC and your FEZ has the latest firmware. Start by checking the release notes online found at this link http://www.tinyclr.com/release-notes/

Now, open the release notes file found on your PC under

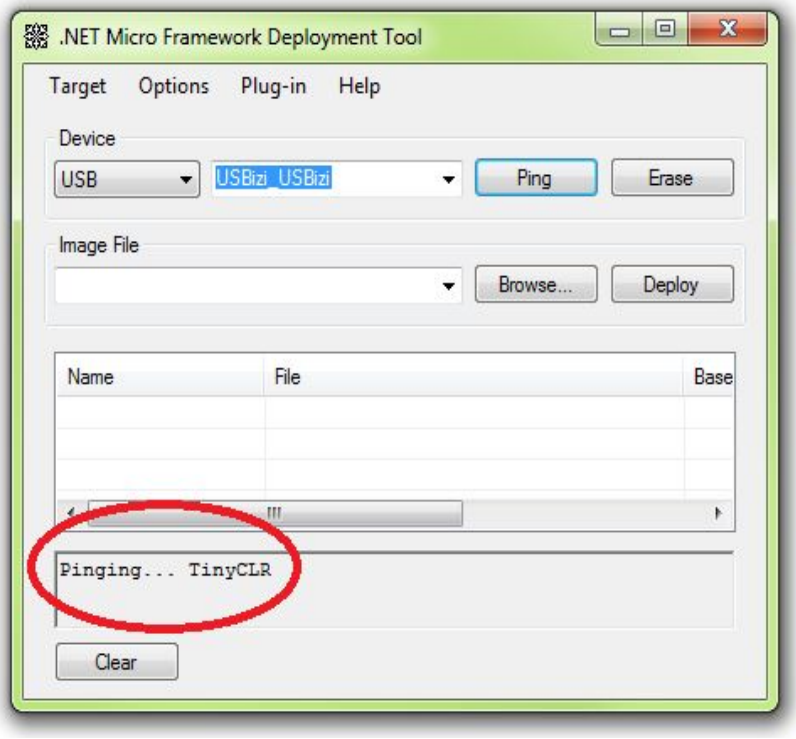
C:\Program Files (x86)\GHI Electronics\GHI NETMF v4.1 SDK\Release Notes.rtf

If your PC has an older version than what is online, you should uninstall the GHI SDK then download and install the newer one from GHI.

The next thing to check is that FEZ has the latest firmware loaded on it, which is also the latest version, as we have done in previous step. We need to start MFDeploy, a software that ships with Microsoft NETMF SDK. You should find it under

C:\Program Files (x86)\Microsoft .NET Micro Framework\v4.1\Tools

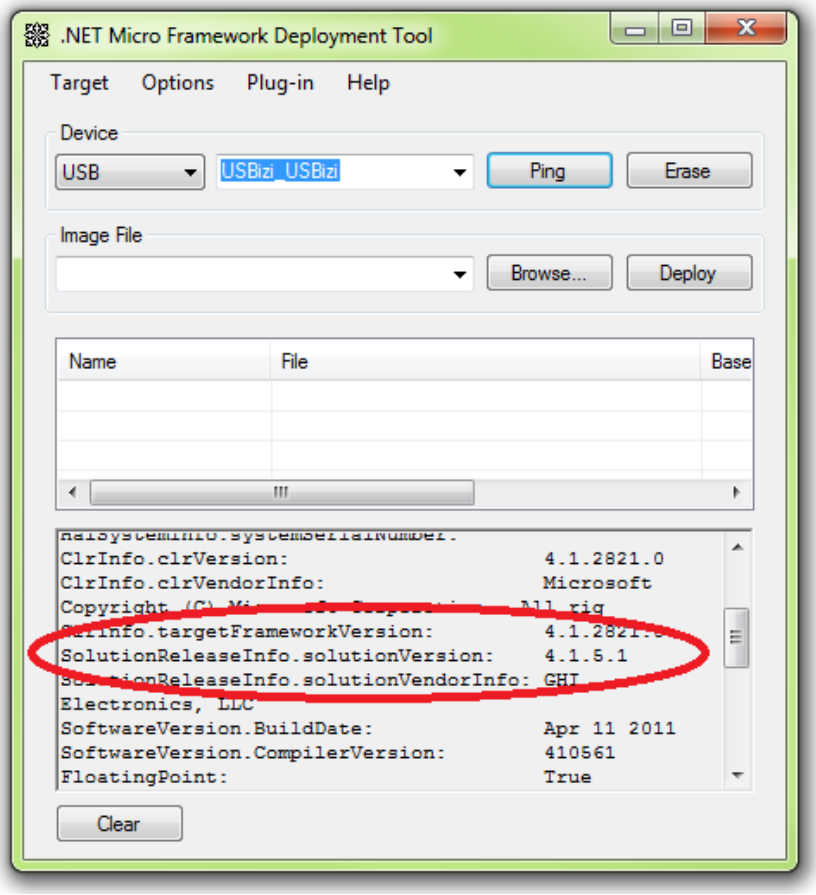
Under “Device”, select USB and you should see USBizi_USBizi in the list. I am assuming you have FEZ connected of course. Now click “Ping” and your FEZ will respond with TinyCLR



From the top menu, run “Target → Device Capabilities” which will query a lot of info from FEZ but we are mainly interested in is the “Solution version”. This number much match the USBizi version number in release notes, which also matches the latest from the website.

Firmware update tutorial is available here:

http://wiki.tinyclr.com/index.php?title=Firmware_Update_USBizi



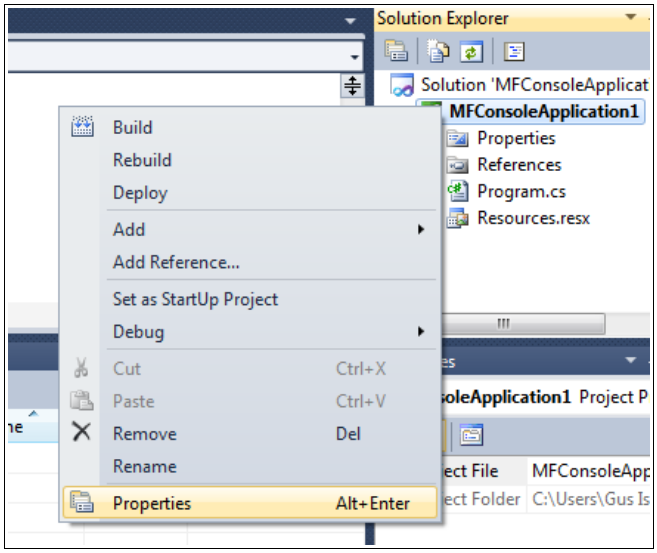
5.3. Testing FEZ Panda II

We now know NETMF is working fine on the emulator so let us do the same but this time on FEZ Panda II. You may have a different FEZ board but this will apply.

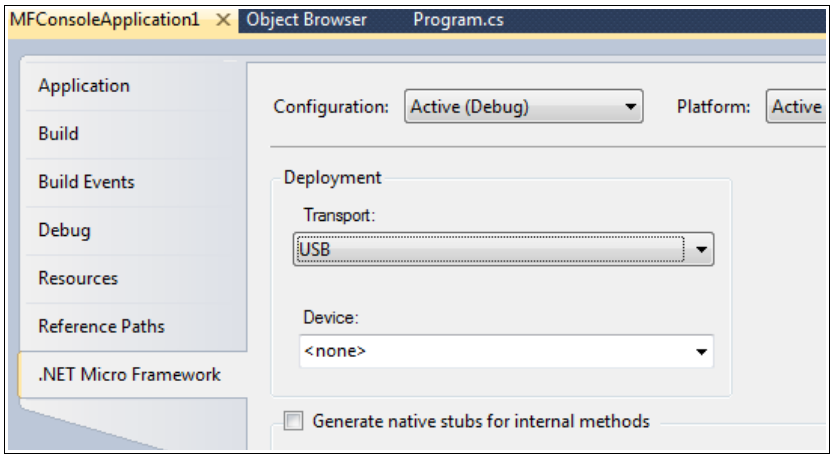
Assuming you already have the GHI NETMF SDK installed and it is usually located at this folder on your PC

“C:\Program Files (x86)\GHI Electronics\GHI NETMF v4.1 SDK”

From the earlier project, enter project properties



Setting the “Deployment Transport” interface is found under the “.NET Micro Framework” tab.



First plug in FEZ Panda II to your PC using the provided USB cable. Do not connect FEZ Panda II to anything besides the USB cable, no shields and no eblocks. It is highly recommend to use a powered USB HUB. If you do not have one, then plug FEZ directly to your PC, not through a HUB. Once it is connected, Windows will ask for drivers, which are found at

"C:\Program Files (x86)\GHI Electronics\GHI NETMF v4.1 SDK\USB Drivers\GHI_NETMF_Interface"

Now, change "Transport" to USB and you should see "USBizi_USBizi" under "Device". Why USBizi? The base processor of FEZ Panda is GHI's commercial USBizi chipset.

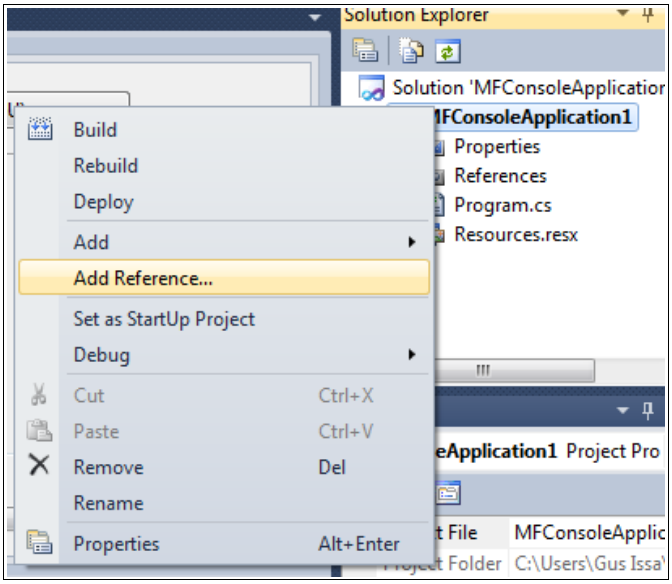
View the source code file and try F10 as before but this time the deploying will happen to FEZ Panda instead of the emulator. Step in the code and verify that you see "Hello world" in the output window as before.

5.4. The on-board LED & Button

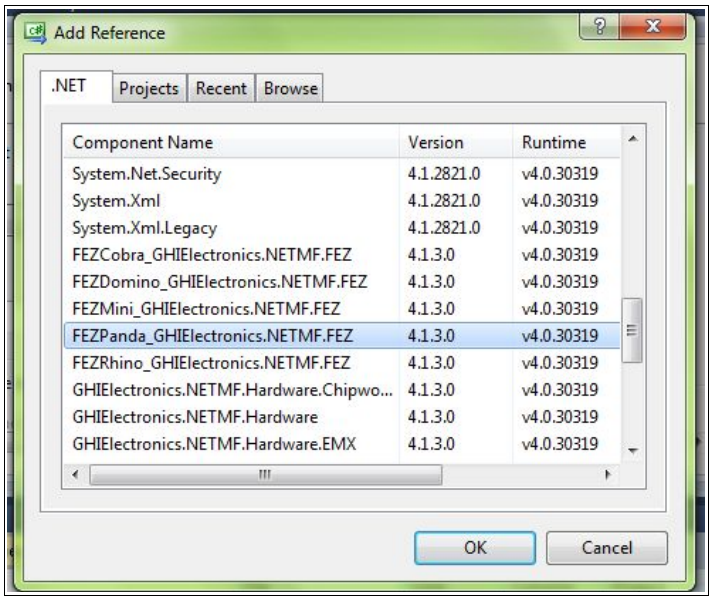
LEDs are those little lights you see in about every electronics devices out there. They draw very little power, extremely cheap and they live almost forever!

There is an LED right on FEZ Panda but what pin the LED is connected to? We could check the circuits schematics but that is not what modern programming is about. There is a library (an assembly) from the GHI SDK that includes all pin definitions. Let us add it to our project.

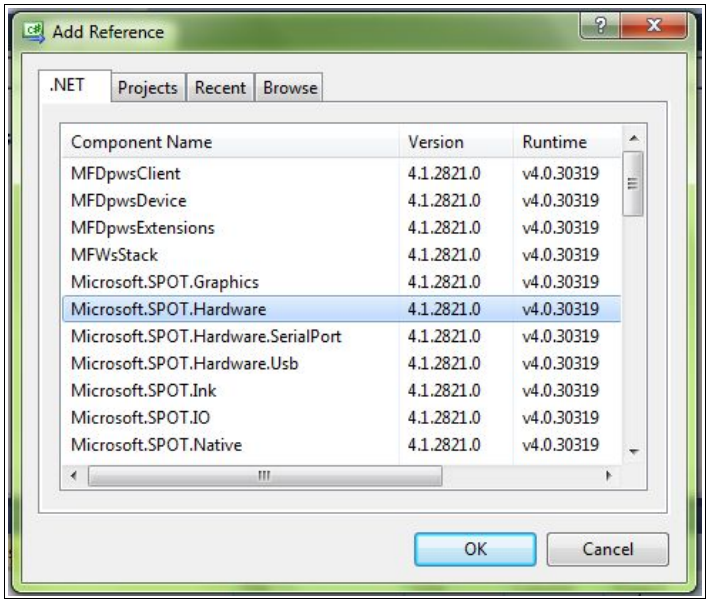
Right click on your project and select "Add Reference..."



Then add FEZPanda_II_GHIElectronics.NETMF.FEZ if you are using FEZ Panda II.



We will be controlling processor ports/pins so we need the Microsoft.SPOT.Hardware. (SPOT is an old name for NETMF)



We can now change the code to match the following. You can copy/paste the code if you like.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

public class Program
{
    static OutputPort MyLED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.LED, true);

    public static void Main()
    {
        while (true)
        {
            MyLED.Write(false);
            Thread.Sleep(300);

            MyLED.Write(true);
            Thread.Sleep(300);
        }
    }
}
```

If you don't understand the code above, we suggest reading the beginner's guide. Basically, the code goes in an endless loop and turns the LED on then off every 300ms.

FEZ Panda II also hosts a button that is used to force the board in boot loader mode but we can also use this button in our application. Modify the code to the following:

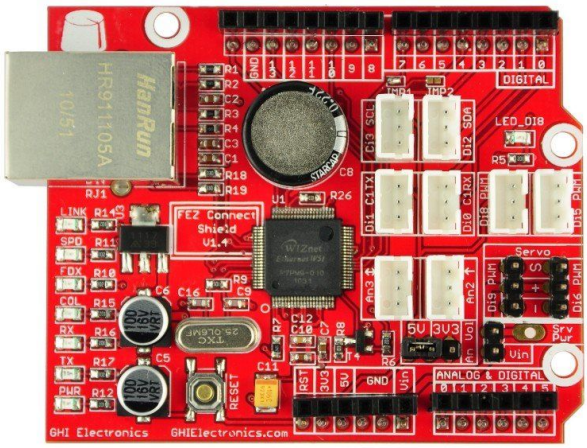
```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

public class Program
{
    static OutputPort MyLED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.LED, true);
    static InputPort MyButton = new InputPort((Cpu.Pin)FEZ_Pin.Digital.LDR, false,
Port.ResistorMode.PullUp);

    public static void Main()
    {
        while (true)
        {
            MyLED.Write( MyButton.Read() );

            Thread.Sleep(10);
        }
    }
}
```

In an endless loop, we are reading the button and setting its value to the LED. Since an unpressed button is high (true) and pressed button is low (false) then the LED will be on when button is not pressed and off when pressed.

The 10ms delay is added there as a good programming practice. There is no reason on why we should use 100% of processor time in a dead-endless-loop and if the time we press the button to the time the LED change was delayed by 10ms then you will probably not see the difference.

5.5. FEZ Connect Shield

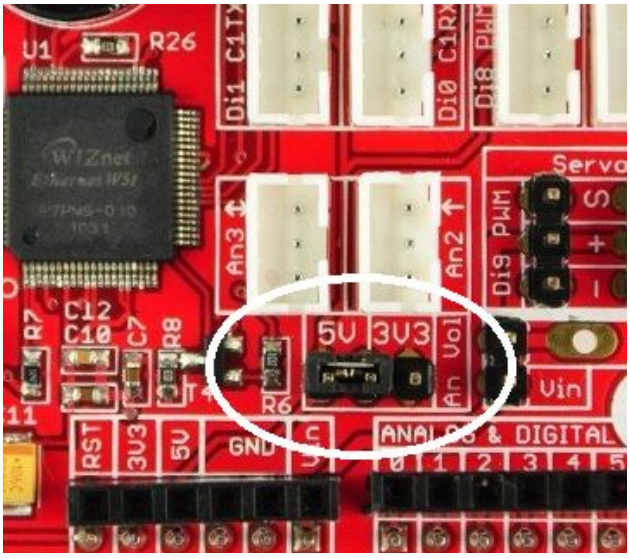
One of the most popular FEZ Panda add-ons is the FEZ Connect shield. This shield has Ethernet interface, with all its required circuitry, and also has connections for eblocks and Servo Motors.



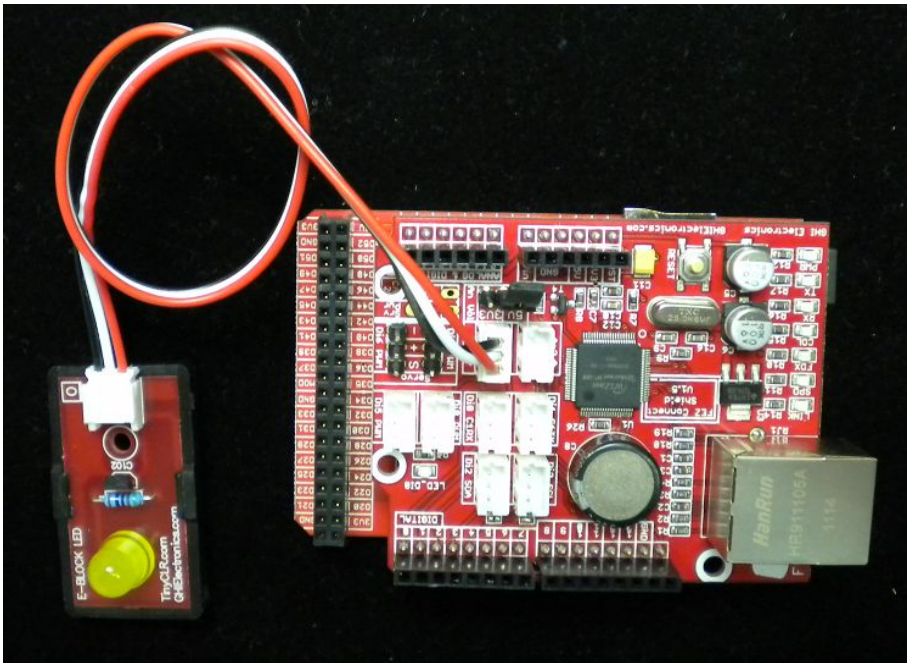
The two servo connections are connected to PWM-capable digital pins. Powering a servo requires 6V which should be connected to the “Srv Pwr” pin. This requires little soldering skills. This is not explained in the book but the FEZ Connect user manual explains all of this in details.

eblocks can be digital or analog, and can even require special peripheral interface from the system, such as PWM or UART. The eblocks' connectors on the FEZ Connect Shield offer UART (serial), I2C, Analog In, Analog Out and PWM. The provided projects will utilize the eblocks showing their functions and possible uses.

All of the eblocks connectors have a standard pin-out, composing of 5V, signal and Ground. Optionally, the 2 analog-related connectors can have 3.3V or 5V through a jumper. If you're not sure what you need, then leave it at 5V, the default.



Let's try to connect an LED eblock through FEZ Connect and blink it, just like we did with the on-board LED. First, disconnect FEZ and plug the FEZ Connect shield on top. Now, plug any of the LED eblocks that came with the kit into any of the eblock connectors. To demonstrate that analog pins also work as digital, we are going to connect the LED to An2, just like shown below.



Then we will take the old code and modify it.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

public class Program
{
    static OutputPort MyLED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.An2, true);

    public static void Main()
    {
        while (true)
        {
            MyLED.Write(false);
            Thread.Sleep(300);

            MyLED.Write(true);
            Thread.Sleep(300);
        }
    }
}
```

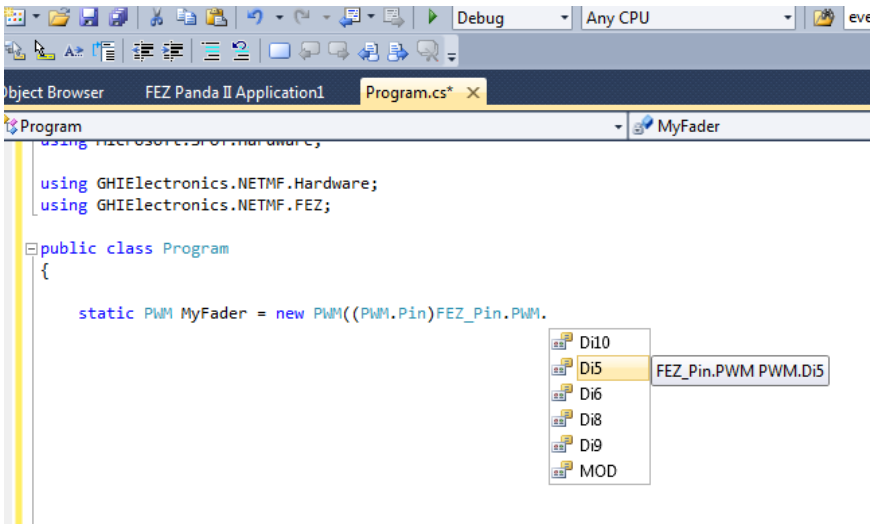
Run the program and observe the LED eblock blinking. Now, can you connect the button eblock to your hardware and control the LED from it? All you need to do is copy the code we did before with the on-board button/LED and change one line of code.

Fading LED

We saw how easy it was to blink an LED but what about fading an LED in and out? This can be done using PWM. See http://www.tinyclr.com/support for PWM tutorials.

PWM controls the level of energy transferred by switching a pin high and low very quickly where the ratio of the ON to OFF state determines the level. For example, 50% duty cycle is 50% energy and so on and so forth. The PWM feature can be found in GHIElectronics.NETMF.Hardware.dll. If you're not sure how to add an assembly then consult http://wiki.tinyclr.com/index.php?title=First_Project

Now, what pin is PWM capable? This is generated by the internal hardware which means the pins will handle the signal with zero processor interaction but this is not available on every single pin. Thanks to VS2010's IntelliSense, we can easily see what pins have PWM feature.



Looking at what IntelliSense gave us and at the board, it seems that the easiest socket to access is Di5 since it's on the edge, so let's use it.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

public class Program
{

    static PWM MyFader = new PWM((PWM.Pin)FEZ_Pin.PWM.Di5);

    public static void Main()
    {
        byte i = 0;
        while (true)
        {
            MyFader.Set(10000, i);
            if (i++ >= 100)
            {
                i = 0;
            }
            Thread.Sleep(10);
        }
    }
}
```

The LED will now be coming in slowly till it is fully on (100%) then it's back to level zero (0%). This can be more exiting by making the LED fade in and out.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

public class Program
{

    static PWM MyFader = new PWM((PWM.Pin)FEZ_Pin.PWM.Di5);

    public static void Main()
    {
        byte i = 0;
        int dirr = 1;
        while (true)
        {
            MyFader.Set(10000, i);
            i =(byte) (i + dirr);
              if (i >= 90)
                dirr = -1;
            if (i <= 10)
                dirr = 1;
```

```
            Thread.Sleep(10);
        }
    }
}
```

Making Noise!

In our coming projects, we may need to generate some sounds as an indication of something. This is where the Peizo eblock becomes very handy. Connect it to a PWM pin and give a frequency of your choice, you can even play some melodies. In the last fading demo we were playing with the duty-cycle but we left the frequency constantly at 10Khz. When generating tones, we will leave the duty-cycle at 50% but we change the frequency. Look at the code below, do you recognize this code? It the the same fading LED code, only with a different eblock.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

public class Program
{

    static PWM MyPWM = new PWM((PWM.Pin)FEZ_Pin.PWM.Di5);

    public static void Main()
    {
        int i = 5000;
        int dirr = 100;
        while (true)
        {
            MyPWM.Set(i, 50);
            i = i + dirr;
            if (i >= 2000)
                dirr *= -1;
            if (i <= 10000)
                dirr *= -1;

            Thread.Sleep(1);
        }
    }
}
```

Try this code and see if you recognize what FEZ is playing!

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

public class Program
{
    static PWM MyPWM = new PWM((PWM.Pin)FEZ_Pin.PWM.Di5);
    const int NOTE_C = 261;
    const int NOTE_D = 294;
    const int NOTE_E = 330;
    const int NOTE_F = 349;
    const int NOTE_G = 392;

    const int WHOLE_DURATION = 1000;
    const int EIGHTH = WHOLE_DURATION / 8;
    const int QUARTER = WHOLE_DURATION / 4;
    const int QUARTERDOT = WHOLE_DURATION / 3;
    const int HALF = WHOLE_DURATION / 2;
    const int WHOLE = WHOLE_DURATION;

    static int[] note = { NOTE_E, NOTE_E, NOTE_F, NOTE_G, NOTE_G, NOTE_F, NOTE_E, NOTE_D,
            NOTE_C, NOTE_C, NOTE_D, NOTE_E, NOTE_E, NOTE_D, NOTE_D, NOTE_E, NOTE_E, NOTE_F,
NOTE_G,
            NOTE_G, NOTE_F, NOTE_E, NOTE_D, NOTE_C, NOTE_C, NOTE_D, NOTE_E, NOTE_D, NOTE_C,
NOTE_C};

    static int[] duration = { QUARTER, QUARTER, QUARTER, QUARTER, QUARTER, QUARTER,
QUARTER,
        QUARTER, QUARTER, QUARTER, QUARTER, QUARTER, QUARTERDOT, EIGHTH, HALF, QUARTER,
QUARTER,
        QUARTER, QUARTER, QUARTER, QUARTER, QUARTER, QUARTER, QUARTER, QUARTER, QUARTER,
QUARTER,
        QUARTERDOT, EIGHTH, WHOLE};

    public static void Main()
    {
        while (true)
        {
            for (int i = 0; i < note.Length; i++)
            {
                MyPWM.Set(note[i], 50);
                Thread.Sleep(duration[i]);
            }
            Thread.Sleep(100);
        }
    }
}
```

What if we don't have a free PWM pin, then how do we use the Piezo? Not to worry, FEZ can generate all kinds of waveforms using a feature called “Output Compare” on any IO. This tutorial covers the details. http://wiki.tinyclr.com/index.php?title=Output_Compare

Open Drain

Two of the eblock connections are I2C-capable pins. These pins are special from other pins because they are open drain. An open drain pin is a pin than can be low or floating but never high. FEZ has on-board resistors pulling the two I2C pins high so these pins (I2C and SDA) can be high and low as usual, but the high state is high through pull up resistors. If you do not understand this fully then do not worry about this for now.

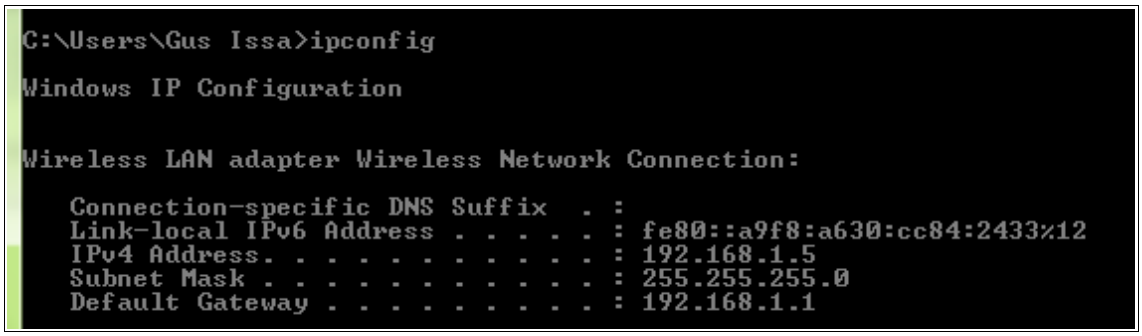
5.6. Connecting Ethernet

The details of sockets and networking are covered in later projects but here we want to make sure Ethernet is connected and working properly.

Start by connecting FEZ through the included Ethernet cable to the same switch where your PC is connected. Note that your PC/laptop can be connected using WiFi but the same switch should also have wired Ethernet connection to where you plug in your FEZ. You could connect FEZ directly to the PC's Ethernet port but then you will not be able to access the internet.

Now, you need to know your local network address. It should be 192.168.x. The reason “192.168” is used is because these addresses are only allowed on local networks and are not routed to the internet. Your router/switch handles Ethernet traffic internally and when you access the internet, your data get translated with your external IP.

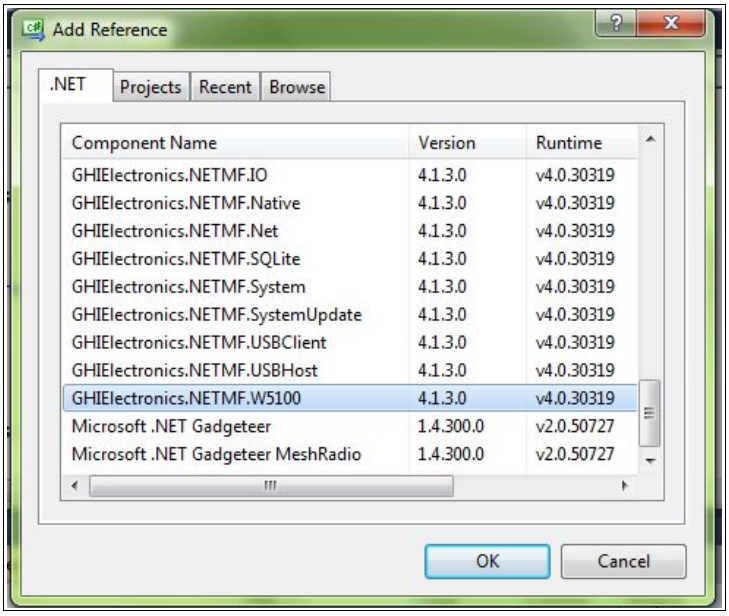
Open your PC's command prompt and enter ipconfig. You should see your internet connection and determine what is your local network address.



From the above image, you can see that I am using WiFi to connect to the router/switch with IP address 192.168.1.5, this means my network address is 192.168.1 and my PC's address is 5. I am not going to use DHCP and I need to make sure I am using an IP that is not used by any other device. It will probably be safe if I assume that address 222 is not

used by any PC or device since I am on a small network in my setup. I only have my PC, my laptop and FEZ.

We need to write some code now. Go back to the last code we created and add GHIElectronics.NETMF.W5100.dll assembly. The Ethernet controller used on FEZ Panda is Wiznet W5100.



To initialize the Ethernet controller you need to choose the SPI module connected to Di13, Di12 and Di11 (`SPI.SPI_module.SPI1`) on FEZ boards. Also you need to choose Di10 as Chip Select and Di7 as W5100 Reset.

```
WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
// WIZnet interface with FEZ Connect
```

Then you need to provide the network settings according to your needs, static or dynamic settings using DHCP. We will use static settings in the following example.

In the network settings, MAC address (physical address) is needed. This is a good tool to generate MAC addresses: http://www.macvendorlookup.com/

Take the LED blinking example and add a new line of code to initialize the Ethernet controller, and some code to set FEZ's IP and MAC addresses as explained before.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;

public class Program
{
    static OutputPort MyLED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.An3, true);

    public static void Main()
    {

        byte[] ip = { 192, 168, 1, 222 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
                                    (Cpu.Pin)FEZ_Pin.Digital.Di7, true);
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 1, 1 });

        while (true)
        {
            MyLED.Write(false);
            Thread.Sleep(300);

            MyLED.Write(true);
            Thread.Sleep(300);
        }
    }
}
```

The arguments used in the above example match where the W5100 Ethernet controller on FEZ Connect Shield is connected to FEZ Panda.

We are now ready to run our program, which will blink an LED and setup the Ethernet Controller. The blinking LED is an indication that the system is up and running. While FEZ is running (blinking), try to ping it from your PC and you should see something like this.

Ping 192.168.1.222

```
C:\Users\Gus Issa>ping 192.168.1.222

Pinging 192.168.1.222 with 32 bytes of data:
Reply from 192.168.1.222: bytes=32 time=1ms TTL=128
Reply from 192.168.1.222: bytes=32 time=1ms TTL=128
Reply from 192.168.1.222: bytes=32 time=1ms TTL=128
Reply from 192.168.1.222: bytes=32 time=1ms TTL=128

Ping statistics for 192.168.1.222:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 1ms, Average = 1ms
```

Important: If you do not see a response then go back and check your code and setup. The next chapters rely on having FEZ Panda being connected to your network.

Accessing the Internet

This is optional but if you have an internet connection you can verify the connection by obtaining GHI's website IP address. Here is the code. You have to make sure that you are using a correct Gateway IP address and DNS server IP address to get internet access.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;

public class Program
{
    static OutputPort MyLED = new OutputPort((Cpu.Pin)69, true);

    public static void Main()
    {

        byte[] ip = { 192, 168, 1, 222 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
                                    (Cpu.Pin)FEZ_Pin.Digital.Di7, true);
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 1, 1 });

        IPHostEntry GHI_ip =Dns.GetHostEntry("www.GHIElectronics.com");
        Debug.Print("GHI's IP = " + GHI_ip.AddressList[0].ToString());
        IPHostEntry TinyCLR_ip = Dns.GetHostEntry("www.TinyCLR.com");
        Debug.Print("TinyCLR's IP = " + TinyCLR_ip.AddressList[0].ToString());

        while (true)
        {
            MyLED.Write(false);
            Thread.Sleep(300);

            MyLED.Write(true);
            Thread.Sleep(300);
        }
    }
}
```

The code prints this in the output window.

```
GHI's IP = 207.58.176.212
TinyCLR's IP = 207.58.176.213
```

Note that in my case, my router did work as my DNS server but this may not be the case for your network setup. If you are not sure of what DNS address to you use, ppen your PC's command prompt and enter ipconfig /all and it will show the DNS server your PC using.

You only need DNS if you want to access a website by its name instead of its IP. But you can always ping a website from your PC to find its IP then use that in your code. Not a good practice as the IP of a website may change.

Here is an output of pinging GHI website, compare to the output above:

```
C:\Users\Gus Issa>ping www.ghielectronics.com

Pinging ghielectronics.com [207.58.176.212] with 32 bytes of data:
Reply from 207.58.176.212: bytes=32 time=53ms TTL=55
Reply from 207.58.176.212: bytes=32 time=52ms TTL=55
Reply from 207.58.176.212: bytes=32 time=58ms TTL=55
Reply from 207.58.176.212: bytes=32 time=47ms TTL=55
```

Using DHCP

In modern networks with many devices connected, it can be very difficult to assign an IP address to every device. Instead, the device starts by requesting an IP address from a DHCP server which assigns a unique IP for the device. The challenge is that we need to know the IP of the device to connect to it. Some code can be added to print the device's IP on the display or the debug output. The examples used in this book assumes a static IP is used. Here is an example code to obtain an IP address using DHCP.

```
public static void Main()
{
    // Enable the Ethernet
    WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
    Dhcp.EnableDhcp(new byte[] { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 }, "AnyName");
Debug.Print("Network settings:");
Debug.Print("IP Address: " + new IPAddress(NetworkInterface.IPAddress).ToString());
Debug.Print("Subnet Mask: " + new IPAddress(NetworkInterface.SubnetMask).ToString());
Debug.Print("Default Getway: " + new IPAddress(NetworkInterface.GatewayAddress).ToString());
Debug.Print("DNS Server: " + new IPAddress(NetworkInterface.DnsServer).ToString());

    // .....
    // .....
```

5.7. We are Ready!

So far, you have tested the functionality of individual components in the system and we are ready to make some fun and exciting projects.

Remember to always consult the contents of this page for future help and explanations: http://www.tinyclr.com/support

6. FEZ TCP/IP Networking Sockets

6.1. User Datagram Protocol (UDP)

UDP is an important member of TCP/IP stack. It is a simple connectionless protocol. For you it means that its communication mechanism is simply sending data to the other peer without verifying whether the data packet is received successfully or not. UDP is widely used with services such as DNS, DHCP, NTP, and TFTP.

Send UDP Message

To send UDP messages, you define the destination IP address and the destination UDP port. For example, the DNS service UDP port is 53.

This example shows how to send UDP messages with FEZ Connect. FEZ will send hello messages to the device with the IP 192.168.1.1 at UDP port 2000.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;
using System.Text;
using Socket = GHIElectronics.NETMF.Net.Sockets.Socket;
public class Program
{
    public static void Main()
    {
        byte[] ip = { 192, 168, 1, 200 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x26, 0x1C, 0x7B, 0x29,0xE8 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di9, true); // WIZnet interface setting on FEZ Connect
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 1, 1 });

        Socket socket = new Socket(AddressFamily.InterNetwork, SocketType.Dgram, ProtocolType.Udp);

        IPAddress DestinationIP = new IPAddress(new byte[] { 192, 168, 0, 1 });
        IPEndPoint DestinationEndPoint = new IPEndPoint(DestinationIP, 2000);

        byte[] buf;
```

```
        for (int y = 0; y < 1000; y++)
        {

         Thread.Sleep(2000);
         buf = Encoding.UTF8.GetBytes("Hello World from FEZ Panda" + y.ToString());
         try
         {
              socket.SendTo(buf, DestinationEndPoint);
         }
         catch
         {
         }
      }
   }
}
```

Receive UDP Messages

To receive UDP messages you need to bind to a specific port number so the other peer can find your UDP service through the IP address and that port.

This example shows how to receive UDP messages with FEZ Connect. FEZ will receive UDP messages sent to port 2000.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;
using System.Text;
using Socket = GHIElectronics.NETMF.Net.Sockets.Socket;

public class Program
{
    public static void Main()
    {
        byte[] ip = { 192, 168, 1, 200 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x26, 0x1C, 0x7B, 0x29,0xE8 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true); // WIZnet interface setting on FEZ Connect
NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 1, 1 });

         Socket serversocket = new Socket(AddressFamily.InterNetwork, SocketType.Dgram,
ProtocolType.Udp);
        EndPoint ServerEndPoint = new IPEndPoint(IPAddress.Any, 2000);
        serversocket.Bind(ServerEndPoint);
          int i = 1;
```

```
        while (true)
        {

            if (serversocket.Poll(-1, SelectMode.SelectRead))
            {
                EndPoint recEndPoint = null;
                byte[] inBuf = new byte[serversocket.Available];
                int count = serversocket.ReceiveFrom(inBuf, ref recEndPoint);
                Debug.Print(new String(Encoding.UTF8.GetChars(inBuf)));
                Debug.Print("From" + recEndPoint .Address.ToString());
            }
        }
    }
}
```

UDP Transceive data with PC

Now we will try to exchange UDP messages between our FEZ device and the PC.

Let's suppose that the PC's IP address is 192.168.0.1 and the FEZ device's IP address is 192.168.0.200, and we will set a UDP server at the PC that receives messages on UDP port 2000. On the other side, we will let our FEZ device send this message "Hello PC" to the PC's IP address and UDP port 2000, then it will wait for the response message from the PC "Hello FEZ device".

Deploy this code on FEZ device

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;
using System.Text;
using Socket = GHIElectronics.NETMF.Net.Sockets.Socket;


public class Program
{
    public static void Main()
    {
        byte[] ip = { 192, 168, 0, 200 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 0, 1 };
        byte[] mac = { 0x00, 0x26, 0x1C, 0x7B, 0x29,0xE8 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di9,true); // WIZnet interface setting on FEZ Connect
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 0, 1 });

      Socket mySocket = new Socket(AddressFamily.InterNetwork, SocketType.Dgram, ProtocolType.Udp);
            IPAddress DestinationIP = new IPAddress(new byte[] { 192, 168, 0, 1 });
       IPEndPoint DestinationEndPoint = new IPEndPoint(DestinationIP, 2000);

        String msg = "Hello PC";
```

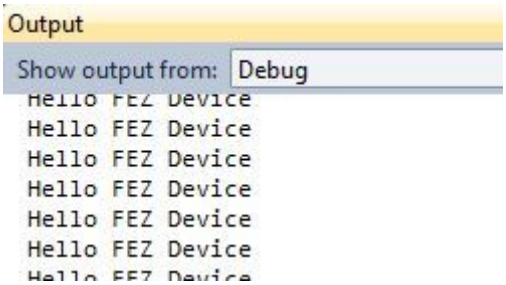
```
        byte[] bytesToSend = Encoding.UTF8.GetBytes(msg);
        while (true)
        {
            mySocket.SendTo(bytesToSend, bytesToSend.Length, SocketFlags.None, DestinationEndPoint);

            while (mySocket.Poll(2000000, SelectMode.SelectRead))
            {
                if (mySocket.Available > 0)
                {
                    byte[] inBuf = new byte[mySocket.Available];

                    EndPoint recEndPoint = new IPEndPoint(IPAddress.Any, 0);
                    mySocket.ReceiveFrom(inBuf, ref recEndPoint);
                    if (!recEndPoint.Equals(DestinationEndPoint))// Check if the received packet is
from the 192.168.0.2
                        continue;
                    Debug.Print(new String(Encoding.UTF8.GetChars(inBuf)));

                }
            }
        }
    }
}
```

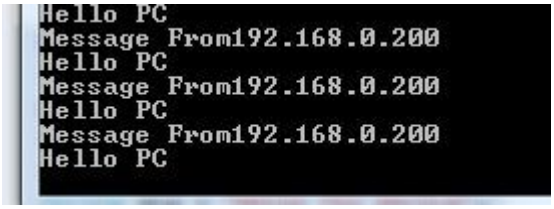
Now create a regular C# console application and add System and System.Net libraries, and add this code

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Net.Sockets;
using System.Net;

class Program
{
    static void Main(string[] args)
    {
        Socket mySocket = new Socket(AddressFamily.InterNetwork, SocketType.Dgram,
ProtocolType.Udp);
        IPEndPoint MyServiceEndPoint = new IPEndPoint(IPAddress.Any, 2000);
        mySocket.Bind(MyServiceEndPoint);

        while (true)
        {
            while(mySocket.Poll(200000,SelectMode.SelectRead))
            {
                if(mySocket.Available>0)
                {
                   byte[] inBuf = new byte[mySocket.Available];
                EndPoint recEndPoint = new IPEndPoint(IPAddress.Any,0);
                   mySocket.ReceiveFrom(inBuf, ref recEndPoint);
                   Console.WriteLine("Message From" + ((IPEndPoint)recEndPoint).Address.ToString());
                Console.WriteLine(new string(Encoding.UTF8.GetChars(inBuf)));
                            String msg = "Hello FEZ Device";
                   byte[] bytesToSend = Encoding.UTF8.GetBytes(msg);
                    mySocket.SendTo(bytesToSend, bytesToSend.Length, SocketFlags.None,
(IPEndPoint)recEndPoint);
```

```
            }
        }
    }

}
}
```

Run this application. You will notice that the PC and the device are exchanging the messages as expected.





6.2. Transmission Control Protocol (TCP)

TCP is the other important member of TCP/IP stack. UDP is connectionless, on the other hand TCP is connection-oriented protocol. This means that you can imagine TCP session as a virtual connection between the client and the server.

The main thing that TCP connection offers is a handshaking mechanism between the client and the server to ensure that the sent TCP packet has been received successfully. You don't need to worry about all these details since they are handled internally. You only need to open the TCP connection using a networking socket in the code and start exchanging data. TCP is also widely used with services such as HTTP(web browsing), Telnet, FTP, SMTP (sending emails), and POP3.

TCP client example

Here is a simple example on how to create a TCP client.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;
using System.Text;
using Socket = GHIElectronics.NETMF.Net.Sockets.Socket;
```

```
public class Program
{
    public static void Main()
    {
        byte[] mac = { 0x00, 0x26, 0x1C, 0x7B, 0x29, 0xE8 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di9, true); // WIZnet interface on FEZ Connect
        Dhcp.EnableDhcp(mac,"FEZ");  // Get the network settings from Dhcp server. The user can
exchange this with static settings.
        Debug.Print("Network settings:");
        Debug.Print("IP Address: " + new IPAddress(NetworkInterface.IPAddress).ToString());
        Debug.Print("Subnet Mask: " + new IPAddress(NetworkInterface.SubnetMask).ToString());
        Debug.Print("Default Getway: " + new IPAddress(NetworkInterface.GatewayAddress).ToString());
        Debug.Print("DNS Server: " + new IPAddress(NetworkInterface.DnsServer).ToString());

        Socket socket = new Socket(AddressFamily.InterNetwork, SocketType.Stream, ProtocolType.Tcp);

        IPAddress ServerIP = new IPAddress(new byte[] { 192, 168, 0, 200 });
        IPEndPoint ServerEndPoint = new IPEndPoint(ServerIP, 12000);

        byte[] buf = Encoding.UTF8.GetBytes("Hello World from FEZ Panda");

        socket.Connect(ServerEndPoint);
        socket.Send(buf);

        if(socket.Poll(5*1000000,SelectMode.SelectRead)) // wait for data from the server
        {
            byte[] inbuf = new byte[socket.Available];
            socket.Receive(inbuf);
            Debug.Print(new string(Encoding.UTF8.GetChars(inbuf)));
        }
        socket.Close();
        }

}
```

TCP server example

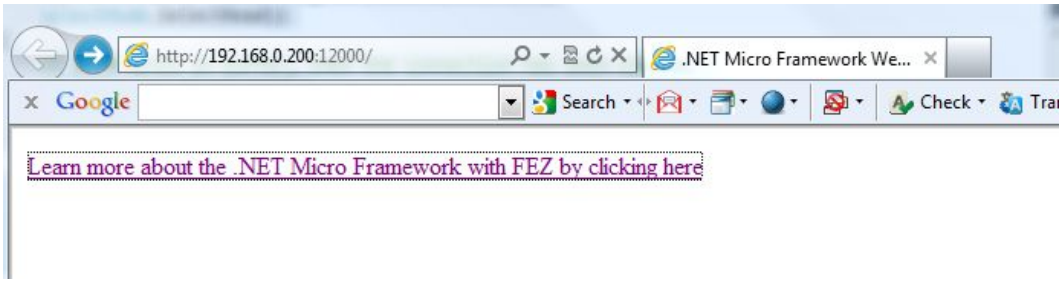
This is a simple web server. Given a request, it returns an HTML document. The same document is returned for all requests and no parsing of the request is done. This example is based on SimpleServer example code available with NETMF SDK example code.

This server IP address is 192.168.0.200 and the network ID is 192.168.0.x. This server is listening on TCP port 12000. You can change these addresses according to your network settings.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;
using System.Text;
using Socket = GHIElectronics.NETMF.Net.Sockets.Socket;
public class Program
{
    public static void Main()
    {
        const Int32 c_port = 12000;
        byte[] ip = { 192, 168, 0, 200 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 0, 1 };
        byte[] mac = { 0x00, 0x26, 0x1C, 0x7B, 0x29,0xE8 };
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 0, 1 });
        Socket server = new Socket(AddressFamily.InterNetwork,
        SocketType.Stream, ProtocolType.Tcp);
        IPEndPoint localEndPoint = new IPEndPoint(IPAddress.Any, c_port);
        server.Bind(localEndPoint);
        server.Listen(1);
        while (true)
        {
            // Wait for a client to connect.
            Socket clientSocket = server.Accept();
            // Process the client request.  true means asynchronous.
            new ProcessClientRequest(clientSocket, true);
        }
    }
        /// <summary>
    /// Processes a client request.
    /// </summary>
    internal sealed class ProcessClientRequest
    {
        private Socket m_clientSocket;

              /// <summary>
              /// The constructor calls another method to handle the request, but can
            /// optionally do so in a new thread.
            /// </summary>
```

```
            /// <param name="clientSocket"></param>
            /// <param name="asynchronously"></param>
            public ProcessClientRequest(Socket clientSocket, Boolean asynchronously)
            {
                m_clientSocket = clientSocket;

                if (asynchronously)
                    // Spawn a new thread to handle the request.
                    new Thread(ProcessRequest).Start();
                else ProcessRequest();
            }

            /// <summary>
            /// Processes the request.
            /// </summary>
            private void ProcessRequest()
            {
                const Int32 c_microsecondsPerSecond = 1000000;

                // 'using' ensures that the client's socket gets closed.
                using (m_clientSocket)
                {
                    // Wait for the client request to start to arrive.
                    Byte[] buffer = new Byte[1024];
                    if (m_clientSocket.Poll(5 * c_microsecondsPerSecond,
                        SelectMode.SelectRead))
                    {
                        // If 0 bytes in buffer, then the connection has been closed,
                        // reset, or terminated.
                        if (m_clientSocket.Available == 0)
                            return;

                        // Read the first chunk of the request (we don't actually do
                        // anything with it).
                        Int32 bytesRead = m_clientSocket.Receive(buffer,
                            m_clientSocket.Available, SocketFlags.None);

                        // Return a static HTML document to the client.
                        String s =
                            "HTTP/1.1 200 OK\r\nContent-Type: text/html; charset=utf-
8\r\n\r\n<html><head><title>.NET Micro Framework Web Server on USBizi Chipset </title></head>" +
                            "<body><bold><a href=\"http://www.tinyclr.com/\">Learn more about the
.NET Micro Framework with FEZ by clicking here</a></bold></body></html>";
                        byte[] buf = Encoding.UTF8.GetBytes(s);

                        int offset = 0;
                        int ret = 0;
                            int len = buf.Length;
                        while (len > 0)
                        {
                            ret = m_clientSocket.Send(buf, offset, len, SocketFlags.None);
                            len -= ret;
                            offset += ret;
                        }

                        m_clientSocket.Close();
                    }
                  }
            }
    }
}
```

To test the server, open any web browser on any station connected to the same network and enter this address //192.168.0.200:1200



You probably noticed that this web server code is simple, but it can be even simpler using the HTTP class provided as you will see in the next examples.

7. FEZ-HTTP

Do you know that you are probably using HTTP daily? HTTP is how web pages are transferred from servers to your internet browser. Let's go back one step and detail this. What defines a web-page's look is something called HTML (Hyper Text Markup Language), a text that defines the look of a page.

Nothing better to explain this than trying a simple example. Open notepad on your PC and put this text in it.

```
<html>
<body>

<h1>FEZ Panda</h1>

<p>Embedded Systems were never easier!</p>

</body>
</html>
```

Save the file and then rename its extension from .txt to .HTML. Now open the file with any browser. It should look like this.

Those HTML files are stored on the server or even dynamically generated and then transferred to your browser using HTTP (Hyper Text Transfer Protocol). This protocol runs on top of TCP. To handle HTTP on FEZ, we can either implement HTTP right on top of TCP or use the HTTP services built in FEZ. Compare this with the Telnet project in upcoming sections.

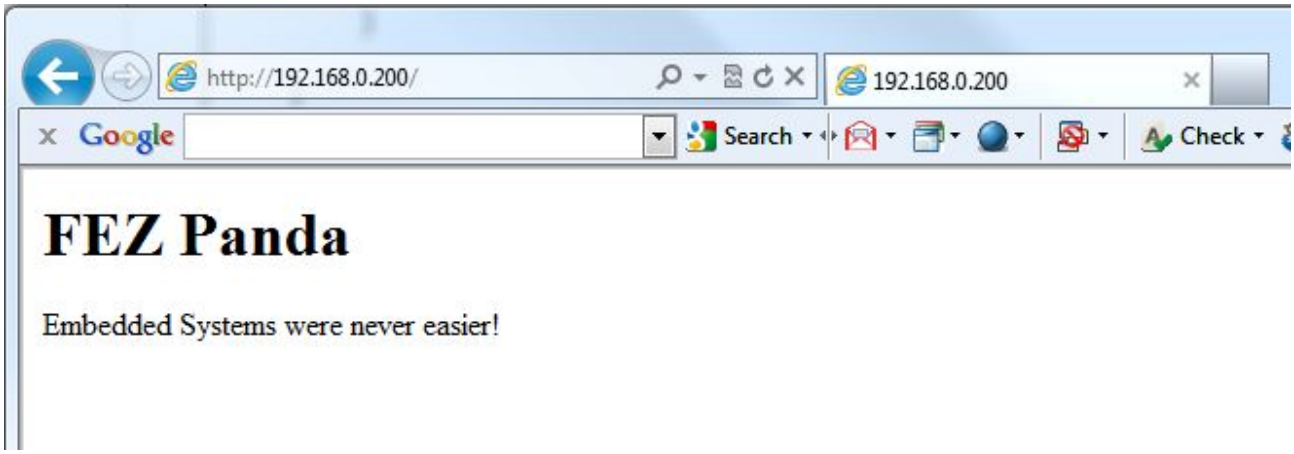
Here is an example that uses HTTP to transfer the HTML code we tested earlier. Note how we are listening on port number 80 which is the default HTTP port.

This FEZ's IP address is 192.168.0.200. and the network ID is 192.168.0.x. you can change these addresses according to your network settings.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;
using System.Text;
using Socket = GHIElectronics.NETMF.Net.Sockets.Socket;


    public class Program
    {
        public static void Main()
        {
            const Int32 c_port = 80;
            byte[] ip = { 192, 168, 0, 200 };
            byte[] subnet = { 255, 255, 255, 0 };
            byte[] gateway = { 192, 168, 0, 1 };
            byte[] mac = { 0x00, 0x26, 0x1C, 0x7B, 0x29, 0xE8 };
            WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
            NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
            NetworkInterface.EnableStaticDns(new byte[] { 192, 168, 0, 1 });

            HttpListener listener = new HttpListener("http", c_port);
            listener.Start();
            while (true)
            {
                HttpListenerResponse response = null;
                HttpListenerContext context = null;
                try
                {
                    context = listener.GetContext();
                    response = context.Response;
                    // We are ignoring the request, assuming GET
                    // HttpListenerRequest request = context.Request;

                    // Sends response:
                    response.StatusCode = (int)HttpStatusCode.OK;
                    byte[] HTML = Encoding.UTF8.GetBytes(
                    "<html><body>" +
                    "<h1>FEZ Panda</h1>" +
                    "<p>Embedded Systems were never easier!</p>" +
                       "</body></html>");
                       response.ContentType = "text/html";
```

```
                    response.OutputStream.Write(HTML, 0, HTML.Length);
                    response.Close();
                }
                catch
                {
                    if (context != null)
                    {
                        context.Close();
                    }
                }
            }
        }

    }
```

To test the server, open any web browser on any station connected to the same network and enter this address //192.168.0.200 if you are using a port other than 80 , then you need to enter //192.168.0.200:*port_number*



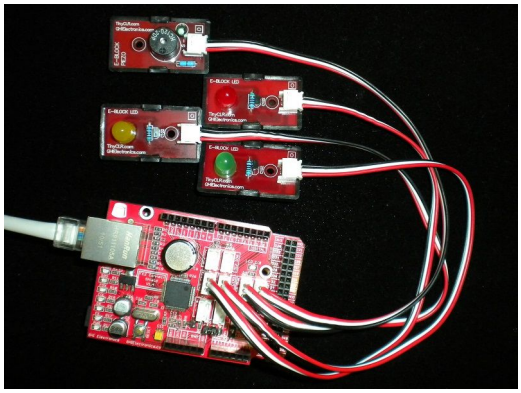
8. Network-Controlled Screamer

In this project, we will use use FEZ to activate lights and sounds remotely, through a network connection and a simple web page. This page can be accessed from a smart phone with a web browser or from any PC's browser on the same network, a perfect gadget for Halloween.

The hosted web page will look like this.

We will first start with LEDs and use the Piezo eblock to make some noise. The next step will be to utilize the audio playback feature to play some scary sounds!

Here is an image of our first setup:



The Connections:

- Red LED eblock on Di1
- Green LED eblock on Di0
- Yellow LED eblock on Di8
- Piezo eblock on Di5

The code is shown below:

```
using System;
using System.Threading;
using System.Text;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;


public class Program
{

    public static void Main()
    {
        OutputPort red = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.Di1, false);
        OutputPort green = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.Di0, false);
        OutputPort yellow = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.Di8, false);
        PWM piezo = new PWM((PWM.Pin)FEZ_Pin.PWM.Di5);

        byte[] ip = { 192, 168, 1, 176 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 };

        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(gateway);

        // start server
        HttpListener listener = new HttpListener("http", 80);
        listener.Start();
        while (true)
        {
            HttpListenerResponse response = null;
            HttpListenerContext context = null;
            try
            {
                context = listener.GetContext();
                response = context.Response;

                // The button is pressed
                if (context.Request.HttpMethod == "POST")
                {
```

```
                    for (int i = 0; i < 10; i++)
                    {
                        piezo.Set(1000, 50);
                        Thread.Sleep(100);
                        piezo.Set(100, 50);
                        Thread.Sleep(100);
                        green.Write(red.Read());
                        yellow.Write(red.Read());
                        red.Write(!red.Read());
                    }

                    // turn off
                    green.Write(false);
                    yellow.Write(false);
                    red.Write(false);
                    piezo.Set(false);
                }


                // Sends response
                response.StatusCode = (int)HttpStatusCode.OK;

                byte[] HTML = Encoding.UTF8.GetBytes(
                "<html><body>" +
                "<h1>Hosted on FEZ Panda II</h1>" +
                "<p>Let's scare some people!</p>" +
                "<form action=\"\" method=\"post\">" +
                "<input type=\"submit\" value=\"Activate!\">" +
                "</form>" +
                "</body></html>");
                response.ContentType = "text/html";
                response.OutputStream.Write(HTML, 0, HTML.Length);
                response.Close();
            }
            catch
            {
                if (context != null)
                {
                    context.Close();
                }
            }
        }
    }
}
```

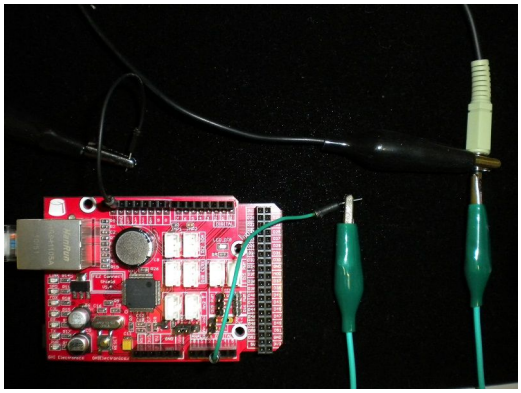
Create a new project and add the above code to it. You will also need to add these assemblies to “references”:

- FEZPanda_II_GHIElectronics.NETMF.FEZ.dll
- GHIElectronics.NETMF.Hardware
- GHIElectronics.NETMF.W5100
- GHIElectronics.NETMF.W5100.Http
- Microsoft.SPOT.Hardware
- Microsoft.SPOT.Native
- mscorelib

You are now ready to run the project on FEZ. Once running, open a browser on the network and enter your device's IP address. This should result in

Note: If the page didn't show then your network settings are different. Please go back to the earlier chapters and make sure you can network-ping the device “ping 192.168.x.x”

Click the button on that page and you should see the LEDs blinking and hear some noise coming from the Piezo. All is fun but not very scary, yet! We need to add some scary audio and also use an amplified speakers to make sure the sound is loud enough. PC speakers are perfect for what we need. We will use some wires to connect the speakers input connector to An3, which is the analog out pin on FEZ Panda.
The audio connector for a speaker has different regions where it gets the audio from. To read more about it see Wikipedia: http://en.wikipedia.org/wiki/TRS_connector
Basically, the sleeve is connected to GND on FEZ and the right or left audio channel is connected to the Audio Out on FEZ. In the image below, the black wire and black clip are connected to ground and the green wire and green clip are connected to the A3 pin:



The audio files supported are in wave format 8000 KHz mono. These can take a lot of memory, so normally you can put them on an SD card or USB thumb drive. But we can include a short one in the Visual Studio project's Resources.

Visual Studio has special handling for Audio resources, so you will get errors when you add an audio file. To solve this, rename the file from scream.wav to scream.bin. The file is found at http://www.ghielectronics.com/downloads/FEZ/scream.wav

Now you can extract the resource and play it. To play the audio files, you need a WAVE parser. Copy the following code and add into a new file in the same project. Name the file WAVE.cs

```
using System;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;


    public class WAVE
    {
        int index;
        int dataSize;
        int sampleRate;

        /// <summary>
        /// Loads a WAV file. ONLY PCM 8-bit Mono.
        /// </summary>
        /// <param name="wav">WAV file bytes.</param>
        public WAVE(byte[] wav)
        {
            // see https://ccrma.stanford.edu/courses/422/projects/WaveFormat/
            index = 0;
            if (wav[index + 0] != 'R' || wav[index + 1] != 'I' || wav[index + 2] != 'F' ||
wav[index + 3] != 'F')
            {
                throw new Exception("File is not RIFF");
            }
            index += 4;

            // ChunkSize
            uint ChunkSize = Utility.ExtractValueFromArray(wav, index, 4);
            index += 4;

            //format
            if (wav[index + 0] != 'W' || wav[index + 1] != 'A' || wav[index + 2] != 'V' ||
wav[index + 3] != 'E')
            {
                throw new Exception("File is not WAVE format");
            }
            index += 4;
            // fmt sub chunk //////////////////////
            //subchunk ID
            if (wav[index + 0] != 'f' || wav[index + 1] != 'm' || wav[index + 2] != 't' ||
wav[index + 3] != ' ')
            {
                throw new Exception("Unexpected fmt subchunk!");
            }
```

```
            index += 4;

            bool BitVarSampleRate16;

            uint Subchunk1Size = Utility.ExtractValueFromArray(wav, index, 4);
            index += 4;
            if(Subchunk1Size == 16)
            {
                BitVarSampleRate16 = true;
            }
            else if(Subchunk1Size == 18)
            {
                BitVarSampleRate16 = false;
            }
            else
            {
                throw new Exception("Invalid Subchunk1Size.");
            }

            ushort AudioFormat = (ushort)Utility.ExtractValueFromArray(wav, index, 2);
            index += 2;
            if (AudioFormat != 1)
            {
                throw new Exception("AudioFormat invalid.");
            }

            ushort NumChannels = (ushort)Utility.ExtractValueFromArray(wav, index, 2);
            index += 2;
            if (NumChannels != 1)
            {
                throw new Exception("Must be mono.");
            }

            sampleRate = (int)Utility.ExtractValueFromArray(wav, index, 4);
            index += 4;
            if (sampleRate != 8000)
            {
                throw new Exception("Sample rate must be 8000KHz.");
            }

            ushort ByteRate = (ushort)Utility.ExtractValueFromArray(wav, index, 4);
            index += 4;

            ushort BlockAlign = (ushort)Utility.ExtractValueFromArray(wav, index, 2);
            index += 2;

            if (BitVarSampleRate16)
            {
                ushort BitsPerSample = (ushort)Utility.ExtractValueFromArray(wav, index,
2);
                index += 2;
                if (BitsPerSample != 8)
                {
                    throw new Exception("Must be 8 bit.");
                }
            }
            else
            {
                uint BitsPerSample = Utility.ExtractValueFromArray(wav, index, 4);
                index += 4;
                if (BitsPerSample != 8)
                {
                    throw new Exception("Must be 8 bit.");
```

```
                }
            }
            //// data sub-chunk //////////////////////////////////////
            if (wav[index + 0] != 'd' || wav[index + 1] != 'a' || wav[index + 2] != 't' ||
wav[index + 3] != 'a')
            {
                throw new Exception("Unexpected data subchunk!");
            }
            index += 4;

            uint Subchunk2Size = (ushort)Utility.ExtractValueFromArray(wav, index, 4);
            index += 4;

            dataSize = (int)Subchunk2Size;
            ////////////////////////////////////////////
        }

        public int GetDataIndex()
        {
            return index;
        }

        public int GetDataSize()
        {
            return dataSize;
        }

        public int GetSampleRate()
        {
            return sampleRate;
        }
    }
```

One **important** note here, since we are adding a resource to our project then things can be tricky for beginners due to the namespace of the resource handler and the namespace of the project. Here is what we suggest, **start a new console project and name it FEZscare.** Then copy/paste the code below to your project and add the new WAVE.cs file.

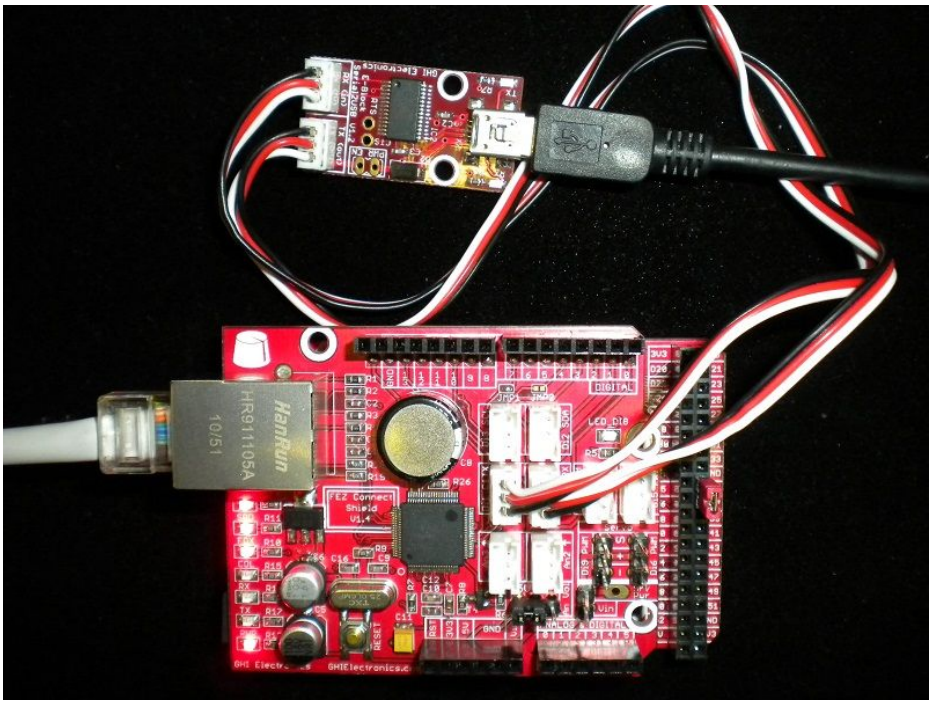
Here's the project code modified to play audio back:

```
using System;
using System.Text;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;

    public class Program
    {
        public static void Main()
        {
            byte[] scare = Resources.GetBytes(Resources.BinaryResources.scream);
            WAV_playback.WAVE wav = new WAV_playback.WAVE(scare);
            AnalogOut audio = new AnalogOut((AnalogOut.Pin)FEZ_Pin.AnalogOut.An3);
            audio.SetLinearScale(0, 255);
```

```
            byte[] ip = { 192, 168, 1, 176 };
            byte[] subnet = { 255, 255, 255, 0 };
            byte[] gateway = { 192, 168, 1, 1 };
            byte[] mac = { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 };

            WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
            NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
            NetworkInterface.EnableStaticDns(gateway);

            // start server
            HttpListener listener = new HttpListener("http", 80);
            listener.Start();
            while (true)
            {
                HttpListenerResponse response = null;
                HttpListenerContext context = null;
                try
                {
                    context = listener.GetContext();
                    response = context.Response;

                    // The button is pressed
                    if (context.Request.HttpMethod == "POST")
                    {
                        audio.Set(scare, wav.GetDataIndex(), wav.GetDataSize(),
wav.GetSampleRate());
                    }
                    // Sends response
                    response.StatusCode = (int)HttpStatusCode.OK;

                    byte[] HTML = Encoding.UTF8.GetBytes(
                    "<html><body>" +
                    "<h1>Hosted on FEZ Panda II</h1>" +
                    "<p>Let's scare some people!</p>" +
                    "<form action=\"\" method=\"post\">" +
                    "<input type=\"submit\" value=\"Activate!\">" +
                    "</form>" +
                    "</body></html>");
                    response.ContentType = "text/html";
                    response.OutputStream.Write(HTML, 0, HTML.Length);
                    response.Close();
                }
                catch
                {
                    if (context != null)
                    {
                        context.Close();
                    }
                }
            }
        }

    }
```

9. Remote Mouse Prank

Building on the previous project, we want to see how we can control the cursor on a PC using an “emulated mouse”. The USB port on FEZ Panda is normally used for deploying and debugging applications. The same USB port can be customized in many ways. An easy example would be to make this port works as if it was a USB mouse. Thanks to the enhanced GHI libraries, developers don't need to have any knowledge of USB classes. In order for us to use the USB port, we first need to switch deploying/debugging to serial port. The kit includes a Serial-to-USB eblock which takes a serial port and converts it into a Serial<->USB connection on the PC. First, connect 2 cables from the eblock to FEZ Connect COM1 sockets, C1TX socket is COM1 TX pin for example. Note that TX pin from the eblock goes to RX pin on FEZ Connect and RX pin on eblock goes to TX pin on FEZ Connect. This is shown in this image:



Connect the USB cable from the eblock to the PC. Windows should be able to automatically download and install the drivers. If not, you can find the drivers at http://www.ftdichip.com/FTDrivers.htm. We now have a serial connection going to the PC but we still need to switch debugging from USB to serial (that is virtual USB<->serial in our case). This is simply accomplished by connecting MODE pin to ground. If you look in the middle of the 40-pin header on FEZ Panda II, you will see MOD pin right next to GND pin. All we need is a wire in between. You can use a metal clip or a jumper as well.

We are now ready to try FEZ with a serial connection instead of USB. Remember that even though you have a USB cable connected to the PC, the eblock creates a USB virtual Serial Connection. So as far as Windows and its software, this is a serial connection. Open MFDeploy and select serial instead of USB then check what COM ports are available. Let's say we have COM1, COM2 and COM5. Now, close MFDeploy, disconnect the USB cable from Serial-to-USB eblock and re-open MFDeploy and check the ports again. You will notice that one of them is missing. That one is then the one we need, which is the eblock virtual serial port. For example, if I now have COM1 and COM2 but no longer have COM5 then COM5 is the one associated with the eblock. We now can use COM5 (in our example) to ping FEZ Panda from MFDeploy. You should see TinyCLR back, just like we did before with USB. If not, go back and check all steps before proceeding. Note that the USB cable going to the eblock doesn't power FEZ Panda so you need to power it up using a power supply or the second USB cable included in the kit.

Once we can ping FEZ Panda from MFDeploy to verify a good debugging connection, copy this code to your project.

```
using System;
using System.Threading;
using System.Text;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;

using GHIElectronics.NETMF.USBClient;

public class Program
{

    public static void Main()
    {
        // start the mouse
        USBC_Mouse mouse = USBClientController.StandardDevices.StartMouse();

        byte[] ip = { 192, 168, 1, 176 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 };
```

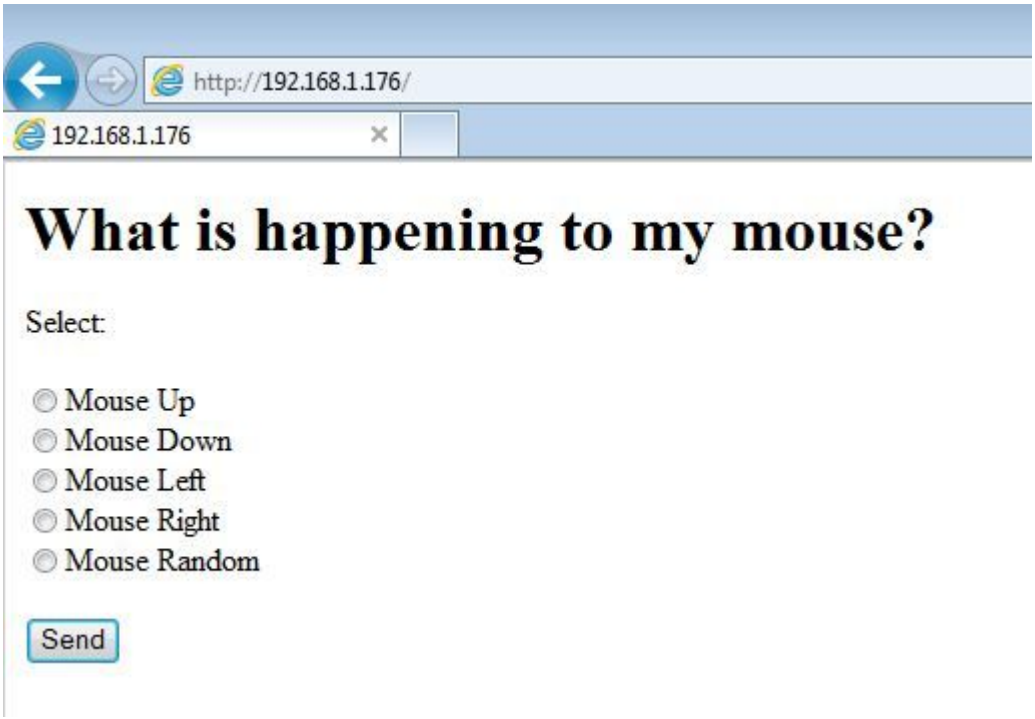
```
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(gateway);

        // start server
        HttpListener listener = new HttpListener("http", 80);
        listener.Start();
        while (true)
        {
            HttpListenerResponse response = null;
            HttpListenerRequest request = null;
            HttpListenerContext context = null;
            try
            {
                context = listener.GetContext();
                response = context.Response;
                request = context.Request;

                // The button is pressed
                if (request.HttpMethod == "POST")
                {
                    if (request.ContentLength64 > 0)
                    {
                        // read te radio value
                        byte[] buffer = new byte[(int)request.ContentLength64];
                        request.InputStream.Read(buffer, 0, buffer.Length);
                        string move = new string(Encoding.UTF8.GetChars(buffer));

                        // now we have "Move=Up" for example, let's get the "Up"
                        int index = move.IndexOf('=');
                        move = move.Substring(index + 1);

                        switch (move)
                        {
                            case "Up":
                                mouse.SendData(0, -100, 0, USBC_Mouse.Buttons.BUTTON_NONE);
                                break;

                            case "Down":
                                mouse.SendData(0, 100, 0, USBC_Mouse.Buttons.BUTTON_NONE);
                                break;

                            case "Right":
                                mouse.SendData(100, 0, 0, USBC_Mouse.Buttons.BUTTON_NONE);
                                break;

                            case "Left":
                                mouse.SendData(-100, 0, 0, USBC_Mouse.Buttons.BUTTON_NONE);
                                break;

                            case "Random":
                                mouse.SendData(100, 0, 0, USBC_Mouse.Buttons.BUTTON_NONE);
                                Thread.Sleep(100);
                                mouse.SendData(0, 100, 0, USBC_Mouse.Buttons.BUTTON_NONE);
                                Thread.Sleep(100);
                                mouse.SendData(-100, 100, 0,
USBC_Mouse.Buttons.BUTTON_NONE);
                                Thread.Sleep(100);
                                break;
                        }
                    }
```

```
                }


                // Sends response
                response.StatusCode = (int)HttpStatusCode.OK;

                byte[] HTML = Encoding.UTF8.GetBytes(
                "<html>" +
                "<body>" +
                "<h1>What is happening to my mouse?</h1>" +
                "Select:" +
                "<form action='' method='post'>" +
                    "<input type='radio' name='Move' value='Up' />Mouse Up</input> <br/>" +
                    "<input type='radio' name='Move' value='Down' />Mouse Down</input>
<br/>" +
                    "<input type='radio' name='Move' value='Left' />Mouse Left</input>
<br/>" +
                    "<input type='radio' name='Move' value='Right' />Mouse Right</input>
<br/>" +
                    "<input type='radio' name='Move' value='Random' />Mouse Random</input>
<br/>" +
                    "<br/>" +
                    "<input type='submit' value='Send' />" +
                 "</form>" +
                "</body>" +
                "</html>"
                );
                response.ContentType = "text/html";
                response.OutputStream.Write(HTML, 0, HTML.Length);
                response.Close();
            }
            catch
            {
                if (context != null)
                {
                    context.Close();
                }
            }
        }
    }
}
```

Make sure you have the following assemblies in references:

- FEZPanda_II_GHIElectronics.NETMF.FEZ
- GHIElectronics.NETMF.Hardware
- GHIElectronics.NETMF.USBClient
- GHIElectronics.NETMF.W5100
- GHIElectronics.NETMF.W5100.Http
- Microsoft.SPOT.Hardware
- Microsoft.SPOT.Native
- mscorelib

Run the project and windows will now detect a USB mouse. This USB Mouse is actually FEZ Panda presenting itself to the PC as a USB Mouse. We can now try the web page hosted from FEZ. Open the browser like in the last project and enter FEZ's IP address. You should see something similar to this image:

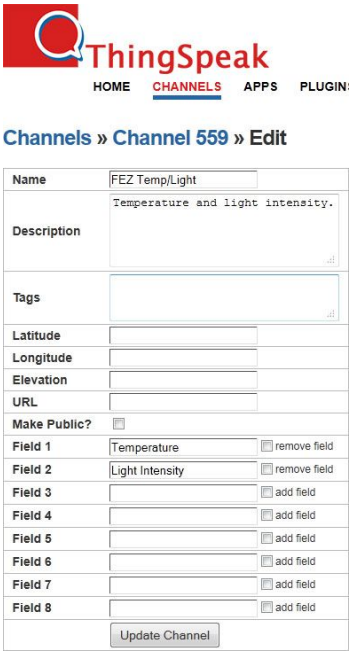


Select one of the radio buttons and click submit. You will notice the mouse moving on the screen. You can now hide FEZ Panda behind the PC and then move the mouse remotely from the phone's browser, a fun way to drive someone crazy!

10. Sensor Monitoring

With the “Internet of Things” catching on so quickly, we are starting to see websites that have services dedicated for “things”. A good example is ThingSpeak which is a free website that lets you upload sensor information to the server and then this data can be retrieved or charted later for analysis. In this project, we will see how to periodically read the thermometer and light sensor eblocks and publish the data to ThingSpeak.

Start by connecting the thermometer eblock to An2 and the light sensor to An3. This is everything we need for hardware but we still need to do some setup on www.ThingSpeak.com.



Once you sign up, you'll be redirected to the Channels page. Now we need to create a channel that we can publish our data to. This is done by clicking “Create New Channel” which will bring up the channel form. For Name let's put "FEZ Temp/Light" and for the Description add "Temperature and light intensity." Since this project publishes two pieces of data, We'll need to use two fields. Label Field1 "Temperature" and then click add field next to Field2 and set it as "Light Intensity." Finally, click Update Channel to save your changes.

Channels » Channel 559

- Edit Channel
- Manage API Keys
- View Charts
- Import Data

Channel ID:	559
Name:	FEZ Temp/Light
Write API Key:	**<Your API Key Is Here>**
Description:	Temperature and light intensity.
Tags:	
Entries:	21
Created:	Fri, Apr 22 at 8:40 am
Latitude:	
Longitude:	
Elevation:	
Field 1:	Temperature
Field 2:	Light Intensity

After saving, you should land on the channel you created. In the data table below is your **Write API Key**. Copy the key value and overwrite the key variable (<*YourThingSpeakKey*>) in Visual Studio.

Copy the code below into a project and run it. As it runs you will see the Debug.Print output every 30 seconds of the data being sent to ThinkSpeak.

Make sure you have the following assemblies in references:

- FEZPanda_II_GHIElectronics.NETMF.FEZ
- GHIElectronics.NETMF.Hardware
- GHIElectronics.NETMF.USBClient
- GHIElectronics.NETMF.W5100
- GHIElectronics.NETMF.W5100.Dhcp
- GHIElectronics.NETMF.W5100.Http
- Microsoft.SPOT.Hardware
- Microsoft.SPOT.Native
- mscorelib

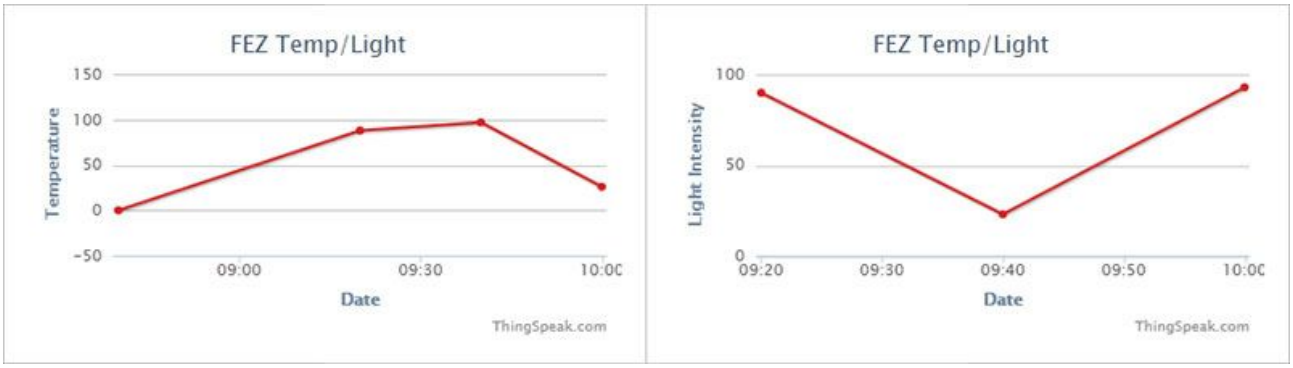
```
using System;
using System.IO;
using System.Threading;
using System.Text;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.FEZ;
using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;

public class Program
{
    static Thread thread;
    static bool running;
    static string url = "http://api.thingspeak.com/update";
    static string key = "<YourThingSpeakChannelKey>";
    static AnalogIn thermometer;
    static AnalogIn lightSensor;
    static int temp;
    static int light;

    public static void Main()
    {
        // Enable the Ethernet
        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
        Dhcp.EnableDhcp(new byte[] { 0x00, 0x26, 0x1C, 0x7B, 0x29, 0xE8 }, "FEZ
```

```
Temp/Light");
        // Show we've started by blinking the LED
        int count = 0;
        bool ledState = false;
        OutputPort led = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.LED, ledState);

        while (count < 20)
        {
            ledState = !ledState;
            led.Write(ledState);
            count++;
            Thread.Sleep(100);
        }

        // Initialize the eblocks
        thermometer = new AnalogIn((AnalogIn.Pin)FEZ_Pin.AnalogIn.An2);
        thermometer.SetLinearScale(-22, 56);

        lightSensor = new AnalogIn((AnalogIn.Pin)FEZ_Pin.AnalogIn.An3);
        lightSensor.SetLinearScale(0, 100);

        // Begin sampling the temperature
        running = true;
        thread = new Thread(MainLoop);
        thread.Priority = ThreadPriority.Highest;
        thread.Start();
    }
    public static void MainLoop()
    {
        string result;

        while (running)
        {
            temp = thermometer.Read();
            light = lightSensor.Read();

            // Convert to Fahrenheit
            temp = ((temp * 9) / 5) + 32;
            Debug.Print("Temperature: " + temp + " F");

            // Swap the intensity making zero complete darkness
            light = 100 - light;
            Debug.Print("Brightness: " + light + "%");

            // ThingSpeak will respond with an Entry ID
            result = SendToThingSpeak(url + "?key=" + key + "&field1=" + temp + "&field2="
+ light);
            Debug.Print("Entry ID: " + result);

            Thread.Sleep(30000);
        }
    }

    public static string SendToThingSpeak(string url)
    {
        string result = null;
        // Create an HTTP Web request.
        HttpWebRequest request = HttpWebRequest.Create(url) as HttpWebRequest;
        // Set request.KeepAlive to use a persistent connection.
        request.KeepAlive = true;
        // Get a response from the server.
        WebResponse resp = null;
        try
```

```
        {
            resp = request.GetResponse();
        }
        catch (Exception e)
        {
            Debug.Print("Exception in HttpWebRequest.GetResponse(): " + e.ToString());
        }

        // Get the network response stream to read the page data.
        if (resp != null)
        {
            Stream respStream = resp.GetResponseStream();
            byte[] byteData = new byte[4096];
            char[] charData = new char[4096];
            int bytesRead = 0;
            Decoder UTF8decoder = System.Text.Encoding.UTF8.GetDecoder();
            int totalBytes = 0;

            // allow 5 seconds for reading the stream
            respStream.ReadTimeout = 5000;

            // If we know the content length, read exactly that amount of
            // data; otherwise, read until there is nothing left to read.
            if (resp.ContentLength != -1)
            {
                for (int dataRem = (int)resp.ContentLength; dataRem > 0; )
                {
                    Thread.Sleep(500);
                    bytesRead =
                        respStream.Read(byteData, 0, byteData.Length);
                    if (bytesRead == 0)
                    {
                        Debug.Print("Error: Received " + (resp.ContentLength - dataRem) + "
Out of " + resp.ContentLength);
                        break;
                    }
                    dataRem -= bytesRead;

                    // Convert from bytes to chars, and add to the page string.
                    int byteUsed, charUsed;
                    bool completed = false;
                    totalBytes += bytesRead;
                    UTF8decoder.Convert(byteData, 0, bytesRead, charData, 0, bytesRead,
true, out byteUsed, out charUsed, out completed);
                    result = result + new String(charData, 0, charUsed);
                }

                result = new String(System.Text.Encoding.UTF8.GetChars(byteData));
            }
            else
            {                // Read until the end of the data is reached.
                while (true)
                {
                    // If the Read method times out, it throws an exception,
                    // which is expected for Keep-Alive streams because the
                    // connection isn't terminated.
                    try
                    {
                        Thread.Sleep(500);
                        bytesRead =
                            respStream.Read(byteData, 0, byteData.Length);
                    }
                    catch (Exception)
```

```
                    {
                        bytesRead = 0;
                    }
                    // Zero bytes indicates the connection has been closed by the server.
                    if (bytesRead == 0)
                        break;
                    int byteUsed, charUsed;
                    bool completed = false;
                    totalBytes += bytesRead;
                    UTF8decoder.Convert(byteData, 0, bytesRead, charData, 0, bytesRead,
true, out byteUsed, out charUsed, out completed);
                    result = result + new String(charData, 0, charUsed);
                }
            }
            // Close the response stream.  For Keep-Alive streams, the
            // stream will remain open and will be pushed into the unused
            // stream list.
            resp.Close();
        }
        return result;
    }
}
```

After allowing the program to run awhile, you'll be ready to view the data. ThingSpeak also has charting tools which enable you to create a line, bar or column graph to visualize your data, including many additional options.



You're now ready to expand upon our example or create a whole new project. For example, ever ask yourself, “Did I close the garage door?” You can now answer that question. Using a light sensor and distance detector you can reasonably record when your garage door is open or closed. Simply log into ThingSpeak to check! Just imagine all the information you can collect and access from the internet.

11. FEZ-Telnet

Telnet is very simple but very powerful. It is basically a TCP connection between 2 nodes and works very well like a terminal software. There are many applications that support Telnet for PCs and for mobile phones. We will run the tests on “Moca Telnet Lite”, a free iPhone app, and on TeraTerm on PC. TeraTerm is a free software that GHI uses for firmware update and it is also recommended for development. Even though it is mostly used with serial connections, it can also work over the network, Telnet.

FEZ will be the server, waiting for client requests to handle specific tasks. We need to run a listening socket and wait for connection. A new thread is spawned for every connection so you can actually have more than one connection. The “Process” method will look for strings ending with enter key, that is '\r' for return. Once it detects the enter key, it will send the command string to the “HandleCommand” method.

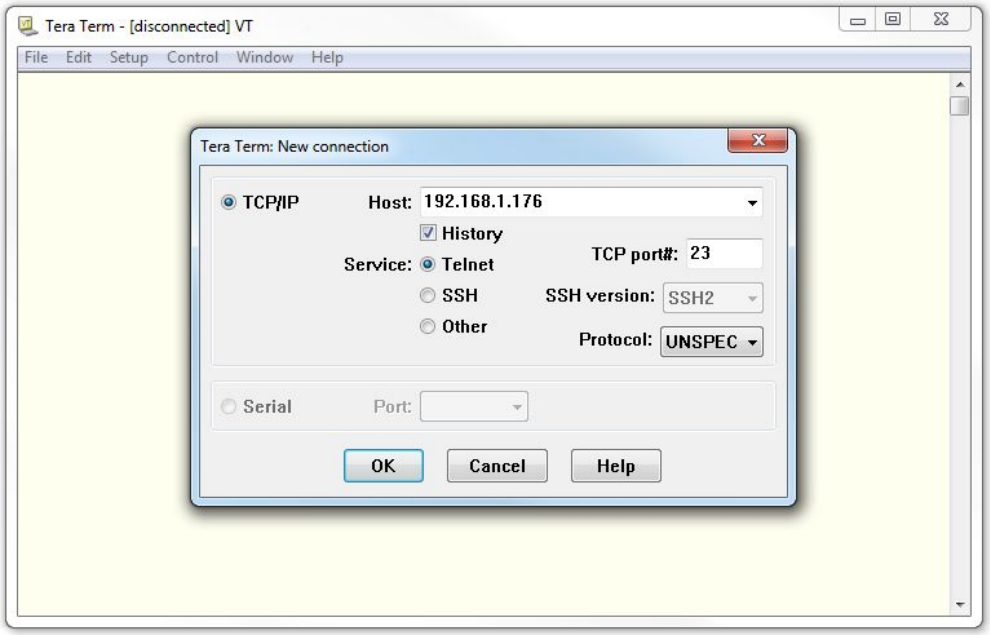
Note that whatever you enter on the Telnet client will be sent to the server but not necessarily shown in the client side (your side). This is resolved by the server echoing the data back to the client. In our code, this is done by entering “echo” command, which toggles EchoIsEnabeled flag. The code also has “LED ON” and “LED OFF” commands so try them out. Note that the LED is connected to Di5.

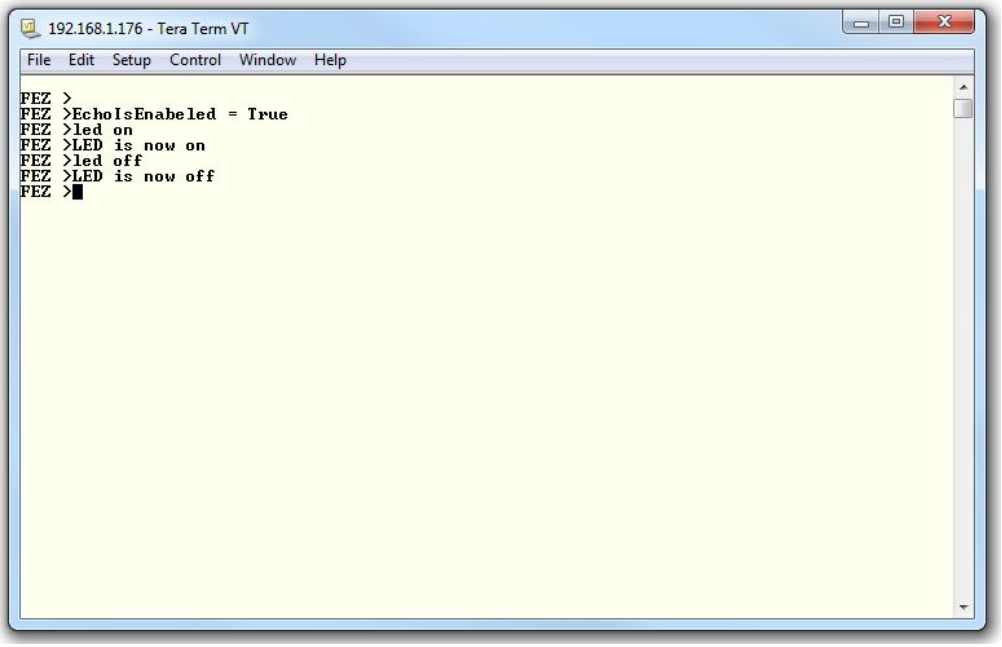
```
using System;
using System.Threading;
using System.Text;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.FEZ;

using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;
using GHIElectronics.NETMF.Net.Sockets;

public static class MySocketServer
{
    // Our LED eblock is connected to Di5
    static OutputPort LED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.Di5, false);

    public static void Main()
    {
        byte[] ip = { 192, 168, 1, 176 };
        byte[] subnet = { 255, 255, 255, 0 };
        byte[] gateway = { 192, 168, 1, 1 };
        byte[] mac = { 0x00, 0x88, 0x98, 0x90, 0xD4, 0xE0 };

        WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
```

```
        NetworkInterface.EnableStaticIP(ip, subnet, gateway, mac);
        NetworkInterface.EnableStaticDns(gateway);

        // Our Listening socket
        Socket server = new Socket(AddressFamily.InterNetwork, SocketType.Stream,
ProtocolType.Tcp);

        // Telnet usually uses port 23
        IPEndPoint localEndPoint = new IPEndPoint(IPAddress.Any, 23);
        server.Bind(localEndPoint);

        // start listening
        server.Listen(1);

        while (true)
        {
            // Wait for a client
            Socket Sock = server.Accept();
            new TelnetProcess(Sock);
        }
    }

    internal sealed class TelnetProcess
    {
        byte[] prompt = Encoding.UTF8.GetBytes("\r\nFEZ >");
        private Socket clientSocket;
        bool EchoIsEnabeled = false;
        public TelnetProcess(Socket Sock)
        {
            clientSocket = Sock;
            // Spawn a new thread
            new Thread(Process).Start();
        }
        private void HandleCommand(string cmd)
        {
            string str;
            cmd = cmd.ToUpper();
            switch (cmd)
            {
                case "ECHO":
                    EchoIsEnabeled = !EchoIsEnabeled;
                    clientSocket.Send(prompt);
                    str = "EchoIsEnabeled = " + EchoIsEnabeled;
                    clientSocket.Send(Encoding.UTF8.GetBytes(str), 0, str.Length,
SocketFlags.None);
                    break;
                case "LED ON":
                    LED.Write(true);
                    clientSocket.Send(prompt);
                    str = "LED is now on";
                    clientSocket.Send(Encoding.UTF8.GetBytes(str), 0, str.Length,
SocketFlags.None);
                    break;
                case "LED OFF":
                    LED.Write(false);
                    clientSocket.Send(prompt);
                    str = "LED is now off";
                    clientSocket.Send(Encoding.UTF8.GetBytes(str), 0, str.Length,
SocketFlags.None);
                    break;
            }
        }
        private void Process()
```

```
        {
            byte[] command = new byte[100];
            int index = 0;

            using (clientSocket)
            {
                clientSocket.Send(prompt);
                while (true)
                {

                    if (clientSocket.Receive(command, index, 1, SocketFlags.None) == 0)
                    {
                        clientSocket.Close();
                        break;
                    }


                    if (command[index] == '\r')
                    {
                        // do we have some data?

                        string cmd = new string(Encoding.UTF8.GetChars(command), 0, index);
                        HandleCommand(cmd);
                        index = 0;
                        clientSocket.Send(prompt);
                    }
                    else if (command[index] >= 32 && command[index] <= 126)
                    {
                        // Echo back
                        if (EchoIsEnabeled)
                            clientSocket.Send(command, index, 1, SocketFlags.None);

                        index++;
                        if (index >= command.Length)
                        {
                            Debug.Print("We have too much data!");
                            index = 0;//dump it all
                        }
                    }
                }
            }
        }
    }
}
```

We can now use Telnet with a few lines of code. This image shows TeraTerm communicating with FEZ:





If we want to read the temperature back from the device, we will add a command called “temp” to return back the temperature form the included Temperature eblock.

12. You've Got Mail, And SMS

In this project, we will create a piece of hardware that reports a door (opened/closed) status through emails. This can be good starting point for a security system or a monitoring system. Maybe you are monitoring the temperature in a warehouse and need a warning email if the temperature is too high or too low. What if you don't have access to email, but you had access to SMS through your phone? This is actually very easy. Each provider, has a specific email that you can use as a gateway for SMS. For example, AT&T in the USA uses xxxxxxxxxx@txt.att.net so if the phone number was 0123456789 then the email to send an SMS is 0123456789@txt.att.net. Contact your cellphone provider for details.

The program flow

1. The system is connected to the Ethernet network and it gets the network settings automatically using DHCP feature.
2. It checks whether the date and time are set and sends an email if they are not.
3. After complete boot up, the system sends an email with the initial door state:
   Subject: FEZ Door Monitor has booted up.
   Body: The system booted up at 04/22/2011 10:54:28 and the door was opened.
4. The systems monitors the door and sends an email as soon as the status changes, for example it sends and email with this message:
   The Door was closed at: 04/22/2011 10:56:15

What we need

1. The main system is our FEZ Panda II board
2. Real Time Clock which is included with FEZ Panda II and is maintained by the on-board super capacitor included on FEZ Connect shield.
3. FEZ Connect shield.
4. A button eblock that we will use as a touch sensor. So when the door is closed the button will be pressed. We are connecting it to Digital I/O Di2.
5. A LED eblock (optional) connected to Digital I/O Di8.

There are many methods of sending emails. In this project we will use the simplest and the

most common method which is Simple Mail Transfer Protocol (SMTP). SMTP is an application layer protocol of the Internet protocol suite. This protocol uses TCP protocol to exchange data between the client and the server. Usually the SMTP server TCP port number is 25.

Here is a simple dialog (from wikipedia) between the SMTP client (the party willing to send the email) and the SMTP server (the party that handle sending the message):

- S: 220 smtp.example.com ESMTP Postfix
- C: HELO relay.example.org
- S: 250 Hello relay.example.org, I am glad to meet you
- C: MAIL FROM:<bob@example.org>
- S: 250 Ok
- C: RCPT TO:<alice@example.com>
- S: 250 Ok
- C: DATA
- S: 354 End data with <CR><LF>.<CR><LF>
- C: From: "Bob Example" <bob@example.org>
- C: To: "Alice Example" <alice@example.com>
- C: Cc: theboss@example.com
- C: Date: Tue, 15 Jan 2008 16:02:43 -0500
- C: Subject: Test message
- C:
- C: Hello Alice.
- C: This is a test message.
- C: Your friend,
- C: Bob
- C: .
- S: 250 Ok: queued as 12345
- C: QUIT
- S: 221 Bye
- {The server closes the connection}

So all we need to let our device send an email is to talk to the SMTP server the same way. In other words:

1. Open a TCP Socket with the SMTP server at port 25.
2. Send the required information for the email as in the example.
3. Verify that the server understands what the device is sending.
4. Close the TCP Connection.

The following class does the SMTP Client part, Copy the code into a new file and add to your project. Name the file SMTP.cs

```
using System;
using Microsoft.SPOT;
using System.Text;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.Sockets;
using GHIElectronics.NETMF.Net.NetworkInformation;


public class SmtpClient
{
    private string _SmtpServerName = null;
    private int _Port = 0;
    private enum SmtpState
    {
        NotConnected,
        DomainAccepting,
        MailFromAccepting,
        RecipientAccepting,
        DataCommandAccepting,
        MessageAccepting,
        ConnectionClosing
    };
    SmtpState state;
    public SmtpClient(string SmtpServerName, Int32 Port)
    {
        if (Port < 0)
            throw new ArgumentOutOfRangeException();
        _SmtpServerName = SmtpServerName;
        _Port = Port;
    }
    public void Send(string from, string recipient, string subject, string body)
    {
        state = SmtpState.NotConnected;
        /* Connect to the Server*/
        // Figure out the Server IP Address
        IPHostEntry SmtpServerHostEntry = Dns.GetHostEntry(_SmtpServerName);
        IPEndPoint SmtpServerEndPoint = new IPEndPoint(SmtpServerHostEntry.AddressList[0],
_Port);

        // Establish the connection with SMTP Server
        Socket SmtpConnection = new Socket(AddressFamily.InterNetwork, SocketType.Stream,
ProtocolType.Tcp);
        SmtpConnection.Connect(SmtpServerEndPoint);
        String ResponseStr = null;
        while (SmtpConnection.Poll(5000000, SelectMode.SelectRead))
        {
            byte[] ReceiveBuffer = new byte[SmtpConnection.Available];
            SmtpConnection.Receive(ReceiveBuffer, ReceiveBuffer.Length, SocketFlags.None);
              // The first 3 bytes hold the message number which is enough for us.
            ResponseStr = new String(Encoding.UTF8.GetChars(ReceiveBuffer), 0, 3);
            int Response = Int16.Parse(ResponseStr);
            switch (state)
            {
                case SmtpState.NotConnected:
                    if (Response == 220) // Domain service ready.
                    {
                            SmtpConnection.Send(Encoding.UTF8.GetBytes("HELO " +
from.Split(new char[] { '@' })[1] + "\r\n"));
                        state = SmtpState.DomainAccepting;
```

```
                        }
                    break;
                case SmtpState.DomainAccepting:
                    if (Response == 250) // Requested mail action okay, completed.
                    {
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("MAIL FROM:<" + from +
">\r\n"));
                        state = SmtpState.MailFromAccepting;
                    }
                    break;
                case SmtpState.MailFromAccepting:
                    if (Response == 250) // Requested mail action okay, completed.
                    {
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("RCPT TO:<" + recipient
+ ">\r\n"));
                        state = SmtpState.RecipientAccepting;
                    }
                    break;
                case SmtpState.RecipientAccepting:
                    if (Response == 250) // Requested mail action okay, completed.
                    {
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("DATA\r\n"));
                        state = SmtpState.DataCommandAccepting;
                    }
                    break;
                case SmtpState.DataCommandAccepting:
                    if (Response == 354) //Start mail input; end with <CRLF>.<CRLF>.
                    {
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("Subject: " + subject +
"\r\n"));
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("From: " + from +
"\r\n"));
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("To: " + recipient +
"\r\n\r\n"));
                        SmtpConnection.Send(Encoding.UTF8.GetBytes(body + "\r\n"));
                        SmtpConnection.Send(Encoding.UTF8.GetBytes(".\r\n"));
                        state = SmtpState.MessageAccepting;
                    }
                    break;
                case SmtpState.MessageAccepting:
                    if (Response == 250) // Requested mail action okay, completed.
                    {
                        SmtpConnection.Send(Encoding.UTF8.GetBytes("QUIT\r\n"));
                        state = SmtpState.ConnectionClosing;
                        }
                    break;
                case SmtpState.ConnectionClosing:
                    if (Response == 221) // Requested mail action okay, completed.
                    {
                        SmtpConnection.Close();
                        return;
                    }
                    break;
            }
        }
        SmtpConnection.Close();
        throw new Exception("SMTP connection Timeout");
    }
}
```

Now we are ready to complete our email based door monitor. Here is the complete

project's main program:

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.Net;
using GHIElectronics.NETMF.Net.NetworkInformation;

using GHIElectronics.NETMF.FEZ;
// This application uses the drivers button.cs and lcd.cs provided by GHI Electronics for
faster developing.
// The user can use different methods to read the button such as InterruptPort class and
OutputPort Class to control the LED.

    public class Program
    {
        static public SmtpClient mySmtp;
        static public FEZ_Components.Button DoorSensor = new
FEZ_Components.Button(FEZ_Pin.Interrupt.Di2);
        static public FEZ_Pin.Interrupt DoorSensorPin = FEZ_Pin.Interrupt.Di2;
        static public FEZ_Components.LED Indicator = new
FEZ_Components.LED(FEZ_Pin.Digital.Di8);
        static public bool IsTimeSet = false;

        public static void Main()
        {
            byte[] SetTimeFlag_helper = new byte[4];
            /*a simple application to set the time and date

            RealTimeClock.SetTime(new DateTime(2011, 04, 22, 10, 14, 00, 0));
            // We will save a flag in RTC Battery RAM indicating that we set the time
            SetTimeFlag_helper[0] = 1;
            BatteryRAM.Write(0, SetTimeFlag, 0, 4);
            Thread.Sleep(Timeout.Infinite);

            */
            try
            {
                WIZnet_W5100.Enable(SPI.SPI_module.SPI1, (Cpu.Pin)FEZ_Pin.Digital.Di10,
(Cpu.Pin)FEZ_Pin.Digital.Di7, true);
                Dhcp.EnableDhcp(new byte[] { 0x00, 0x26, 0x1C, 0x7B, 0x29, 0xE8 },
"FEZ_SMTP");
                Debug.Print("Network settings:");
                Debug.Print("IP Address: " + new
IPAddress(NetworkInterface.IPAddress).ToString());
                Debug.Print("Subnet Mask: " + new
IPAddress(NetworkInterface.SubnetMask).ToString());
                   Debug.Print("Default Getway: " + new
IPAddress(NetworkInterface.GatewayAddress).ToString());
                Debug.Print("DNS Server: " + new
IPAddress(NetworkInterface.DnsServer).ToString());

                mySmtp = new SmtpClient("smtp.comcast.net", 25);


                // In our application we saved this SetTimeFlag[0] to 1 when we set the
correct time and date.
                BatteryRAM.Read(0, SetTimeFlag_helper, 0, 4);
```

```
                    if (SetTimeFlag_helper[0] == 1)
                        IsTimeSet = true;

                if (IsTimeSet)// The time and date are still set correctly in the Real Time
Clock and we can use it in our application
                {
                    // Set system's clock
                    Utility.SetLocalTime(RealTimeClock.GetTime());
                    Indicator.StartBlinking(1000, 1000); // This means that the led will
blink every one second. This tells the user that the system's time and date are still set
correctly.

                }
                else // This means that the Real Time Clock has lost power, so the time and
date need to be set again by the user.
                {
                    mySmtp.Send("fez@somedomain1.com", "recipient@somedomain.com", "The
date and time are not set", "The date and dime are not set, please set the correct time and
date.\n");
                    Indicator.StartBlinking(50, 50); // This will let the led blink fast to
tell the user that the time and date are not set.

                }

                mySmtp.Send("fez@somedomain1.com",
                            "recipient@somedomain.com",
                            "FEZ door Monitor has booted up",
                            "The system booted up at " + (IsTimeSet ?
DateTime.Now.ToString() : "time is invalid") + "and the door was " + (DoorSensor.GetState()
== FEZ_Components.Button.ButtonState.Pressed ? "closed\n" : "opened"));
                DoorSensor.ButtonPressEvent += new
FEZ_Components.Button.ButtonPressEventHandler(DoorSensor_ButtonPressEvent);
                Thread.Sleep(Timeout.Infinite);
            }
            catch
            {
                Indicator.StartBlinking(100, 1000); // This means that something wrong has
happened and the system is not currently working.
                Thread.Sleep(Timeout.Infinite);

            }

        }

        static void DoorSensor_ButtonPressEvent(FEZ_Pin.Interrupt pin,
FEZ_Components.Button.ButtonState state)
        {
            if (pin == DoorSensorPin)
            {
                if (state == FEZ_Components.Button.ButtonState.NotPressed)
                {
                    mySmtp.Send("fez@somedomain1.com",
                                "recipient@somedomain.com",
                            "FEZ Door Monitor",
                            "The door was opened at: " + (IsTimeSet ?
DateTime.Now.ToString() : "time is invalid") + "\n");
                }
                else
                {
                    mySmtp.Send("fez@somedomain1.com",
                                "recipient@somedomain.com",
                                    "FEZ Door Monitor",
```

```
                                    "The door was closed at: " + (IsTimeSet ?
DateTime.Now.ToString() : "time is invalid") + "\n");
                }
            }
        }
    }
```

Important note: The sender's email address should be a real address or the server will refuse to send the message.

We now can change the email address with the SMS gateway's email and the email will be transmitted as a SMS message.

What is next?

1. Develop an NTP (Network Time Protocol) client to get the correct time from the internet and feed it to the real time clock.
2. Add other kinds of sensors to report other information through emails.
3. Add an attachment feature.

13. FEZmote- Internet TV-Remote

How many times have you looked for the TV remove and you couldn't find it? How many remotes do you have in your living room? Since you probably own a smart phone which is always in your pocket, wouldn't it be great if you could open up the web browser and change the station or the volume on your TV? Even better, the same smart phone can control the satellite receiver? Well, here is how to make one!

This project can be divided into smaller parts:

1. Learn the original remote signal and record it.
2. Replay the recorded signal to simulate the original remote.
3. Use a web page to control the signal.

Part 3 above is very similar to the earlier “screamer” project. I will not cover this here but I will show you how to record a TV remote signal and how to play it back.

Digital Signal Recording

The TV remotes usually transmit an Infrared signal with a 38KHz carrier frequency. The Infrared eblock filters out the carrier giving us the actual remote signal, which is exactly what we need. FEZ is very well capable of decoding the signal. This means FEZ can tell when the mute button is pressed for example. This won't be necessary for this project. FEZ will record the signal and play it back later without knowing what is in the signal.

GHI NETMF devices include a class called PinCapture which takes an int array and records the time between any transitions on a pin. For the remote demo, 100 samples should be enough but let's get 300 samples. Here is the code to record the signal on pin Di2 when a button is pressed on Di3. There is also an LED on Di5 which lights up when FEZ is recording.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

public class Program
{
```

```
    static PinCapture cap = new PinCapture((Cpu.Pin)FEZ_Pin.Digital.Di2,
Port.ResistorMode.Disabled);
    static uint[] buffer = new uint[300];
    static OutputPort LED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.Di5, false);

    public static void Main()
    {
        InterruptPort Button = new InterruptPort((Cpu.Pin)FEZ_Pin.Interrupt.Di3, true,
Port.ResistorMode.PullUp, Port.InterruptMode.InterruptEdgeLow);

        // Add a button event
        Button.OnInterrupt += new NativeEventHandler(Button_OnInterrupt);
        Thread.Sleep(Timeout.Infinite);
    }

    static void Button_OnInterrupt(uint data1, uint data2, DateTime time)
    {
        Debug.Print("Capturing...");
        LED.Write(true);
        // button was pressed
        int edges = cap.Read(false, buffer, 0, buffer.Length, 3000);
        if (edges == 0)
        {
            Debug.Print("Nothing was captured");
        }
        else
        {
            Debug.Print("We have " + edges + " edges");
            for (int i = 0; i < edges; i++)
            {
                Debug.Print("Edge #" + i + "= " + buffer[i]);

            }
        }
        LED.Write(false);
    }
}
```

```
'Microsoft.SPOT.Debugger.CorDebug.dll' (Managed): Loaded 'C:\Prc
'Microsoft.SPOT.Debugger.CorDebug.dll' (Managed): Loaded 'C:\Prc
'Microsoft.SPOT.Debugger.CorDebug.dll' (Managed): Loaded 'C:\Prc
'Microsoft.SPOT.Debugger.CorDebug.dll' (Managed): Loaded 'C:\Prc
The thread '<No Name>' (0x2) has exited with code 0 (0x0).
Capturing...
We have 155 edges
Edge #0= 3412
Edge #1= 3301
Edge #2= 857
Edge #3= 822
Edge #4= 857
Edge #5= 822
Edge #6= 846
```

Signal Playback

Another unique feature of GHI's NETMF devices is OutputCompare, which helps in generating digital waveforms. We want to take the signals recorded earlier and pass it on to OutputCompare for playback. The challenge here is in generating the 38KHz carrier frequency. This can be done with PWM but then we will need a PWM pin for the carrier plus a free pin for signal. Not to worry, the OutputCompare has a built-in carrier frequency generator.

In this example code, we will use the button to playback the signal. If the button is held down for 5 seconds then FEZ goes into recording mode and the LED comes on. We will take the same setup from before and add an IrLED eblock to Di8.

The steps are simple:

1. Press and hold the button eblock for 5 seconds till the Red LED comes on. Quickly do the next step as FEZ will timeout in 3 seconds.
2. Bring the TV remote and face it to the 32KHz infrared receiver eblock. Hit one of the buttons you want to learn.
3. Once FEZ learns the one button on the remote then the Red LED shuts off.
4. Press and release the button eblock and FEZ will transmit the learned signal.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;

using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

public class Program
{
    static PinCapture cap = new PinCapture((Cpu.Pin)FEZ_Pin.Digital.Di2,
Port.ResistorMode.Disabled);
    static OutputPort LED = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.Di5, false);
    static OutputCompare RemoteGenerator = new OutputCompare((Cpu.Pin)FEZ_Pin.Digital.Di8,
false, 300);
    static uint[] buffer = new uint[300];
    static int edges;
    static Timer ButtonTimer = new Timer(new TimerCallback(ButtonTimerHandler), null, -1,
-1);
    public static void Main()
    {

        InterruptPort Button = new InterruptPort((Cpu.Pin)FEZ_Pin.Interrupt.Di3, true,
Port.ResistorMode.PullUp, Port.InterruptMode.InterruptEdgeBoth);

        // Add a button event
        Button.OnInterrupt += new NativeEventHandler(Button_OnInterrupt);
        Thread.Sleep(Timeout.Infinite);
```

```
    }
    static void ButtonTimerHandler(object o)
    {
        Debug.Print("Programming mode");
        Debug.Print("Press and hold a button on the TV remote");
        LED.Write(true);
        edges = cap.Read(false, buffer, 0, buffer.Length, 3000);
        if (edges == 0)
        {
            Debug.Print("Nothing was captured!");
        }
        else
        {
            Debug.Print("We have " + edges + " edges");
        }
        LED.Write(false);
        Debug.Print("Done programing!");
    }
    static void Button_OnInterrupt(uint port, uint state, DateTime time)
    {
        if (state == 0)//pressed
        {
            ButtonTimer.Change(5000, -1);
        }
        else
        {
            ButtonTimer.Change(-1, -1);
            //send the signal
            LED.Write(true);
            Debug.Print("Send TV signal");
            RemoteGenerator.SetBlocking(true, buffer, 0, edges, 100, true, 38000);
            LED.Write(false);
        }
    }
}
```

Note that the IrLED eblock uses a tiny LED. You will need to be close to the TV for it to work. If desired, an experienced user can modify the eblock with a transistor and a high power IrLED.

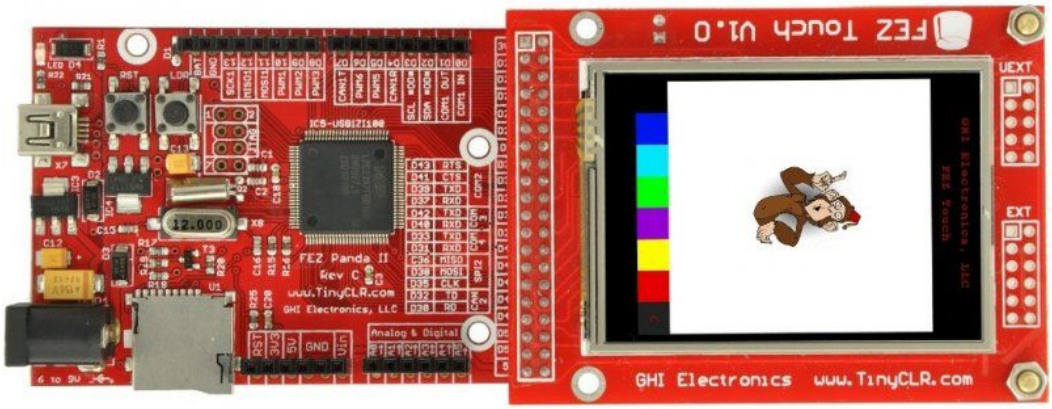
We Need More

The project needs to be expanded to learn multiple buttons. Also, the recorded signals should be stored on the SD card. You can even use the touch display to create a fancy full color display universal remote control.

14. Using FEZ Touch

GHI provides drivers for the color display and for the touch interface. A sample "paint" application demonstrates the driver and the touch interface.

http://code.tinyclr.com/project/277/fez-touch-lcd-component/



15. What Is Next?

One important place to always visit is this page that has all the resources needed and many tutorial links:
http://www.tinyclr.com/support

This is a list of other resources that should help in your next invention!

- The official FEZ website with all the fun:
  http://www.tinyclr.com/
- GHI blog is always a good place to visit:
  http://ghielectronics.blogspot.com
- The GHI community wiki:
  http://wiki.tinyclr.com
- The GHI community code share:
  http://code.tinyclr.com
- Facebook:
  http://www.facebook.com/pages/GHI-Electronics/201366383211427
- Twitter:
  http://twitter.com/GHIElectronics
- YouTube:
  http://www.youtube.com/GHIElectronics
- A good and free eBook to continue learning about C# is available at:
  http://www.programmersheaven.com/2/CSharpBook
- Microsoft's .NET Micro Framework community:
  http://www.netmf.com/