G30 SoC User Manual

Rev. 0.01 June 26, 2015 User Manual

G30 System on Chip

Document Information

Information	Description
Abstract	This document covers information about the G30 SoC, specifications, tutorials and references.

Revision History		
Rev No.	**Date**	**Modification**
Rev. 0.01	8/26/14	Preliminary version.

*** This is a preliminary version ***

Table of Contents

1. Introduction

The G30 SoC is a powerful, yet low-cost, surface-mount System on Chip (SoC) running the .NET Micro Framework software, which enables the SoC to be programmed from Microsoft's Visual Studio, through a USB cable. Programming in a modern managed language, such as C# and Visual Basic, allows developers to accomplish much more work in less time by taking advantage of the extensive built-in libraries for networking, file systems, graphical interfaces and many peripherals.

A simple two layer circuit, with just power and some connectors, can utilize the G30 SoC to bring the latest technologies to any products. There are no additional licensing or fees and all the development tools and SDKs are freely available.

1.1. G30 SoC Key Features

- .NET Micro Framework
- 84 MHz ARM Cortex-M4 processor
- 96 kB RAM
- 512 kB FLASH
- Embedded LCD controller
- 46 GPIO Pins
- 46 Interrupt Inputs (16 at a time)
- 2 SPI
- I2C
- 2 UART
- 16 12-Bit Analog Input
- 4Bit SD/MMC Memory card interface
- 15 PWM
- 112 mA max @ 25ºC
- 1.5 mA Hibernate Mode
- -40ºC to +105ºC Operational
- RoHS Lead Free
- Dimensions: (16.7 mm x 16.7 mm)
- File System (SD)

1.2. Example Applications

- Measurement tools and testers
- Networked sensors
- Robotics

- Central alarm system
- Smart appliances
- Industrial automation devices

1.3. The .NET Micro Framework

Inspired by its full .NET Framework, Microsoft developed a lightweight version called .NET *Micro* Framework (NETMF).

NETMF focuses on the specific requirements of resource-constrained embedded systems. Development, debugging and deployment is conveniently performed using Microsoft's powerful Visual Studio tools, all through standard USB cable.

Programming is done in C# or Visual Basic. This includes libraries to cover sockets for networking, modern memory management with garbage collector and multitasking services. In addition to supporting standard .NET features, NETMF has embedded extensions supporting:

- General Purpose IO (GPIO with interrupt handling
- Analog input/output
- Standard buses such I2C, SPI, USB, Serial (UART)
- PWM
- Networking
- File System
- Display graphics, supporting images, fonts and controls.

1.4. GHI Electronics and NETMF

For years, GHI Electronics has been the lead Microsoft partner on .NET Micro Framework (NETMF). The core NETMF was also extended with new exclusive libraries for an additional functionality, such as USB Host.

One of the important extensions by GHI Electronics is Runtime Loadable Procedures (RLP), allowing native code (Assembly/C) to be compiled and loaded right from withing managed code (C#/Visual Basic) to handle time critical and processor intensive tasks. IT can also be used to add new native extensions to the system.

As for networking, WiFi and PPP libraries are added by GHI Electronics to the NETMF core. Combined with Ethernet and the other managed services, it is a complete toolbox for the internet of things.

All the mentioned features are loaded and tested on the G30 SoC. GHI Electronics continuously maintains, upgrades and solves any of the issues on the G30 SoC firmware, to provide regular and free releases. Users can simply load the new software on the G30 SoC using USB or Serial, and even use the in-field-update feature. This feature allows the upgrade to be done through any of the available interface, including file system and networking.

2. The Hardware

The G30 SoC core components includes the processor, 512kB flash, and 96KB RAM.

The small, 38.1 x 26.7 x 3.55 mm (only 1 x 1.5 inches), module contains everything needed to run a complex embedded-system in a cost-effective and flexible solution. All that is needed is a 3.3V power source and some connections to take advantage of the G30 SoC's long list of available features.

2.1. Microcontroller

The microcontroller is the heart of G30 SoC. Running at 180Mhz, 32Bit, Cortex-M4 and includes a long list of available peripherals. The NETMF core libraries, combined with the GHI Electronics extensions, provide a long list of methods to access the available peripherals.

3. Pin-Out Description

Many signals on the G30 SoC are multiplexed to offer multiple functions on a single pin. Developers can decide on the pin functionality through the provided libraries. These are some important facts pertaining to the available pins:

Advanced details on all pins can be found in the STM32F401 datasheet.

3.1. Pin-out Table

G30	GPIO	Multiplexed Function(s)	Notes
1	VBAT		
2	PC13	LDR1	
3	PC14	32 KHz IN	RTC Crystal
4	PC15	32 kHz OUT	
5	PH0	12MHz IN	Main Crystal
6	PH1	12MHz OUT	
7	RESET		Active low, not 5V tolerant.
8	PC0	ADC10	
9	PC1	ADC11	
10	PC2	ADC12	
11	PC3	ADC13	
12	GND		
13	3.3V		This power source is for the internal analog circuitry.
14	PA0	ADC0, COM2 CTS, PWM3	
15	PA1	ADC1, COM2 RTS, PWM4	
16	PA2	ADC2, COM2 TX, PWM5	
17	PA3	ADC3, COM2 RX, PWM6	
18	GND		
19	3.3V		

G30	GPIO	Multiplexed Function(s)	Notes
20	PA4	ADC4	Not 5V tolerant.
21	PA5	ADC5	Not 5V tolerant.
22	PA6	ADC6	
23	PA7	ADC7	
24	PC4	ADC14	
25	PC5	ADC15	
26	PB0	ADC8	
27	PB1	ADC9	
28	PB2		10k Resistor pull to GND
29	PB10	MODE (debug interface)	High = USB, Low = Serial
30	VCAP		2.2uF to GND
31	GND		
32	3.3V		
33	PB12		
34	PB13	SPI2 SCK	
35	PB14	SPI2 MISO	
36	PB15	SPI2 MOSI	
37	PC6	PWM7	
38	PC7	PWM8	
39	PC8	PWM9, SD DATA0	
40	PC9	PWM10, SD DATA1	
41	PA8	PWM0, MCO1	
42	PA9	COM1 TX, PWM1	
43	PA10	COM1 RX, PWM2	10k Resistor pull to 3.3V
44	PA11	USB Device D-	
45	PA12	USB Device D+	
46	PA13		
47	GND		
48	3.3V		

G30	GPIO	Multiplexed Function(s)	Notes
49	PA14		
50	PA15	LDR0	
51	PC10	SD DATA2	
52	PC11	SD DATA3	
53	PC12	SD CLOCK	
54	PD2	SD CMD	
55	PB3	SPI1 CLOCK	
56	PB4	SPI1 MISO	
57	PB5	SPI1 MOSI	
58	PB6	I2C SCL, PWM11	
59	PB7	I2C SDA, PWM12	
60	Reserved		
61	PB8	PWM13	
62	PB9	PWM14	
63	GND		
64	3.3V		

All pins are 5V tolerant if not otherwise is stated.

4. G30 SoC Boot Up

To be added.

5. The GHI Boot Loader

The GHI Boot Loader software is pre-loaded and locked on the G30 SoC. It is used to update the firmware and can be used to do a complete erase all flash memory. The GHI boot loader is rarely needed but it is recommended to keep access available in all project designs.

The GHI boot loader accepts simple commands sent with the help of a terminal service software, such as TeraTerm or Hyper Terminal. A command character is sent and the boot loader performs an action; results are returned in a human friendly format followed by a "BL" indicating that the boot loader is ready for the next command. All commands and responses use ASCII encoded characters.

The G30 SoC boot up section provides the required information on how to choose the access interface and how to access the GHI boot loader.

5.1. The Commands

Command	Description	Notes
V	Returns the GHI Loader version number.	Format *X.XX* *e.g. 1.06*
E	Erases the Flash memory	Confirm erase by sending Y or any other character to abort. This command erases TinyBooter, the G30 SoC firmware and the user's application.
X	Loads the new TinyBooter file	Error: Reference source not found section explains this command process in more detail.
R	Runs firmware.	Exits the GHI boot loader mode and runs TinyBooter.
B	Changes the baud rate to 921600	User needs to change the baud rate on the terminal service accordingly. Available on serial access interface only.

Notes:

- Commands are not followed by pressing the “ENTER” key. The single command letter is sent to the G30 SoC; which immediately begins executing the command.
- The Boot loader commands are case sensitive.

… To be completed!

6. NETMF TinyCLR (firmware)

The Firmware is the main piece of embedded software running on the G30 SoC. It is what interprets and runs the user's managed application and it is what Microsoft's Visual Studio use to deploy, hook-into and debug the managed application. As explained in Error: Reference source not found section, hardware interfaces between TinyCLR and the host development system is either USB or Serial. In this chapter the examples use the USB interface.

If necessary, the module's firmware can be updated as described in the Error: Reference source not found chapter.

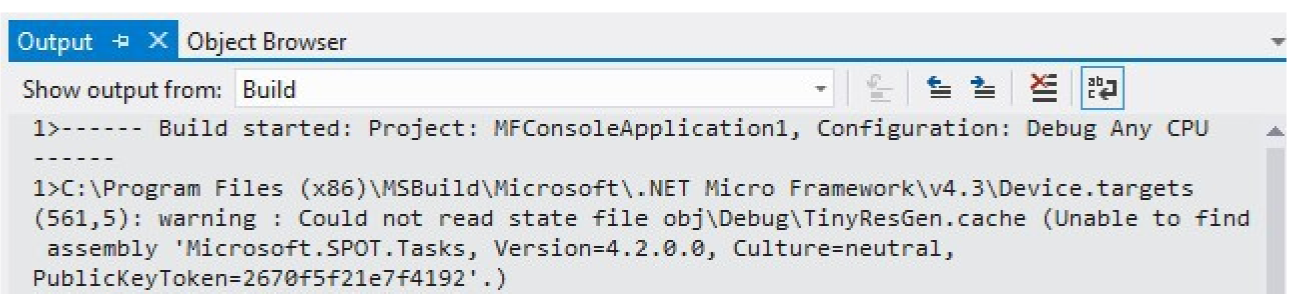
6.1. Assemblies Version Matching

The firmware includes extensions added by GHI Electronics. These extensions are often improved and further extended. If the managed application (C# or Visual Basic) uses any of the GHI specific extensions, care must be taken when a new SDK is installed.

This is due to the fact that the existing Visual Studio projects will include a local copy of the assemblies supplied by the old SDK; during compilation of the application, the extensions may not match what is found.

Additionally, the assemblies themselves are compiled for use with specific SDK versions.

For example where an application was previously compiled with 4.2, then the 4.3 SDK is installed; even if a successful compilation occurs (no extension conflicts were found), then the deployment process will begin to load 4.2 assemblies; this will cause loading errors when compiling for 4.3. This will not harm the G30 SoC. Visual Studio's Output panel will contain something like:

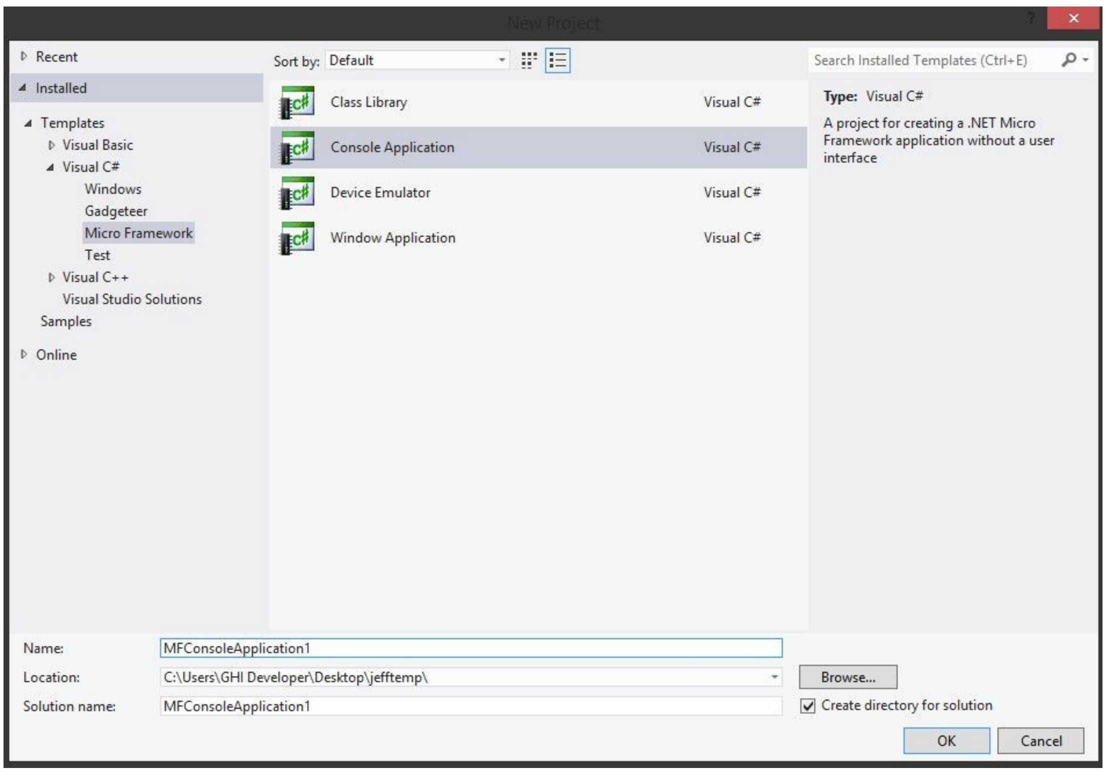


there is further discussions of assemblies in the Loading Assemblies section of chapter 7.

6.2. Deploying to the Emulator

Once the latest SDK is installed and the G30 SoC is loaded with the latest TinyBooter and NETMF TinyCLR, using Visual Studio to load/debug C# and Visual Basic application is very easy. If not installed yet, the latest SDK should be downloaded and installed on the development machine. The following link points to a page on the GHI Electronics website that shows what software components are necessary to install along with the latest SDK www.ghielectronics.com/support/netmf

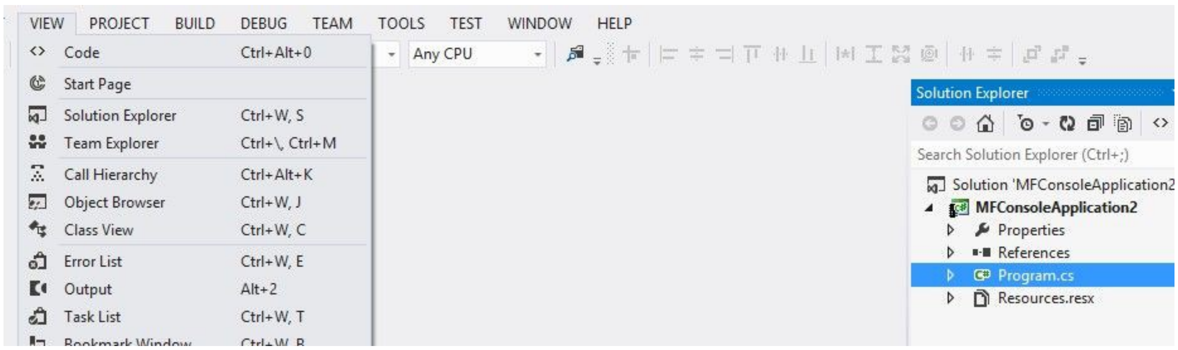
When done, Visual Studio can be started to create a new Micro Framework project Console Application.



C# is selected in this example but Visual Basic will be very similar. Run the code as is by pressing F5 or clicking the start button. This should open up the emulator and run the program. This program prints “Hello World” on the output window, not on the screen. If the output window is not visible, it can be opened from the “VIEW” top menu. When running the emulator has a pre-developed device that appears. The program closes when done causing the emulator device to close. The output window of Visual Studio should be full of messages... from loading assemblies (libraries) on power up to loading the application, to the actual “Hello

World!."

Now view open the program that was created automatically, Program.cs:



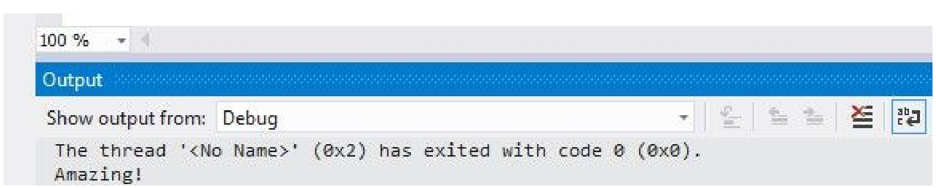
Change the program to the following.

```
using System;
using Microsoft.SPOT;

public class Program
{
    public static void Main()
    {
        Debug.Print("* Amazing! *");
    }

}
```

Press the F5 key. The output window will now show something similar to the following image.

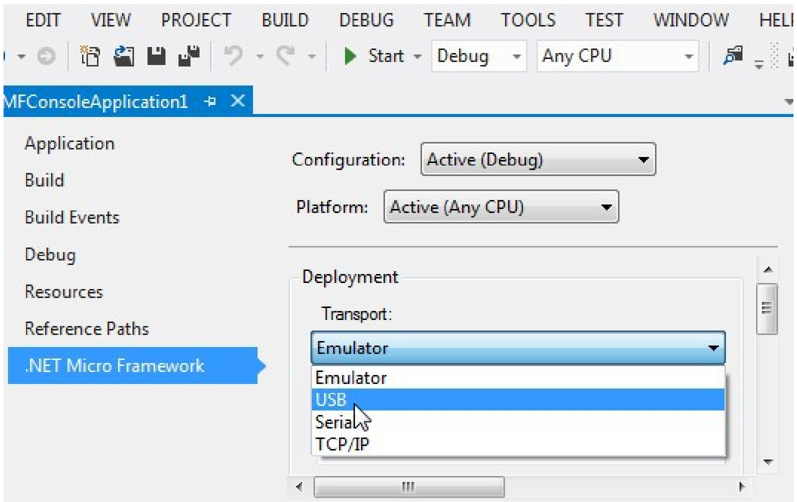


6.3. Deploying to the G30 SoC

This section relies on the work done in the previous section as loading to the actual hardware device is exactly the same as loading to the emulator. The only difference is in selecting the device instead of the emulator. This is done by going to the project properties:

In this example, the G30 SoC is connected to the PC using the USB interface (see Error: Reference source not found section). To deploy the application to the module select USB for "Transport."

Running the application (F5 key) will load the exact same program on the G30 SoC and then run it. The output window of Visual Studio will still show very similar messages but they are

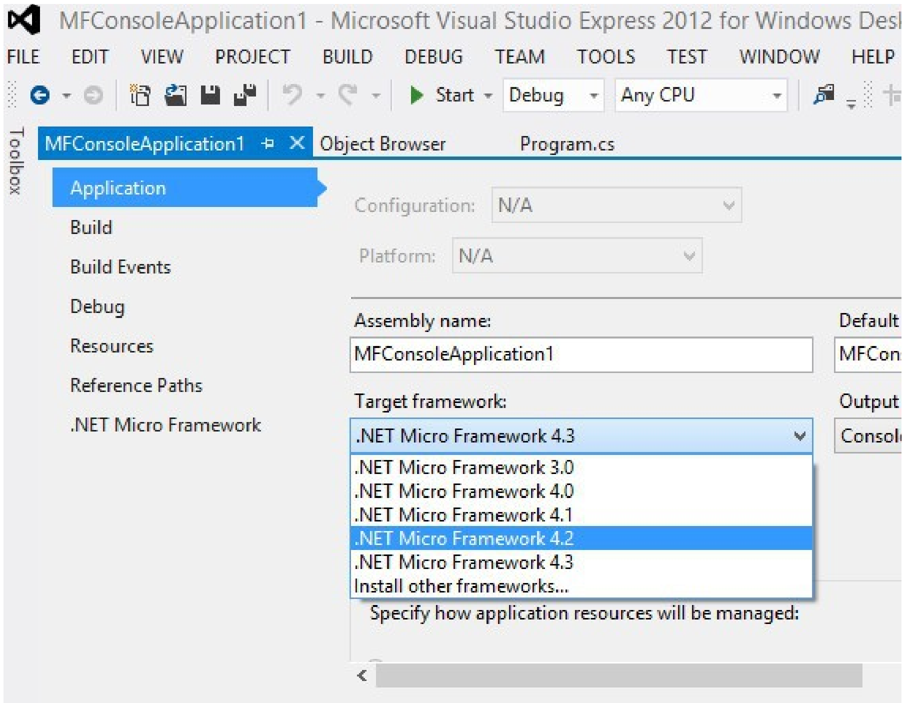


now coming from the G30 SoC directly.

If necessary, the deployed program can use the full power of the Visual Studio debugger; including, stepping through lines, inspecting variables, setting breakpoints, etc.

6.4. Targeting Different Versions of the Framework

There are times when it may be useful to compile and deploy applications for an older version of the SDK. For example, if there is a module with older firmware and there is an older application that needs to be deployed. GHI Electronics and Microsoft makes this easy by shipping the previous version of the framework as part of the current package. Under Project Properties, use the Application panel to target the desired version:


MFConsoleApplication1 - Microsoft Visual Studio Express 2012 for Windows Desk
FILE EDIT VIEW PROJECT BUILD DEBUG TEAM TOOLS TEST WINDOW HELP
Start Debug Any CPU
Toolbox
MFConsoleApplication1
Object Browser
Program.cs
Application
Build
Build Events
Debug
Resources
Reference Paths
.NET Micro Framework
Configuration: N/A
Platform: N/A
Assembly name:
MFConsoleApplication1
Default
MFCon
Target framework:
.NET Micro Framework 4.3
Output
Consol
.NET Micro Framework 3.0
.NET Micro Framework 4.0
.NET Micro Framework 4.1
.NET Micro Framework 4.2
.NET Micro Framework 4.3
Install other frameworks...
Specify how application resources will be managed:

7. The Libraries

Similar to the full desktop .NET, NETMF includes many services to help in modern application development. One example would be threading. This is typically very difficult to deal with on embedded systems, but thanks to NETMF, this is very easy and works as well as it does on a desktop application.

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

public class Program
{
    // We will print a counter every 1 second
    static int Count=0;
    static void CounterThread()
    {
        while (true)// Infinite loop
        {
            Thread.Sleep(1000);// Wait for 1 second
            Count++;// Increment the count
            Debug.Print("Count = " + Count);// Print the count
        }
    }
    // ************************************************
    static void Main()
    {
        //Create a second thread, main is automatically a thread
        Thread EasyThread = new Thread(CounterThread);
        EasyThread.Start();// Run the Counter Thread

        // We can now do anything we like
        // We will print Hi once every 2 seconds
        while (true)// Infinite loop
        {
            Debug.Print("Hi");
            Thread.Sleep(2000);
        }
    }
}
```

The output from the earlier program will look similar to this:

```
Hi
Count = 1
Hi
```

```
Count = 2
Count = 3
Hi
Count = 4
Count = 5
Hi
Count = 6
```

7.1. Finding NETMF Library Documentation

While this user manual is not meant to be a tutorial on the use of NETMF, a lot of details are provided to aid newcomers to NETMF. For further details, see the documentation library on the GHI website. Also, the main support page for NETMF includes links to the library reference documentation (NETMF APIs).

Because NETMF is a subset of the full .NET platform, services such as file input/output and Networking are very close, sometimes identical, between the full .NET Framework and the smaller .NET Micro Framework. The internet is a great source of .NET examples code that often can be used in a NETMF program with no changes!

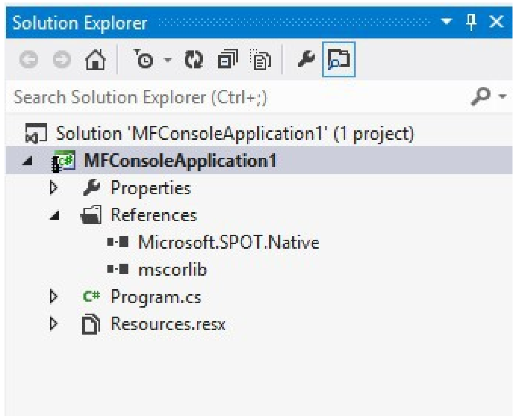
7.2. Loading Assemblies

In an earlier example, the threading libraries were used. This was done by identifying the `namespace` via the statement:

```
using System.Threading;
```

The compiled code for classes in the Threading library are part of the mscorlib assembly (DLL).

To use other libraries, the proper assembly file (DLL) must be added to the project. Such as in adding the Microsoft.SPOT.Hardware to use a GPIO pin. Assembly files used by a project are managed as “References” in Visual Studio:

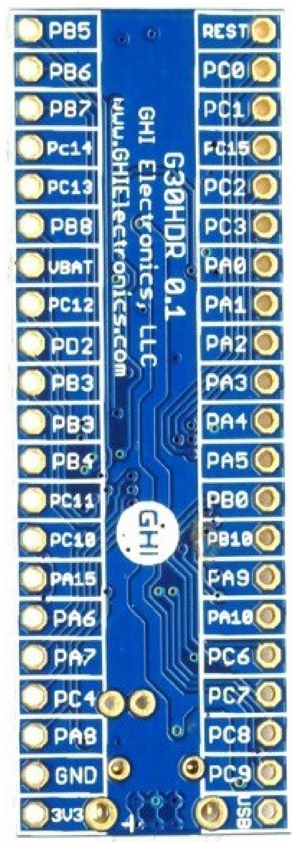


Important note: The emulator will only work with the Microsoft assemblies. GHI Electronics' libraries will not run on the emulator.

8. The G30HDR Board

The G30 SoC is also available in a DIP42-compatible trough hole format. It includes the requires crystal and passive components for the G30 SoC to operate. A USB port is also found on the G30HDR. Only a 3.3V power source is needed to operate the G30HDR.

SPI1 MOSI	PB5
SCL/PWM11	PB6
SDA/PWM12	PB7
OSC32 IN	PC14
LDR1	PC13
PWM13	PB8
	VBAT
SD CLK	PC12
SD CMD	PD2
SPI1 CLK	PB3
ADC8	PB0
SPI1 MISO	PB4
SD D3	PC11
SD D2	PC10
LDR0	PA15
ADC6	PA6
ADC7	PA7
ADC14	PC4
PWM0/MCO1	PA8
	GND
	3V3



REST	
PC0	ADC10
PC1	ADC11
PC15	OSC32 OUT
PC2	ADC12
PC3	ADC13
PA0	ADC0/COM2 CTS/PWM3
PA1	ADC1/COM2 RTS/PWM4
PA2	ADC2/COM2 TX/PWM5
PA3	ADC3/COM2 RX/PWM6
PA4	ADC4
PA5	ADC5
PB0	ADC8
PB10	MODE
PA9	COM1 TX/PWM1
PA10	COM2 RX/PWM2
PC6	PWM7
PC7	PWM8
PC8	PWM9/SD D0
PC9	PWM10/SD D1
USB	VBUS

8.1. Digital Inputs/Outputs

GPIO (General Purpose Input Output) are used to set a specific pin high or low states when the pin is used as an output. On the other hand, when the pin is an input, the pin can be used to detect a high or low state on the pin. High means there is voltage on the pin, which is referred to as “true” in programming. Low means there is no voltage on the pin, which is referred to as “false”. Pins can also be enabled with an internal weak pull-up or pull-down resistor. Here is a blink LED example.

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

public class Program
{
    public static void Main()
    {
        OutputPort LED = new OutputPort(Cpu.Pin.GPIO_Pin0, true);
        while (true)
        {
            LED.Write(true);
            Thread.Sleep(500);
            LED.Write(false);
            Thread.Sleep(500);

        }
    }
}
```

This is available through the Microsoft.SPOT.Hardware assembly.

While it is clear that the earlier example blinks an LED every one second (on for 500ms and off for another 500ms), it is not clear what pin on G30 SoC will be controlled. Instead of using the generic GPIO_Pin0 name, the actual G30 SoC name can be found in the GHI.Pins assembly. This example now uses the actual G30 SoC pin name using the GHI.Pins assembly.

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

using GHI.Pins;

public class Program
{
    public static void Main()
    {
        OutputPort LED = new OutputPort(GHI.Pins.G30.Gpio.PA0, true);
        while (true)
        {
            LED.Write(true);
            Thread.Sleep(500);
            LED.Write(false);
            Thread.Sleep(500);

        }
    }
}
```

Reading Input pins is as simple! This example will blink an LED only when the button is pressed.

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

using GHI.Pins;

public class Program
{
    public static void Main()
    {
        OutputPort LED = new OutputPort(GHI.Pins.G30.Gpio.PA0, true);
        InputPort Button = new InputPort(GHI.Pins.G30.Gpio.PA1,false,
Port.ResistorMode.PullUp);
        while (true)
        {
            if (Button.Read() == true)
            {
                LED.Write(true);
                Thread.Sleep(500);
                LED.Write(false);
                Thread.Sleep(500);
            }
        }
    }
}
```

Interrupt Pins

The beauty of modern and managed language shines with the use of events and threading. This example will set a pin high when a button is pressed. It should be noted here that the system in this example spends most its time a in a lower power state.

Note: Only pins on port 0 and port 2 are interrupt capable.

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

using GHI.Pins;

public class Program
{
    public static OutputPort LED = new OutputPort(GHI.Pins.G30.Gpio.PA0, true);
    public static void Main()
    {
        InterruptPort Button = new InterruptPort(GHI.Pins.G30.Gpio.PA1,true,
Port.ResistorMode.PullUp,
            Port.InterruptMode.InterruptEdgeBoth);

        Button.OnInterrupt += Button_OnInterrupt;
        // The system can do anything here, even sleep!
        Thread.Sleep(Timeout.Infinite);
    }

    static void Button_OnInterrupt(uint port, uint state, DateTime time)
    {
        LED.Write(state > 0);
    }
}
```

8.2. Analog Inputs

Analog inputs can read voltages from 0V to 3.3V with a 10-Bit resolution.

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

public class Program
{
    public static void Main()
    {
        AnalogInput ain = new AnalogInput(GHI.Pins.G30.AnalogInput.PA0);
        Debug.Print("Analog Pin =" + ain.Read());
    }
}
```

This is available through the Microsoft.SPOT.Hardware assembly.

8.3. PWM

The available PWM pins have a built-in hardware to control the ration of the pin being high vs low, duty cycle. A pin with duty cycle 0.5 will be high half the time and low the other half. This is used to control how much energy is transferred out from a pin. An example would be to dim an LED. With output pins, the LED can be on or off but with PWM, it can be set to 0.1 duty cycle to give the LED only 10% of the energy.

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

public class Program
{
    public static void Main()
    {
        PWM LED = new PWM(GHI.Pins.G30.PwmOutput.PA0, 10000, 0.10, false);
        LED.Start();
    }
}
```

This is available through the the Microsoft.SPOT.Hardware.PWM assembly.

Another use of PWM is to generate tones. In this case, the duty cycle is typically set to 0.5 but then the frequency will be changed as desired.

In the case of servo motor control, or when there is a need to generate a pulse at a very specific timing, PWM provides a way to set the high and low pulse with.

8.4. Signal Generator

Using Signal Generator, developers can produce different waveforms. This is available on any digital output pin.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using GHI.Pins;
using GHI.IO;

public class Program
{
    public static void Main()
    {
        uint[] signal = new uint[4] {1000,2000,3000,4000};
        SignalGenerator pin = new SignalGenerator(GHI.Pins.G30.Gpio.PA0, false);

        pin.Set(false, signal);

        Thread.Sleep(Timeout.Infinite);
    }
}
```

While handeled in software, the SignalGenerator runs through internal interrupts in the background and so is not blocking to the system. Another Blocking methd is also provided for higher accuracy. For example, the blocking method can generate acarrier frequency. This is very useful for infrared remote control applications.

This is available through the GHI.Hardware assembly.

8.5. Signal Capture

Signal Capture monitors a pin and records any changes of the pin into an array. The recorded values are the times taken between each signal change.

```
using System;
using System.Threading;
using Microsoft.SPOT;
using Microsoft.SPOT.Hardware;
using GHI.Pins;
using GHI.IO;
```

```
public class Program
{
    public static void Main()
    {
        uint[] signal = new uint[100];
        SignalCapture pin = new
SignalCapture(GHI.Pins.G30.Gpio.PA0,Port.ResistorMode.Disabled);

        pin.Read(false, signal);

        Thread.Sleep(Timeout.Infinite);
    }
}
```

This is available through the GHI.Hardware assembly.

8.6. Serial Port (UART)

One of the oldest and most common protocols is UART (or USART).

Important Note: Serial port pins have 3.3V TTL levels where the PC uses RS232 levels. For proper communication with RS232 serial ports (PC serial port), an RS232 level converter is required. One common converter is MAX232.

Note: If the serial port is connected between two TTL circuits, no level converter is needed but they should be connected as a null modem. Null modem means RX on one circuit is connected to TX on the other circuit, and vice versa.

```
using System;
using System.IO.Ports;
using System.Threading;
using Microsoft.SPOT;

public class Program
{
    public static void Main()
    {
        SerialPort COM1 = new SerialPort("COM1");
        int c = COM1.ReadByte();

        // ...
    }
}
```

This is available through the Microsoft.SPOT.Hardware.SerialPort assembly.

8.7. SPI

G30 SoC supports two SPI interfaces, SPI1 and SPI2. SPI Bus is designed to interface with multiple SPI slave devices, the active slave is selected by asserting the Chip Select line on the relative slave device.

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

public class Program
{
    public static void Main()
    {
        SPI.Configuration MyConfig =
             new SPI.Configuration(Cpu.Pin.GPIO_Pin1,
             false, 0, 0, false, true, 1000, SPI.SPI_module.SPI1);
        SPI MySPI = new SPI(MyConfig);

        byte[] tx_data = new byte[10];
        byte[] rx_data = new byte[10];

        MySPI.WriteRead(tx_data, rx_data);

        Thread.Sleep(Timeout.Infinite);
    }
}
```

This is available through the Microsoft.SPOT.Hardware assembly.

8.8. I2C

I2C is a two-wire addressable serial interface.

The G30 SoC supports one master I2C port.

```
// Setup the I2C bus
I2CDevice.Configuration con =
    new I2CDevice.Configuration(0x38, 400);
I2CDevice MyI2C = new I2CDevice(con);
// Start a transaction
I2CDevice.I2CTransaction[] xActions =
    new I2CDevice.I2CTransaction[2];
byte[] RegisterNum = new byte[1] { 2 };
xActions[0] = I2CDevice.CreateWriteTransaction(RegisterNum);
```

This is available through the Microsoft.SPOT.Hardware assembly.

8.9. One-wire

Through one-wire, a master can communicate with multiple slaves using a single digital pin. One-wire can be activated on any Digital I/O on G30 SoC.

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

public class Program
{
    public static void Main()
    {
        // Change this to correct GPI pin for the onewire used in the project!
        OutputPort myPin = new OutputPort(GHI.Pins.G30.Gpio.PA0, false);

        OneWire ow = new OneWire(myPin);

        while (true)
        {
            if (ow.TouchReset() > 0)
            {
                Debug.Print("Device is detected.");
            }
            else
            {
                Debug.Print("Device is not detected.");
            }

            Thread.Sleep(10000);
        }
    }
}
```

This is available through the Microsoft.SPOT.Hardware.OneWire.

8.10. Graphics

The G30 SoC does not have internal support for graphics/ However, graphical display can still be added and used, typically using the SPI bus. The software added will need to draw the fonts and shapes manually. Examples exist on the GHI electronics' website, under the community's codeshare.

8.11. Accessing Files and Folders

The File System feature in NETMF is near very similar to the full .NET and can be tested from within the Microsoft NETMF emulator with minor changes. Changes include removing any of the GHI library dependencies. There are no limits on file sizes and counts, beside the limits of the FAT file system itself. NETMF supports FAT16 and FAT32. Files are made accessible on SD cards.

Most online examples on how to use .NET to access files on PCs can be used to read and write files on the G30 SoC. The GHI Electronics' online documentation has further examples as well.

This is available through the GHI.Hardware, System.IO and Microsoft.SPOT.IO.

```
using System;
using System.IO;
using Microsoft.SPOT;
using Microsoft.SPOT.IO;

using GHI.IO.Storage;

class Program
{
    public static void Main()
    {
        // ...
        // SD Card is inserted
        // Create a new storage device

        SD sdPS = new SDCard();

        // Mount the file system
        sdPS.Mount();

        // Assume one storage device is available, access it through
        // NETMF and display the available files and folders:
        Debug.Print("Getting files and folders:");
        if (VolumeInfo.GetVolumes()[0].IsFormatted)
        {
            string rootDirectory =
                VolumeInfo.GetVolumes()[0].RootDirectory;
            string[] files = Directory.GetFiles(rootDirectory);
            string[] folders = Directory.GetDirectories(rootDirectory);

            Debug.Print("Files available on " + rootDirectory + ":");
            for (int i = 0; i < files.Length; i++)
                Debug.Print(files[i]);

            Debug.Print("Folders available on " + rootDirectory + ":");
            for (int i = 0; i < folders.Length; i++)
                Debug.Print(folders[i]);
        }
        else
        {
            Debug.Print("Storage is not formatted. " +
                "Format on PC with FAT32/FAT16 first!");
        }
        // Unmount when done
        sdPS.Unmount();
    }
}
```

SD/MMC Memory

SD and MMC memory cards have similar interfaces. G30 SoC supports both cards and also supports SDHC/SDXC cards. The interface runs through a true 4-bit SD interface. SD cards are available in different sizes but they are all of an identical function making them all supported on the G30 SoC.

8.12. Networking (TCP/IP)

There is no built in networking support for networking; however, there are many low-cost network interface devices that can be controlled using UART or SPI to give G30 SoC a networking option. An example is Wiznet's Ethernet chipsets.

8.13. USB Client (Device)

To be added.

8.14. Real Time Clock

The G30 SoC processor includes a real-time clock (RTC) that can operate while the processor is off, through a backup battery or a super capacitor. An appropriate 32.768KHz crystal must also be added to the system. All details about power and required crystal can be found in the STM32F401 datasheet and user manual.

NETMF has its own time keeping that is independent from the real time clock. If actual time is need, the software should read the RTC and set the system's time.

```
using System;
using GHI.Processor;
using Microsoft.SPOT;

public class Program
{
    public static void Main()
    {
        DateTime DT;
        try
        {
            DT = RealTimeClock.GetDateTime();
            Debug.Print("Current Real-time Clock " + DT.ToString());
        }
        catch
        {
            // If the time is not good due to powerloss
            // an exception will be thrown and a new time will need to be set
            Debug.Print("The date was bad and caused a bad time");
            // This will set a time for the Real-time Clock clock to 1:01:01 on 1/1/2012
            DT = new DateTime(2012, 1, 1, 1, 1, 1);
            RealTimeClock.SetDateTime(DT);
        }

        if (DT.Year < 2011)
        {
            Debug.Print("Time is not resonable");
        }

        Debug.Print("Current Real-time Clock " + RealTimeClock.GetDateTime().ToString());
        // This will set the clock to 9:30:00 on 9/15/2011
        DT = new DateTime(2011, 9, 15, 7, 30, 0);
        RealTimeClock.SetDateTime(DT);
        Debug.Print("New Real-time Clock " + RealTimeClock.GetDateTime().ToString());
    }
}
```

Tip: The system time can also be set using time services through the internet.

8.15. Watchdog

Watchdog is used to reset the system if it enters an erroneous state. The error can be due to internal fault or the user's managed code. When the Watchdog is enabled with a specified timeout, the user must keep resetting the Watchdog counter within this timeout interval or otherwise the system will reset.

```
// Enable with 10 second timeout
GHI.Processor.Watchdog.Enable(10 * 1000);
while (true)
{
    // Do some work
    GHI.Processor.Watchdog.ResetCounter();
}
```

8.16. Power Control

Embedded devices often must limit power usage as much as possible. Devices may lower their power consumption in many ways:

1. Reduce the processor clock
2. Shutdown the processor when system is idle (keep peripherals and interrupts running)
3. Shutdown specific peripherals
4. Hibernate the system

A common way to wake a device is using the RTC alarm. Whenever the alarm goes off, it will wake the device. These examples require the GHI.Hardware and Microsoft.SPOT.Hardware assemblies.

Use Microsoft.SPOT.Hardware.HardwareEvent.OEMReserved2 for RTC alarm. When the program starts, it will set an RTC alarm for 30 seconds in the future and then hibernate until then.

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

public class Program
{
    public static void Main()
    {
        RealTimeClock.SetAlarm(DateTime.Now.AddSeconds(30));

        PowerState.Sleep(SleepLevel.DeepSleep, HardwareEvent.OEMReserved2);

        ///Continue on with your program here
    }
}
```

The device will awaken whenever an interrupt port is triggered. Some devices can use interrupts internally that can cause spurious wakeups if not disabled. Use Microsoft.SPOT.Hardware.HardwareEvent.OEMReserved1 for interrupts.

NETMF's interrupt ports only function when their glitch filter is enabled or they have an event handler subscribed.

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

public class Program
{
    public static void Main()
    {
        var interrupt = new InterruptPort(Cpu.Pin.GPIO_Pin0, true, Port.ResistorMode.PullUp,
Port.InterruptMode.InterruptEdgeHigh);
        interrupt.OnInterrupt += interrupt_OnInterrupt;

        PowerState.Sleep(SleepLevel.DeepSleep, HardwareEvent.OEMReserved1);

        ///Continue on with your program here
    }

    private static void interrupt_OnInterrupt(uint data1, uint data2, DateTime time)
    {
        //Interrupted
    }
}
```

9. Advanced Use Of The Microcontroller

The G30 SoC is based on the STM32F4021 microcontroller. There are times when direct programming is needed. GHI has extended NETMF to allow assembly level access from managed code to the microcontroller.

All these examples use the GHI.Hardware assembly.

9.1. Register

This class is used for manipulating the processor registers directly.

To be completed.

```
var EMCCLKSEL = new GHI.Processor.Register(0x400FC100);
EMCCLKSEL.ClearBits(1 << 0);  // OVERDRIVE
//EMCCLKSEL.SetBits(1 << 0);    // NORMAL
```

9.2. AddressSpace

Allows applications to read and write memory directly. This code reads a byte from address 0xA0000000.

```
GHI.Processor.AddressSpace.Read(0xA0000000);
```

9.3. Battery RAM

To be added.

9.4. EEPROM

To be added.

10. Design Consideration

To be added.

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