



- I have a great idea
- .NET Micro Framework
- C#
- Hardware & NETMF
- Necessary software
- Your first program
- The programming language
- Possible extensions
- Conclusion


2


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 **.NET Micro Framework**

- **What is .NET?**
 - **Full Framework**
- **What is .Net Compact Framework?**
 - **Runs on Windows CE & smart phones**
- **What is .NET Micro Framework?**
 - **OS independent**





3 

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 **.NET Micro Framework**

- The typical .NET Micro Framework device has a 32 bit processor with no external memory management unit (MMU) and could have as little as 64K of random-access memory (RAM).



4 

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.NET Micro Framework

5

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.NET Micro Framework

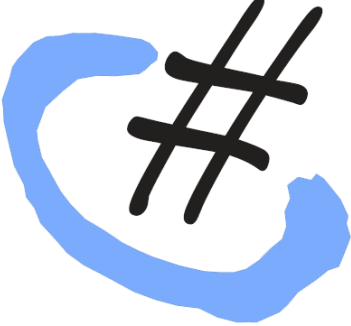
- **Advantages**
 - If you are using .NET Micro Framework then there are many advantages:
 - 1. It runs on Microsoft's Visual C# Express, free and high-end IDE.
 - 2. .NET Micro Framework is open-source and free.
 - 3. Your code will run on all these devices with almost no changes.
 - 4. Full debugging capabilities. (Breakpoints, stepping in code, variables...etc.)
 - 5. Has been tested in many commercial products so quality is assured.
 - 6. Includes many bus drivers. (SPI, UART, I2C...etc.)
 - 7. No need to use processors datasheets because of the standard framework.
 - 8. If you are already a PC C# programmer then you are already an embedded system developer with NETMF!

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C#

- **What is C#**
 - garbage collector
 - run-time validation
 - object-oriented
 - shrink down the bug-possibilities




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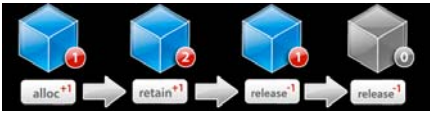
C#

- **Garbage Collection**
 - The term garbage collection can be defined as management of the allocation and release of memory in an application.



Reference counting

- Programmers were only responsible →




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C#

- **Automatic Garbage Collection in .Net**
 - The garbage collector in .Net takes care of bulk of the memory management responsibility, freeing up the developer to focus on core issues.



9

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Get Turnkey Hardware **Hardware & NETMF**

		Version 4.0 Support	Wired Network Connectivity	Wireless Network Connectivity	USB Device	LCD	Touch Screen
Academus	EELiod270 Educational Kit	√	√			√	√
	Phycore LPC3180 (NXP)		√				
Adeneo Embedded	Avnet Blackfin BF518F (ADI)	√				√	√
	AT91SAM9261-EK (Atmel)	√	√		√	√	√
Avnet	Analog Devices BF518F FMC Development Kit	√	√		√	(optional)	(optional)
AUG Elektronik	AUG AMI DevKit	√	√			√	√
Crossbow	WSN Imote2 .Builder Kit	√		√			
	Gemini Development Kit						

Original Equipment Manufacturers (OEM)

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Get Turnkey Hardware **Hardware & NETMF**

		Version 4.0 Support	Wired Network Connectivity	Wireless Network Connectivity	USB Device	LCD	Touch Screen
CSIP	Gemini Development Kit (currently available only in China)	√	√		(optional)	√	(optional)
	Meridian/P Micro Development Kit	√	(optional)		√	√	
Device Solutions	Tahoe II Development Kit	√	√	(optional)	√	√	√
	ConnectCore 9P9215 JumpStart Kit		√			(optional)	(optional)
Digi	Connect ME JumpStart Kit		√				
	Emtrion HiCO.ARM9 Starter Kit		√			√	√

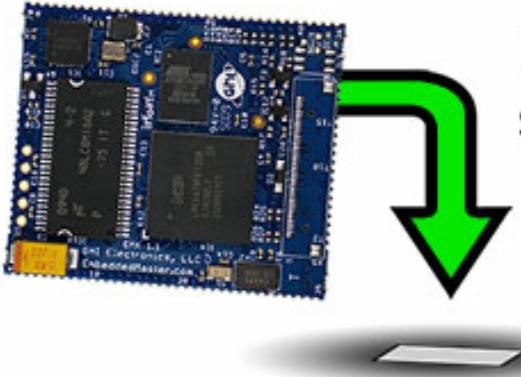
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Get Turnkey Hardware **Hardware & NETMF**

		Version 4.0 Support	Wired Network Connectivity	Wireless Network Connectivity	USB Device	LCD	Touch Screen
	CANxtra In-Box Development System	√	√		√	√	
	ChipworkX Development System	√	√	(optional)	√	√	√
	Embedded Master TFT Development System	√	√	(optional)	√	√	√
	Fez Domino	√			√	(optional)	
	Fez Mini	√			√	(optional)	
	USBizi Development System	√		(optional)	√		
GHI	Embedded Development Kit	√	√				
SJJ Micro	MF 4 Micro Development Kit	√	√		√	(optional)	(optional)

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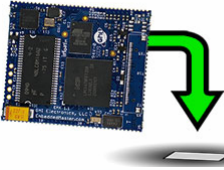
What offers GHI Electronics ? **Hardware & NETMF**



Drop-in solutions.

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What offers GHI Electronics ? **Hardware & NETMF**



Drop-in solutions.

Porting requires a considerable cost, extensive time, and a lot of experience.

.NET Micro Framework Based Solution	Managed Application USB Data logging App, CAN-to-Ethernet Bridge App, ...	App. coding	Your Scope of Work
	Application Services Extended Object Model: Web Services, WPF,Net Micro Framework Porting	GHI's Scope of work
	Managed Libraries Basic Object Model: Threading, I/O, TCP/IP sockets, ...		
	Managed Run-Time CLR, Interpreter, Executive, and Interop		
	Platform Abstraction Layer (PAL) HW independent facilities: File system, TCP/IP stack, ...		
	Hardware Abstraction Layer (HAL) SD driver, Ethernet driver, USB driver, LCD driver ...	Design and Prototyping	
Hardware ARM processor, RAM, Flash, Preipherals: Ethernet MAC/PHY, Serial Interfaces, GPIOs			

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GHI Electronics offers an extensive range from the very basic to the very advance.

- ChipworkX
- EMX
- USBizi
- FEZ Family
 - FEZ Domino and FEZ Mini
 - FEZ Rhino
 - FEZ Cobra

...and many more.



USBizi Chip EMX Module ChipworkX

Hardware & NETMF

ChipworkX Development System

*Advanced.
Feature rich.
Powerful.*



EMX Development System

Extensive capabilities. Rapid prototyping.




FEZ COBRA Complete system in a box.



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ChipworkX Module

- ***If processing power and customization is needed ChipworkX runs a:***
- 200Mhz ARM processor with 64MB
- 32-bit SDRAM and 8MB for user applications
- 256MB internal flash for file system storage
- all NETMF major features
- WiFi and USB host support ...etc.
- ChipworkX also adds SQLite database support




USBizi Chip EMX Module ChipworkX

Hardware & NETMF



MINI926II V1.4


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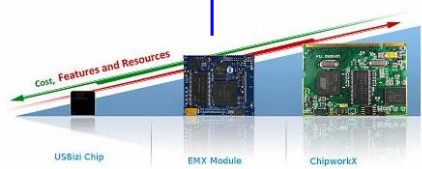


EMX Module

Hardware & NETMF


- *small module includes all NETMF major features and adds many features:*
- TCP/IP,
- SSL,
- Graphics,
- debugging and more NETMF features
- WiFi,
- PPP,
- USB host,
- USB device
- builder,
- CAN,
- Analog in/out,
- PWM
- It is 72Mhz ARM processor with 8MB SDRAM and 4.5MB FLASH.
NXP LPC2478






Cost, Features and Resources

USBiz Chip EMX Module ChipworkX

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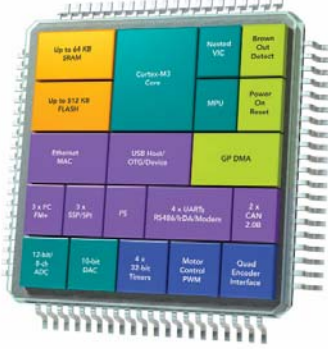
EMX Module


Hardware & NETMF

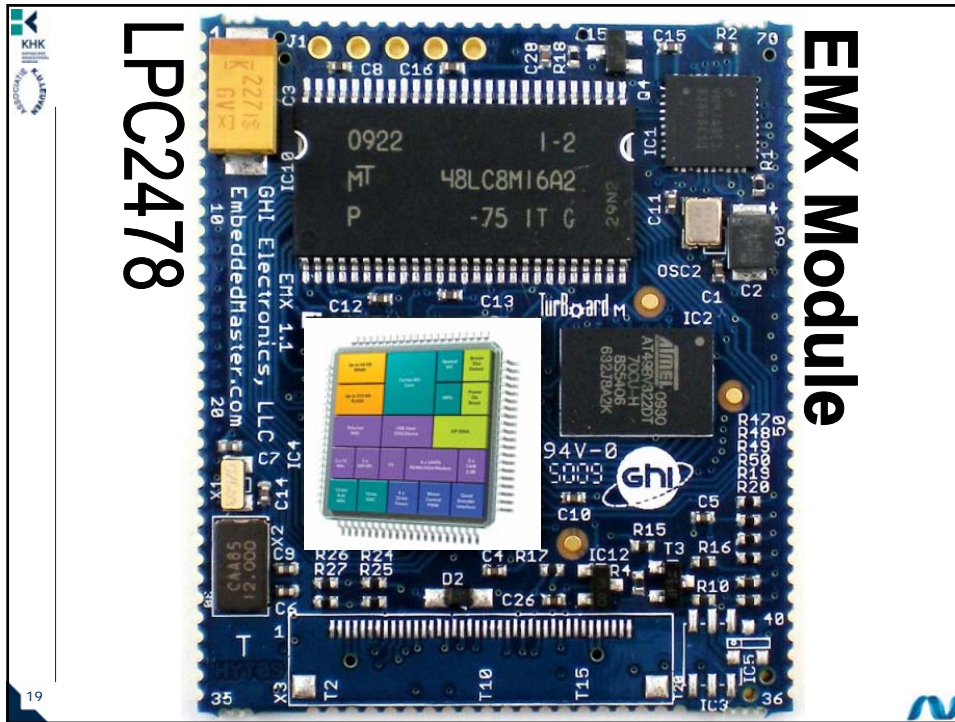
Runtime Loadable Procedure (RLP)

- allowing users to load their own compiled native code (C or assembly)
- run it directly through managed Micro Framework.
- Similar to the use of DLLs on PCs and usually used to implement highprocessing and time-critical routines.





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19

USBizi Chipset

Hardware & NETMF

- **USBizi is the smallest and only single-chip running NETMF in the world.**
- USBizi LQFP100 (14x14 mm) chipset is based on LPC2387 from NXP.
- **Software**
 - Microsoft .Net Micro Framework
 - USB Host (Storage Device, HID, Printer and more)
 - FAT File System
 - Peripherals Access (SPI, PWM...etc)
 - Runtime Loadable Procedure
 - Register Access
 - Hibernate Mode
- **Hardware**
 - 72Mhz ARM7 Processor
 - 96 KB RAM
 - 512 KB Flash
 - USB Device
 - 67 GPIO
 - 35 Interrupt Inputs
 -ect.

USBizi Chip EMX Module ChipworkX

20

FEZ Family **Hardware & NETMF**

**Fez stand for:
"Freakin Easy"**

**FREAKIN
EASY!**

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FEZ Family **Hardware & NETMF**

FEZ offers many features:

- Based on Microsoft's .NET Micro Framework.
- Runs on a 72Mhz NXP ARM processors.
- Supports run time debugging (breakpoints, variable inspection, stepping, etc.)
- Uses Visual Studio C# Express Edition for development.
- Advanced capabilities like FAT, USB device and USB host.
- Easily upgrades to hardware such as Embedded Master.
- Open source hardware design files.
- Use existing shields and holder boards.
- Based on the USBizi chipset (ideal for commercial use).
- FEZ Mini pin-out compatible with BS2.
- FEZ Domino pin-out compatible with Arduino.

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FEZ Family **Hardware & NETMF**

When using FEZ, the possibilities are endless...




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The image shows a custom-built robot. It has a blue FEZ board mounted on a black chassis. The robot has two large orange wheels and a smaller black wheel at the back. Various sensors and components are connected to the board with wires. The robot is shown from a top-down perspective.


FEZ Family **Hardware & NETMF**

- FEZ Domino and FEZ Mini are very small (open source) boards targeted for beginners.



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The image shows a small red FEZ board. It is a compact single-board computer. Next to it is a silver coin and a yellow pencil for scale. The board has various ports, including USB, and a microcontroller chip. The text 'EV' is visible on the board.



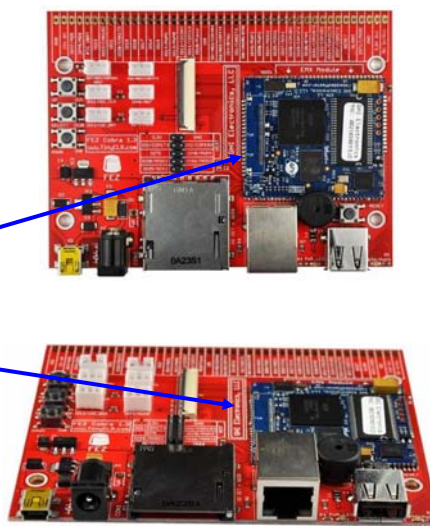
FEZ Family

- FEZ Cobra is an open source circuit board based on EMX module.

**EMX module
ARM LPC2478**




Hardware & NETMF



25

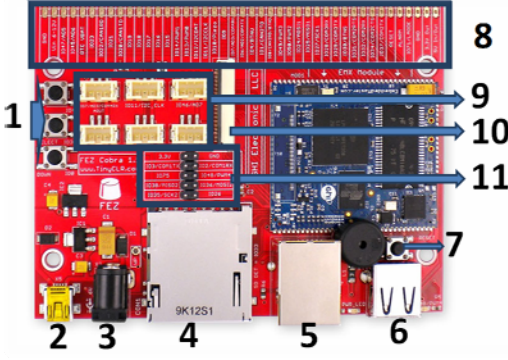

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FEZ Cobra Hardware

1. Input buttons
2. USB-Client
3. 6V supply input
4. SD/SDHC/MMC inp.
5. RJ-45 connector
6. USB-Host
7. Reset button
8. Extra inputs
9. JST Connectors (Xbee, Bluetooth, ...)
10. TFT Display connector
11. UEXT Connector (Wifi, MP3, ...)

Hardware & NETMF

26

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FEZ Family

Hardware & NETMF



CUSTOM ENCLOSURES



4.3" color display with touchscreen

FEZ Cobra OEM BOX

WiFi option available

USB host

Ethernet




SD socket

USB client

27

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FEZ Cobra 1.3


Hardware & NETMF

- Key Features *EMX Module with .NET Micro Framework*
 - 72 MHz 32-bit ARM 7 Processor
 - 16MB RAM and 4.5MB FLASH
 - TFT Display connector for Display Expansion
 - RJ-45 Ethernet connector.
 - GHI NETMF WiFi Expansion compatible.
 - GPIO signals with interrupts exposed on 0.1" header pins.
 - 2 SPI Master bus (8/16bit).
 - I2C interface.
 - 4 exposed UART (serial ports)
 - 7 analog inputs (ADC), 2 are used with touch screen.
 - 1 analog output (DAC).
 - 2 CAN interfaces.
 - 6 PWM signals.
 - One-wire interface support
 - SD/MMC card connector with spring.
 - USB Device port
 - USB Host port
 - 6 JST connectors for additional components such as XBee.
 - UEXT interface for easy expansions such as GPS, MP3 decoder.
 - LEDs and push buttons.
 - On-board Piezo.
 - Powered by USB or DC power (input 6 volts through 2.1mm power connector).
 - Custom Enclosure is available.
 - RoHS Lead Free

28

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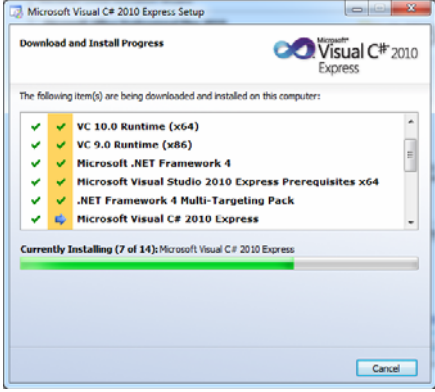





TinyCLR


Necessary software

1. Microsoft visual C# Express 2010



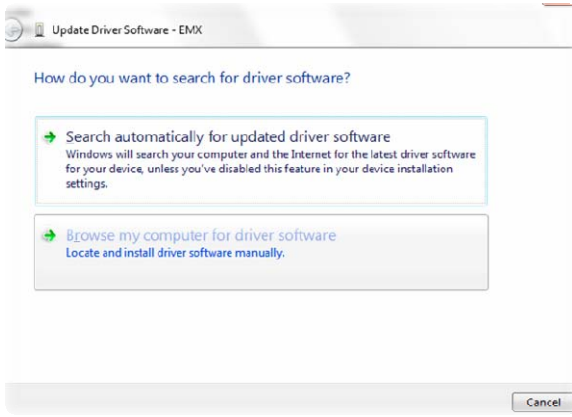
2. Microsoft NETMF 4.1 SDK
3. GHI NETMF 4.1 SDK
4. TeraTerm

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Installing the USB Drivers

Necessary software



- Select Browse my computer for driver software
- Select:
 - C:\Program Files (x86)\GHI Electronics\GHI NETMF v4.1 SDK\USB Drivers

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Your first program

- Open Visual C#



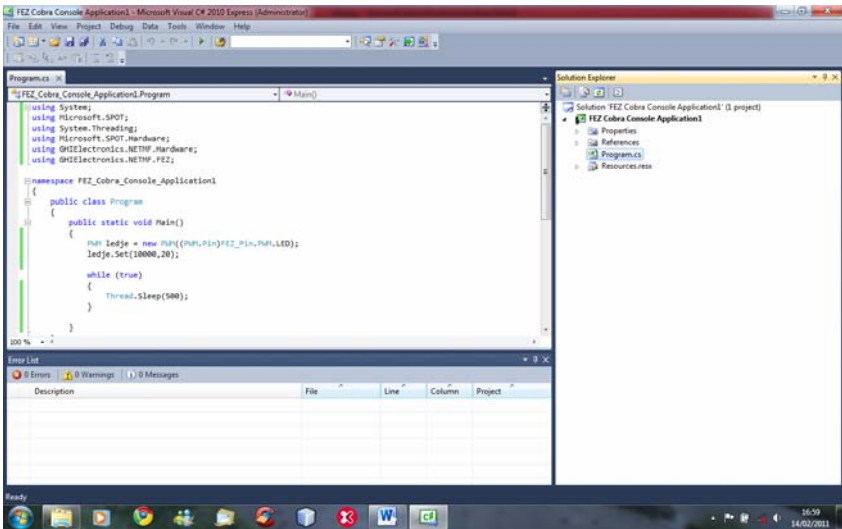
31

- Choose new FEZ Cobra console app.

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Your first program

- Open program.cs



```

using System;
using Microsoft.SPOT;
using System.Threading;
using Microsoft.SPOT.Hardware;
using GHIElectronics.NETMF.Hardware;
using GHIElectronics.NETMF.FEZ;

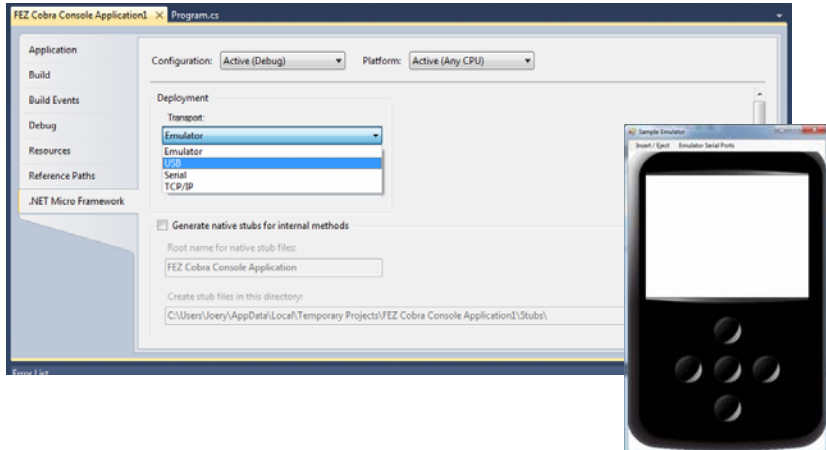
namespace FEZ_Cobra_Console_Application1
{
    public class Program
    {
        public static void Main()
        {
            Pin ledje = new Pin((MPLPIN)FEZ_PIN_PWM_LED);
            ledje.Set(10000,20);
            while (true)
            {
                Thread.Sleep(500);
            }
        }
    }
}
    
```

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Your first program

- Deployment method

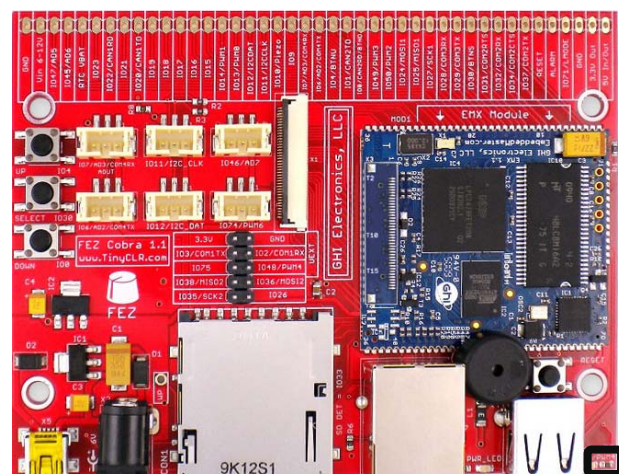


33

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Your first program

- Default program
- Led blinks (250Ms interval)



34

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Your first program

To declare output:
`OutputPort led = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.LED, ledState);`

To declare input:
`InputPort Button = new InputPort((Cpu.Pin)FEZ_Pin.Digital.ButtonUp, false, Port.ResistorMode.PullUp);`

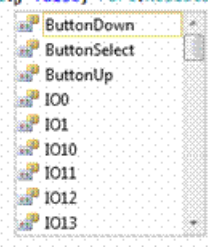
“GHIElectronics.NETMF.FEZ” library.

```

OutputPort led = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.LED, ledState);
InputPort Button = new InputPort((Cpu.Pin)FEZ_Pin.Digital., false, Port.ResistorMode.PullUp);

while (true)
{
    while (Button.Read() == false)
    {
        // Sleep for 500 milliseconds
        Thread.Sleep(500);

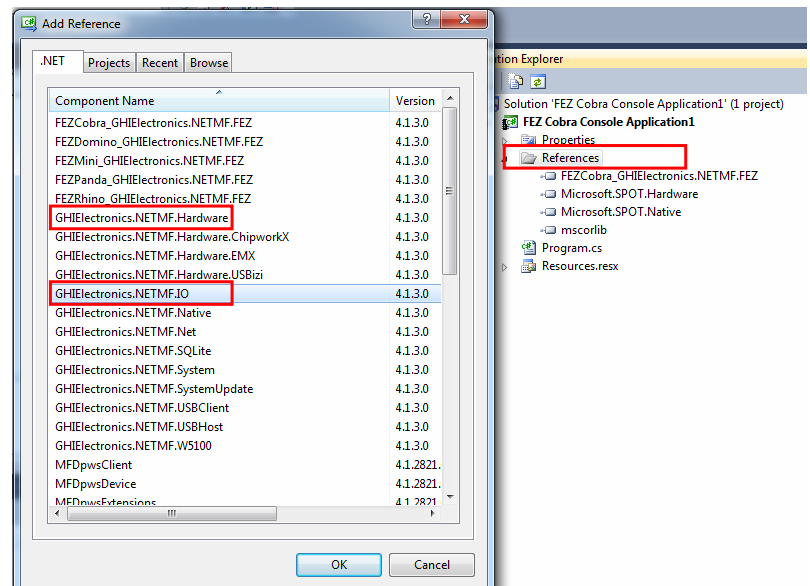
        // toggle LED state
        ledState = !ledState;
        led.Write(ledState);
    }
}
    
```



35

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Your first program



36

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Example Blink Board

```

1  using System;
2  using System.Threading;
3  using Microsoft.SPOT;
4  using Microsoft.SPOT.Hardware;
5  using GHIElectronics.NETMF.FEZ;
6  namespace FEZ_Cobra_Console_Application1
7  {
8      public class Program
9      {
10         public static void Main()
11         {
12             // Blink board LED
13             bool ledState = false;
14             OutputPort led = new OutputPort((Cpu.Pin)FEZ_Pin.Digital.LED, ledState);
15             while (true)
16             {
17                 // Sleep for 250 milliseconds
18                 Thread.Sleep(250);
19                 // toggle LED state
20                 ledState = !ledState;
21                 led.Write(ledState);
22             }
23         }
24     }
25 }
                
```

Solution Explorer showing project references for 'FEZ Cobra Console knipperlicht'. The reference 'FEZCobra_GHIElectronics.NETMF.FEZ' is highlighted with a red box.

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Example Pulse Whith Modulation

```

1  using System;
2  using System.Threading;
3  using Microsoft.SPOT;
4  using Microsoft.SPOT.Hardware;
5  using GHIElectronics.NETMF.Hardware;
6  using GHIElectronics.NETMF.FEZ;
7  namespace FEZ_Cobra_Console_Application1
8  {
9      public class Program
10     {
11         public static void Main()
12         {
13             PWM ledje = new PWM((PWM.Pin)FEZ_Pin.PWM.LED);
14             while (true)
15             {
16                 ledje.Set(10000, 0);
17                 Thread.Sleep(1000);
18                 ledje.Set(10000, 10);
19                 Thread.Sleep(1000);
20                 ledje.Set(10000, 50);
21                 Thread.Sleep(1000);
22                 ledje.Set(10000, 100);
23                 Thread.Sleep(1000);
24             }
25         }
26     }
27 }
                
```

Adjust the brightness of the LED

← 10KHz, 50%

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Servo Motor Example

1. Expect a pulse every 20 ms to 30 ms
2. The method `PWM.SetPulse` needs the high time between 1.25 ms to 1.75 ms

1.50 ms: Neutral

1.25 ms: 0 degrees

1.75 ms: 180 degrees

- Use inside the processor a special **PWM hardware**.
- The processor set some registers.
- After initialisation there is no processor interaction.
- Use an `OutputCompare` class.

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Servo Motor Example

The method `SetPulse` accepts value in nanoseconds

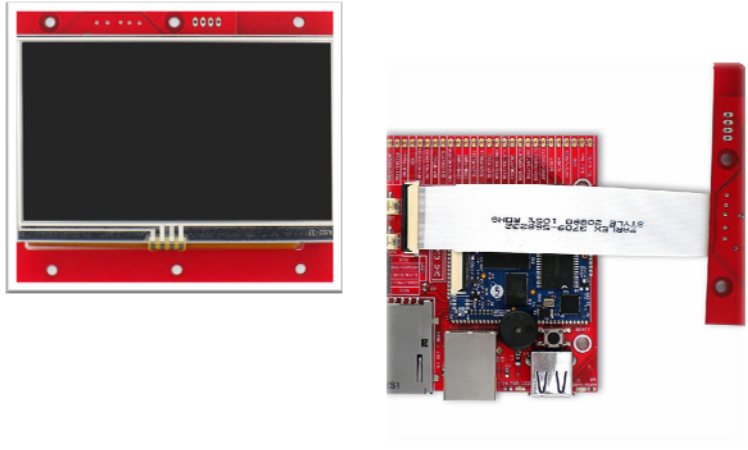
```

1 public static void Main()
2 {
3     PWM servo = new PWM((PWM.Pin)FEZ_Pin.PWM.Di5);
4     while (true)
5     {
6         // 0 degrees. 20ms period and 1.25ms high pulse
7         servo.SetPulse(20 * 1000 * 1000, 1250 * 1000);
8         Thread.Sleep(1000); //wait for a second
9
10        // 90 degrees. 20ms period and 1.50ms high pulse
11        servo.SetPulse(20 * 1000 * 1000, 1500 * 1000);
12        Thread.Sleep(1000); //wait for a second
13
14        // 180 degrees. 20ms period and 1.75ms high pulse
15        servo.SetPulse(20 * 1000 * 1000, 1750 * 1000);
16        Thread.Sleep(1000); //wait for a second
17    }
18    Thread.Sleep(-1);
19 }
    
```

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 Possible extensions

- **4.3" TFT Display – 149.9\$**



41

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 Possible extensions

- **FEZ Cobra Enclosure – 24.95\$**




42

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 Possible extensions


- **MP3 Decoder Extension – 40.95\$**



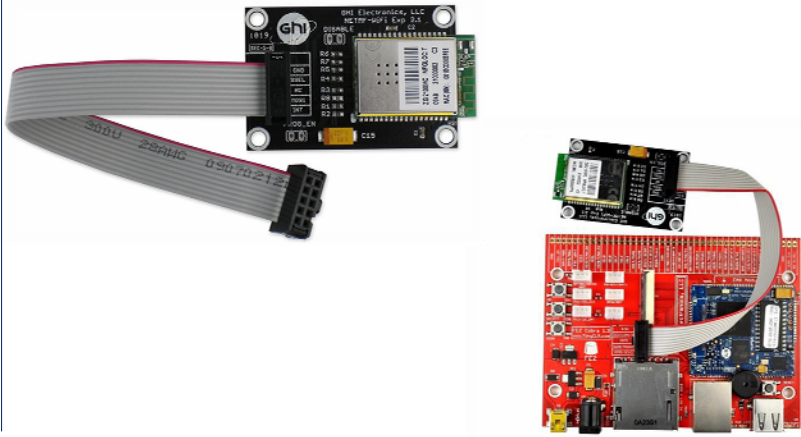
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This slide shows a small, red MP3 decoder extension board. The board is compact and features a black plastic case on top. A silver coin is placed next to it for scale. The board has various components, including a microcontroller, capacitors, and connectors. The text 'Possible extensions' is written in blue at the top left, and the price 'MP3 Decoder Extension – 40.95\$' is listed below it. The slide number '43' is in the bottom left corner, and 'AmiEs Chania 2011' is at the bottom center.

 Possible extensions



- **WiFi Extension – 91.45\$**



44

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This slide shows a WiFi extension board. The board is black with a ribbon cable attached. It is shown next to a red PCB, which is the main board it connects to. The text 'Possible extensions' is written in blue at the top left, and the price 'WiFi Extension – 91.45\$' is listed below it. The slide number '44' is in the bottom left corner, and 'AmiEs Chania 2011' is at the bottom center.






Possible extensions

- There are a lot more extensions possible for the FEZ Cobra board.
- These can be found [here](#)

<http://www.ghielectronics.com/catalog/>

45

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Conclusion

- .NET Micro Framework is easy to use to develop **embedded systems**
- The hardware is small
- Many library's are included
- C# is not hard to understand
- C# Looks a lot like java
- The Dev.boards supports many different extensions

46


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 Questions




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 Questions


- What is FEZ?
- Where do I get more help?
- I want to try before I buy. Can I use an emulator?
- What device should I select? Is USBizi powerful enough?
- How does FEZ work? Is it fast?
- Is FEZ Real-time?
- Is FEZ open source?
- Who makes these products? How do they relate to Arduino?
- I want to design my own board. What should I do?
- Can I build a commercial product with FEZ?
- How can I lower the cost?
- What if I need more memory?
- TinyCLR, NETMF, USBizi, FEZ... How do they relate?
- What are components, shields and extensions?
- What do you have for academic institutions and instructors/professors?
- How much RAM and flash memory do I have for my application?
- What assemblies (libraries) do I need to add to my project?
- NETMF is open source so why do I need FEZ or any other GHI product?
- What features GHI adds on top of NETMF and what is included from NETMF?

<http://www.tinyclr.com/faq/#7>

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 **Is FEZ Real-time?**

- Answer
 - FEZ runs NETMF -> not RTOS
 - you can stop all threads and only hold on the critical event
- Example TV remote control (IR signal)
 - InterruptPort Class
 - Small assembly -> FEZ will only command the secondary chip
- UART, SPI, I2C, One Wire, Can



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