FTF | FREESCALE TECHNOLOGY FORUM
POWERING INNOVATION

USB Debugging and Development

FTF-ENT-F0085

Tabitha Miller (Total Phase)
Rudan Bettelheim (Freescale)

Updated May 2012

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Abstract

Your new MCU project now includes USB to connect to several devices and peripherals, and it looks a lot more complex than the SPI and UARTs you are used to. Come to this session to learn how to implement, analyze and debug USB systems on Freescale MCUs using the Beagle Protocol Analyzer.

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Agenda

- Introduction to the Freescale MCUs, Kinetis, and Tower System
- Introduction to Total Phase Development Tools
- Review of I2C, SPI, and USB Protocols
- Lab
  - Lab Introduction
  - Programming the EEPROM
  - Bug 1: Enumeration of the CDC Device
  - Bug 2: SPI Programming
  - Feature: I2C LEDs
- Q&A

TOTALPHASE

Facebook.com/Freescale
Tag yourself in photos
and upload your own!

Tweeting?
Please use hashtag
#FTF2012

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Look for announcements in the FTF Group on LinkedIn or follow Freescale on Twitter

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Freescale MCUs, Kinetis, and the Tower System

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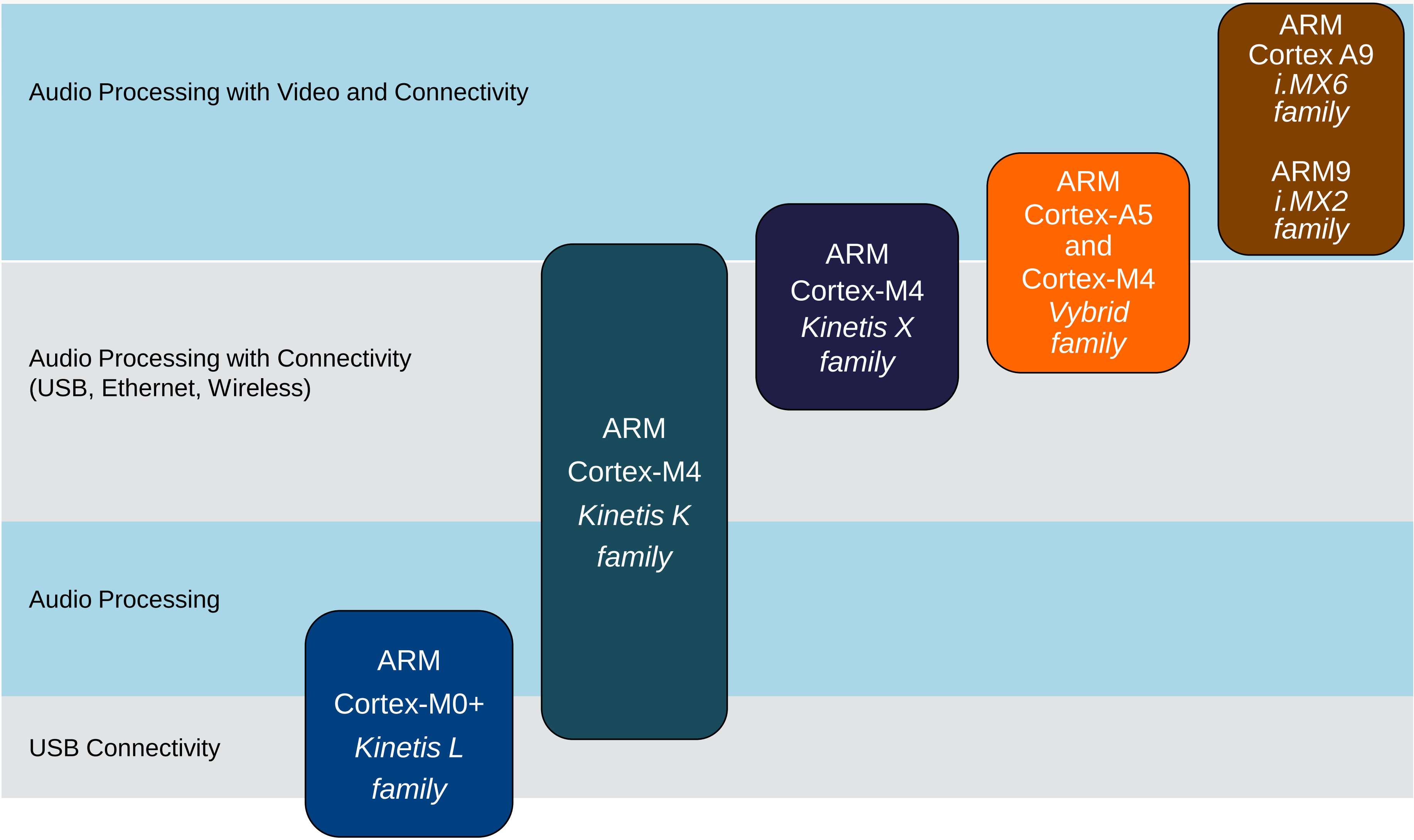
Accessories and Digital Audio



Audio Processing with Video and Connectivity

Audio Processing with Connectivity
(USB, Ethernet, Wireless)

Audio Processing

USB Connectivity

ARM
Cortex-M0+
Kinetis L
family

ARM
Cortex-M4
Kinetis K
family

ARM
Cortex-M4
Kinetis X
family

ARM
Cortex-A5
and
Cortex-M4
Vybrid
family

ARM
Cortex A9
i.MX6
family

ARM9
i.MX2
family

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Kinetis: Freescale Enablement Bundle

Freescale Tower System

Kinetis MCU modules from $69

- Modular, expandable, open-source h/ware development platform for 8/16/32-bit MCUs/MPUs
- Rapid evaluation and prototyping with maximum h/ware reuse
- Supported by a growing range of peripheral plug-in boards (WiFi, Sensing, Graphics LCD, Audio,...)
- www.freescale.com/tower

Open source, reusable hardware platform

Freescale CodeWarrior IDE

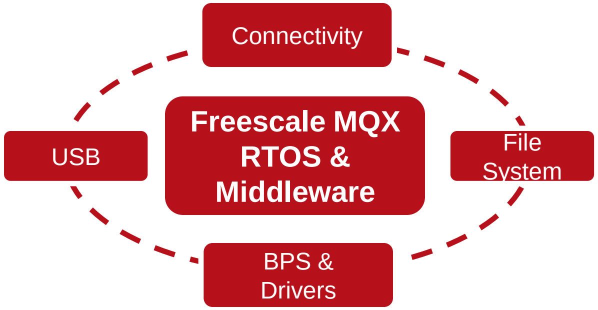
Free of charge up to 128KB

- Eclipse environment
- Includes **Processor Expert code generation wizard**
- Creates MQX-aware drivers
- Build, debug and flash tools
- Software analysis
- Kernel-aware debug
- Special Edition $0 up to 128KB
- www.freescale.com/codewarrior

Powerful IDE with code generation wizard for $0!

Freescale MQX RTOS

Free of charge ($95K est. value)



Freescale MQX RTOS & Middleware

Connectivity

USB

File System

BPS & Drivers

- Full-featured, scalable, proven RTOS with TCP/IP, USB, Graphics, Security and File Systems plug-ins
- Makes application code more stable, more maintainable and easier to upgrade – reduces time-to-market!
- Compatible with CodeWarrior, IAR, Keil & Green Hills IDEs
- www.freescale.com/mqx

Bundled RTOS for $0!

One Stop Shop for Silicon, IDE & RTOS

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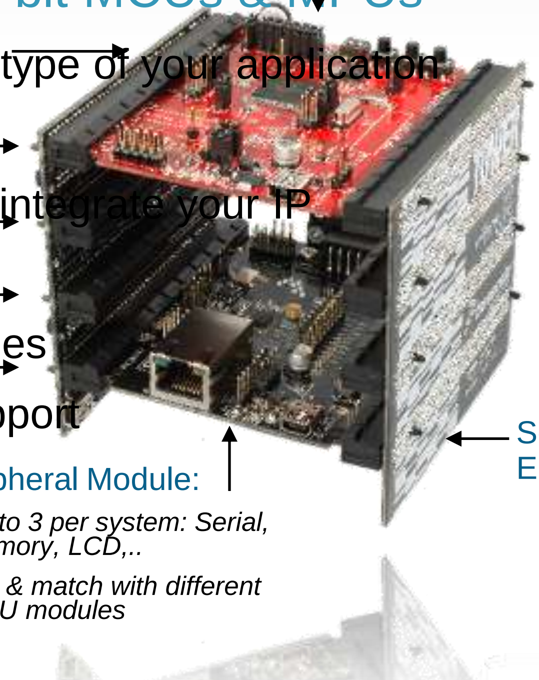
The Freescale Tower System

A modular development platform for 8/16/32-bit MCUs & MPUs

- Quickly combine Tower Modules to build a prototype of your application
- Modules sold individually or in kits
- Open Source: Build your own Tower Module to integrate your IP
- Cost-optimized hardware
- Software support from Freescale and Third Parties
- Growing community of Third Party hardware support
- On-line community: www.towergeeks.org



MCU/MPU Module:

- *Tower controller board*
- *Standalone or in Tower System*

Peripheral Module:

- *Up to 3 per system: Serial, Memory, LCD,..*
- *Mix & match with different MCU modules*

Rapidly build a prototype of your end application

Support for all ColdFire+ and Kinetis MCUs!

TWR-MEM

TWR-LCD

TWR-SENSOR-PAK

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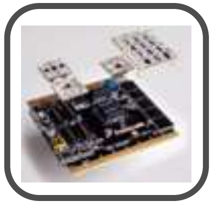
netis Tower System: Reusable, modular development platform

www.freescale.com/tower   www.towergeeks/org

MCU Families Supported	TWR Part Number	Contents	Price (SRP)
K30/40	TWR-K40X256	TWR-K40X256 (144MGA), TWRPI-SLCD	$69
	TWR-K40X256-KIT	TWR-K40X256 (144MBGA), TWRPI-SLCD TWR-SER, TWR-ELEV	$139
K50	TWR-K53N512	TWR-K53N512 (144MBGA), TWRPI-SLCD	$109
	TWR-K53N512-KIT	TWR-K53N512 (144MBGA), TWRPI-SLCD, TWR-SER, TWR-ELEV	$179
K10/20/60	TWR-K60N512	TWR-K60N512 (144MBGA)	$69
	TWR-K60N512-KIT	TWR-K60N512 (144MBGA), TWR-SER, TWR-ELEV	$139
	TWR-K60N512-IAR IAR SYSTEMS	TWR-K60N512-KIT (144MBGA), TWR-PROTO, Segger J-Link Lite Debug Probe, IAR EWARM IDE (eval. version)	$239
	TWR-K60N512-KEIL KEIL Tools by ARM	TWR-K60N512-KIT (144MBGA), UNLINK-ME Debug Probe, KEIL MDK IDE (eval. version)	$199

- IDEs: FSL CodeWarrior, IAR Embedded Workbench, Keil MDK, ...
- Freescale MQX RTOS
- OSJTAG Debug circuitry – program & debug with USB cable
- Low power touch sensing & plug-in socket for expansion: Sensors, Radio, etc…
- Fully compatible with all Tower peripheral modules



TWR-SENSOR-PAK

TWR-LCD

TWR-WIFI-RS2101

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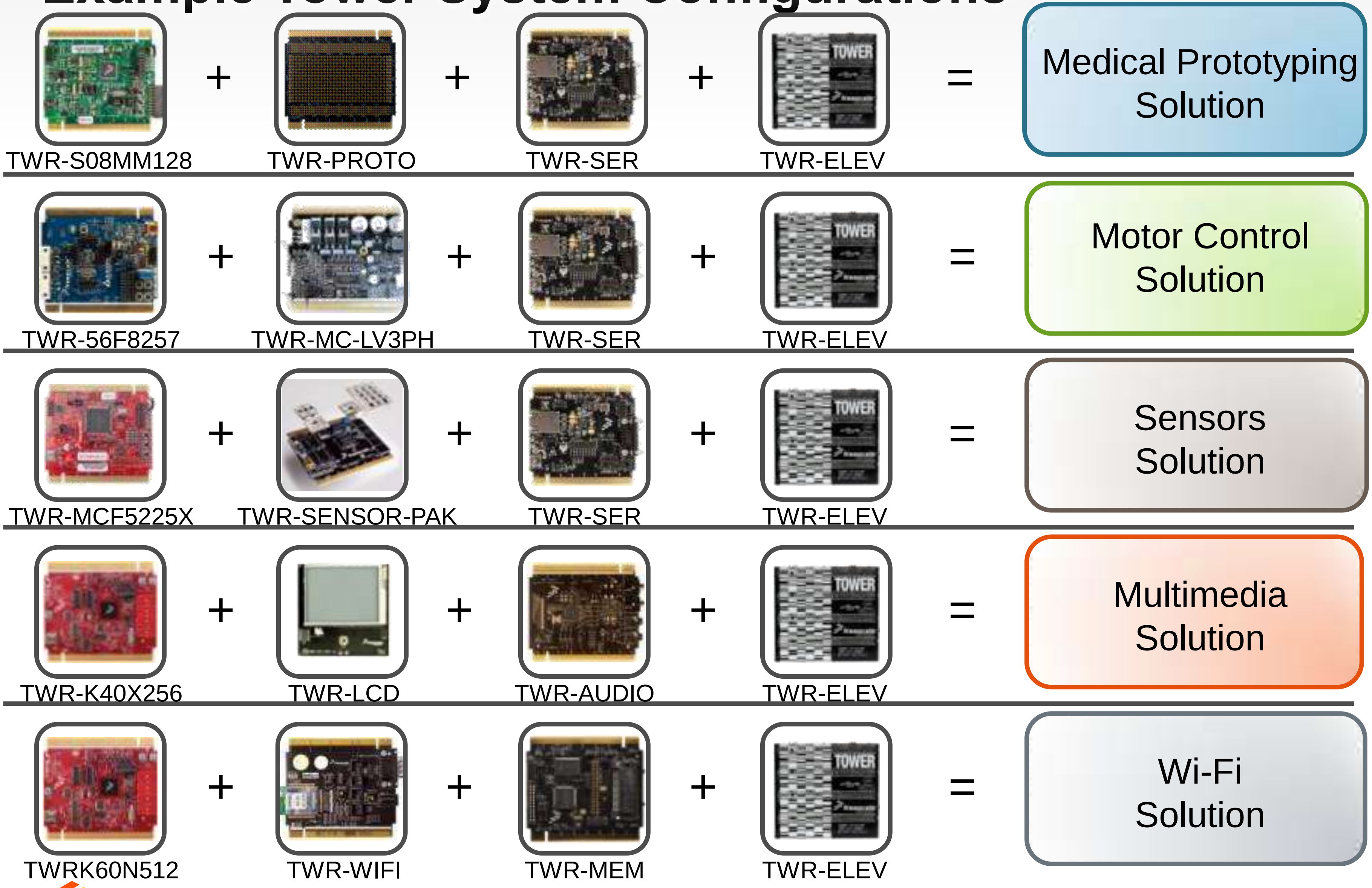
Example Tower System Configurations



TWR-S08MM128 + TWR-PROTO + TWR-SER + TWR-ELEV = Medical Prototyping Solution

TWR-56F8257 + TWR-MC-LV3PH + TWR-SER + TWR-ELEV = Motor Control Solution

TWR-MCF5225X + TWR-SENSOR-PAK + TWR-SER + TWR-ELEV = Sensors Solution

TWR-K40X256 + TWR-LCD + TWR-AUDIO + TWR-ELEV = Multimedia Solution

TWRK60N512 + TWR-WIFI + TWR-MEM + TWR-ELEV = Wi-Fi Solution

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Available Tower System Modules www.freescale.com/tower

Processor Modules
($39-$119)

8bit

TWR-S08LL64
TWR-S08LH64
TWR-S08JE128
TWR-S08MM128
TWR-S08GW64
TWR-S08UNIV

16bit

TWR-S12GN32
TWR-S12G128

DSC

TWR-56F8257

32bit - ColdFire

TWR-MCF51JE
TWR-MCF51CN
TWR-MCF51MM
TWR-MCF51QM
TWR-MCF5225X
TWR-MCF5441X

32bit – Power Arch

TWR-MPC5125

32bit Kinetis

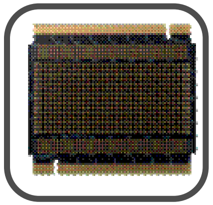
TWR-K60N512
TWR-K40X256
TWR-K60N512-IAR
TWR-K60N512-KEIL
TWR-K53N512
KWIKSTIK-K40

Peripheral Modules
($15 – $149)

Serial

TWR-SER
TWR-SER2

Prototyping



TWR-PROTO

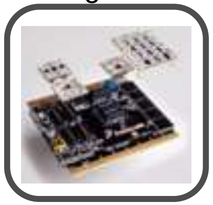
Wi-Fi

TWR-WIFI-RS2101
TWR-WIFI-G1011MI
TWR-WIFI-AR4100

Memory

TWR-MEM

Sensors & Plug-Ins



TWR-SENSOR-PAK
TWR-SENSOR-PAK-AUTO
TWRPI-MMA6900
TWRPI-MPL115A

Displays

TWR-LCD

Medical

MED-EKG

Analog

TWR-ADCDAC-LTC

Audio

TWR-AUDIO-SGTL

Mesh Networking

TWR-RF-SNAP

MFi

TWR-DOCK

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Kinetis Tower System

- TWR-K60N512 Module
  - Features include:
    - 3-axis acceloremeter
    - Capacitive touch pads
    - Tower connectivity to USB, CAN, SPI, and I2C
    - Part of the Freescale Tower system

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ontroller Module: TWR-K60D100M

K60 100MHz Tower Board

TWR-K60D100M

MSRP: $69
Launch: Jan 2012
Status: In Design

Hardware:

- K60DN512VMD10 MCU
- New Low Power Modes Enabled
- OSJTAG
- SD Card Socket
- Potentiometer
- Accelerometer
- Touch Sense Buttons
- Infrared
- TWRPI Socket

Software:

- MQX RTOS
- Code Warrior IDE
- IAR IDE

Related Modules:

- TWR-SER

Controller

Peripheral

Plug-In

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Controller Module: TWR-K40D100M

K40 100MHz Tower Board

Controller

Peripheral

Plug-In

TWR-K40D100M

MSRP: $69
Launch: Feb 2012
Status: In Design

Hardware:

- K40DX256VMD10 MCU
- New Low Power Modes Enabled.
- OSJTAG
- SD Card Socket
- Potentiometer
- Accelerometer
- Touch Sense Buttons
- Infrared
- TWRPI Socket

Software:

- MQX RTOS
- Code Warrior IDE
- IAR IDE

Related Modules:

- TWR-SER
- TWRPI-SLCD

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Tower Plug In: TWRPI-MMA845XQ

3-axis accelerometer

TWRPI-MMA845XQ

MSRP: $25
Launched: Sept 14, 2011

Hardware:

- MMA8451Q I2C 3-axis accelerometer
- Smart low-power, three-axis, capacitive micromachined accelerometer with 14 bits of resolution
- Programmable interrupts
- Freefall/Motion, Pulse, & Jolt Detection
- Compatible with the Freescale Tower System modules that utilize swappable (Tower) plug-ins (TWRPIs), including:
  - QWIKSTIK
  - TWR-SENSOR-PAK
  - TWR-K60N512
  - TWR-K40X256

Partner:

- If applicable, enter Partner name and website

Controller

Peripheral

Plug-In

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Freescale's MFi Solution

Freescale's MFi solutions are based on the TWR-DOCK peripheral module

- TWR-DOCK supports development and rapid prototyping of electronic accessories for iPod, iPhone and iPad devices.
  - Access to the 30-pin connection
  - Analog audio and video signals with standard RCA and S-Video connectors
  - Digital audio streaming in both directions over USB
  - Control and communication with various devices
- TWR-DOCK concentrates all MFi controlled items on one Tower module, without including any processors or other Freescale products
- TWR-DOCK may be used with a wide range of Tower System MCU/MPU, peripheral, sensor and communication modules
- Kinetis-based demos are available

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Total Phase Development Tools

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Total Phase Solutions

- By using debugging tools manufactured by Total Phase you can:
  - Debug in real time
  - Quickly evaluate embedded systems
  - Program EEPROMs and flash memories
  - Easily collaborate with colleagues
  - Maximize productivity

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Aardvark I2C/SPI Host Adapter

- General purpose I2C/SPI master or slave
  - Active communication on the SPI bus up to 8 MHz as an SPI master, 4 MHz as an SPI slave
  - Active communication on the I2C bus up to 800 kHz

Aardvark I2C/SPI Host Adapter

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Flash Center Software

- Designed to work with the host adapter line
  - Quickly program I2C or SPI EEPROMs or flash memories
  - In-system and stand-alone programming
  - Built-in XML part library
  - Gang programming support
  - Windows, Linux, Mac OS X

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Control Center Software

- Designed to work with the Aardvark I2C/SPI Host Adapter
  - Read and write I2C/SPI messages
  - XML Batch Script support
  - Built-in Help System
  - Multiple adapter support
  - Windows, Linux, Mac OS X

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Beagle I2C/SPI Protocol Analyzer

- Non-intrusively monitor an I2C or SPI bus
  - Interactive real-time display, filter, and search
  - Monitors I2C data up to 4 MHz
  - Monitors SPI data up to 24 MHz

Beagle I2C/SPI
Protocol Analyzer

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Beagle USB 480 Protocol Analyzer

- Non-intrusively monitor high-, full-, low-speed USB 2.0
  - Interactive real-time display, filter, and search
  - Real-time class-level decoding
  - 64 MB on-board hardware buffer

Beagle I2C/SPI
Protocol Analyzer

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Data Center Software

- Designed to work with the Beagle Protocol Analyzers
  - LiveDisplay
  - LiveFilter
  - LiveSearch
  - 32-bit and 64-bit support
  - Tree View and Block view
  - Windows, Linux, Mac OS X

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Komodo CAN Duo Interface

- Two channel USB-to-CAN adapter and analyzer
  - Actively transmit CAN data up to 1 Mbps
  - Non-intrusive CAN bus monitoring
  - Interactive real-time display, filter, and search

Komodo CAN Duo Interface

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I2C Overview

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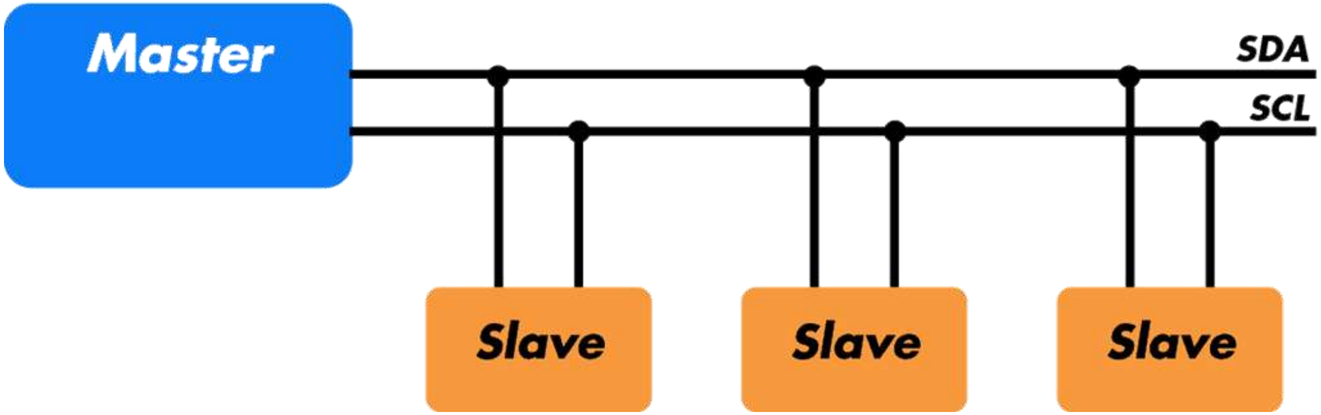
I2C Overview

- Inter-IC Bus
  - A low bandwidth, short distance protocol for on-board communications
  - All devices are connected through two wires:
    - Serial Data (SDA)
    - Serial Clock (SCL)
  - All devices on a bus must have a unique address



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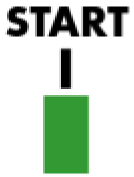
I2C Theory of Operation

- Master device issues start condition informing slave devices to listen on the serial data line for their address



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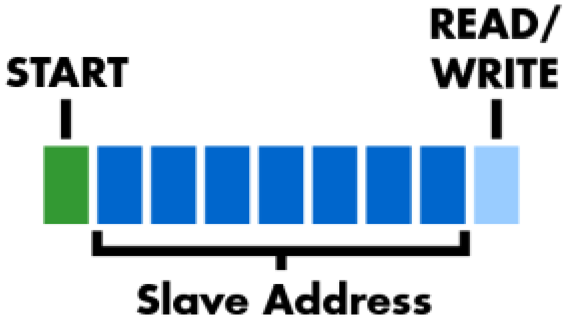
I2C Theory of Operation

- Master device issues start condition informing slave devices to listen on the serial data line for their address
- Master device sends address of target slave device and R/W flag



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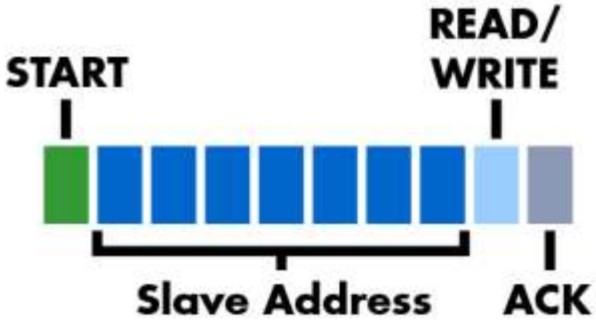
I2C Theory of Operation

- Master device issues start condition informing slave devices to listen on the serial data line for their address
- Master device sends address of target slave device and R/W flag
- Slave device with matching address responds with ACK



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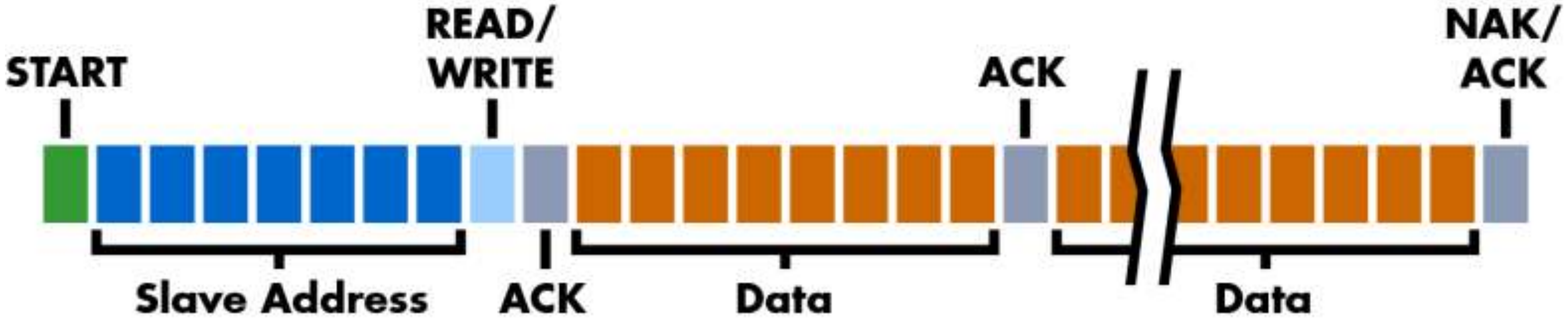
I2C Theory of Operation

- Master device issues start condition informing slave devices to listen on the serial data line for their address
- Master device sends address of target slave device and R/W flag
- Slave device with matching address responds with ACK
- Communication proceeds between master and slave
  - Either can receive of transmit: Transmitter sends 8 bits and receiver replies with a 1 bit ACK/NAK



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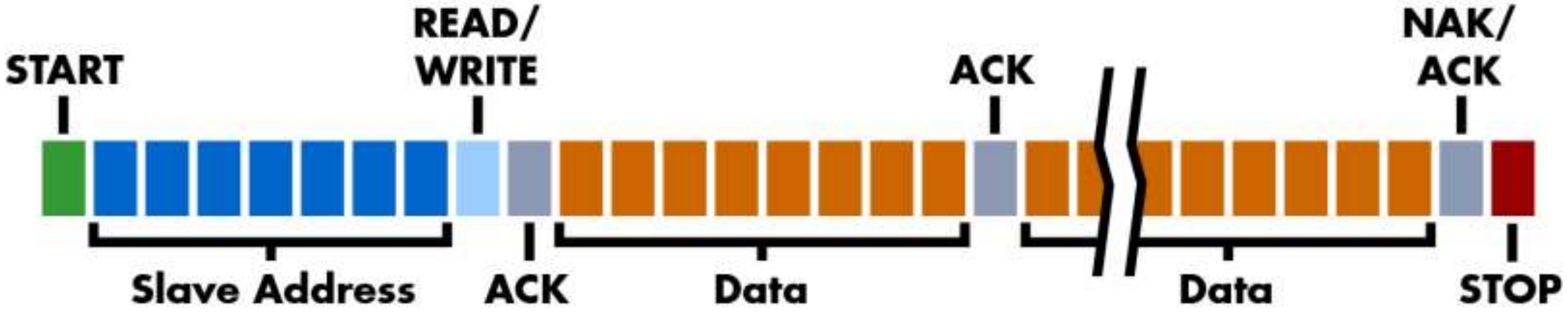
I2C Theory of Operation

- Master device issues start condition informing slave devices to listen on the serial data line for their address
- Master device sends address of target slave device and R/W flag
- Slave device with matching address responds with ACK
- Communication proceeds between master and slave
  - Either can receive of transmit: Transmitter sends 8 bits and receiver replies with a 1 bit ACK/NAK
- Master issues STOP condition to terminate



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SPI Overview

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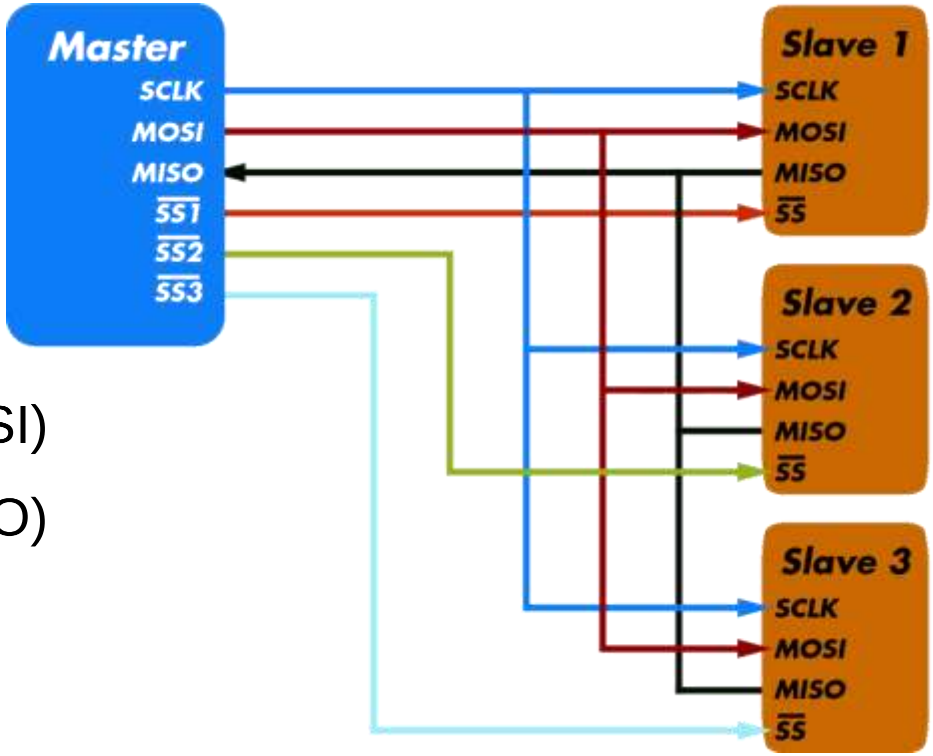
SPI Overview

- Serial Peripheral Interface bus
  - Full-duplex protocol
  - Ideally suited to data streaming applications



- Requires four signals:
  - Clock (SCLK)
  - Master out/Slave in (MOSI)
  - Master in/Slave out (MISO)
  - Slave select (SS)

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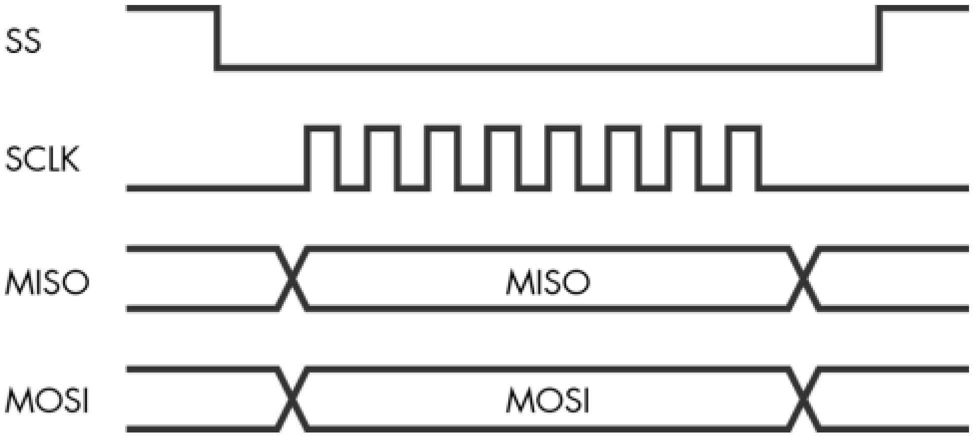
SPI Theory of Operation

- All devices share SCLK, MOSI, MISO lines
  - SCLK is generated by master device for synchronization
  - Data is always transferred in both directions (MOSI/MISO)
- Each device on the SPI bus has its own SS line
  - The master pulls low on a slave's SS line to select a device for communication
- Exchange has no pre-defined protocol



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USB Overview

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USB Overview

- Universal Serial Bus
  - A serial communications interface between devices
  - Standard interface for connecting peripheral devices to a host computer
  - Self-identifying devices and intelligent configuration

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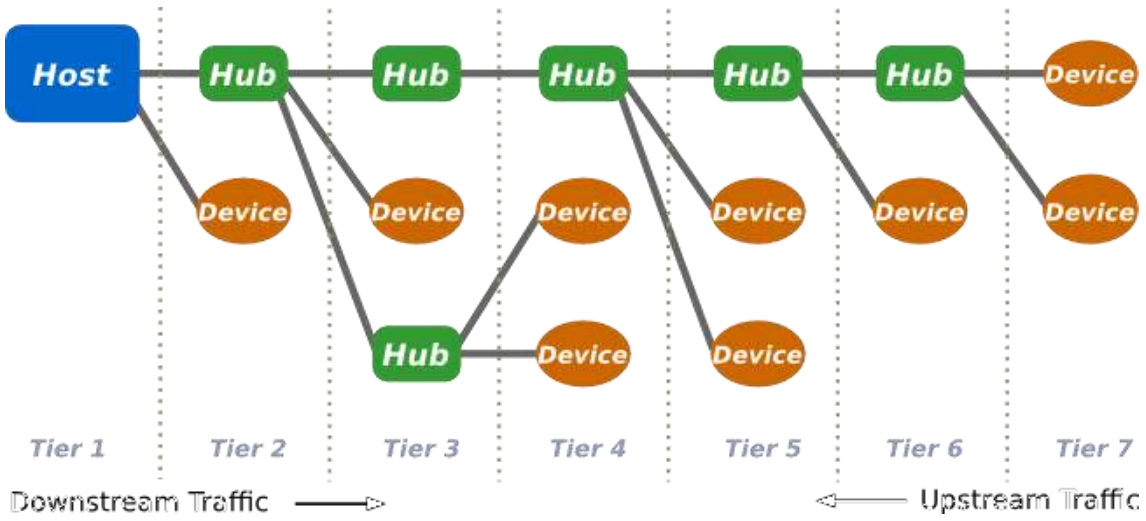
USB Architectural Overview

- Host-scheduled, token-based serial bus protocol
  - One Host
    - Usually a PC or embedded host
  - Up to 127 Devices
    - Respond to IN and OUT requests from the host



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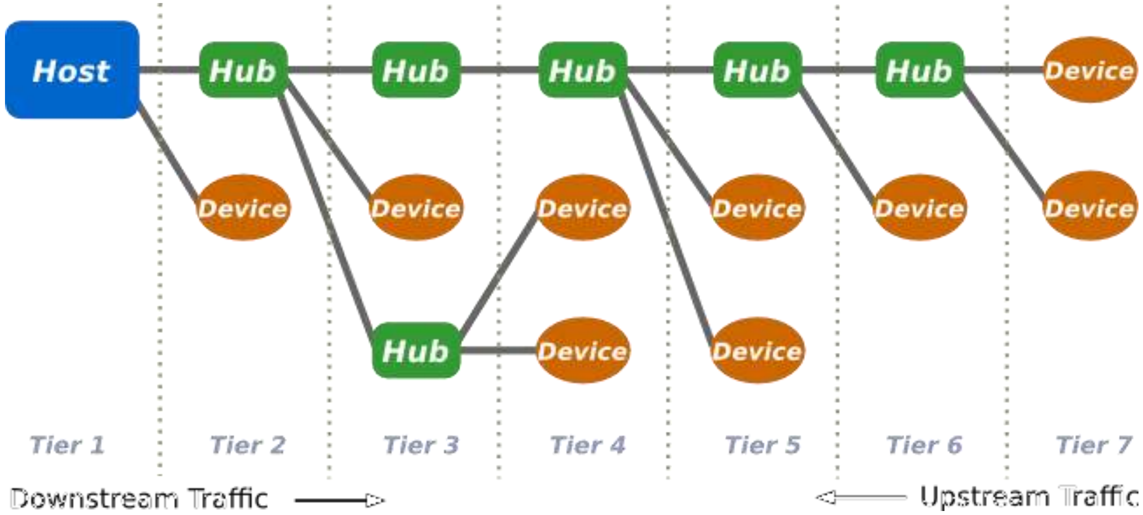
USB Architectural Overview

- Host-scheduled, token-based serial bus protocol
  - Zero or more hubs
    - Allows connection of multiple downstream devices to an upstream host or hub
  - Seven Tiers
    - Upper limit of 7 tiers, max number of hubs at 5 with the root host at tier 1



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USB Terminology

- Packet
  - The smallest element of data transmitted on the bus
- Endpoint and Pipe
  - **Endpoint** is the fundamental unit of communication in USB
  - **Pipes** represent a data pathway between the host and the device's endpoint

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USB Terminology

- Four types of USB transfers
  - **Control**: Non-periodic transfers
    - Typically used for configuration
  - **Interrupt**: Guaranteed to occur in a certain time interval
  - **Isochronous**: Periodic, continuous transfer
    - No error checking
    - Good for video, audio
  - **Bulk**: General transfer scheme for large amounts of data
    - Error checking

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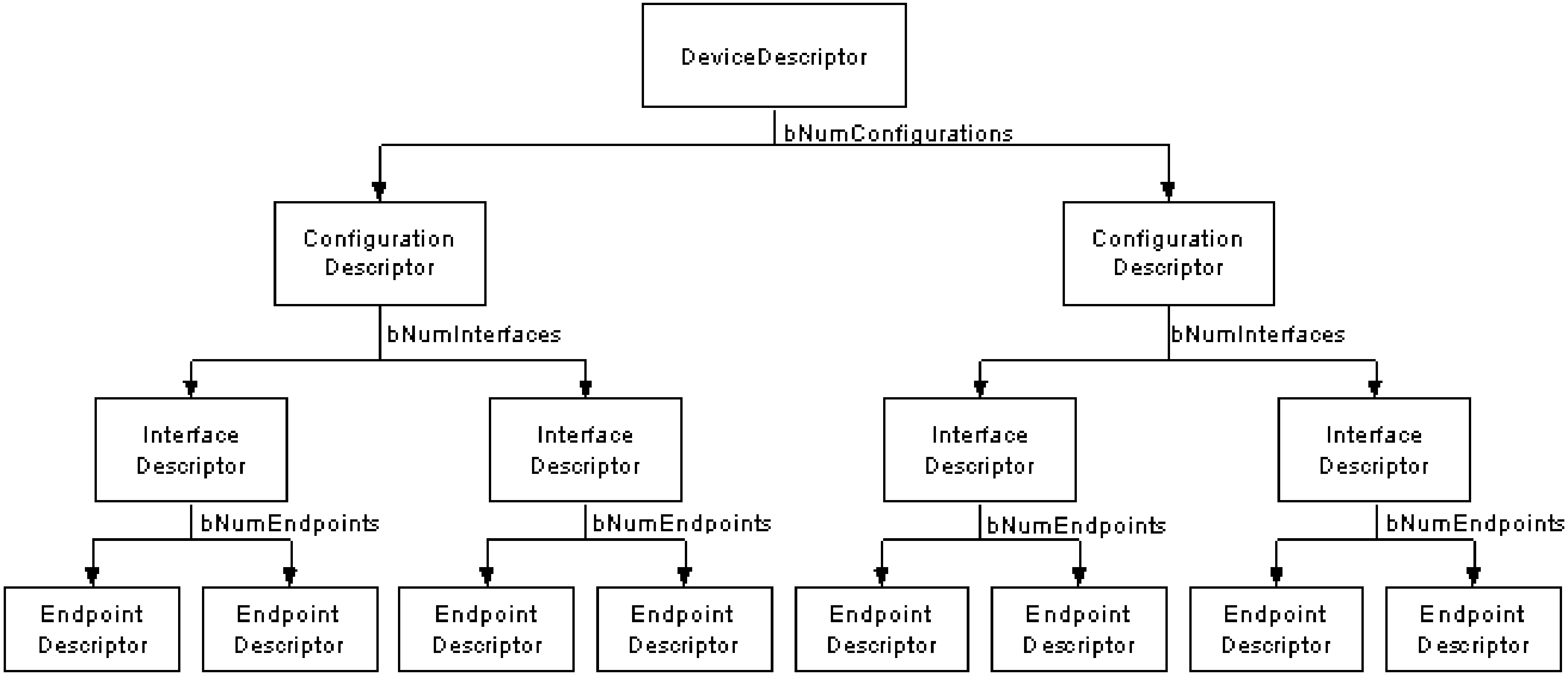
USB Terminology

- Descriptors



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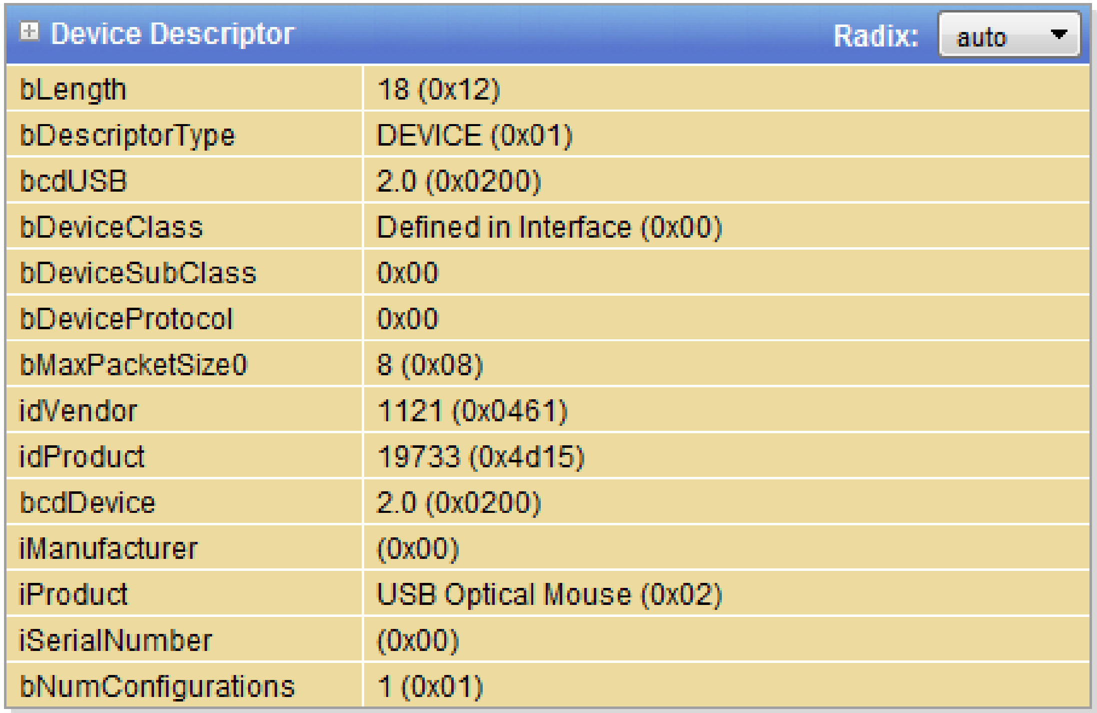
USB Terminology

- Descriptor
  - Lists device information and capabilities
  - Device



Device Descriptor

Radix: auto

bLength	18 (0x12)
bDescriptorType	DEVICE (0x01)
bcdUSB	2.0 (0x0200)
bDeviceClass	Defined in Interface (0x00)
bDeviceSubClass	0x00
bDeviceProtocol	0x00
bMaxPacketSize0	8 (0x08)
idVendor	1121 (0x0461)
idProduct	19733 (0x4d15)
bcdDevice	2.0 (0x0200)
iManufacturer	(0x00)
iProduct	USB Optical Mouse (0x02)
iSerialNumber	(0x00)
bNumConfigurations	1 (0x01)

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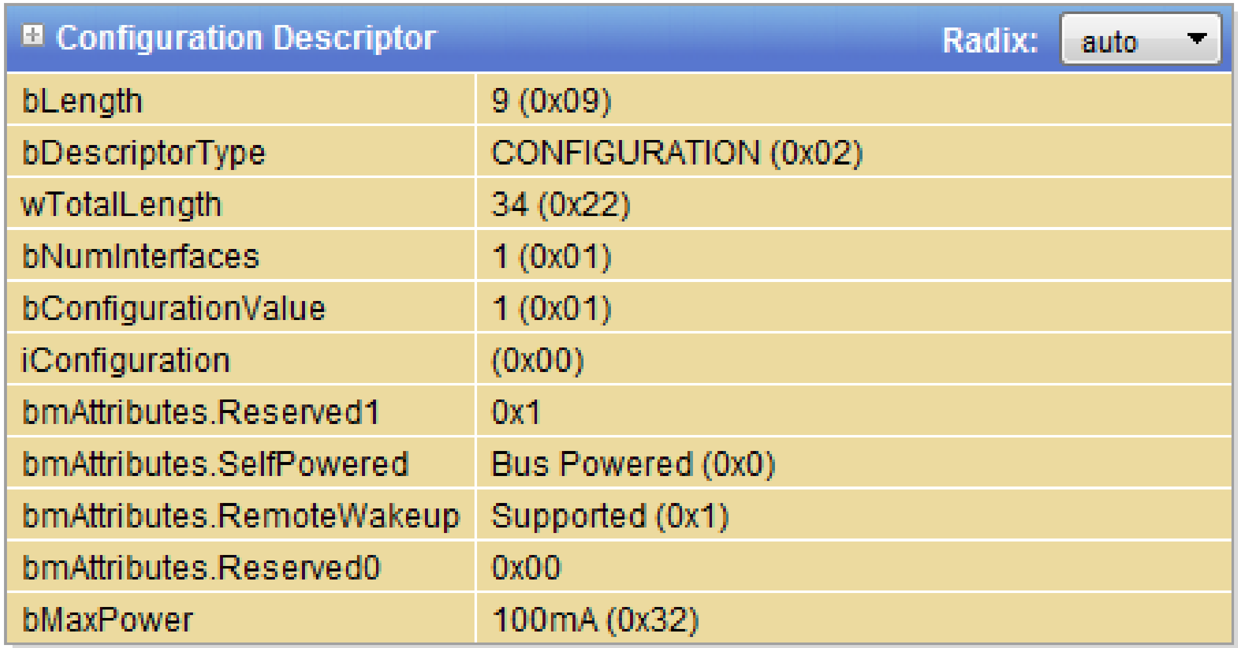
USB Terminology

- Descriptor
  - Lists device information and capabilities
  - Device, Configuration



bLength	9 (0x09)
bDescriptorType	CONFIGURATION (0x02)
wTotalLength	34 (0x22)
bNumInterfaces	1 (0x01)
bConfigurationValue	1 (0x01)
iConfiguration	(0x00)
bmAttributes.Reserved1	0x1
bmAttributes.SelfPowered	Bus Powered (0x0)
bmAttributes.RemoteWakeup	Supported (0x1)
bmAttributes.Reserved0	0x00
bMaxPower	100mA (0x32)

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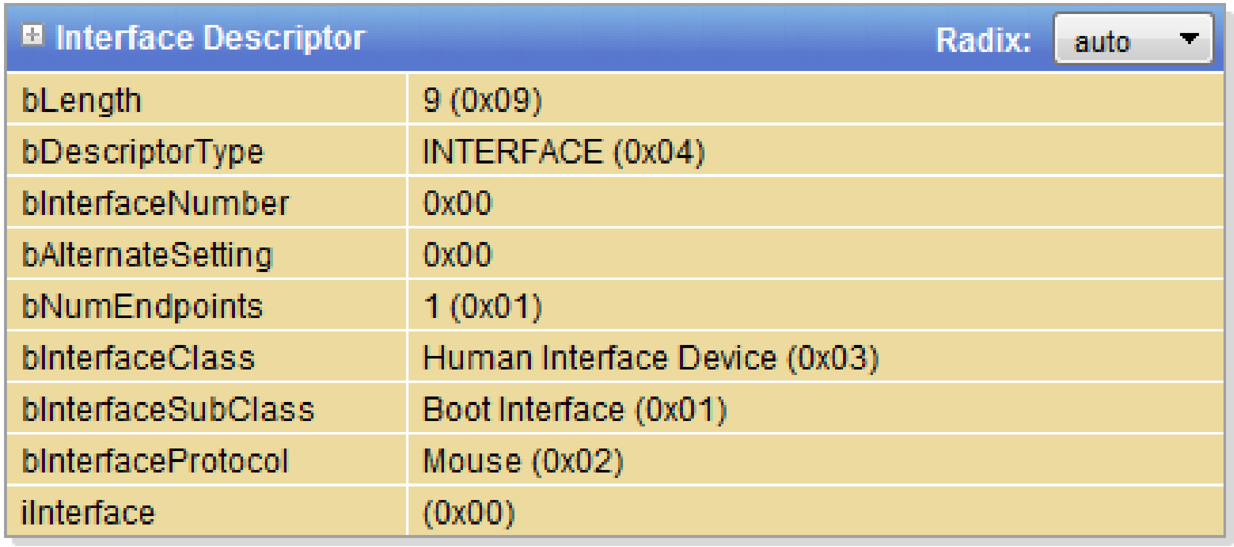
USB Terminology

- Descriptor
  - Lists device information and capabilities
  - Device, Configuration, Interface



⊞ Interface Descriptor

Radix: auto

bLength	9 (0x09)
bDescriptorType	INTERFACE (0x04)
bInterfaceNumber	0x00
bAlternateSetting	0x00
bNumEndpoints	1 (0x01)
bInterfaceClass	Human Interface Device (0x03)
bInterfaceSubClass	Boot Interface (0x01)
bInterfaceProtocol	Mouse (0x02)
iInterface	(0x00)

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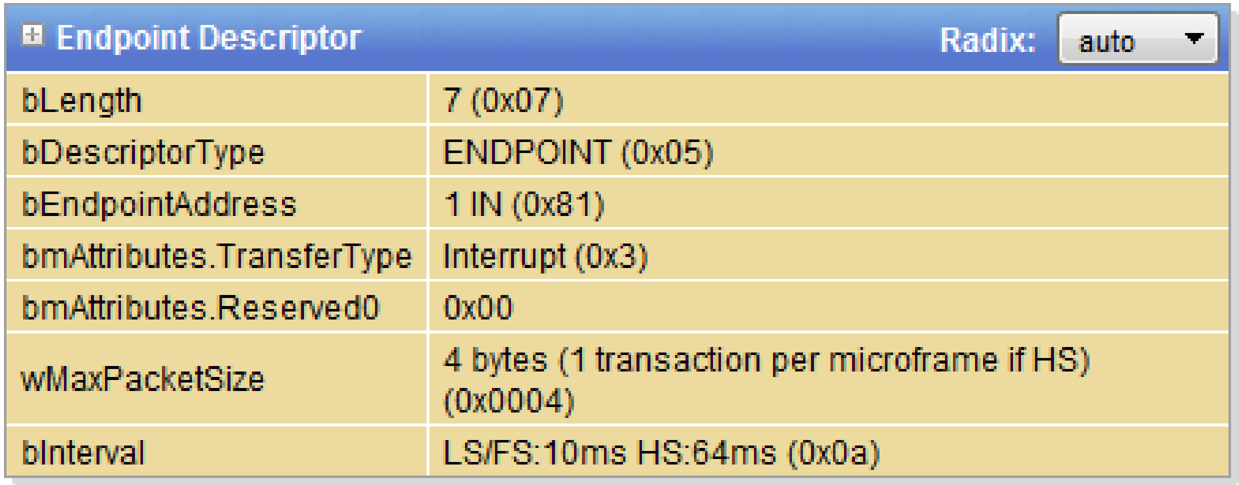
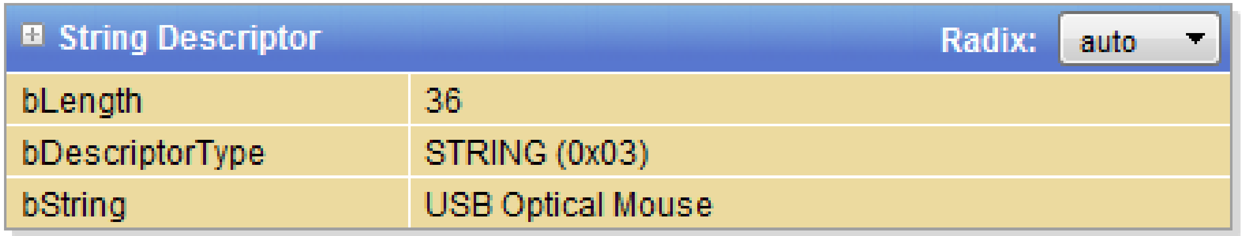
USB Terminology

- Descriptor
  - Lists device information and capabilities
  - Device, Configuration, Interface, Endpoint, and String



⊞ Endpoint Descriptor Radix: auto ▼

bLength	7 (0x07)
bDescriptorType	ENDPOINT (0x05)
bEndpointAddress	1 IN (0x81)
bmAttributes.TransferType	Interrupt (0x3)
bmAttributes.Reserved0	0x00
wMaxPacketSize	4 bytes (1 transaction per microframe if HS) (0x0004)
bInterval	LS/FS:10ms HS:64ms (0x0a)



⊞ String Descriptor Radix: auto ▼

bLength	36
bDescriptorType	STRING (0x03)
bString	USB Optical Mouse

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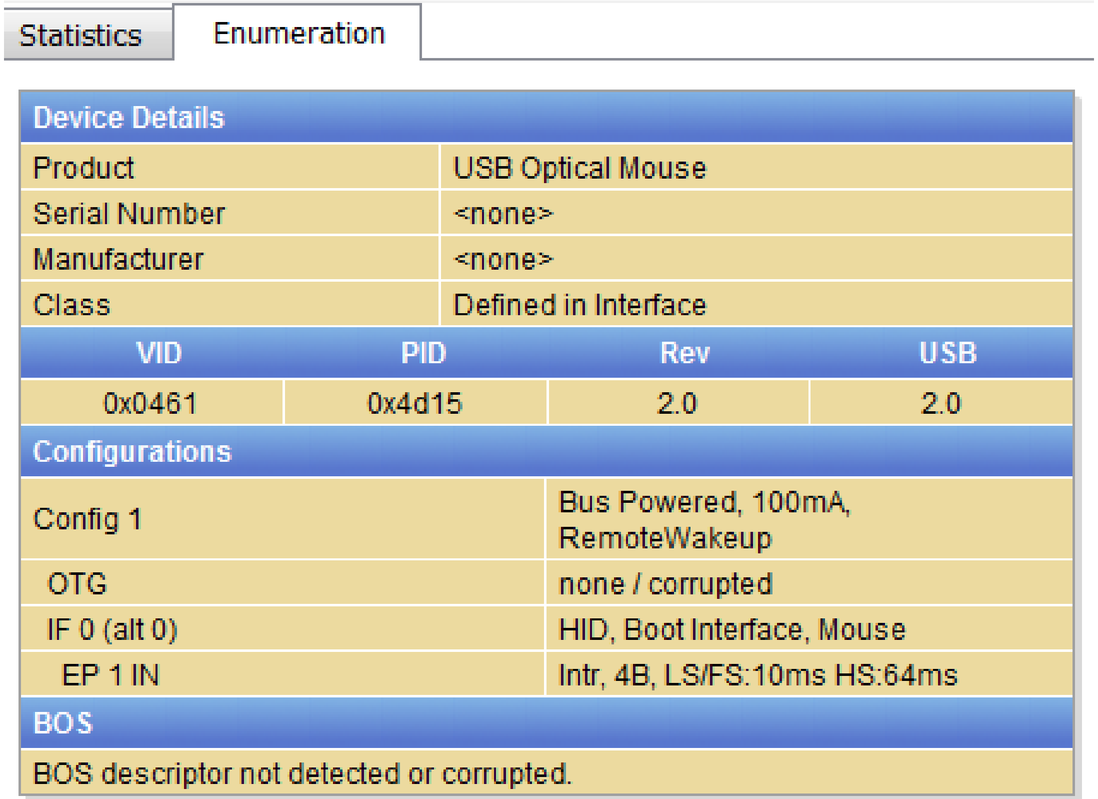
USB Terminology

- Enumeration
  - Process where the host detects the devices on the bus, assigns an address, and reads their descriptors



Device Details

Product	USB Optical Mouse
Serial Number	<none>
Manufacturer	<none>
Class	Defined in Interface

VID	PID	Rev	USB
0x0461	0x4d15	2.0	2.0

Configurations

Config 1	Bus Powered, 100mA, RemoteWakeup
OTG	none / corrupted
IF 0 (alt 0)	HID, Boot Interface, Mouse
EP 1 IN	Intr, 4B, LS/FS:10ms HS:64ms

BOS

BOS descriptor not detected or corrupted.

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USB Terminology

- Class
  - Pre-defined protocols to simplify drivers from common types of devices
  - Popular USB classes

Class	Usage	Description
01h	Interface	Audio
02h	Device & Interface	Communications and CDC Control
08h	Interface	Mass Storage
09h	Device	USB hub

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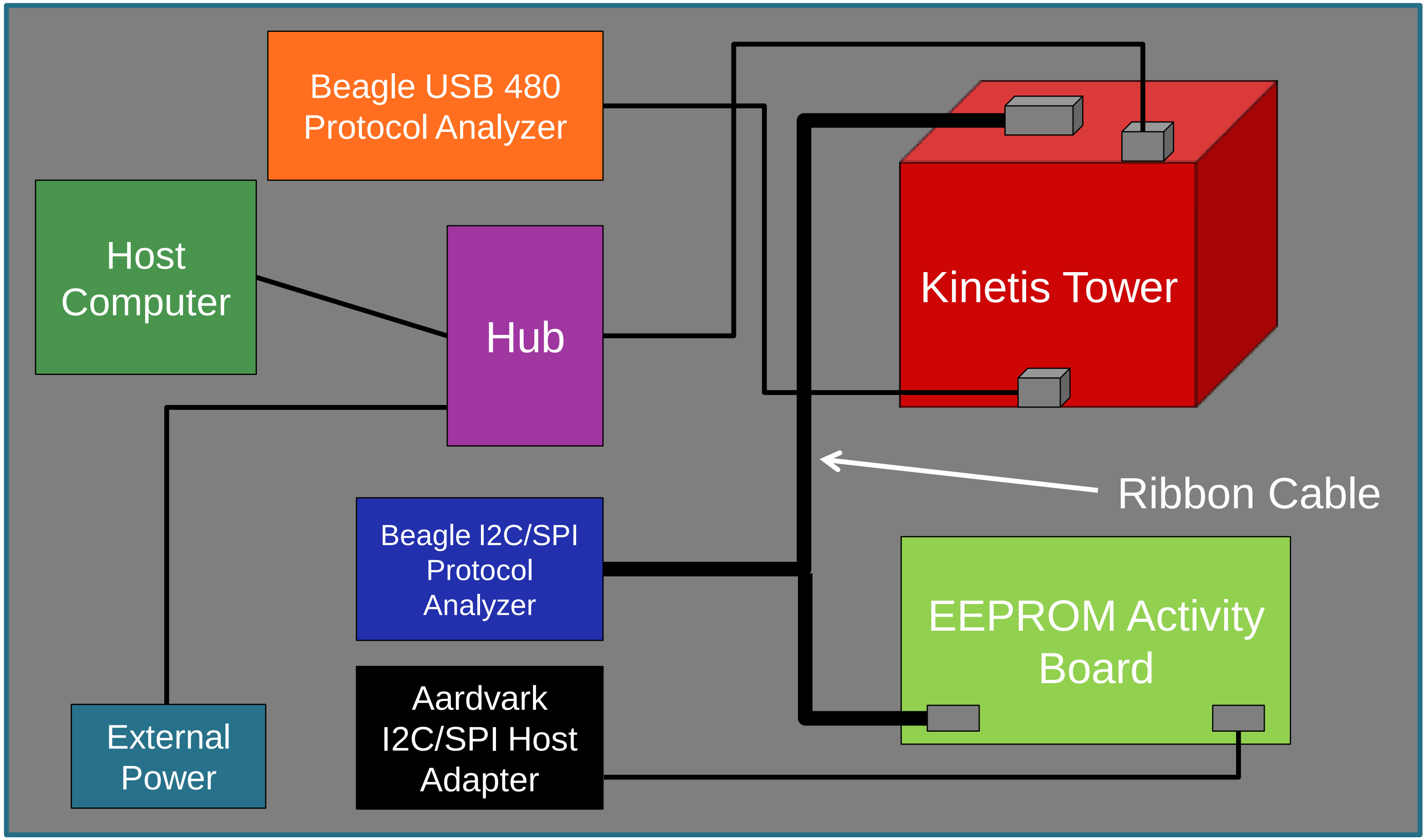
Lab Set Up

Physical Set Up


Beagle USB 480 Protocol Analyzer
Host Computer
Hub
Kinetis Tower
Ribbon Cable
Beagle I2C/SPI Protocol Analyzer
EEPROM Activity Board
External Power
Aardvark I2C/SPI Host Adapter

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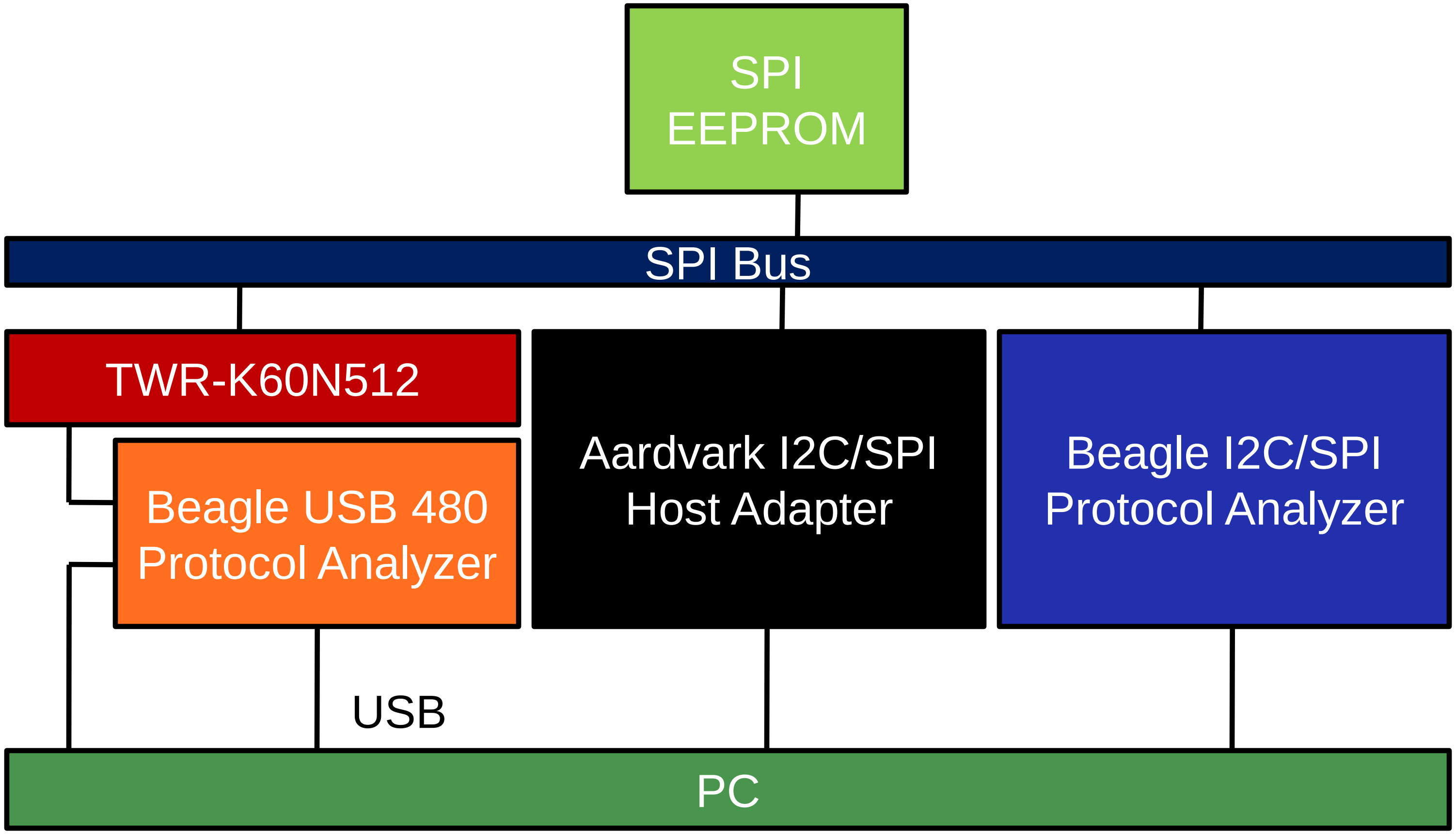
Lab Set Up

Logical Set Up



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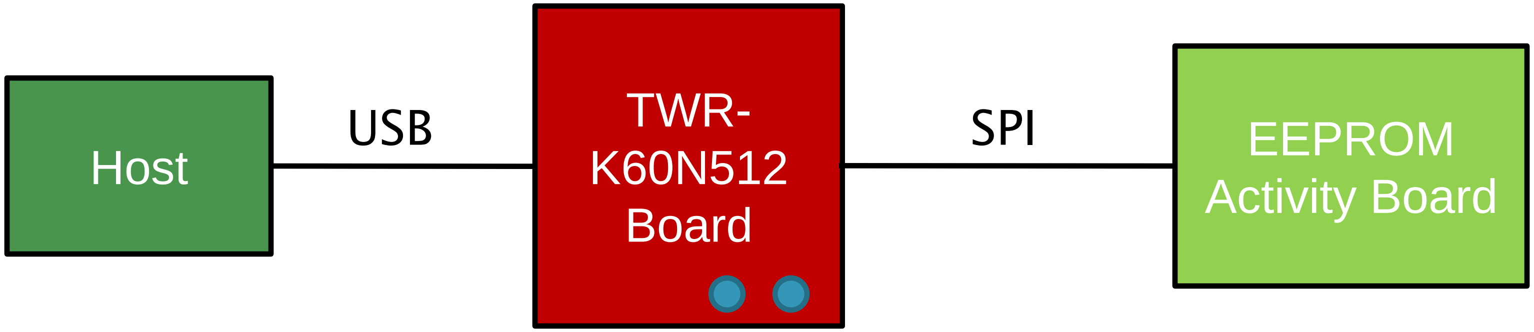
Lab Set Up

Final Product Design

- TWR-K60N512 fetches a record from the SPI EEPROM on button press
- TWR-K60N512 sends record over CDC USB and displays on host



- Button Behavior
  - SW1: Displays next record
  - SW2: Displays previous record

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Programming the EEPROM

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Programming the EEPROM

- **Objective**: Introduce the Aardvark I2C/SPI Host Adapter and Flash Center Software

- **Task**: Use the Aardvark I2C/SPI Host Adapter and Flash Center Software to read and program the SPI EEPROM

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Programming the EEPROM

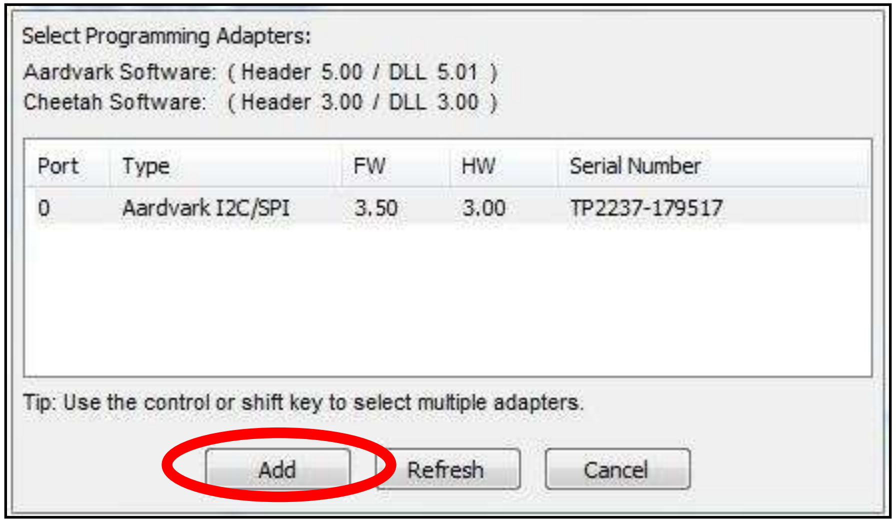
Configuring the Aardvark I2C/SPI Host Adapter for use

1. Open the **Flash Center Software**

2. Click on **Add Adapters**

3. Select Aardvark I2C/SPI Host Adapte

4. Click **Add**



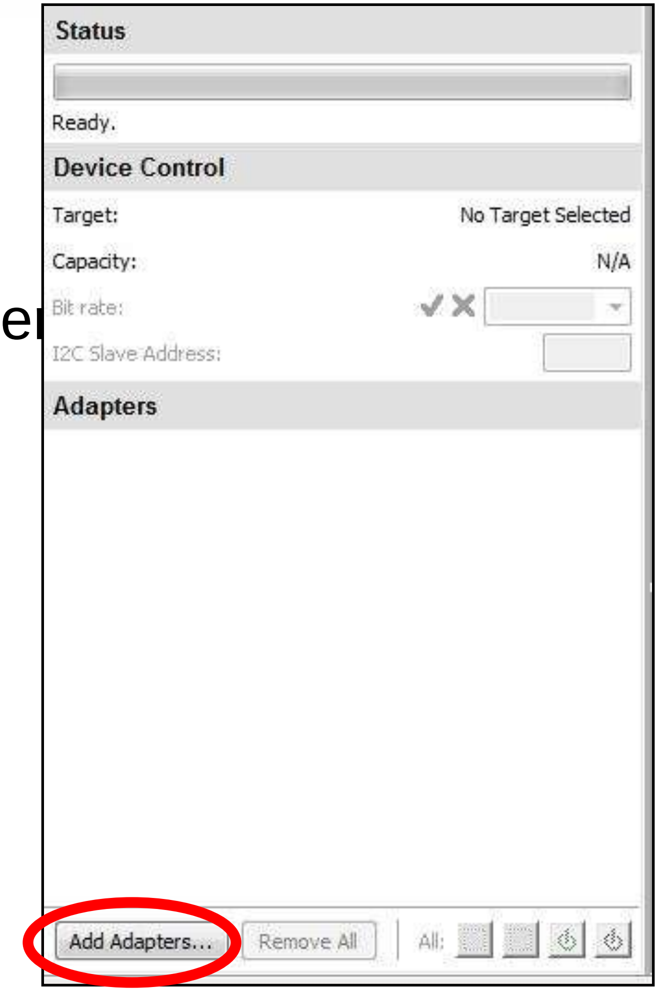
Select Programming Adapters:

Aardvark Software: (Header 5.00 / DLL 5.01)

Cheetah Software: (Header 3.00 / DLL 3.00)

Port	Type	FW	HW	Serial Number
0	Aardvark I2C/SPI	3.50	3.00	TP2237-179517

Tip: Use the control or shift key to select multiple adapters.



Status

Ready.

Device Control

Target: No Target Selected

Capacity: N/A

Bit rate:

I2C Slave Address:

Adapters

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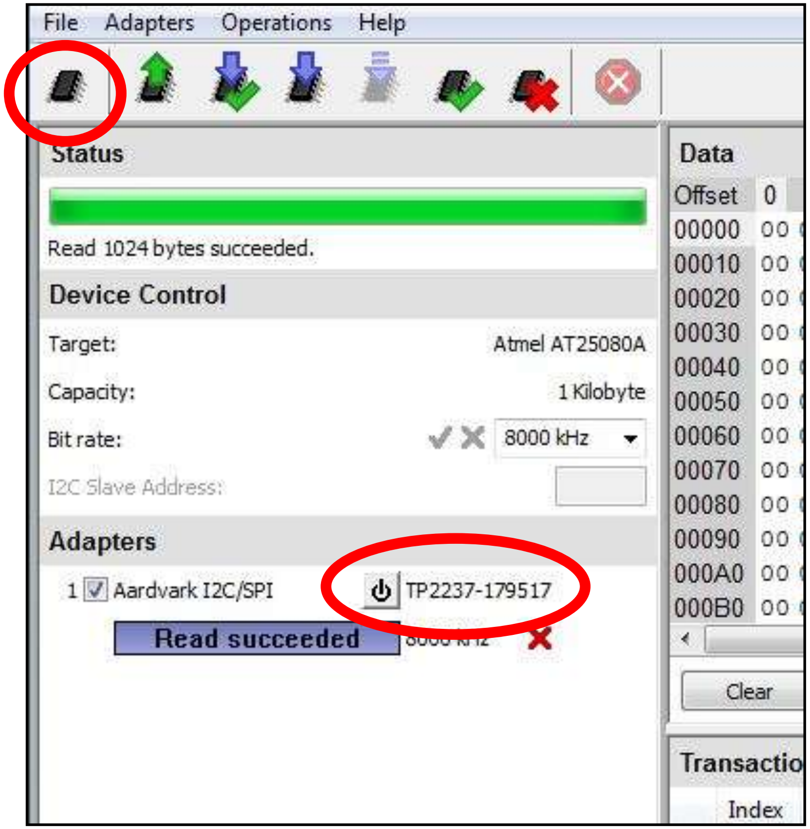
Programming the EEPROM

5. Turn on the **Target Power** button

6. Click on **Choose Target** to specify which part you will be using



Read 1024 bytes succeeded.

Target: Atmel AT25080A

Capacity: 1 Kilobyte

Bit rate: 8000 kHz

I2C Slave Address:

1 ☑ Aardvark I2C/SPI TP2237-179517

Read succeeded 8000 kHz

```
Offset  0
00000  00
00010  00
00020  00
00030  00
00040  00
00050  00
00060  00
00070  00
00080  00
00090  00
000A0  00
000B0  00
```

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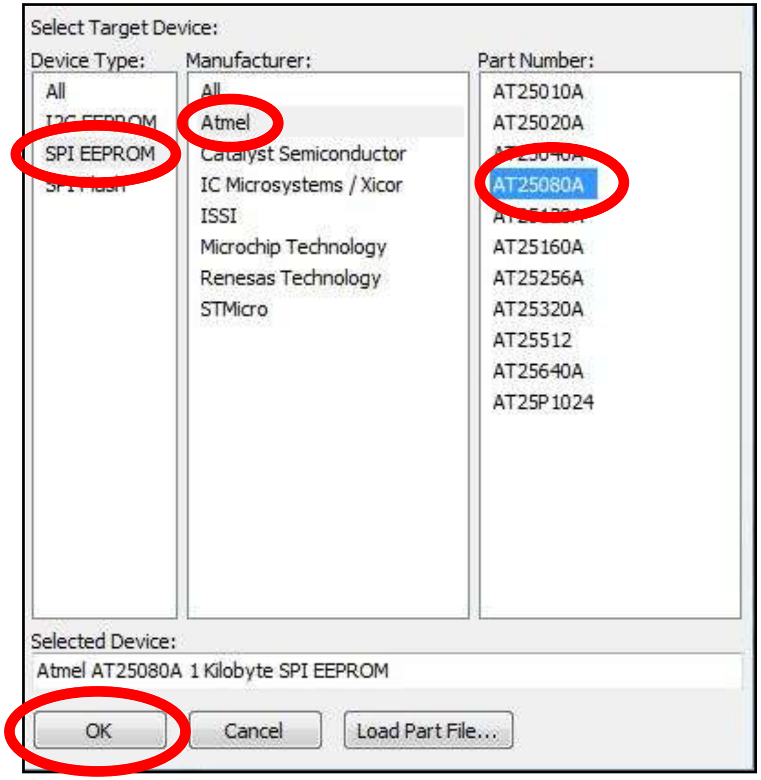
Programming the EEPROM

7. Select **SPI EEPROM** under Device Type

8. Under Manufacturer, select **Atmel**

9. Under Part Number, choose **AT25080A**

10. Click **OK**



Selected Device: Atmel AT25080A 1 Kilobyte SPI EEPROM

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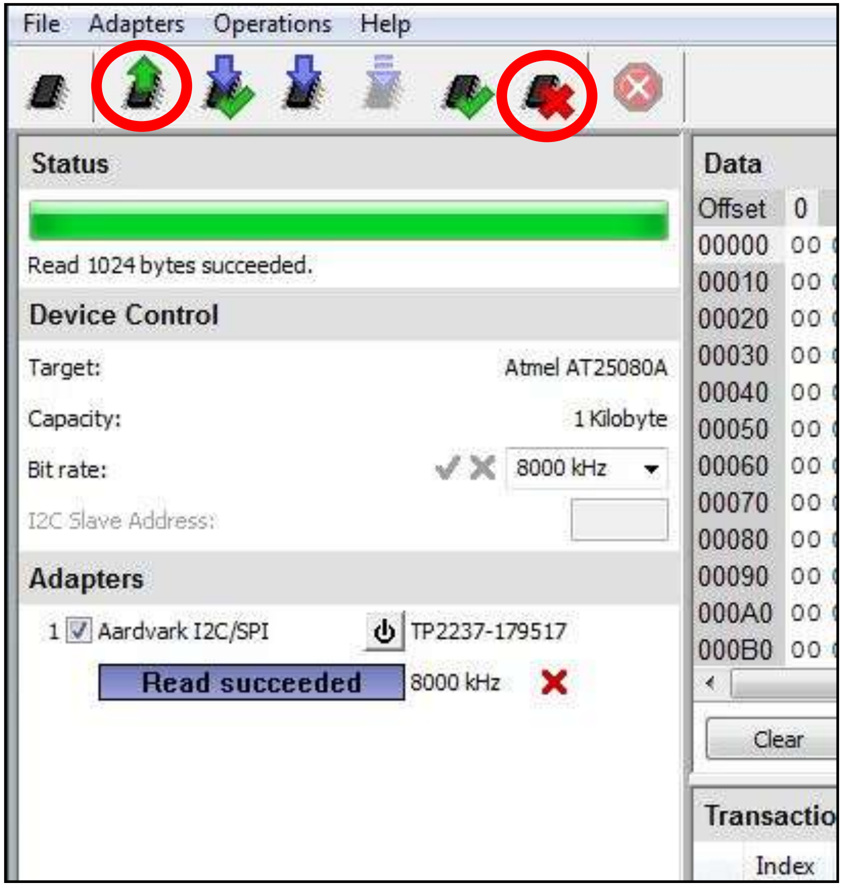
Programming the EEPROM

Reading and Erasing the SPI EEPROM Contents

11. Click the **Read Target** icon
12. Click **Erase**
13. Select **OK**
14. Click **Read Target** again



Status

Read 1024 bytes succeeded.

Device Control

Target: Atmel AT25080A

Capacity: 1 Kilobyte

Bit rate: 8000 kHz

I2C Slave Address:

Adapters

1 ☑ Aardvark I2C/SPI TP2237-179517

Read succeeded 8000 kHz

Data

Offset	0
00000	00
00010	00
00020	00
00030	00
00040	00
00050	00
00060	00
00070	00
00080	00
00090	00
000A0	00
000B0	00

Transactio

Index

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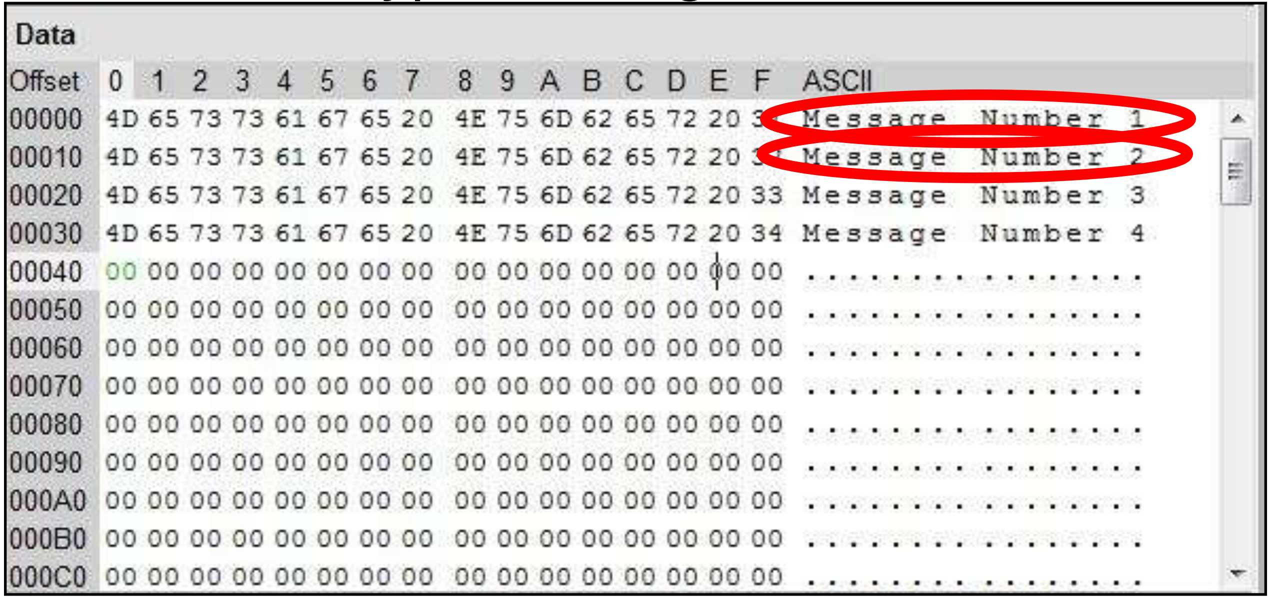
Programming the EEPROM

Writing Data to the SPI EEPROM

15. Click into the ASCII editor

16. On the first line, type **Message Number 1**

17. On the second line, type **Message Number 2**



```
Data
Offset 0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F   ASCII
00000  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 3[illegible]  Message Number 1
00010  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 3[illegible]  Message Number 2
00020  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 33  Message Number 3
00030  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 34  Message Number 4
00040  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00050  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00060  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00070  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00080  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00090  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000A0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000B0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000C0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
```

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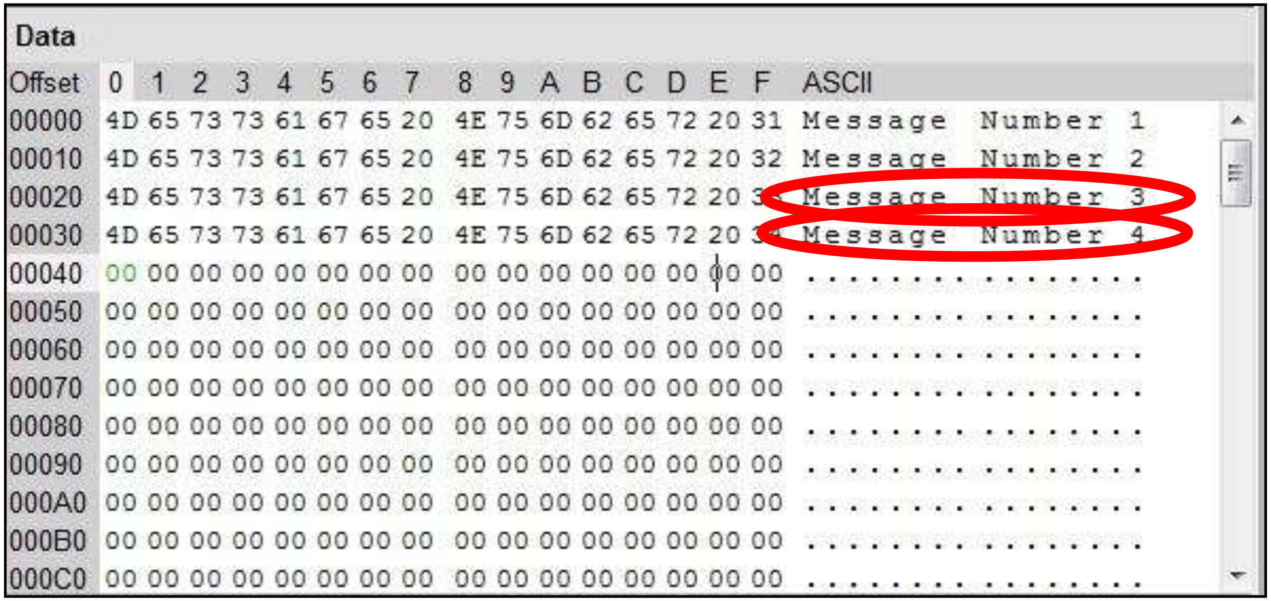
Programming the EEPROM

18. On the third line, type **Message Number 3**

19. On the fourth line, type **Message Number 4**



Data

```
Offset 0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F  ASCII
00000  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 31  Message Number 1
00010  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 32  Message Number 2
00020  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 33  Message Number 3
00030  4D 65 73 73 61 67 65 20  4E 75 6D 62 65 72 20 34  Message Number 4
00040  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00050  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00060  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00070  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00080  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00090  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000A0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000B0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000C0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
```

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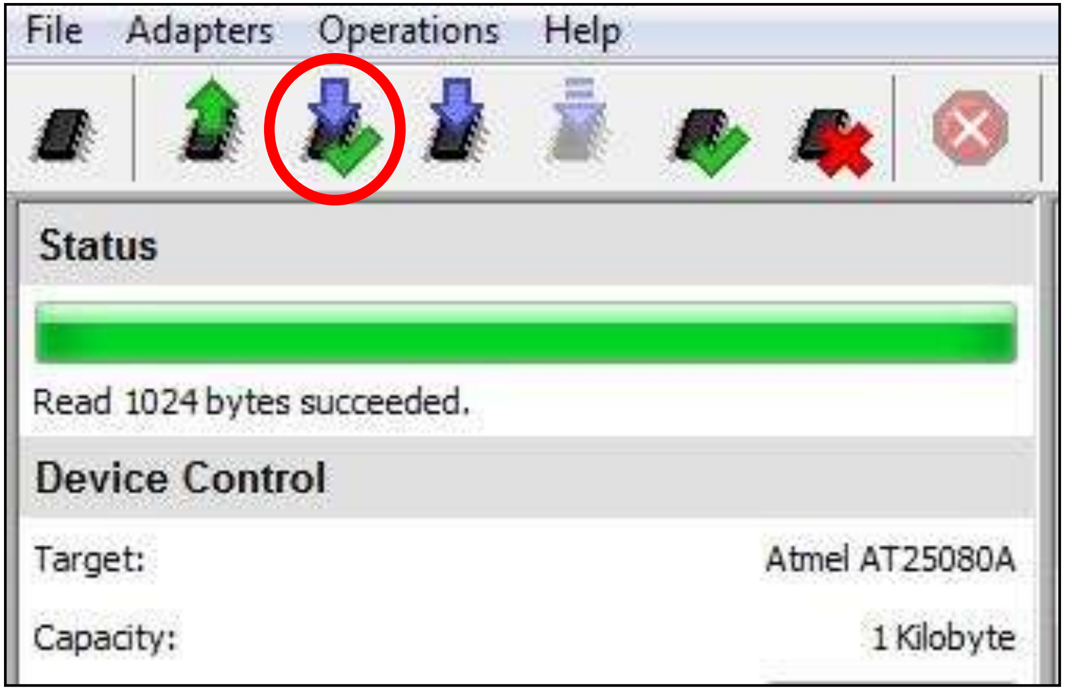
Programming the EEPROM

18. On the third line, type **Message Number 3**

19. On the fourth line, type **Message Number 4**

20. Select the **Program and Verify** icon



Status

Read 1024 bytes succeeded.

Device Control

Target: Atmel AT25080A

Capacity: 1 Kilobyte

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Bug 1: Enumeration of CDC Device

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Bug 1: Enumeration of CDC Device

- **Objective:** Introduce the Beagle USB 480 Protocol Analyzer and Data Center Software to view enumeration details.

- **Task:** Set up and start a live capture using the Data Center Software to assist in fixing the error in the device descriptors.

Beagle USB 480
Protocol Analyzer

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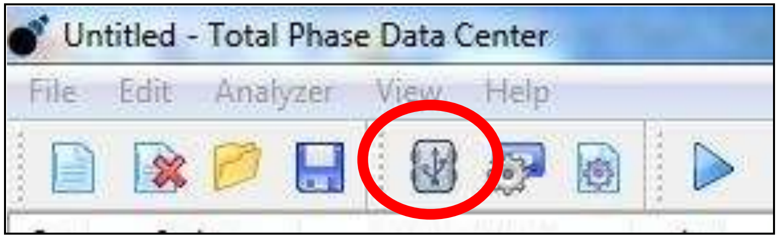
Bug 1: Enumeration of CDC Device

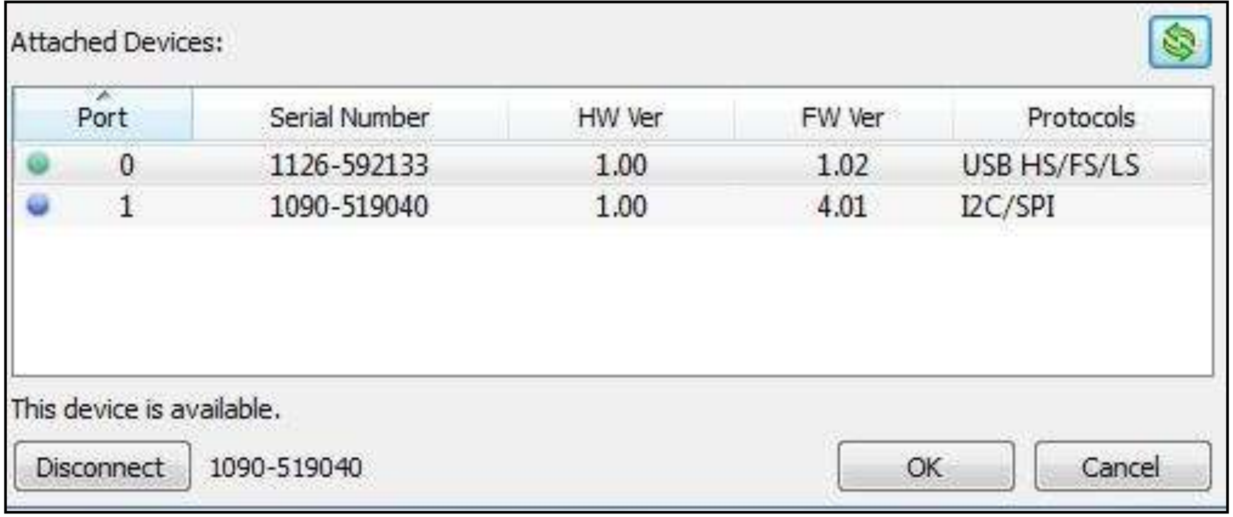
Configuring the Beagle USB 480 Protocol Analyzer for use

1. Open the Data Center Software



2. Click **Connect to Analyzer**

3. Select the USB HS/FS/LS analyzer and click **OK**



Attached Devices:

Port	Serial Number	HW Ver	FW Ver	Protocols
0	1126-592133	1.00	1.02	USB HS/FS/LS
1	1090-519040	1.00	4.01	I2C/SPI

This device is available.

1090-519040

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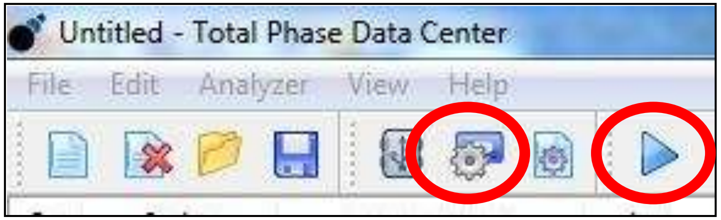
Bug 1: Enumeration of CDC Device

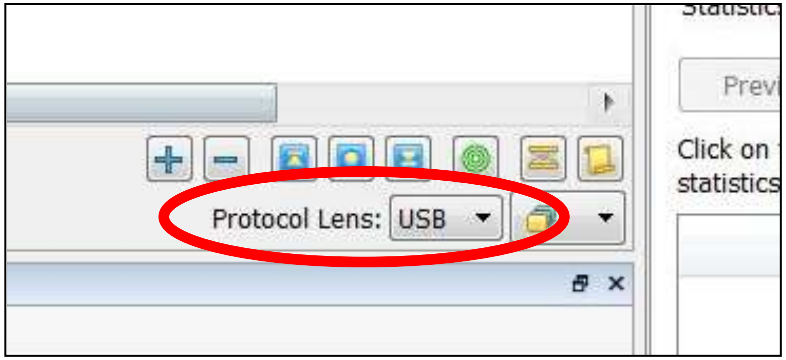
4. Click **Device Settings**.

5. Change the capture protocol to **USB**

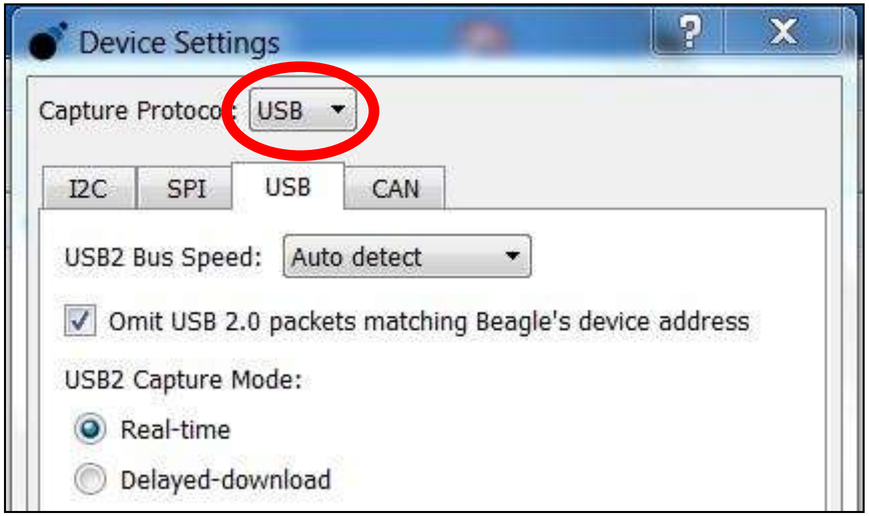
6. Set the protocol lens to **USB**

7. **Start** the capture





Protocol Lens: USB



Capture Protocol: USB

USB2 Bus Speed: Auto detect

☑ Omit USB 2.0 packets matching Beagle's device address

USB2 Capture Mode:

● Real-time

○ Delayed-download

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Bug 1: Enumeration of CDC Device

Launching the Project and the Kinetis Tower System

8. Launch the **IAR Embedded Workbench**

9. Click **File** → **Open** → **Workspace**

10. Open the **TotalPhaseKinetisTower.work** folder in Desktop\TotalPhase\materials\kinetis_projects

11. Select the **TotalPhaseKinetisTower.eww** project

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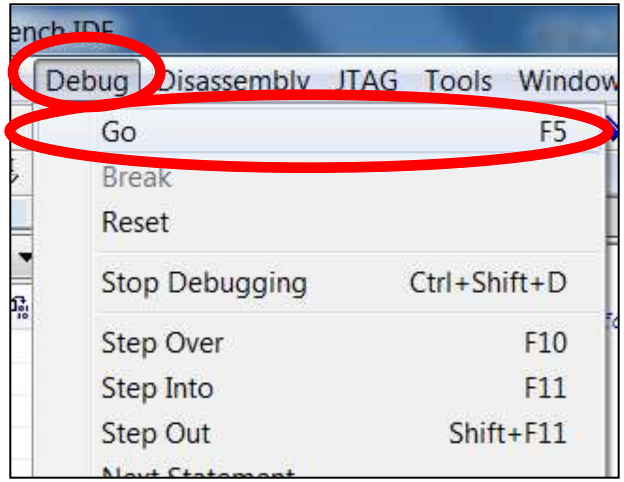
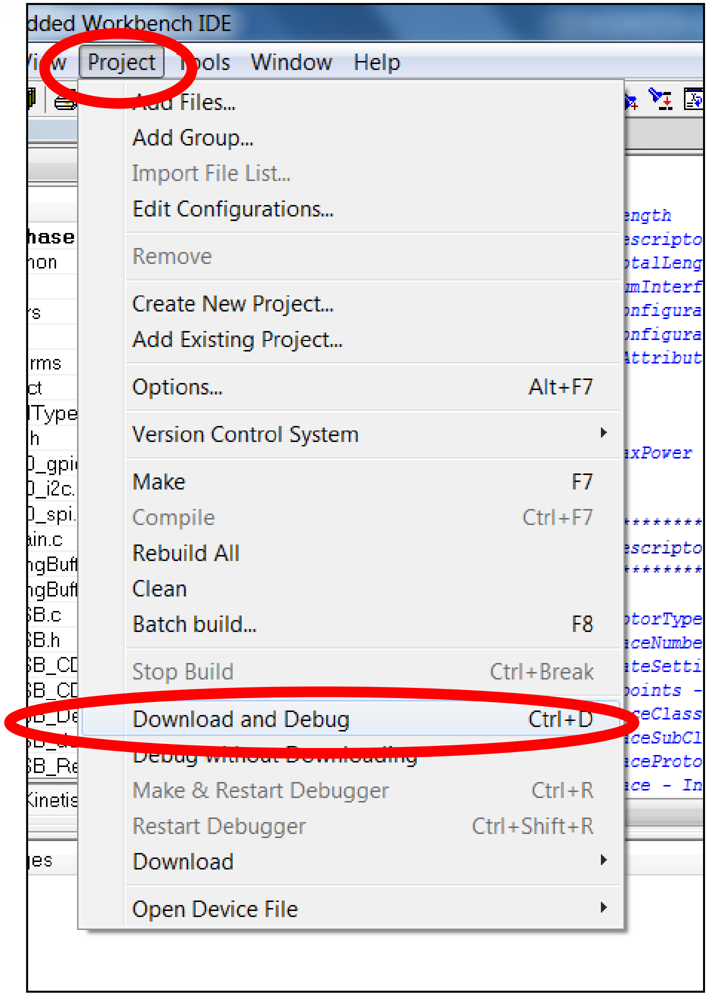
Bug 1: Enumeration of CDC Device

13. Select **Project → Download and Debug**

14. Select **Debug → Go**





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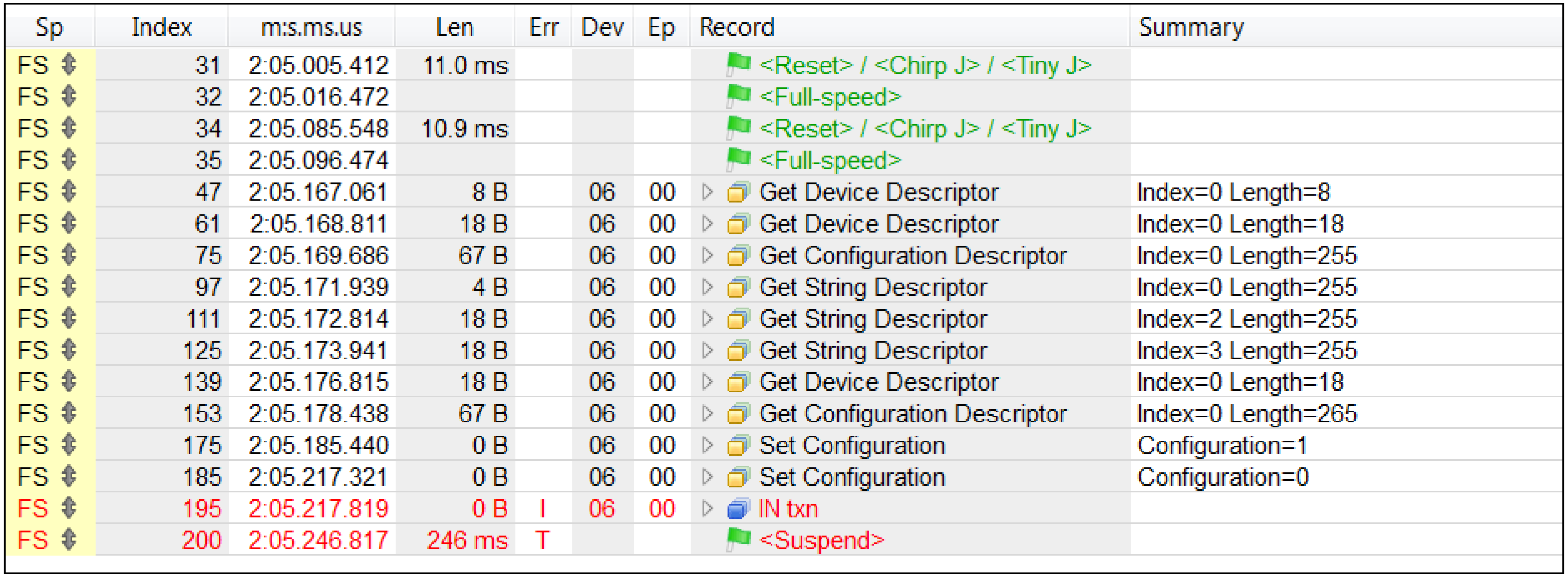
Bug 1: Enumeration of CDC Device

- Go back to the Data Center Software. You should notice the device has gone into Suspend.



Sp	Index	m:s.ms.us	Len	Err	Dev	Ep	Record	Summary
FS	31	2:05.005.412	11.0 ms				<Reset> / <Chirp J> / <Tiny J>	
FS	32	2:05.016.472					<Full-speed>	
FS	34	2:05.085.548	10.9 ms				<Reset> / <Chirp J> / <Tiny J>	
FS	35	2:05.096.474					<Full-speed>	
FS	47	2:05.167.061	8 B		06	00	Get Device Descriptor	Index=0 Length=8
FS	61	2:05.168.811	18 B		06	00	Get Device Descriptor	Index=0 Length=18
FS	75	2:05.169.686	67 B		06	00	Get Configuration Descriptor	Index=0 Length=255
FS	97	2:05.171.939	4 B		06	00	Get String Descriptor	Index=0 Length=255
FS	111	2:05.172.814	18 B		06	00	Get String Descriptor	Index=2 Length=255
FS	125	2:05.173.941	18 B		06	00	Get String Descriptor	Index=3 Length=255
FS	139	2:05.176.815	18 B		06	00	Get Device Descriptor	Index=0 Length=18
FS	153	2:05.178.438	67 B		06	00	Get Configuration Descriptor	Index=0 Length=265
FS	175	2:05.185.440	0 B		06	00	Set Configuration	Configuration=1
FS	185	2:05.217.321	0 B		06	00	Set Configuration	Configuration=0
FS	195	2:05.217.819	0 B	I	06	00	IN txn	
FS	200	2:05.246.817	246 ms	T			<Suspend>	

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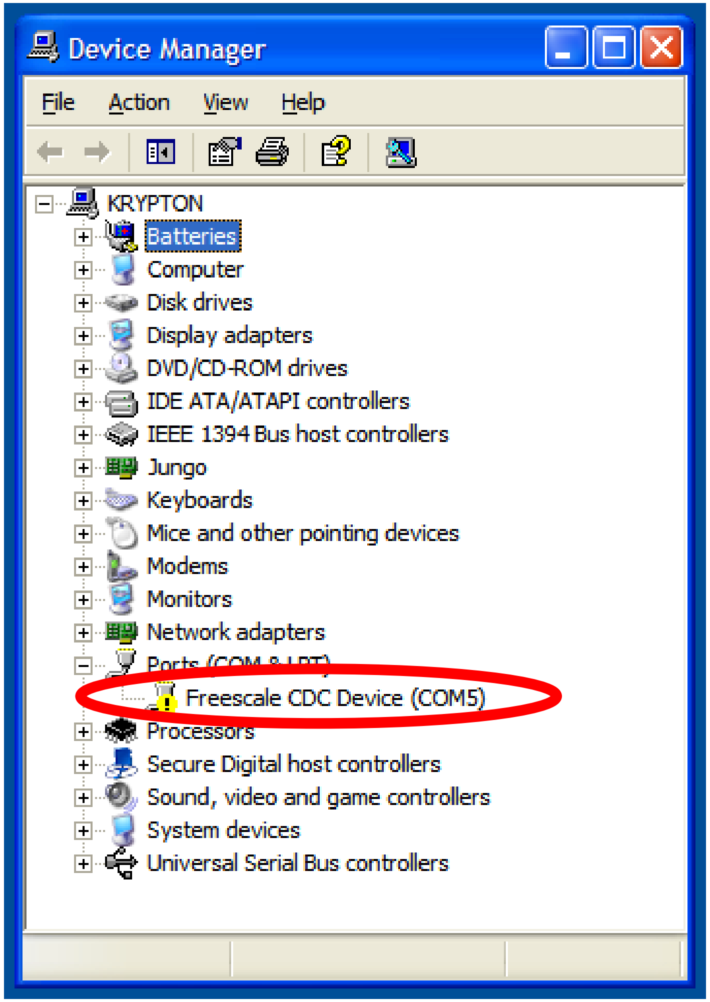
Bug 1: Enumeration of CDC Device

- Device manager with flagged device



KRYPTON
- Batteries
- Computer
- Disk drives
- Display adapters
- DVD/CD-ROM drives
- IDE ATA/ATAPI controllers
- IEEE 1394 Bus host controllers
- Jungo
- Keyboards
- Mice and other pointing devices
- Modems
- Monitors
- Network adapters
- Ports (COM & LPT)
  - Freescale CDC Device (COM5)
- Processors
- Secure Digital host controllers
- Sound, video and game controllers
- System devices
- Universal Serial Bus controllers

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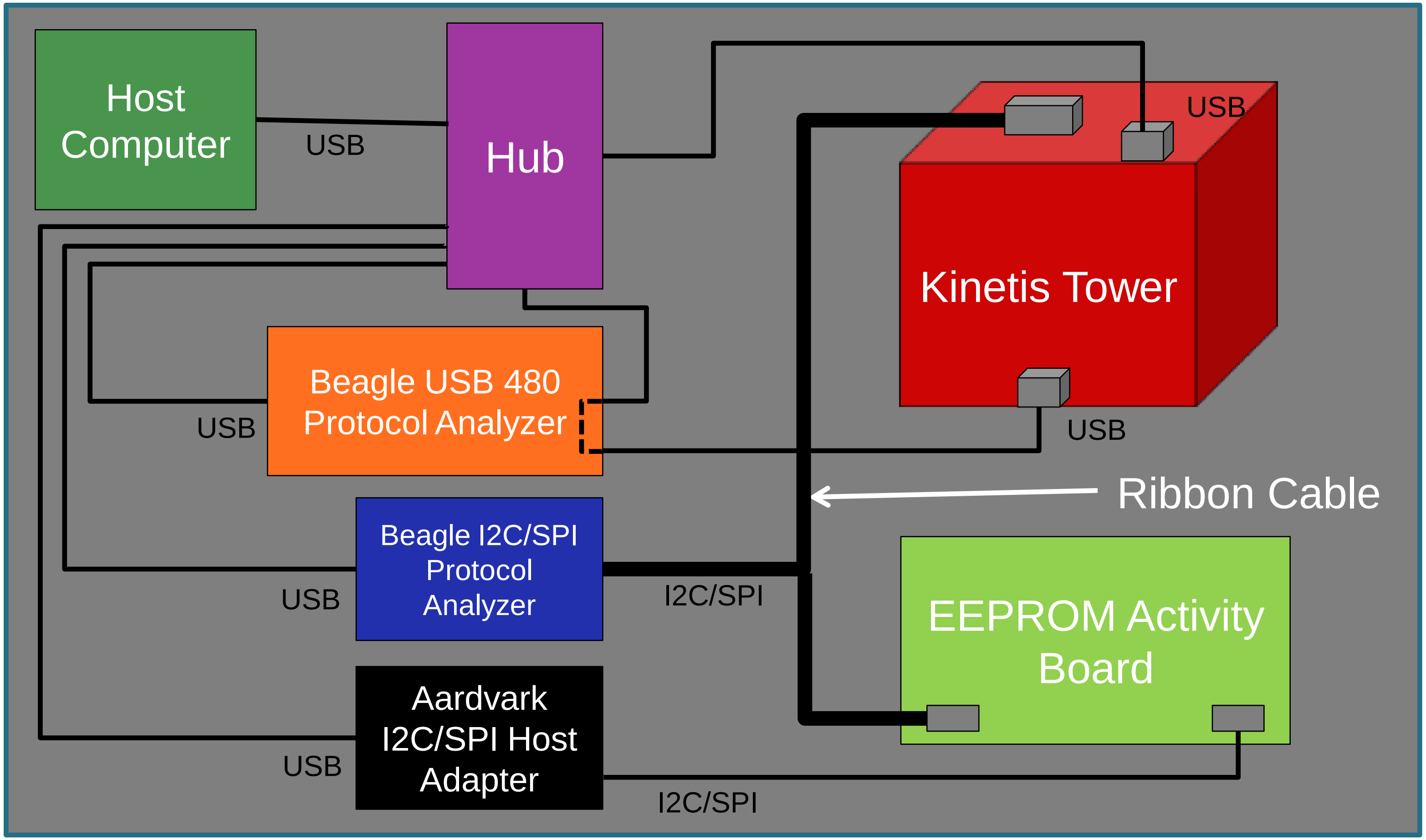
Please spend the next few minutes debugging this problem



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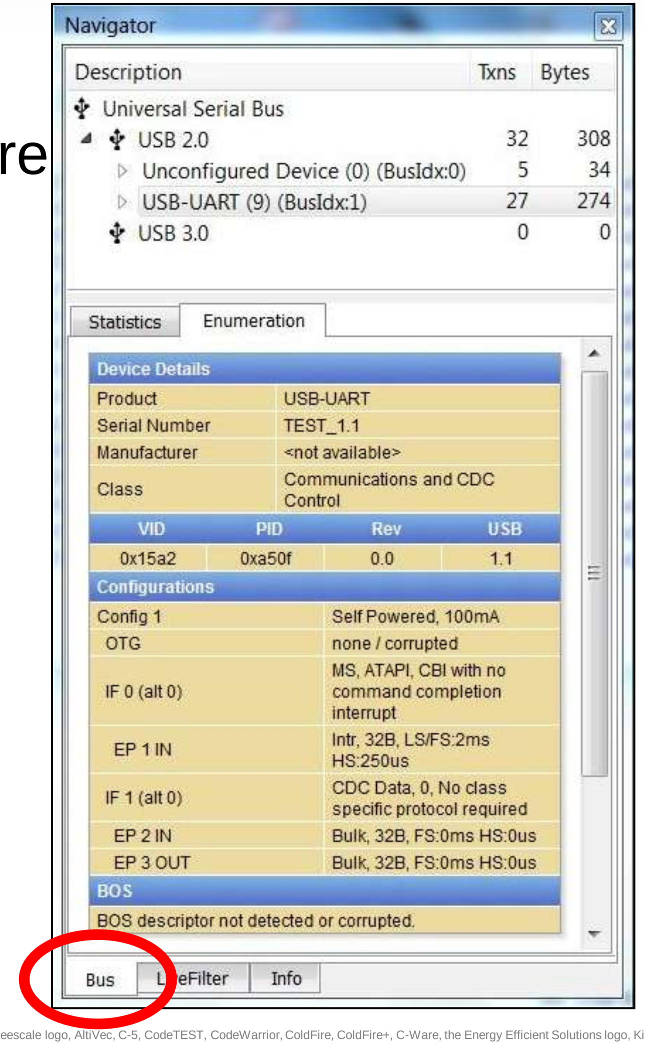
Bug 1: Enumeration of CDC Device

Using the Data Center Software to Find the Problem

14. Go back to the Data Center Software

15. Go to the **Bus** pane



Description	Txns	Bytes
Universal Serial Bus		
USB 2.0	32	308
Unconfigured Device (0) (BusIdx:0)	5	34
USB-UART (9) (BusIdx:1)	27	274
USB 3.0	0	0

Device Details	
Product	USB-UART
Serial Number	TEST_1.1
Manufacturer	<not available>
Class	Communications and CDC Control

VID	PID	Rev	USB
0x15a2	0xa50f	0.0	1.1

Configurations	
Config 1	Self Powered, 100mA
OTG	none / corrupted
IF 0 (alt 0)	MS, ATAPI, CBI with no command completion interrupt
EP 1 IN	Intr, 32B, LS/FS:2ms HS:250us
IF 1 (alt 0)	CDC Data, 0, No class specific protocol required
EP 2 IN	Bulk, 32B, FS:0ms HS:0us
EP 3 OUT	Bulk, 32B, FS:0ms HS:0us

BOS

BOS descriptor not detected or corrupted.

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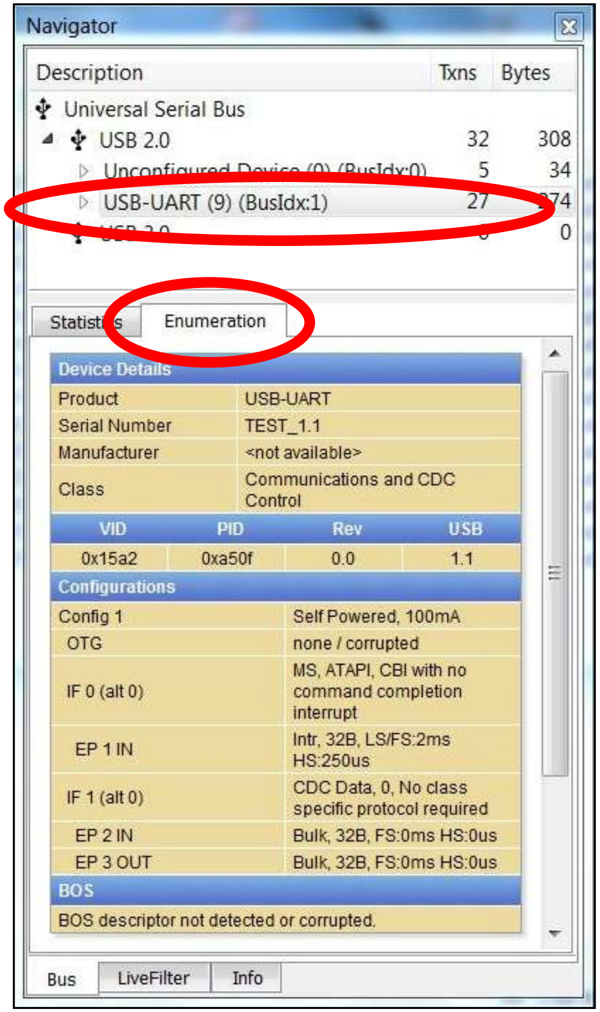
Bug 1: Enumeration of CDC Device

Using the Data Center Software to Find the Problem

16. Select the **USB-UART** device

17. Click on the **Enumeration** tab



Description	Txns	Bytes
Universal Serial Bus		
USB 2.0	32	308
Unconfigured Device (0) (BusIdx:0)	5	34
USB-UART (9) (BusIdx:1)	27	274
USB 2.0	0	0

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Manufacturer	<not available>
Class	Communications and CDC Control

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IF 1 (alt 0)	CDC Data, 0, No class specific protocol required
EP 2 IN	Bulk, 32B, FS:0ms HS:0us
EP 3 OUT	Bulk, 32B, FS:0ms HS:0us

BOS

BOS descriptor not detected or corrupted.

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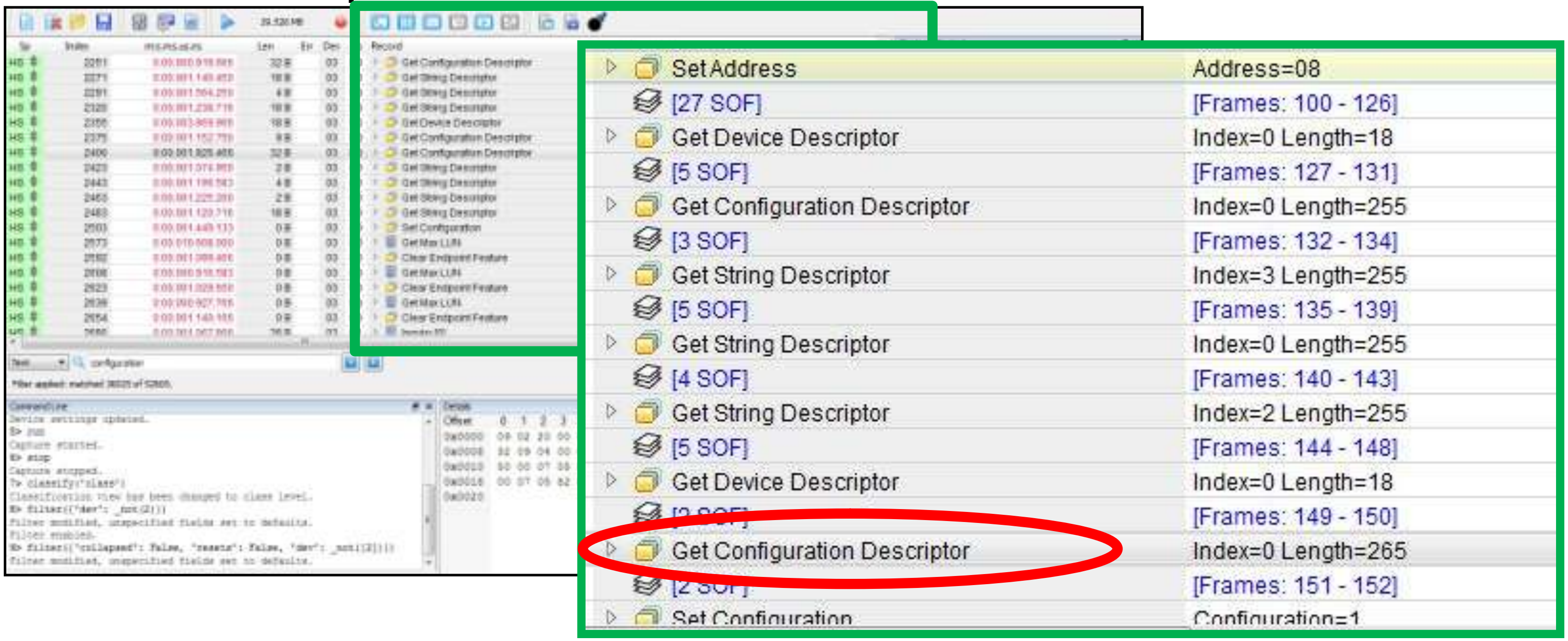
Bug 1: Enumeration of CDC Device

18. Go to the Data Transaction Window

19. Scroll to find the second **Get Configuration Descriptor** packet

20. Click on the packet



```
▷ Set Address                     Address=08
  [27 SOF]                        [Frames: 100 - 126]
▷ Get Device Descriptor           Index=0 Length=18
  [5 SOF]                         [Frames: 127 - 131]
▷ Get Configuration Descriptor    Index=0 Length=255
  [3 SOF]                         [Frames: 132 - 134]
▷ Get String Descriptor           Index=3 Length=255
  [5 SOF]                         [Frames: 135 - 139]
▷ Get String Descriptor           Index=0 Length=255
  [4 SOF]                         [Frames: 140 - 143]
▷ Get String Descriptor           Index=2 Length=255
  [5 SOF]                         [Frames: 144 - 148]
▷ Get Device Descriptor           Index=0 Length=18
  [2 SOF]                         [Frames: 149 - 150]
▷ Get Configuration Descriptor    Index=0 Length=265
  [2 SOF]                         [Frames: 151 - 152]
▷ Set Configuration               Configuration=1
```

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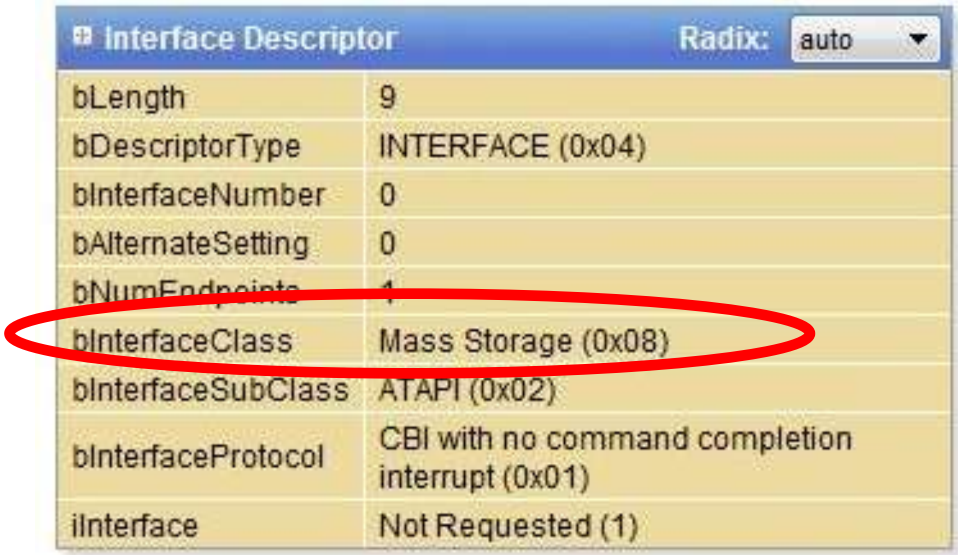
Bug 1: Enumeration of CDC Device

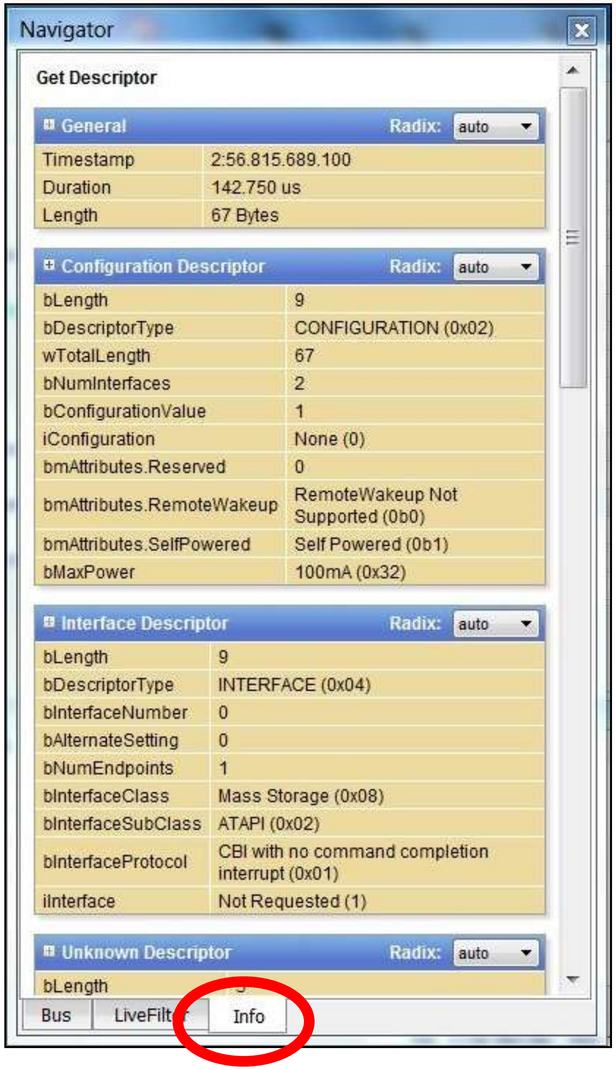
21. Go to the **Info** tab

22. Note the **bInterfaceClass** description



Interface Descriptor Radix: auto

bLength	9
bDescriptorType	INTERFACE (0x04)
bInterfaceNumber	0
bAlternateSetting	0
bNumEndpoints	1
bInterfaceClass	Mass Storage (0x08)
bInterfaceSubClass	ATAPI (0x02)
bInterfaceProtocol	CBI with no command completion interrupt (0x01)
iInterface	Not Requested (1)



Navigator

Get Descriptor

General Radix: auto

Timestamp	2:56.815.689.100
Duration	142.750 us
Length	67 Bytes

Configuration Descriptor Radix: auto

bLength	9
bDescriptorType	CONFIGURATION (0x02)
wTotalLength	67
bNumInterfaces	2
bConfigurationValue	1
iConfiguration	None (0)
bmAttributes.Reserved	0
bmAttributes.RemoteWakeup	RemoteWakeup Not Supported (0b0)
bmAttributes.SelfPowered	Self Powered (0b1)
bMaxPower	100mA (0x32)

Interface Descriptor Radix: auto

bLength	9
bDescriptorType	INTERFACE (0x04)
bInterfaceNumber	0
bAlternateSetting	0
bNumEndpoints	1
bInterfaceClass	Mass Storage (0x08)
bInterfaceSubClass	ATAPI (0x02)
bInterfaceProtocol	CBI with no command completion interrupt (0x01)
iInterface	Not Requested (1)

Unknown Descriptor Radix: auto

bLength	

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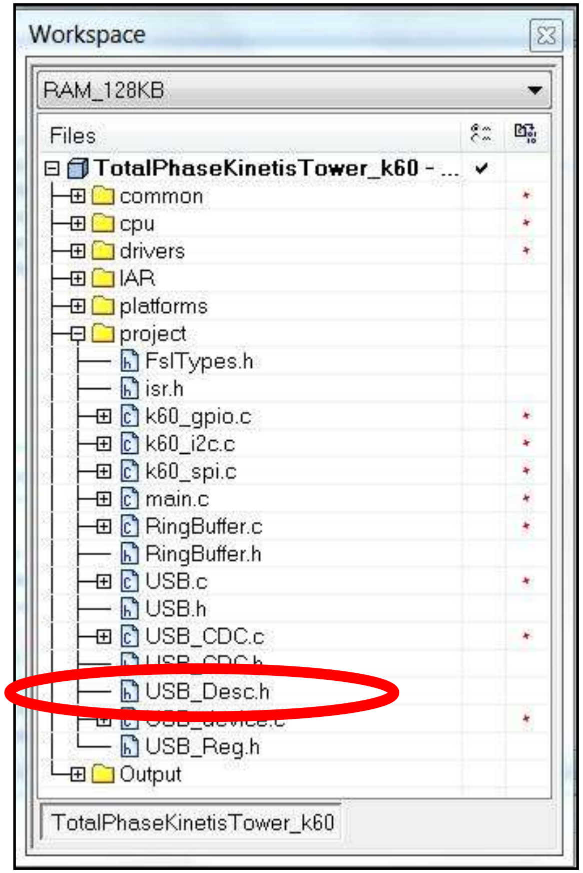
Bug 1: Enumeration of CDC Device

Fixing the USB Descriptor Bug

23. Go back to the IAR Embedded Workbench program

24. Open **USB_Desc.h** from the directory



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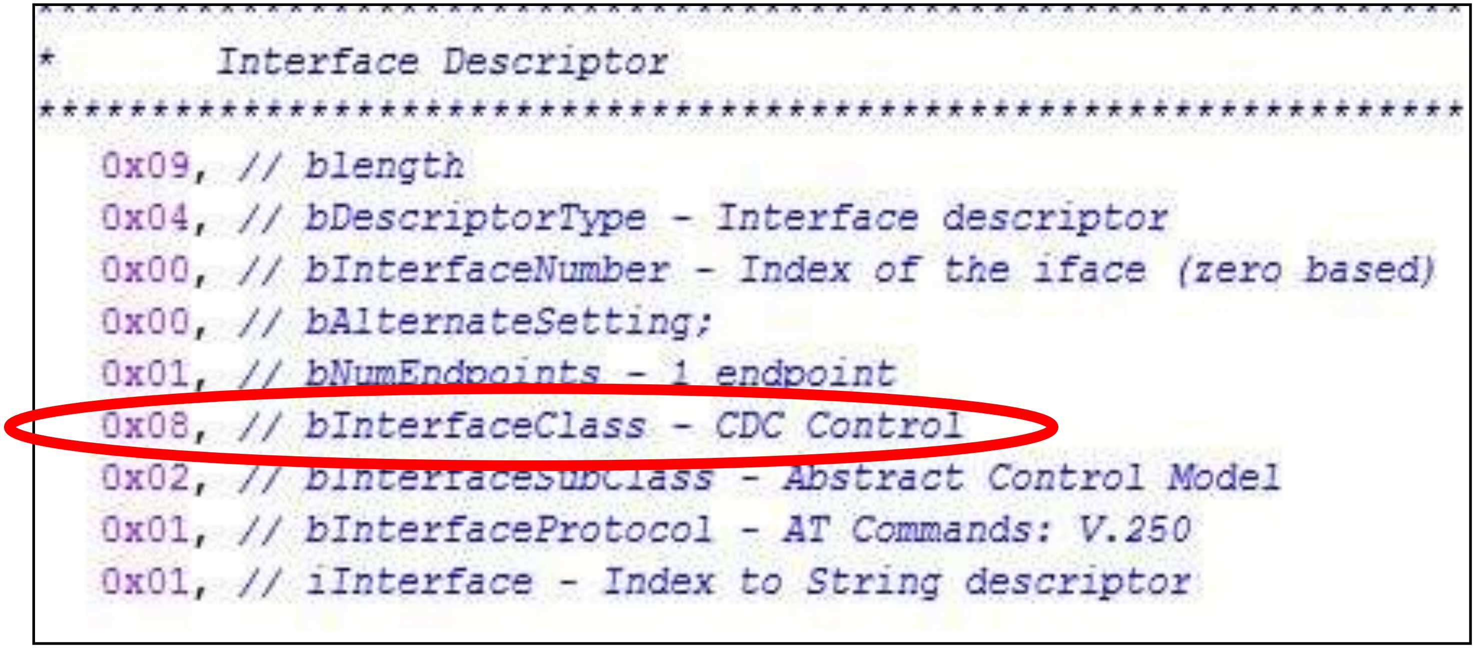
Bug 1: Enumeration of CDC Device

25. Scroll and find the first Interface Descriptor section

26. Change the bInterface class from 0x08 to **0x02** in Line 123



```
****************************************************************
*       Interface Descriptor
****************************************************************
   0x09, // blength
   0x04, // bDescriptorType - Interface descriptor
   0x00, // bInterfaceNumber - Index of the iface (zero based)
   0x00, // bAlternateSetting;
   0x01, // bNumEndpoints - 1 endpoint
   0x08, // bInterfaceClass - CDC Control
   0x02, // bInterfaceSubClass - Abstract Control Model
   0x01, // bInterfaceProtocol - AT Commands: V.250
   0x01, // iInterface - Index to String descriptor
```

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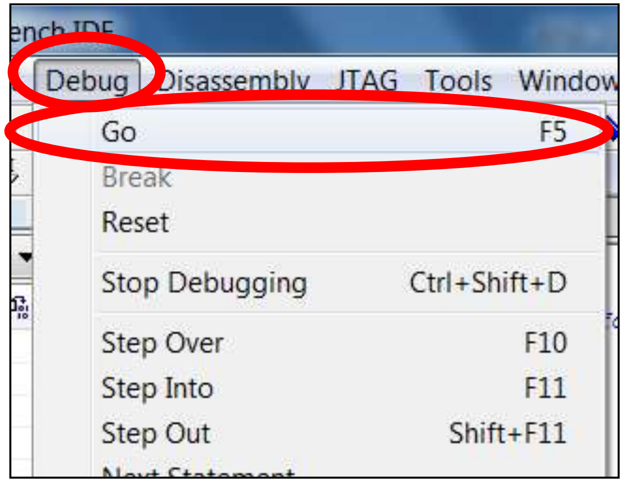
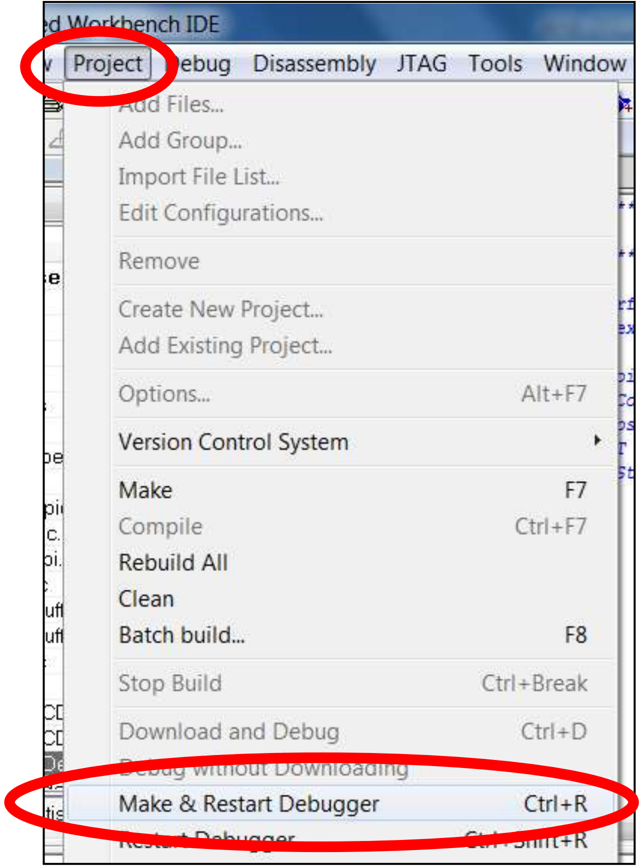
Bug 1: Enumeration of CDC Device

Verifying the Solution

27. Select **Project → Make_Restart_Debugger**

28. Select **Debug → Go**





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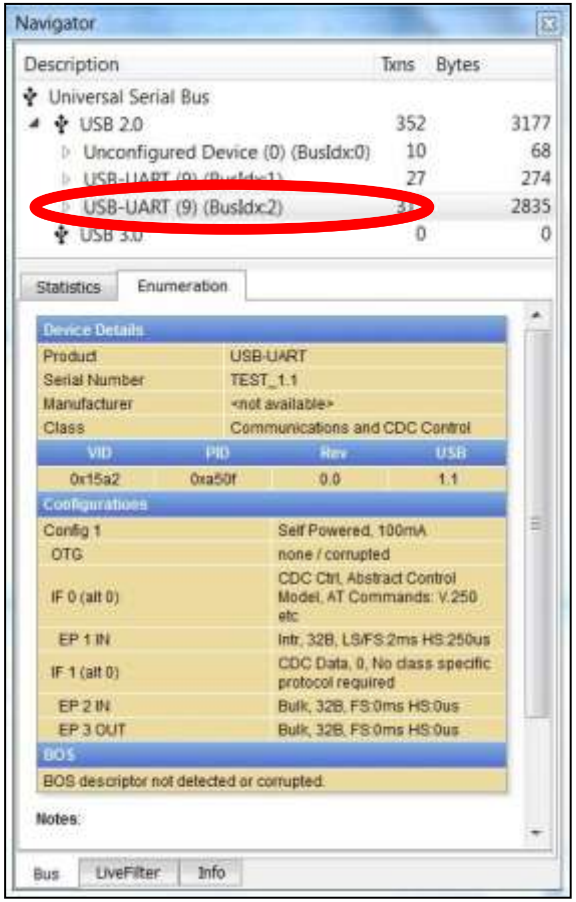
Bug 1: Enumeration of CDC Device

29. Go back to the Data Center Software

30. Go back to the **Bus** pane and select the second **USB-UART** device



Navigator

Description	Txns	Bytes
Universal Serial Bus		
USB 2.0	352	3177
Unconfigured Device (0) (BusIdx:0)	10	68
USB-UART (9) (BusIdx:1)	27	274
USB-UART (9) (BusIdx:2)	31	2835
USB 3.0	0	0

Device Details	
Product	USB-UART
Serial Number	TEST_1.1
Manufacturer	<not available>
Class	Communications and CDC Control

VID	PID	Rev	USB
0x15a2	0xa50f	0.0	1.1

Configurations	
Config 1	Self Powered, 100mA
OTG	none / corrupted
IF 0 (alt 0)	CDC Ctrl, Abstract Control Model, AT Commands: V.250 etc
EP 1 IN	Intr, 32B, LS/FS:2ms HS:250us
IF 1 (alt 0)	CDC Data, 0, No class specific protocol required
EP 2 IN	Bulk, 32B, FS:0ms HS:0us
EP 3 OUT	Bulk, 32B, FS:0ms HS:0us

BOS

BOS descriptor not detected or corrupted.

Notes:

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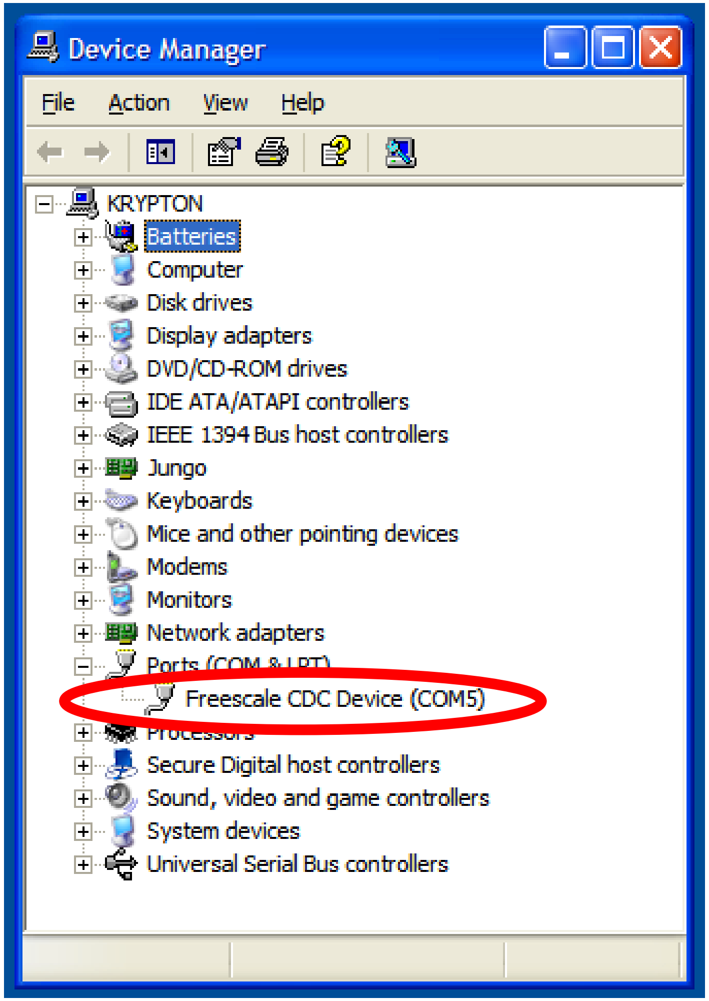
Bug 1: Enumeration of CDC Device

31. Go back to the **Device Manager**



- KRYPTON
  - Batteries
  - Computer
  - Disk drives
  - Display adapters
  - DVD/CD-ROM drives
  - IDE ATA/ATAPI controllers
  - IEEE 1394 Bus host controllers
  - Jungo
  - Keyboards
  - Mice and other pointing devices
  - Modems
  - Monitors
  - Network adapters
  - Ports (COM & LPT)
    - Freescale CDC Device (COM5)
  - Processors
  - Secure Digital host controllers
  - Sound, video and game controllers
  - System devices
  - Universal Serial Bus controllers

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Bug 2: SPI Programming

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Bug 2: SPI Programming

- **Objective**: Introduce the Beagle I2C/SPI Protocol Analyzer and establish communication with the Kinetis Tower from the host PC

- **Task**: Use the Terminal Window application to connect to the COM port exposed by the CDC USB device

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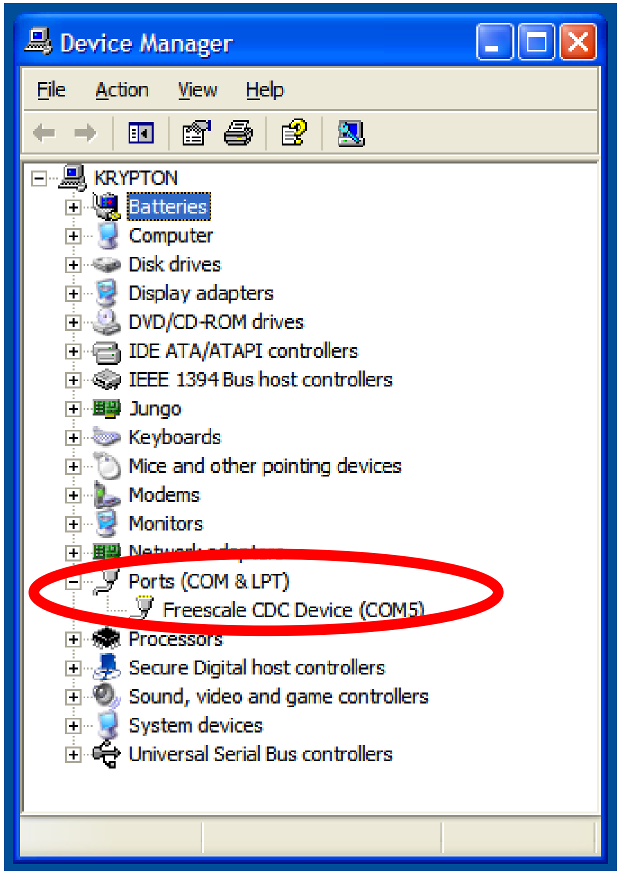
Bug 2: SPI Programming

1. Go back to the **Device Manager** and select **Ports**

2. Please note your number after the **“COM”**

3. Write this number down



KRYPTON
- Batteries
- Computer
- Disk drives
- Display adapters
- DVD/CD-ROM drives
- IDE ATA/ATAPI controllers
- IEEE 1394 Bus host controllers
- Jungo
- Keyboards
- Mice and other pointing devices
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- Monitors
- Network adapters
- Ports (COM & LPT)
    - Freescale CDC Device (COM5)
- Processors
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- Sound, video and game controllers
- System devices
- Universal Serial Bus controllers

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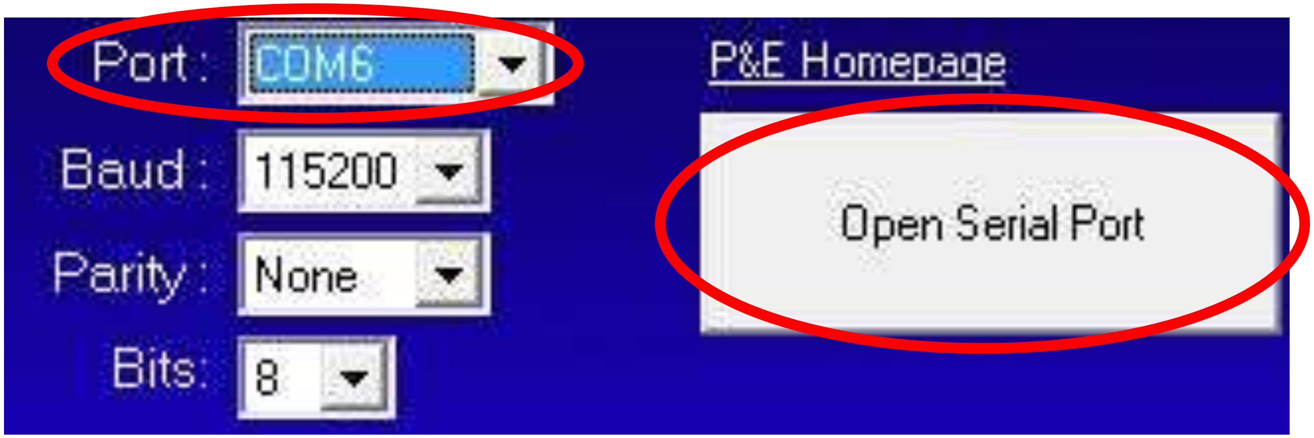
Bug 2: SPI Programming

Communicating using the CDC Device

4. Open the Kinetis Toolkit by clicking Start > Programs > P&E Toolkit > Utilities > TerminalWindow

5. Select COM#, where # represents the number written down previously

6. Click Open Serial Port



Port : COM6

Baud : 115200

Parity : None

Bits: 8

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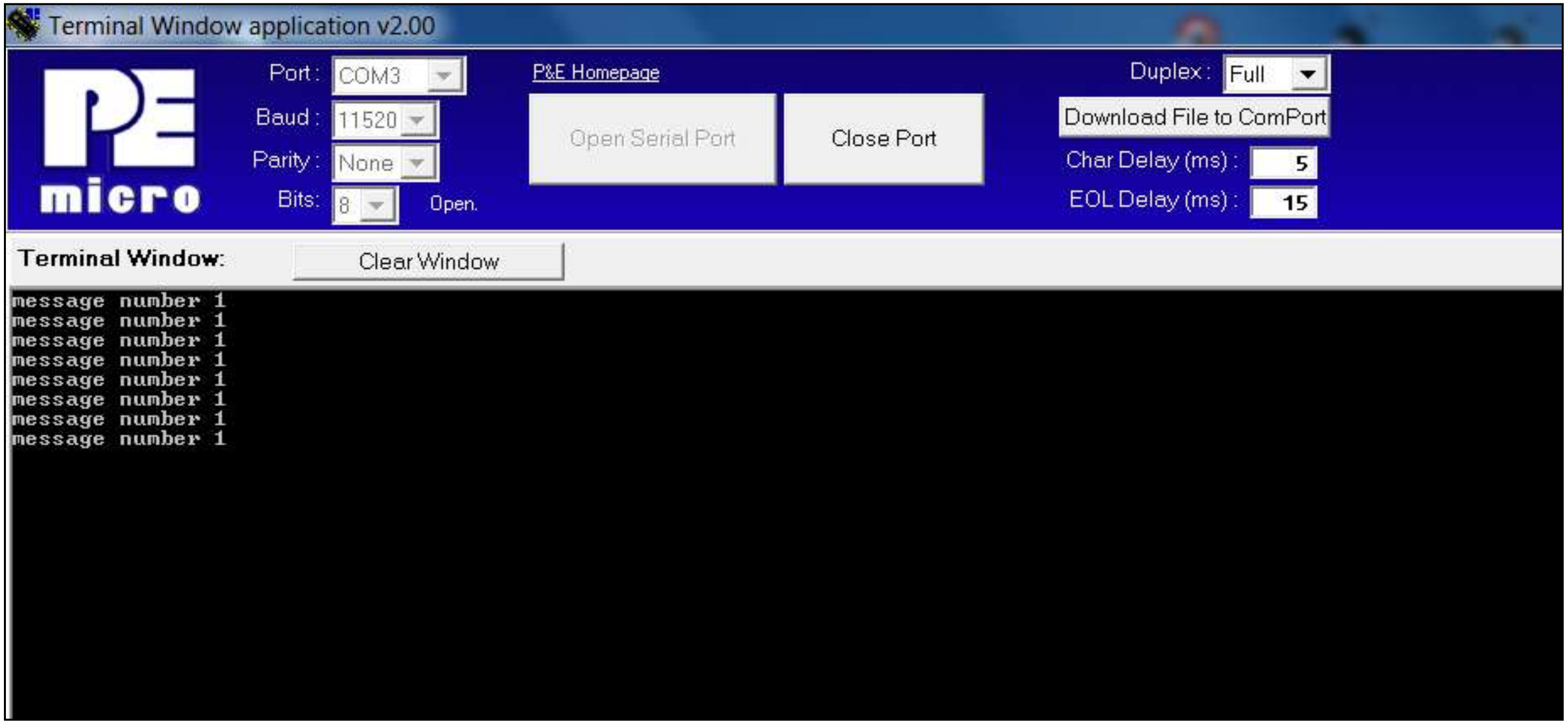
Bug 2: SPI Programming

7. Click on one of the two blue buttons located on the board
8. Click the buttons a few times. You may receive a message like this:



```
message number 1
message number 1
message number 1
message number 1
message number 1
message number 1
message number 1
message number 1
```

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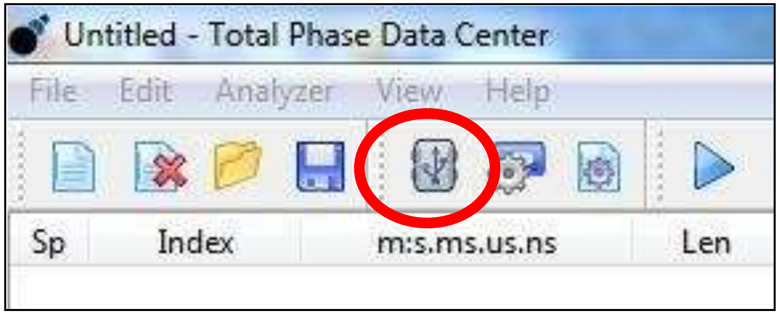
Bug 2: SPI Programming

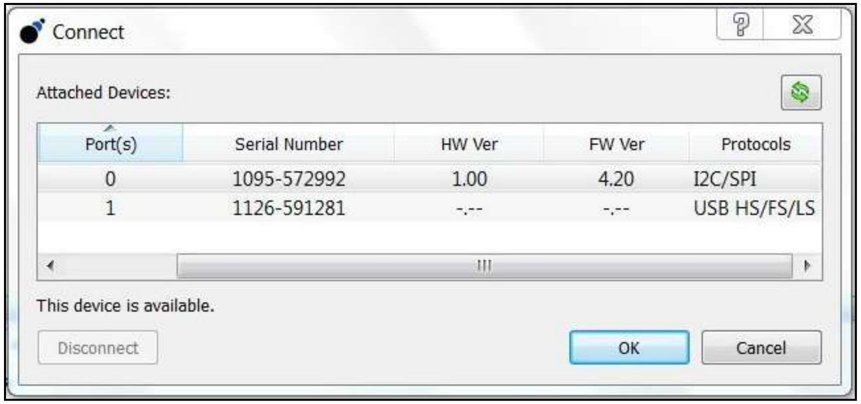
Configuring the Beagle I2C/SPI Protocol Analyzer for use

9. Open another instance of the **Data Center Software**

10. Click **Connect**



11. Connect to the **Beagle I2C/SPI Protocol Analyzer**



Attached Devices:

Port(s)	Serial Number	HW Ver	FW Ver	Protocols
0	1095-572992	1.00	4.20	I2C/SPI
1	1126-591281	-.--	-.--	USB HS/FS/LS

This device is available.

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Bug 2: SPI Programming

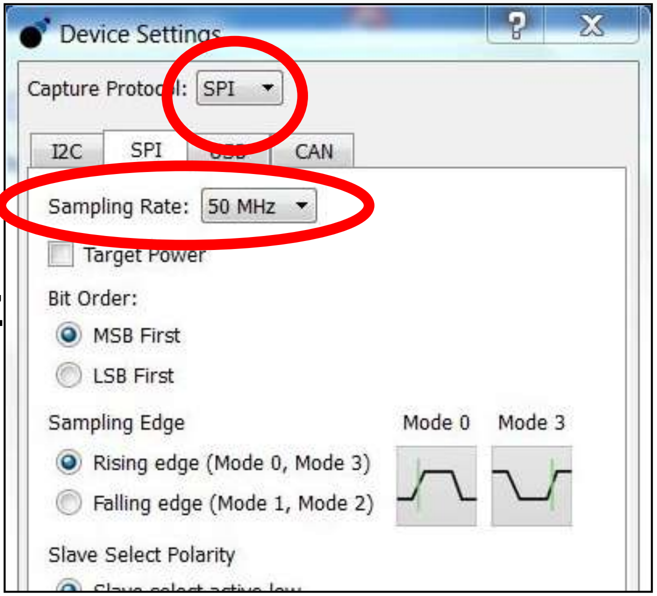
12. Go **to Device Settings**

13. Select **SPI** in the pull down menu

14. Change the sampling rate to **50 MHz**

15. Change the protocol lens to **SPI**

16. **Start** the capture



Capture Protocol: SPI

Sampling Rate: 50 MHz

□ Target Power

Bit Order:

● MSB First

○ LSB First

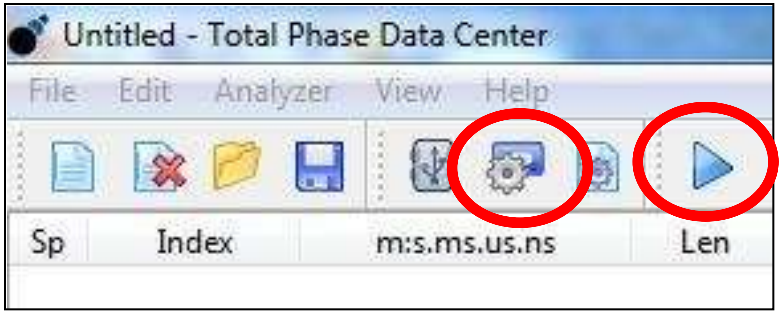
Sampling Edge

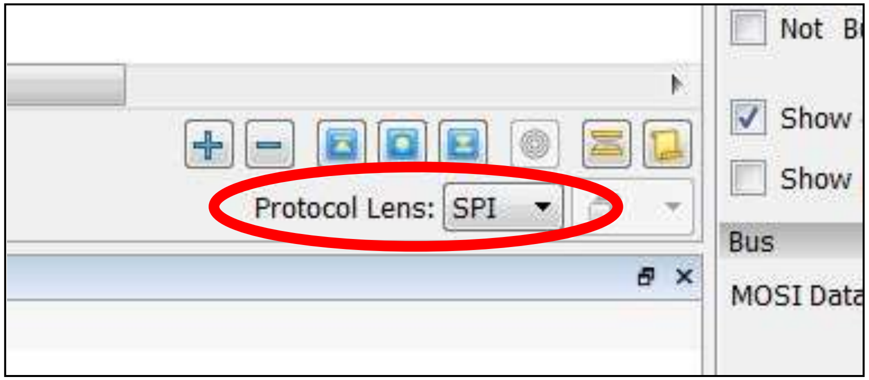
● Rising edge (Mode 0, Mode 3)

○ Falling edge (Mode 1, Mode 2)

Slave Select Polarity

● Slave select active low





Protocol Lens: SPI

□ Not B

☑ Show

□ Show

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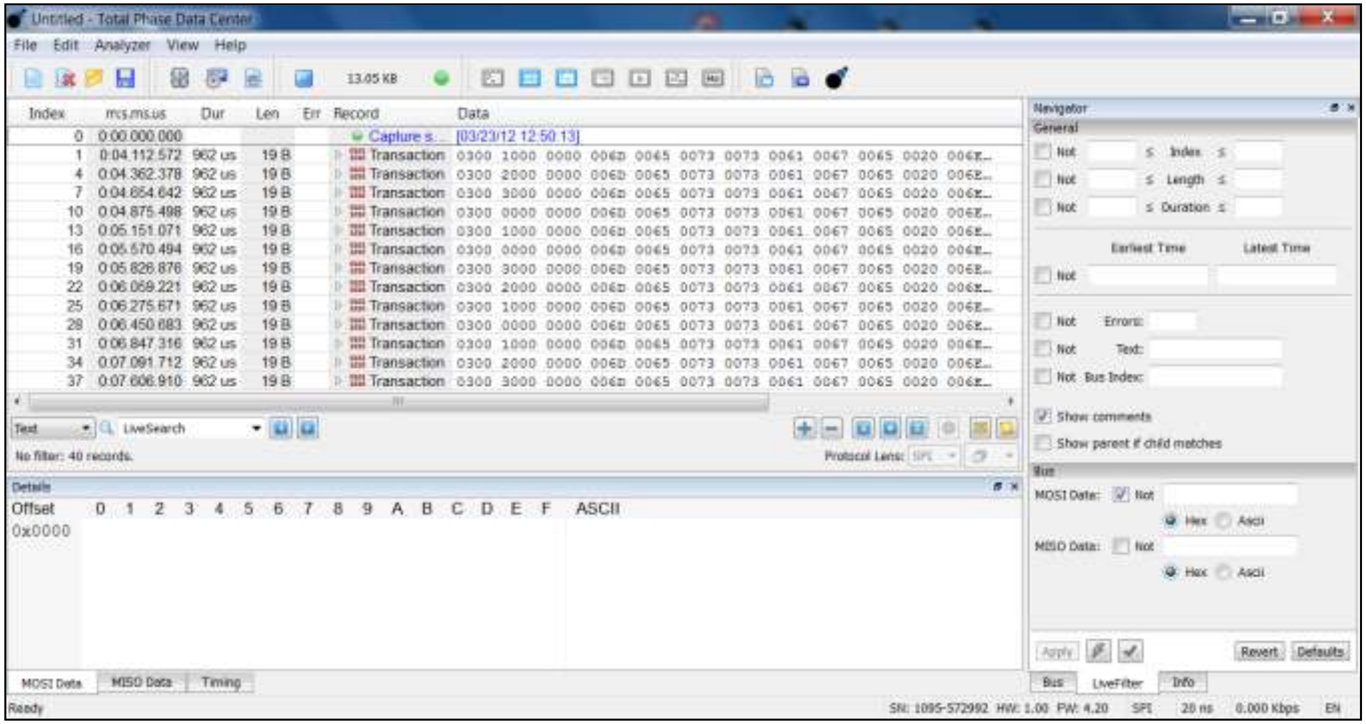
Bug 2: SPI Programming

Finding the SPI Bug

17. Click the buttons on the Kinetis Tower

18. Observe the behavior in the Data Center Software



Index	m:s.ms.us	Dur	Len	Err	Record	Data
0	0:00.000.000				Capture s...	[03/23/12 12:50:13]
1	0:04.112.572	962 us	19 B		Transaction	0300 1000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
4	0:04.362.378	962 us	19 B		Transaction	0300 2000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
7	0:04.654.642	962 us	19 B		Transaction	0300 3000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
10	0:04.875.498	962 us	19 B		Transaction	0300 0000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
13	0:05.151.071	962 us	19 B		Transaction	0300 1000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
16	0:05.570.494	962 us	19 B		Transaction	0300 0000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
19	0:05.826.876	962 us	19 B		Transaction	0300 3000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
22	0:06.069.221	962 us	19 B		Transaction	0300 2000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
25	0:06.275.671	962 us	19 B		Transaction	0300 1000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
28	0:06.450.683	962 us	19 B		Transaction	0300 0000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
31	0:06.847.316	962 us	19 B		Transaction	0300 1000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
34	0:07.091.712	962 us	19 B		Transaction	0300 2000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
37	0:07.606.910	962 us	19 B		Transaction	0300 3000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...

No filter: 40 records.

Offset 0 1 2 3 4 5 6 7 8 9 A B C D E F ASCII
0x0000

Ready SN: 1095-572992 HW: 1.00 FW: 4.20 SPI 20 ns 0.000 Kbps EN

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Bug 2: SPI Programming

__Debugging the SPI EEPROM__

- SPI EEPROM size = 1 kilobyte
- Understanding read format

	Opcode	Addr	Data	Data	Data
read:	0x03	0xAAAA	0xDD	0xDD	…

- Use the Data Center Software to debug

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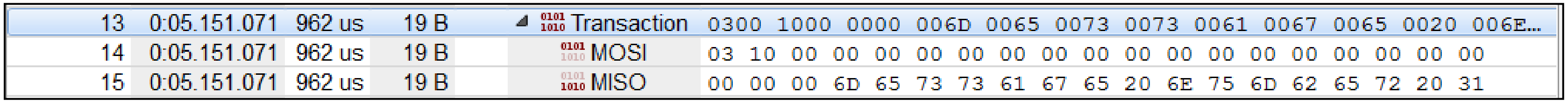
Bug 2: SPI Programming

Solution

- Address has the wrong endianness



13	0:05.151.071	962 us	19 B	◢ 0101 1010 Transaction	0300 1000 0000 006D 0065 0073 0073 0061 0067 0065 0020 006E...
14	0:05.151.071	962 us	19 B	0101 1010 MOSI	03 10 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
15	0:05.151.071	962 us	19 B	0101 1010 MISO	00 00 00 6D 65 73 73 61 67 65 20 6E 75 6D 62 65 72 20 31

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Bug 2: SPI Programming

Solution

- Original code (in read_eeprom) in Line 84

```
// Message address
uint16_t addr = 0x10 * msg_index;
* (uint16_t) (&out_data[1]) = addr;
```

- Modified code

```
// Message address
uint16_t addr = 0x10 * msg_index;
out_data[1] = addr >> 8;
out_data[2] = addr & 0xff;
```

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Feature: I2C LEDs

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Feature: I2C LEDs

- **Objective**: Use the buttons on the Kinetis Tower to control the LEDs

- **Task**: Use the Total Phase tools to prototype the advanced feature for the I2C LEDs and then implement on the Kinetis Tower

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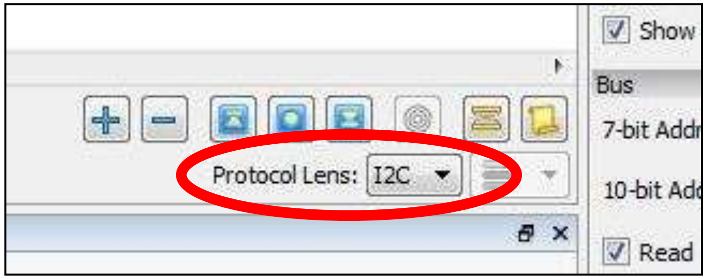
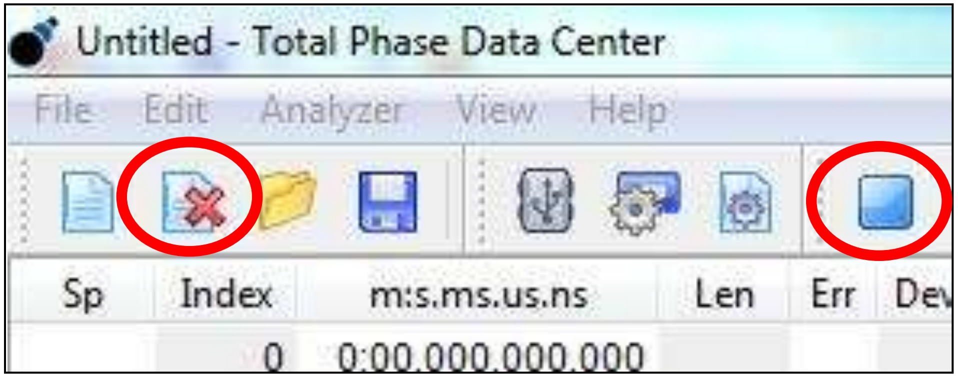
Feature: I2C LEDs

Configuring the Data Center Software to run an I2C capture

1. Go back to the Data Center Software running SPI
2. **Stop** the capture
3. **Clear** the transaction window
4. Change the **Device Settings** and **Protocol Lens** to **I2C**



Protocol Lens: I2C


Untitled - Total Phase Data Center

Sp	Index	m:s.ms.us.ns	Len	Err	Dev
	0	0:00.000.000.000			

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Feature: I2C LEDs

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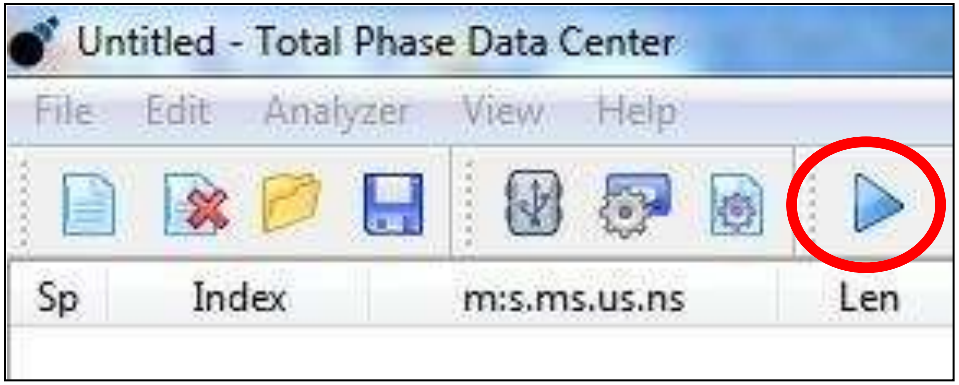
4. Change the **Device Settings** and **Protocol Lens** to **I2C**
5. **Start** the capture



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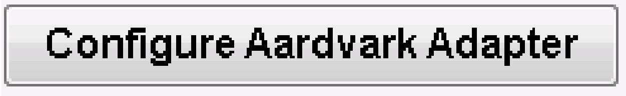
Feature: I2C LEDs

Configuring the Control Center Software for use

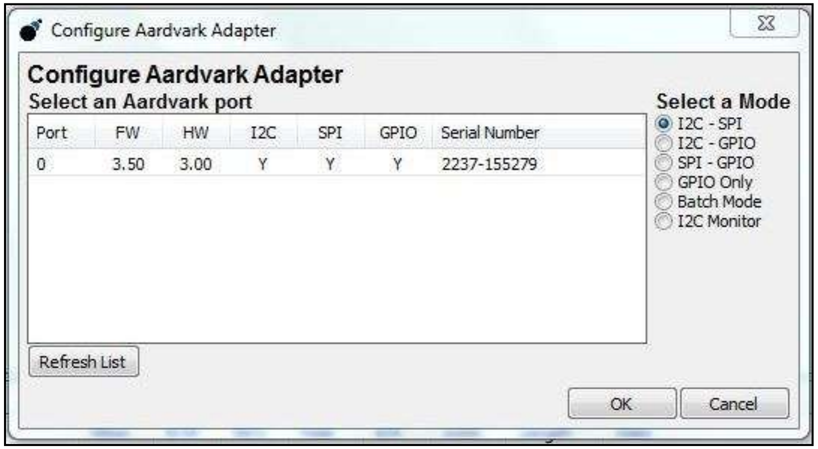
6. Close the **Flash Center Software**

7. Launch the **Aardvark_GUI.exe** to open the Control Center Software

8. Click on **Configure Aardvark Adapter**



9. Select the device and click **OK**



Configure Aardvark Adapter

Select an Aardvark port

Port	FW	HW	I2C	SPI	GPIO	Serial Number
0	3.50	3.00	Y	Y	Y	2237-155279

Select a Mode

- ● I2C - SPI
- ○ I2C - GPIO
- ○ SPI - GPIO
- ○ GPIO Only
- ○ Batch Mode
- ○ I2C Monitor

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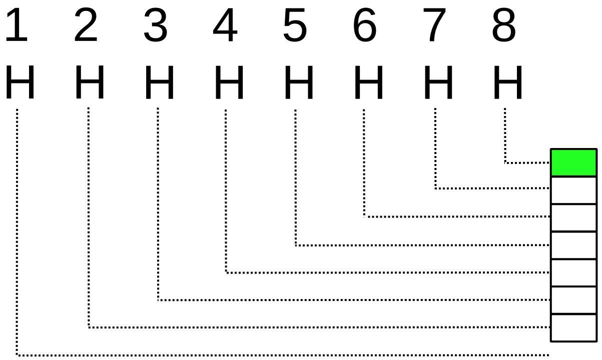
Feature: I2C LEDs

Understanding the I2C Lights

- Command structure for communicating with I2C LEDs

	Addr	Cmd	Data
Init:	0x38	0x03	0x00

	Addr	Cmd	Data
Updating:	0x38	0x01	0xHH



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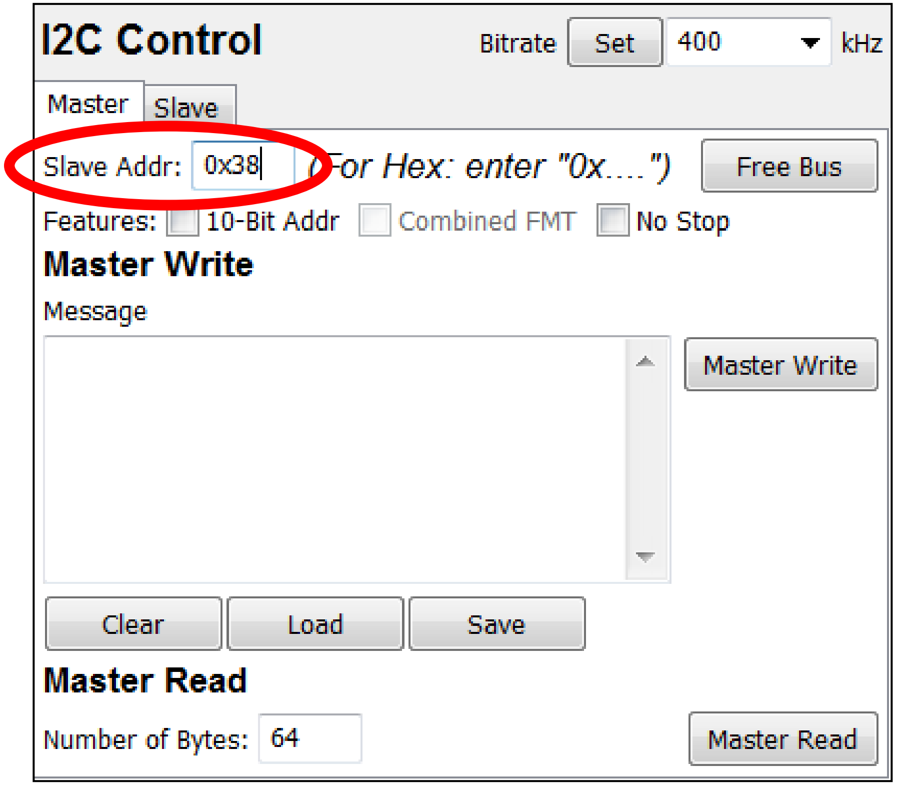
Feature: I2C LEDs

Configuring the Control Center Software for use

10. Type in the slave address 0x38



I2C Control

Bitrate 400 kHz

Master Slave

Slave Addr: 0x38 (For Hex: enter "0x....")

Features: □ 10-Bit Addr □ Combined FMT □ No Stop

Master Write

Message

Master Read

Number of Bytes: 64

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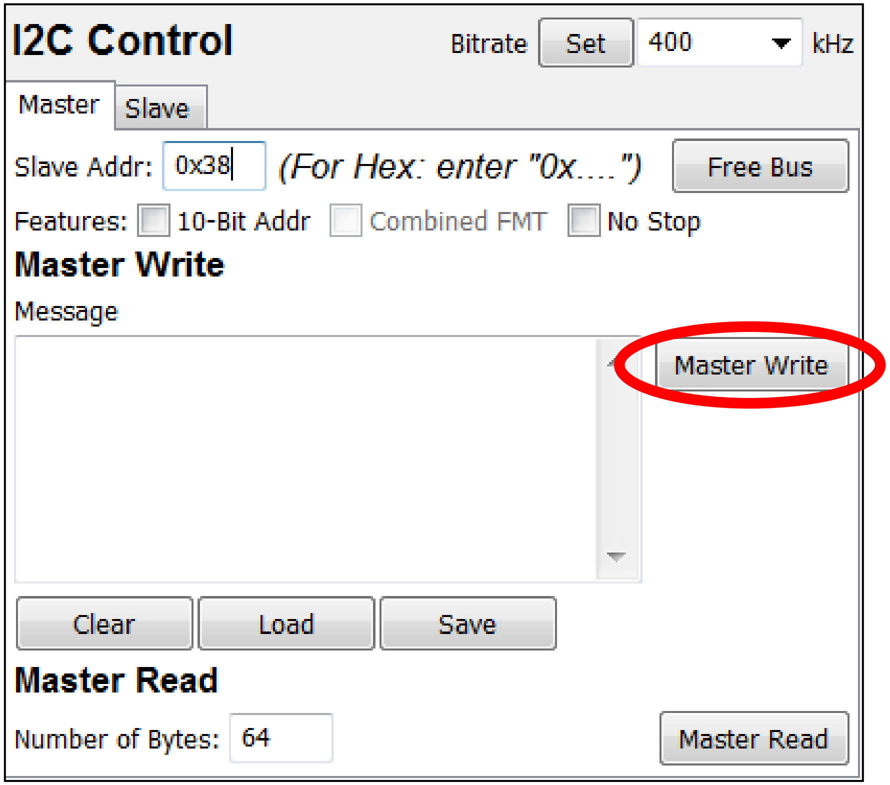
Feature: I2C LEDs

Initializing the LEDs

11. Type **03 00** in the message box.



I2C Control

Bitrate 400 kHz

Slave Addr: 0x38 *(For Hex: enter "0x....")*

Features: □ 10-Bit Addr □ Combined FMT □ No Stop

Master Write

Message

Master Read

Number of Bytes: 64

12. Click **Master Write**

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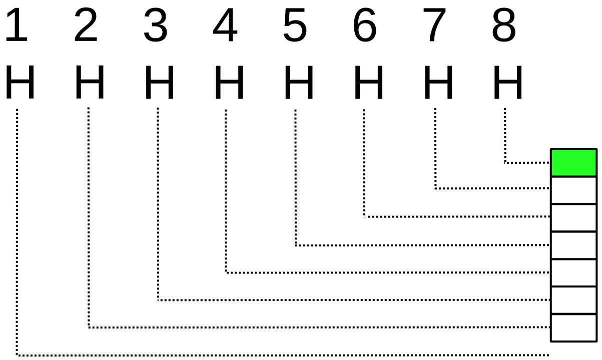
Feature: I2C LEDs

Understanding the I2C Lights

- Command structure for communicating with I2C LEDs

	Addr	Cmd	Data
Init:	0x38	0x03	0x00

	Addr	Cmd	Data
Updating:	0x38	0x01	0xHH



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Feature: I2C LEDs

- Function to communicate with I²C slaves:
  - Call i2c_write (uint8_t slave_addr, uint8_t *data, int len);

- Implement:
  - static void init_leds()
  - static void set_leds(u08 index)

- Observe implementation with Beagle Data Center software

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Feature: I2C LEDs

Solution

13. Implement init_leds and set_leds in main.c

```
void init_leds () {
  uint8_t data[2];
  data[0] = 0x03;
  data[1] = 0x00;
  i2c_write(0x38, data, 2);
}

void set_leds (uint8_t val) {
  uint8_t data[2];
  data[0] = 0x01;
  data[1] = ~(0x01 << val);
  i2c_write(0x38, data, 2);
}
```

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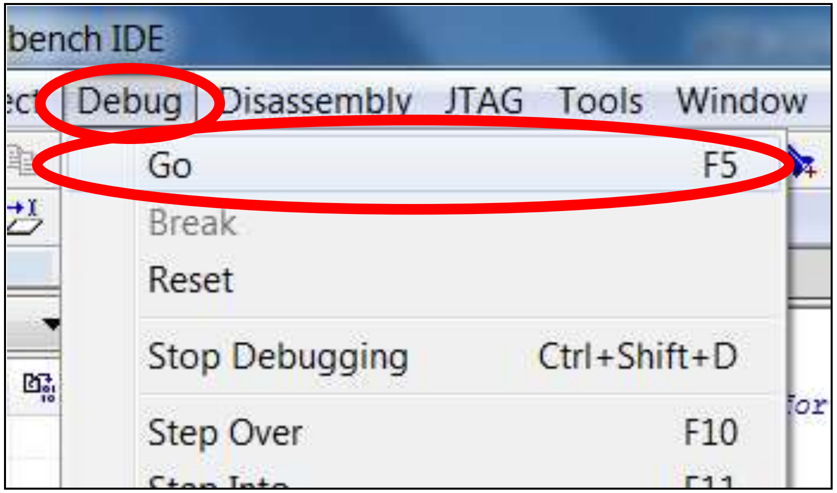
Feature: I2C LEDs

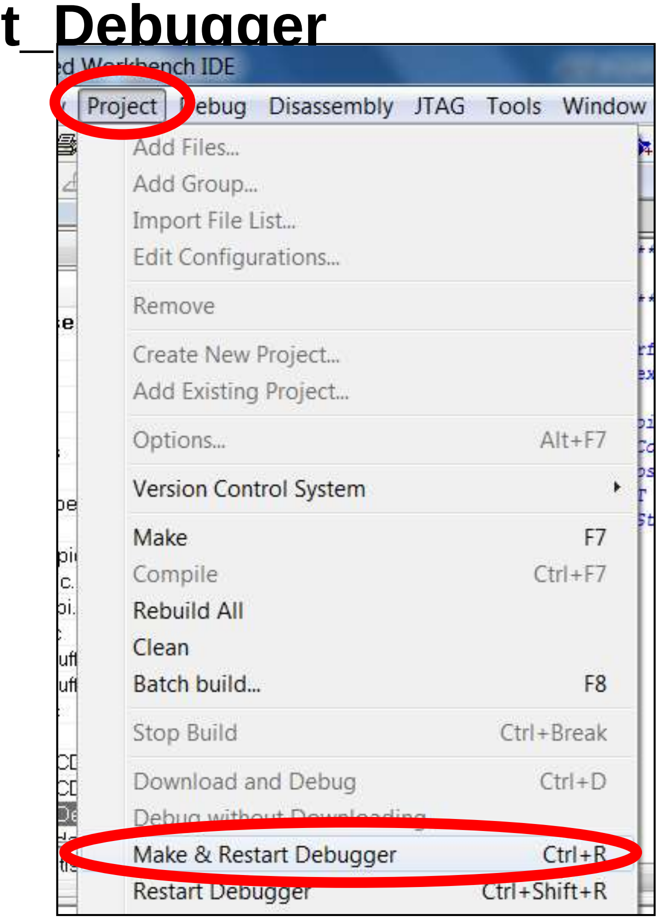
Verifying the Solution

14. Select **Project → Make_Restart_Debugger**

15. Select **Debug → Go**

16. Press Switch 3





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Questions

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Thank You

Don’t forget to fill out the evaluation form.

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