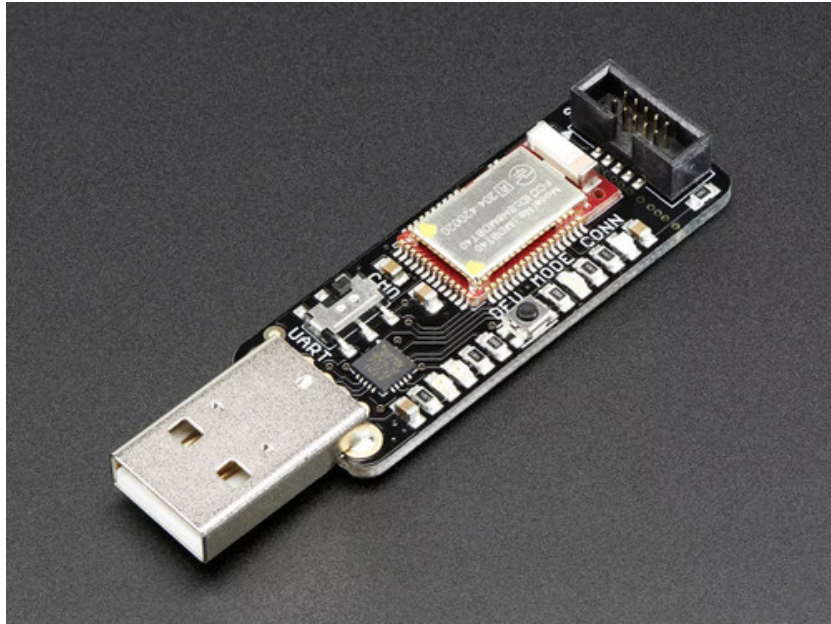




## Introducing the Adafruit Bluefruit LE Friend

Created by Kevin Townsend



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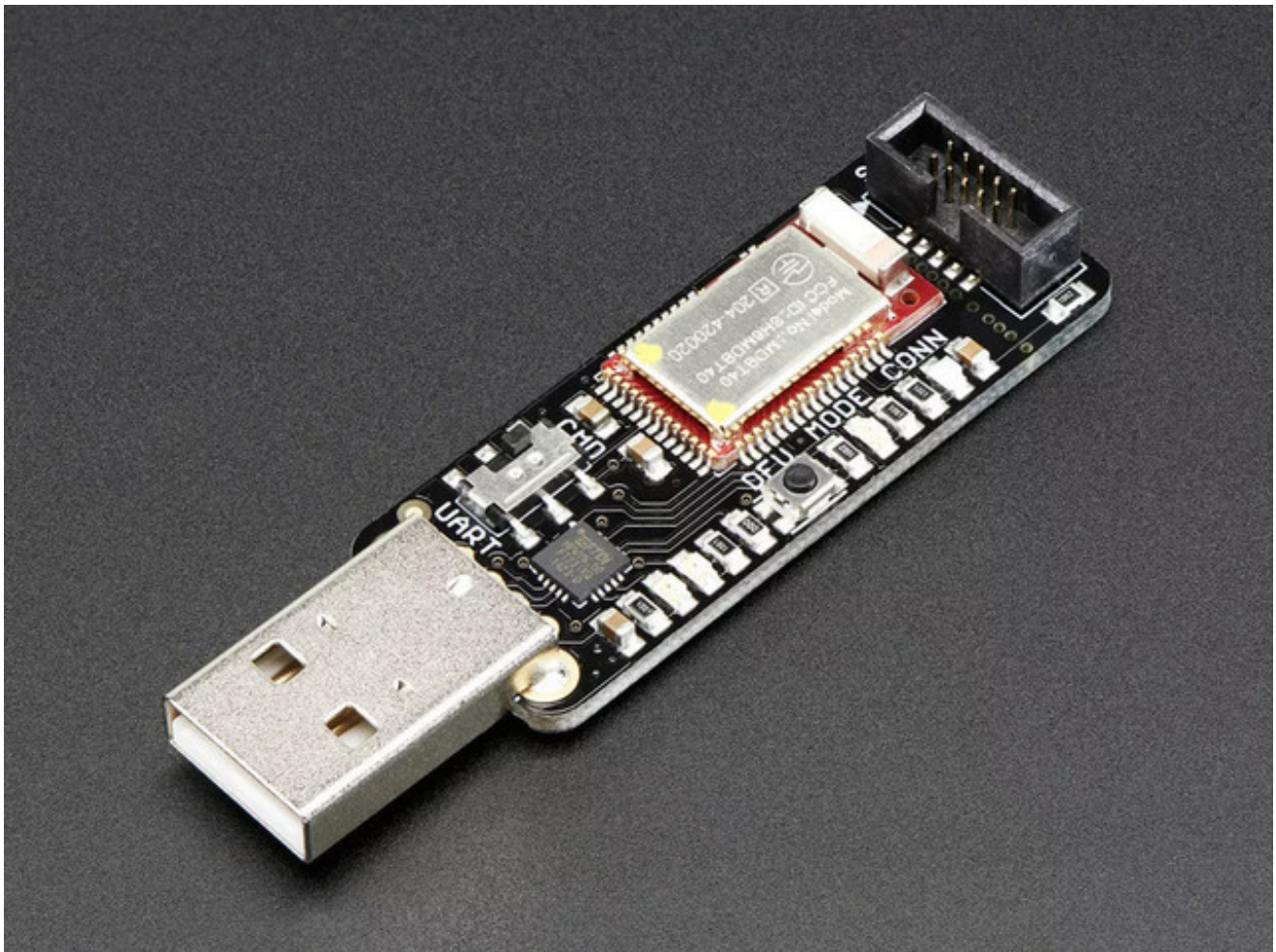
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# Introduction

The BLEFriend makes it easy to get any USB enabled device talking to your BLE enabled phone or tablet using a standard USB CDC connection.

Please note that there are two versions of this board. An older v1.0 blue PCB which uses 16KB SRAM parts and can run firmware 0.5.0 and lower, and a newer v2.0 black PCB that uses the latest 32KB parts and can run old firmware plus version 0.6.2 and higher.



In it's simplest form, it works on the same principle as a common USB/Serial adapter (the [FTDI Friend](http://adafru.it/dQa) (<http://adafru.it/dQa>), for example!). Any data that you enter via your favorite terminal emulator on your development machine will be transferred over the air to the connected phone or tablet, and vice versa.

## Why Not Just Use a BLE USB Dongle?

Good question! You can get a [Bluetooth 4.0 USB dongle \(http://adafru.it/ecb\)](http://adafru.it/ecb) from the store already, and it's a useful tool to have (particularly on the Raspberry Pi or BBB), but that won't solve some problems out of the box.

To start with, Bluez (Linux) has a decent learning curve (and doesn't run on OS X if you're a Mac user). Windows 7 doesn't even support Bluetooth Low Energy, and on OS X you'll have to sort through the native Bluetooth APIs and development tools that require an annual paid license and specific license terms to access. There isn't a standard, open source, cross-platform way to talk BLE today.

With the BLEFriend, you can be up and running in under an hour on just about anything with a USB port, with easy migration across platforms and operating systems. It's not perfect (it's currently a peripheral mode only solution), but it's the easiest way you'll find to get any USB device talking to your iOS or Android device.

## So it's a Fancy Pants Wireless UART Adapter?

The board is capable of much more than simulating a basic UART bridge (and this is still early days for the Bluefruit LE board family)! Thanks to an easy to learn [AT command set \(http://adafru.it/iCO\)](http://adafru.it/iCO), you can also [create you own basic GATT Services \(http://adafru.it/iCP\)](http://adafru.it/iCP) and Characteristics, [simulate Beacons \(http://adafru.it/iCu\)](http://adafru.it/iCu), and change the way that the device advertises itself for other Bluetooth Low Energy devices to see.

To make sure that your device stays up to date and can benefit from the latest Bluefruit LE firmware from Adafruit, you can also [update the firmware on your BLEFriend over the air \(http://adafru.it/iCQ\)](http://adafru.it/iCQ) using any supported iOS or Android device.

You can even pick up a sniffer edition of the board that comes pre-flashed with special firmware that [turns your BLEFriend into a low cost Bluetooth Low Energy sniffer \(http://adafru.it/iCR\)](http://adafru.it/iCR), capturing data and pushing it out to Wireshark. We currently offer this as a separate product, though, since the firmware isn't compatible with the over the air bootloader used on the standard products, but we'll address this in the future with a tutorial for J-Link owners, allowing you to switch between modes using your SWD debugger.

## Why Use Adafruit's Module?

There are plenty of BLE modules out there, with varying quality on the HW design as well as the firmware. We always try to keep the bar as high as possible at Adafruit, and one of the biggest advantages of the BLEFriend and the entire Bluefruit LE family is that **we wrote all of the firmware running on the devices ourselves from scratch.**

We control every line of code that runs on our modules ... and so we aren't at the mercy of any third party vendors who may or may not be interested in keeping their code up to date or catering to our customer's needs.



Because we control everything about the product, we add features that are important to *our* customers, benefit from being able to use the latest Bluetooth specifications, can solve any issues that do come up without having to persuade a half-hearted firmware engineer on the other side of the planet, and we can even change Bluetooth SoCs entirely if the need ever arises!

# Getting Started

If you just want to get up and running quickly, this is the right guide for you, and the QuickStart section should have you up and running in no time.

If you're new to Bluetooth Low Energy, and want to get a high level overview of how data is organized and how devices communicate with each other, you might want to have a look at our [Introduction to Bluetooth Low Energy \(http://adafru.it/iCS\)](http://adafru.it/iCS) learning guide, or buy [Getting Started with Bluetooth Low Energy \(http://adafru.it/1978\)](http://adafru.it/1978) from the store.\*

\* Full disclosure: co-written by me :)

# QuickStart Guide

The BLEFriend board is designed to be easy to use and get started with.

In most circumstance, the only thing you'll need is an FTDI driver, and a terminal emulator to start working with BLE from your development machine.

This guide will explain some of the different [operating modes](http://adafru.it/iCT) that the BLEFriend board can be configure to operate in, how to setup your [terminal emulator](http://adafru.it/iCU) to start talking to the BLEFriend, and a basic example of [sending bi-directional data](http://adafru.it/iCV) between the BLEFriend and a BLE-enabled phone or tablet.

The BLEFriend is (of course) capable of much more than basic UART data exchanges! You can use it to create custom GATT services and characteristics. You can [emulate a Beacon](http://adafru.it/iCu) for indoor navigation purposes. You can [update the firmware on your device](http://adafru.it/iCQ) over the air, or even develop your own firmware thanks to the on-board SWD connector if you possess a HW debugger like the Segger J-Link.

Depending on the version of the board you have or whether or not you have access to a J-Link, you can even use the BLEFriend as a powerful [Bluetooth Low Energy sniffer](http://adafru.it/iCW) to debug or reverse engineer existing BLE devices, and write your own custom applications or drivers for existing HW!

Have a look through this quick start guide to familiarise yourself with the basics, though, and you should be able to quickly move on to more advanced topics in no time!

# HW Setup

## Software Requirements

Setting up the BLEFriend is super easy. All you need to start talking to the device is a standard FTDI driver for the FT231x located on the device.

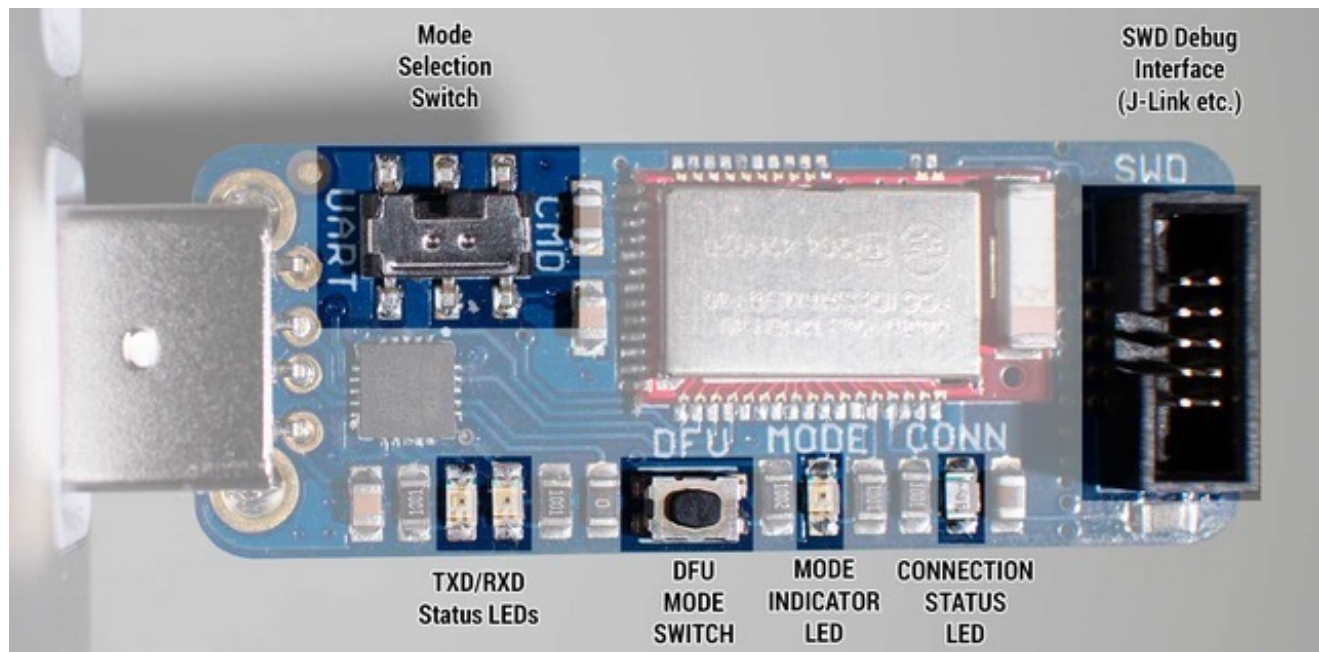
Find the appropriate FTDI VCP installer on the [FTDI Driver Download Page \(http://adafru.it/aJv\)](http://adafru.it/aJv), install it on you system, and then insert the BLEFriend in any USB port on your system.

Currently Supported VCP Drivers:

Operating System	Release Date	Processor Architecture							Comments	
		x86 (32-bit)	x64 (64-bit)	PPC	ARM	MIPSII	MIPSIV	SH4		
Windows*	2014-09-29	Available as <a href="#">setup.executable</a> Contact <a href="mailto:support1@ftchip.com">support1@ftchip.com</a> if looking to create customised drivers					-	-	-	2.12.00 WHQL Certified Available as <a href="#">setup.executable</a> <a href="#">Release Notes</a>
Linux	2009-05-14	1.5.0	1.5.0	-	-	-	-	-	All FTDI devices now supported in Ubuntu 11.10, kernel 3.0.0-19 Refer to <a href="#">TN-101</a> if you need a custom VCP VID/PID in Linux	
Mac OS X	2012-08-10	2.2.18	2.2.18	2.2.18	-	-	-	-	Refer to <a href="#">TN-105</a> if you need a custom VCP VID/PID in MAC OS	

## HW Layout

There are a few items on the BLEFriend you should be familiar with before you start working with it. To help you get started quickly, we've highlighted them in the image below:



## Mode Selection Switch

This switch can be moved between 'CMD' (Command Mode) and 'UART' (Data Mode), which will change the way that the device behaves in your terminal emulator.

For more information on these two operating modes, see the [Operating Modes \(http://adafru.it/iCT\)](http://adafru.it/iCT) page in this learning guide.

## TXD/RXD Status LEDs

These two LEDs are provided primarily for debug purposes to help you visualise the incoming and outgoing characters over the USB CDC interface.

## DFU Mode Switch

Holding this switch down when you insert the device into the USB port will cause the device to enter a special 'DFU' mode, which allows you to update the firmware over the air.

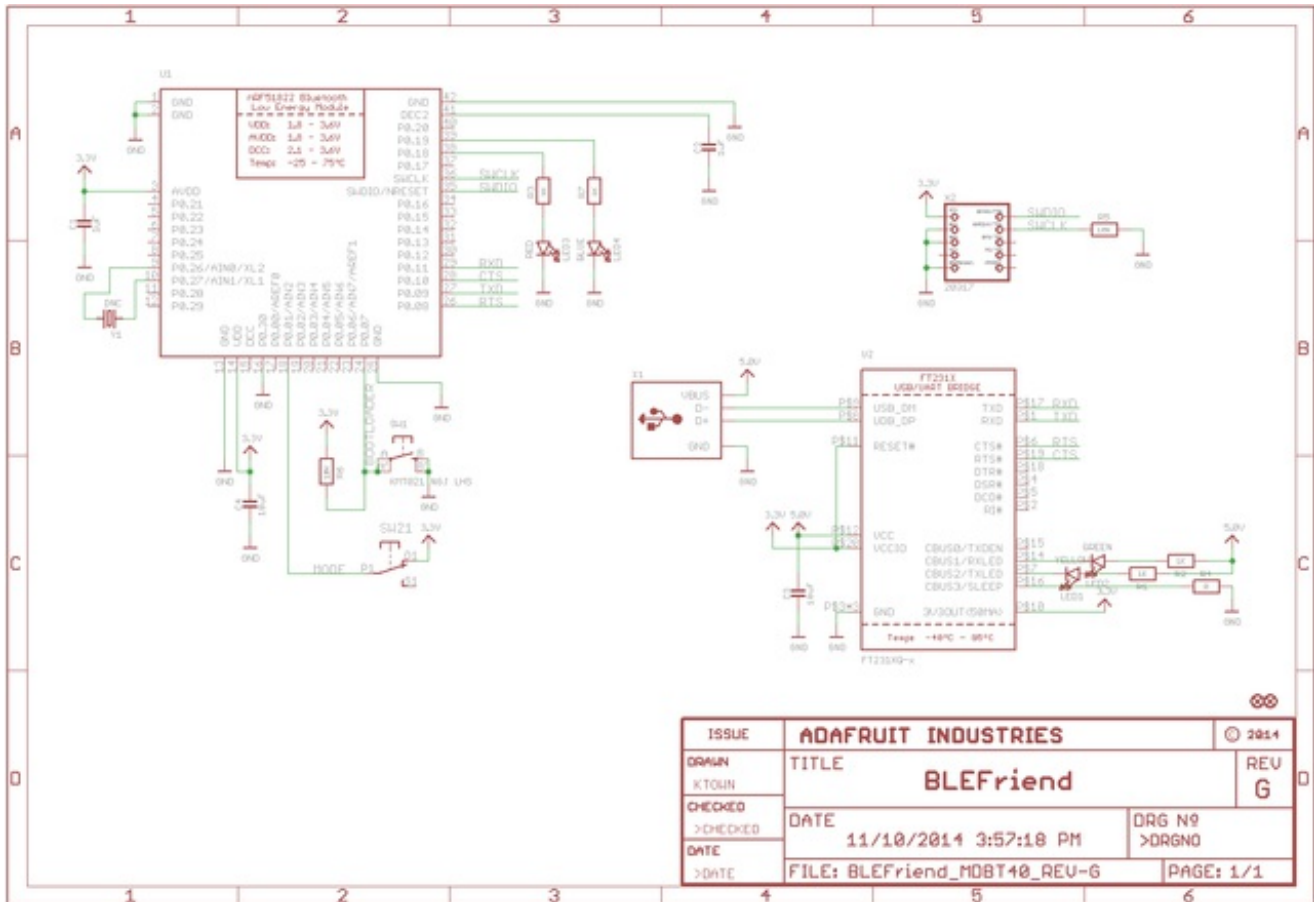
For more information on DFU mode see the [Field Updates \(http://adafru.it/iCQ\)](http://adafru.it/iCQ) page.

## Mode Indicator LED

This LED is used to indicate the mode that the device is currently operating in (Data, Command or DFU).

## Connection Status LED

This LED will be enabled when the BLEFriend has successfully established a connection with another BLE device, and it useful for debugging purposes.



# Operating Modes

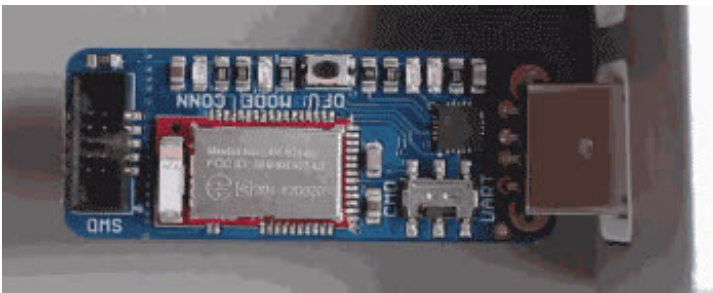
BLEFriend modules can be operated in one of three modes:

## Data Mode

Data mode makes use of the BLE UART Service, and turns the BLEFriend into a HW UART bridge between a BLE Central device (your phone or tablet) and your PC or USB-enabled device.

To use data mode, simply connect your BLEFriend module to the USB port on your PC, mode the mode selection switch to **UART** and start sending or receiving data at 9600 bps using your favorite terminal software.

If the MODE LED blinks twice followed by a three second delay you are in **Data Mode**:

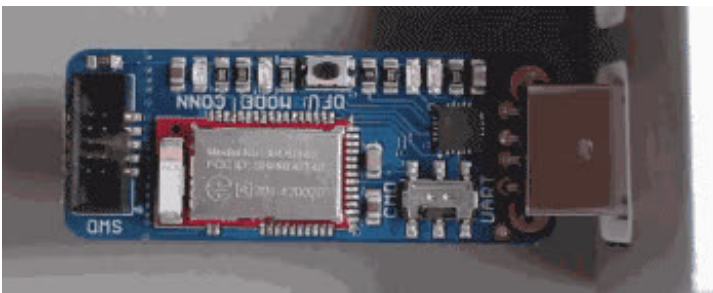


## Command Mode

Command mode is used to send configuration commands to the module or retrieve information about the module itself or the device connected on the other side of the BLE connection.

To use command mode, make sure that the mode selection switch is set to **CMD**, and enter a valid Hayes AT style command using your favorite terminal emulator at 9600 bps (for example 'ATI' to display some basic info about the module).

If the MODE LED blinks three times followed by a three second delay you are in **Command Mode**:



For more information on this operating mode see the dedicated [Command Mode](http://adafru.it/iCO) page in this learning guide.

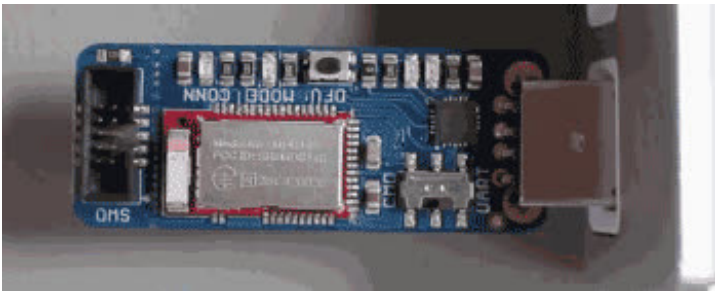
# DFU Mode

DFU Mode (which stands for 'device firmware upgrade' or sometimes 'device field update') is a special mode that allows you to update the firmware on the BLEFriend over the air using dedicated DFU applications available on iOS and Android.

This allows you to update your device with the latest BLEFriend firmware from Adafruit without having to purchase an external HW debugger like the [Segger J-Link \(http://adafru.it/e9G\)](http://adafru.it/e9G).

To enter DFU mode hold down the **DFU** button while inserting the BLEFriend into the USB port.

If the LED blinks at a constant rate, you know that you are in DFU mode:



For more information on DFU mode see the dedicate [Device Field Update \(DFU\) page \(http://adafru.it/iCQ\)](http://adafru.it/iCQ).

# Terminal Settings

Since the BLEFriend board uses UART for the data transport, you will need to configure your favorite terminal emulator software with the appropriate settings to send or receive data over UART.

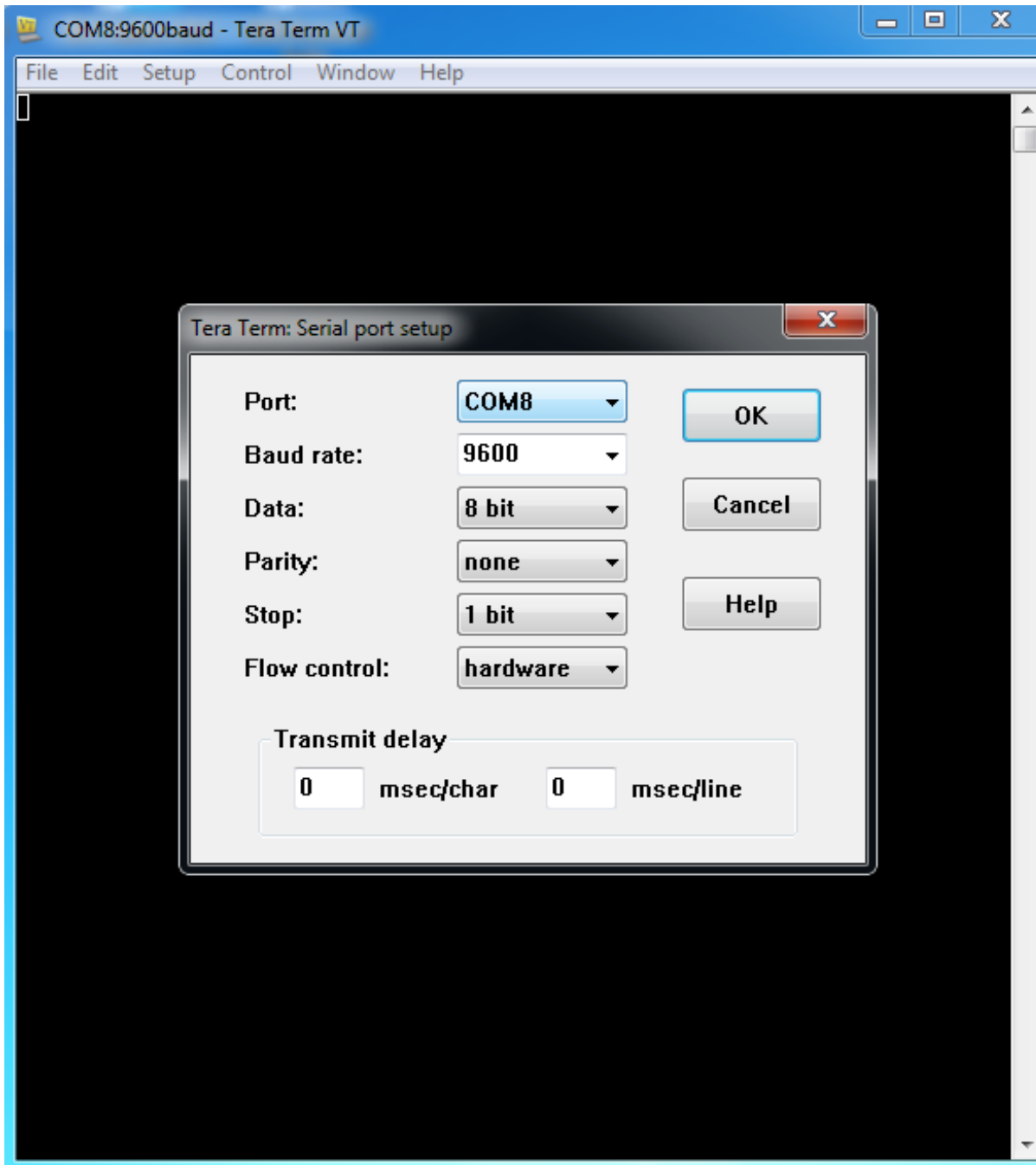
The BLEFriend is configured to run with the following settings:

- **9600 bps**
- **HW flow control** (CTS+RTS)
- **8n1** (8-bit data, no parity, 1 stop bit)

## TerraTerm (Windows)

If you are using Windows we recommend using [TeraTerm](http://adafru.it/e9I) (<http://adafru.it/e9I>), which should be configured as follows (via the 'Setup > Serial Port' menu):

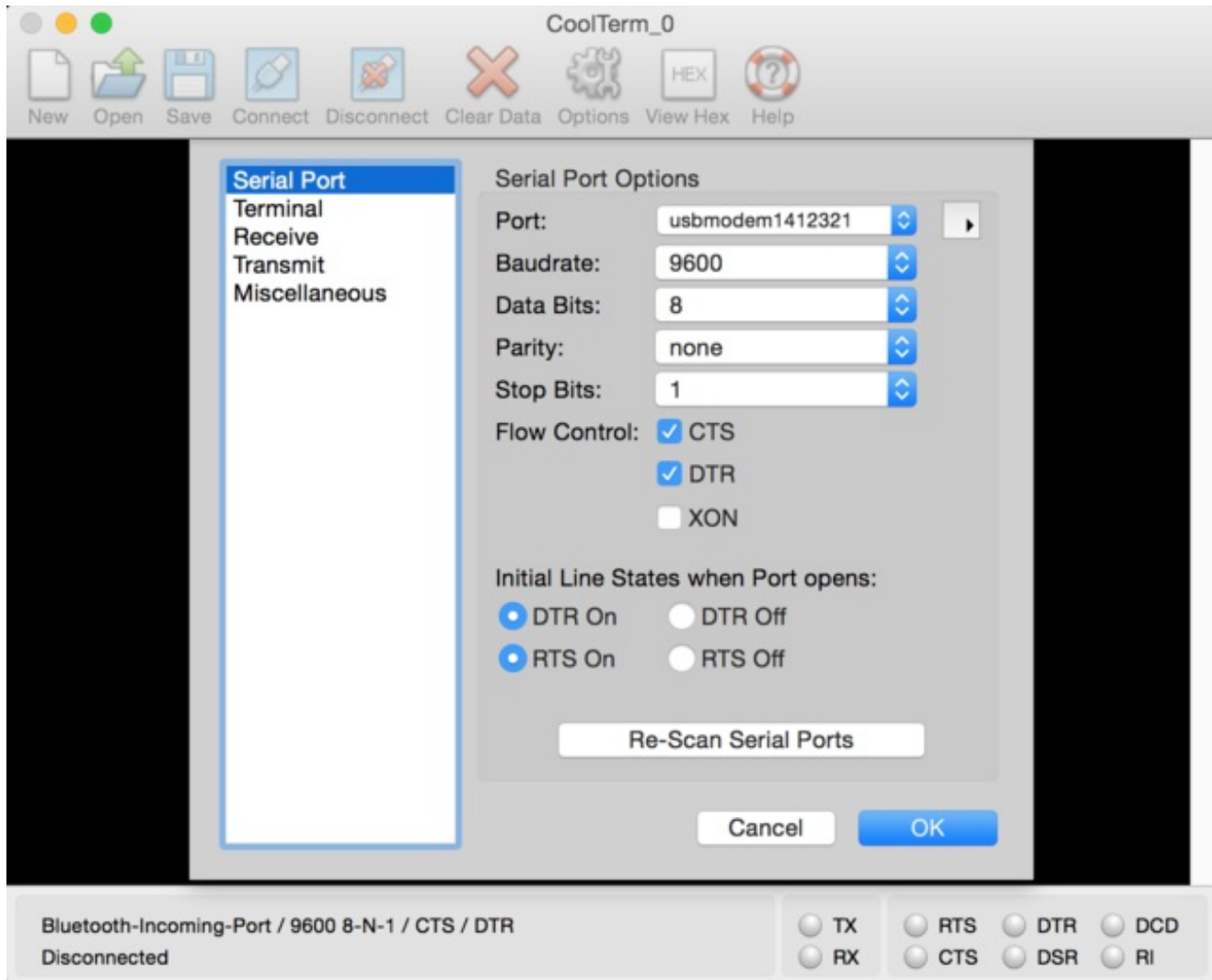




## CoolTerm (OS X)

If you are using OS X, we recommend using [CoolTerm](http://adafru.it/e9J) (<http://adafru.it/e9J>), a free and reasonably fully featured terminal emulator package.

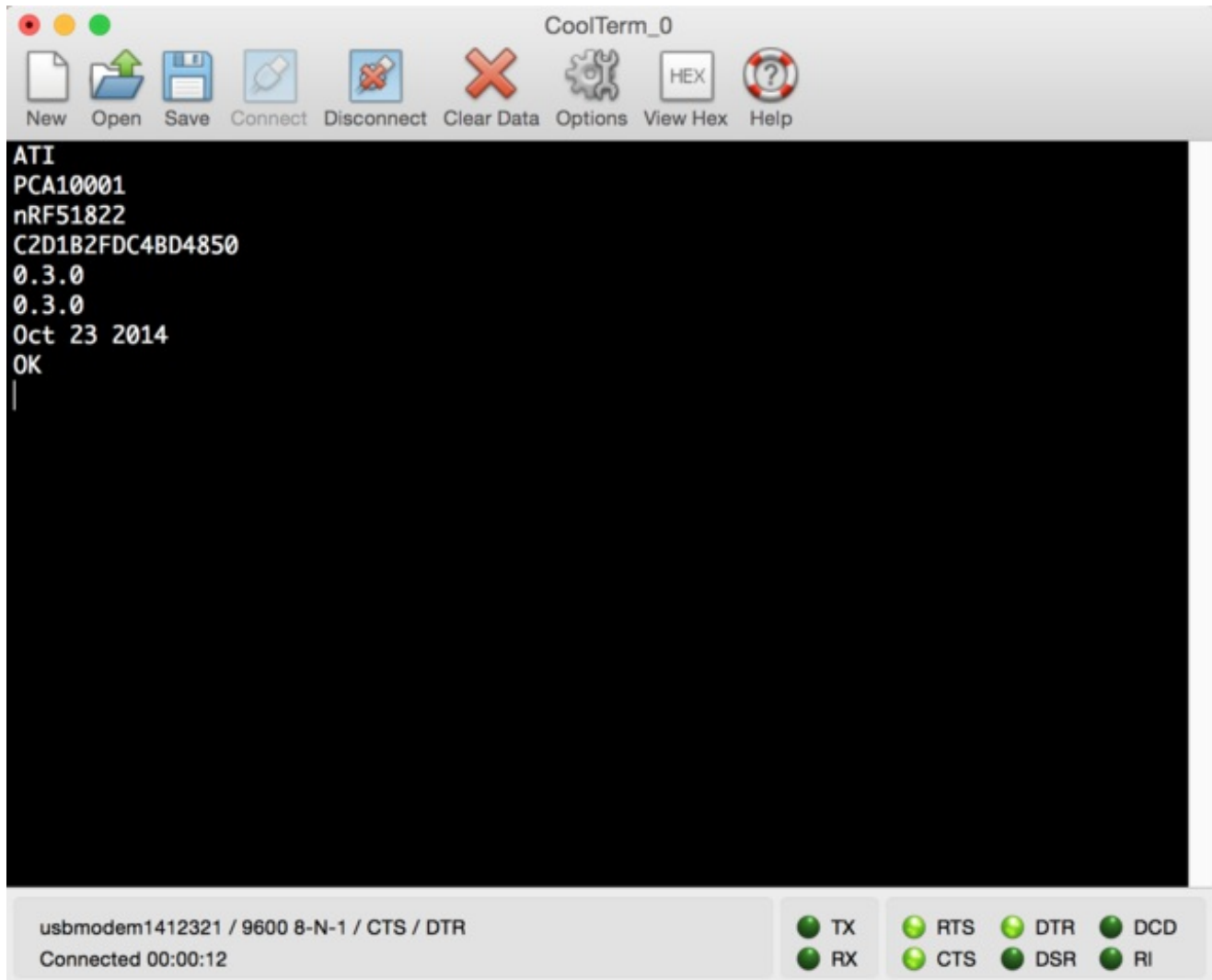
You'll need to set the following configuration options in Coolterm to communicate with the Bluefruit LE Pro module:



Make sure you click the 'Connect' button to open the connection in CoolTerm, and 'Disconnect' to close the connection when you are done.

## Testing the Terminal Config

To make sure the connection is properly configured, you can set the device in **Command Mode** (the LED should blink three times followed by a short delay in this mode), and enter the **ATI** command, as shown below (which will provide some basic information about the BLE module):



Make sure you are in CMD mode or you won't get any echo or AT command replies!

# UART Test

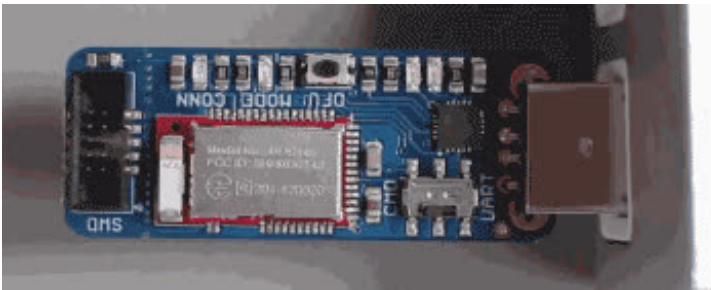
To test out the BLE UART service that is used to transfer data between the BLEFriend and your Bluetooth Low Energy enabled mobile device, you can use the **nRF UART** application from Nordic Semiconductors for [iOS \(http://adafru.it/dd7\)](http://adafru.it/dd7) or [Android \(http://adafru.it/dd6\)](http://adafru.it/dd6).

This tutorial uses the Android version of nRF UART but the iOS UI is reasonably similar.

## BLEFriend Configuration

Set the BLEFriend to **DATA MODE** by placing the mode selector switch (near the USB connector) to the **UART** position.

The 'MODE' indicator LED will blink two times and then pause for three seconds when you are in DATA mode:

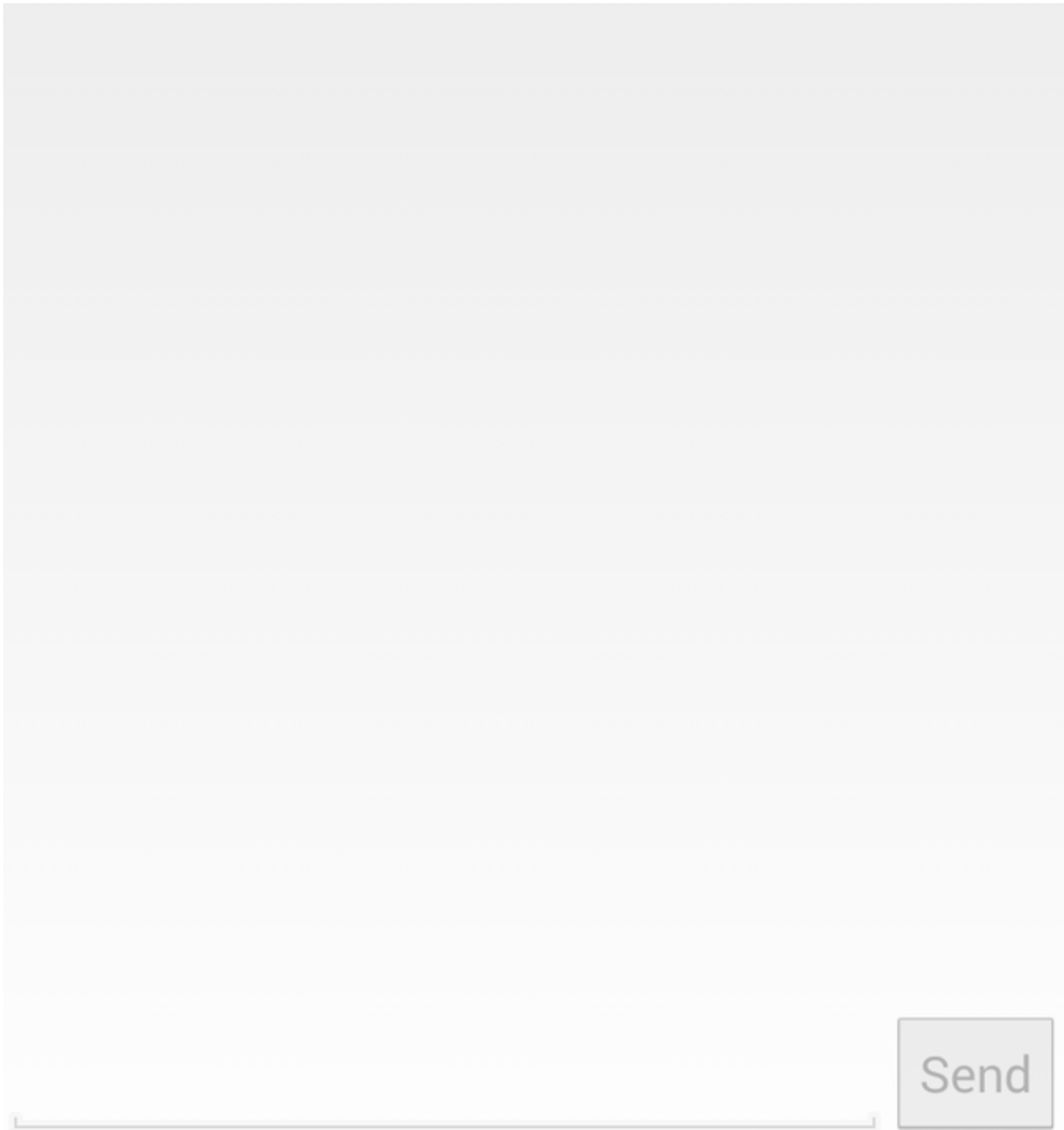


Using your [favorite terminal emulator \(http://adafru.it/iCU\)](http://adafru.it/iCU), connect to the BLEFriend at **9600 baud** with HW flow control enabled.

## nRF UART Configuration

Open the nRF UART application on Android or iOS, and click the 'Connect' button





Send

Device: <Select a device>



After clicking on 'Connect' you should see a list of BLE peripherals in range:





nRF UART v2.0

Connect

nRF UART v2.0

Select a device



UART

E4:C6:C7:31:95:11

Rssi = -73

14:99:E2:05:29:CF

Rssi = -90

Gear Fit (E52B)

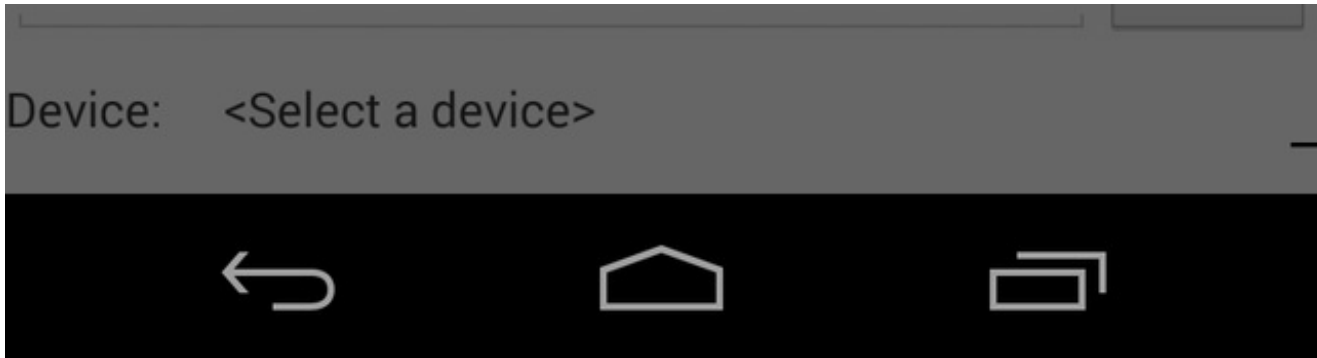
68:48:98:B8:E5:2B

Rssi = -82

paired

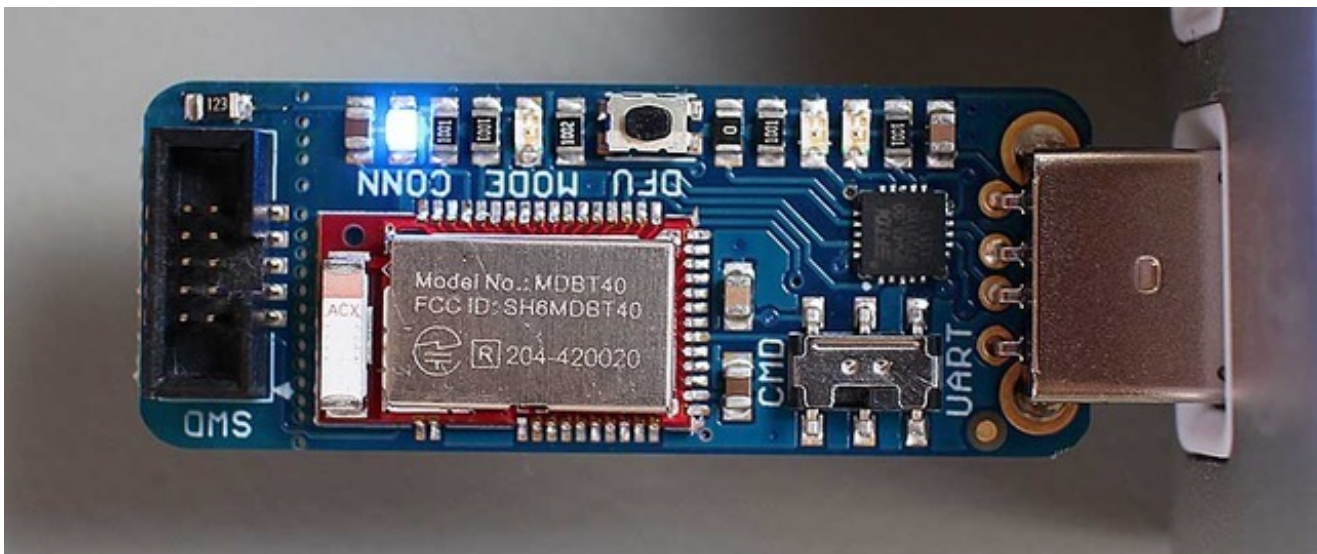
Cancel

Send



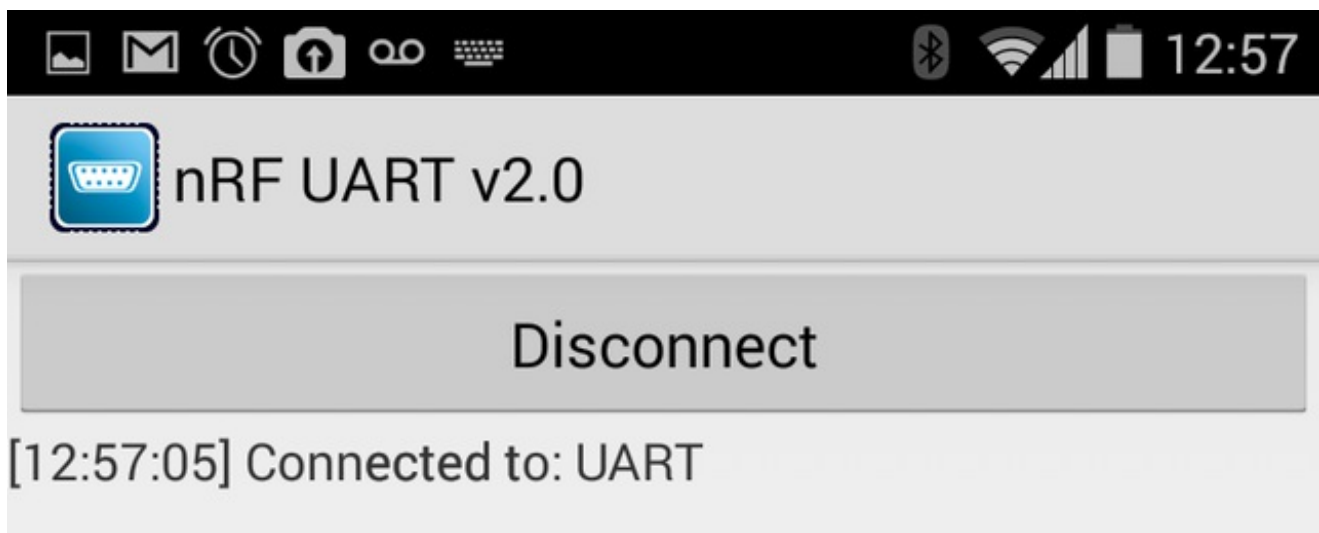
Select the '**UART**' device by clicking on it from the popup selection dialogue, and a connection will be established between the BLEFriend and your phone or tablet.

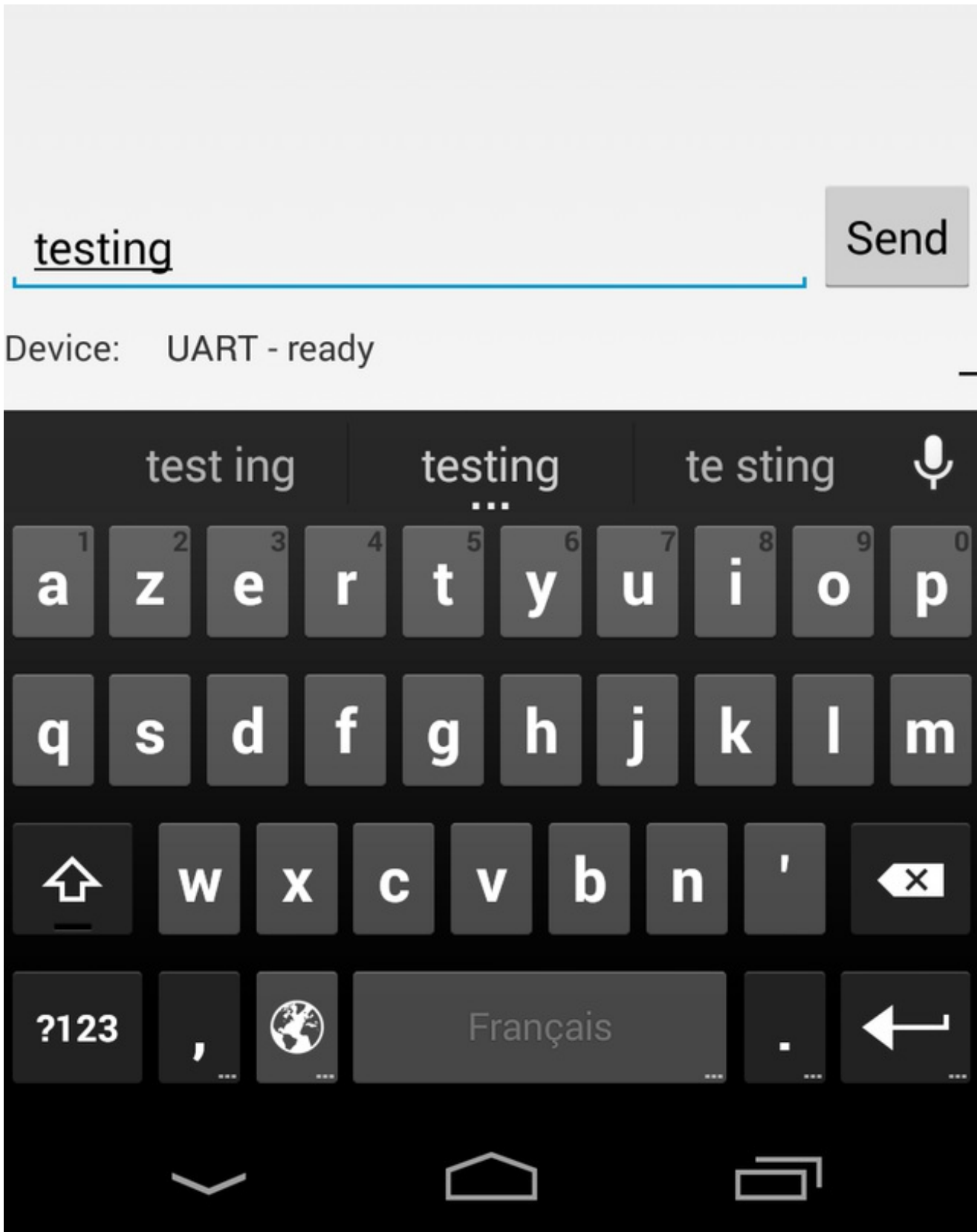
**NOTE:** You know that you are connected to another device when the **CONN** LED is lit up on the BLEFriend:



Once you see the 'Connected To: UART' message in nRF UART, you can start sending and receiving data between the two devices using the mobile app or the terminal emulator.

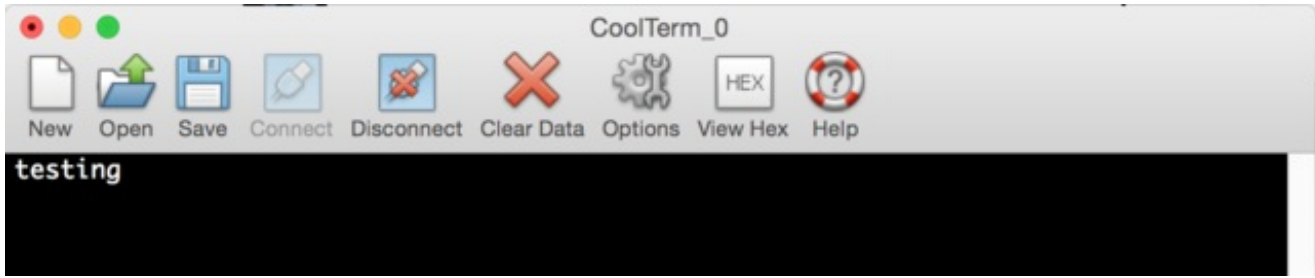
Sending data from one device should cause the text to appear on the other end:



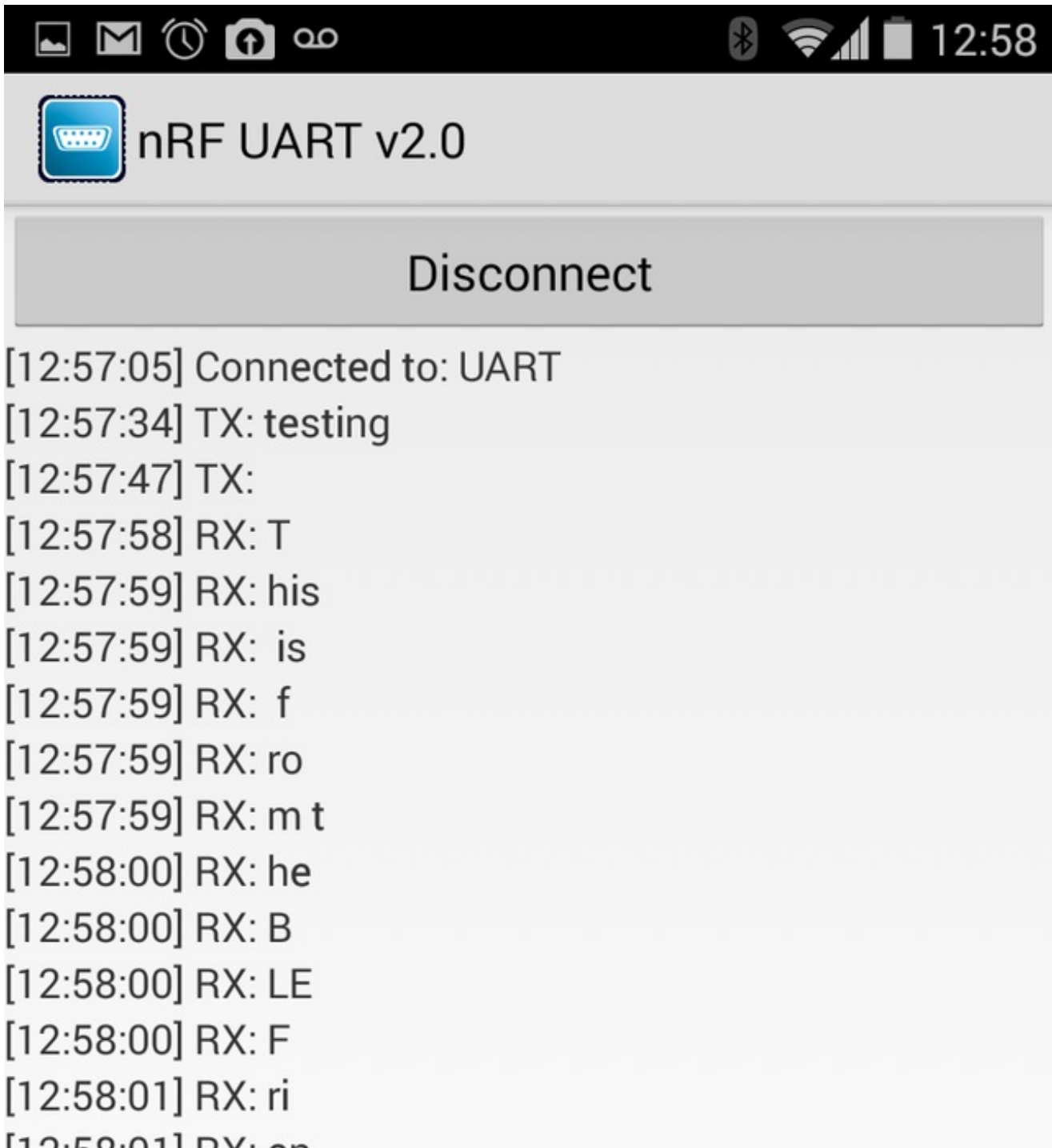


On the BLEFriend side we can see the 'testing' string that was sent from nRF UART in the terminal emulator below:





Typing data into the terminal emulator will cause it to appear in the nRF UART application, as shown below:



[12:58:01] TX: d

[12:58:01] RX: d

Send

Device: UART - ready



The incoming data is broken up into small packets because it is transferred in chunks of up to 20 bytes per payload.

All data transfers in BLE occur at a rate controlled by the BLE central device (the phone or tablet).

Every  $n$  milliseconds, the phone will ping the BLE peripheral (the BLEFriend) and check if there is any data available.

If anything is found in the UART FIFO, for example, it will be sent and data will start to accumulate again in the FIFO until the next connection event.

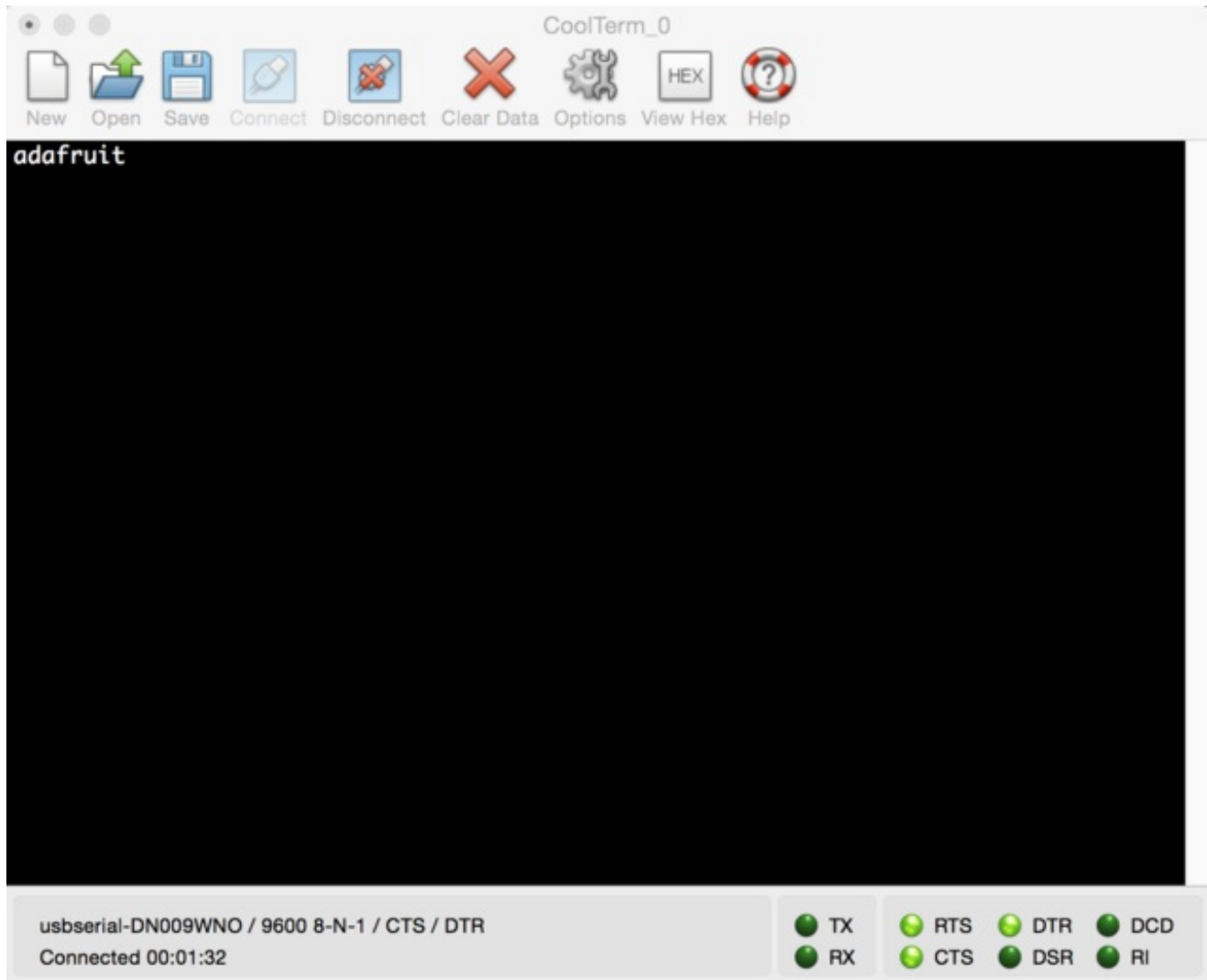
## Sample Video

Download the screen capture below to see nRF UART in action, first receiving 'this is a test' from the BLEFriend (typed in on the terminal emulator), and then sending 'adafruit' out to the BLEFriend, where it will appear in the terminal emulator.

nRFUART\_640.mp4

<http://adafru.it/ea5>

Depending on which terminal emulator SW you use, you would see something like this on your development machine running a similar demo yourself:



# Factory Reset

As of version 0.5.0+ of the firmware, you can perform a factory reset by holding the DFU button down for 10s until the blue CONNECTED LED lights up, and then releasing the button.

If you have any problems with your BLEFriend module, you can perform a factory reset by entering command mode (set the mode selection switch to 'CMD'), and entering the following command in your terminal emulator:

```
AT+FACTORYRESET
```

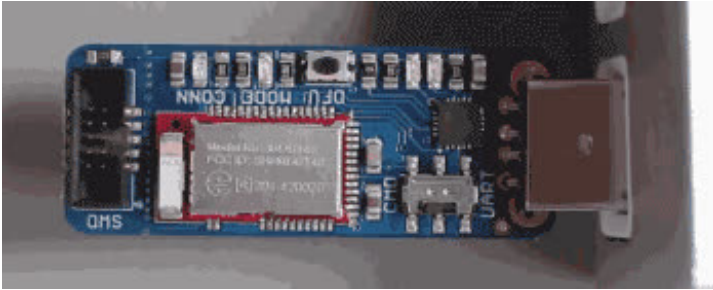
This will erase the non volatile memory section where the config data is stored and reset everything to factory default values, and perform a system reset.

When you see the 'OK' response the device should be ready to use.

# Command Mode

By placing the BLEFriend module in 'Command' mode (set the mode selection switch to **CMD**) you can enter a variety of Hayes AT style commands to configure the device or retrieve basic information about the module of BLE connection.

You can determine if you are in Command Mode by looking at the mode LED. It should blink three times followed by a three second pause, as shown below:



# Hayes/AT Commands

When operating in command mode, the Bluefruit LE Pro modules use a [Hayes AT-style command set](http://adafru.it/ebJ) (<http://adafru.it/ebJ>) to configure the device.

The advantage of an AT style command set is that it's easy to use in machine to machine communication, while still being somewhat user friendly for humans.

# Test Command Mode '=?'

'Test' mode is used to check whether or not the specified command exists on the system or not.

Certain firmware versions or configurations may or may not include a specific command, and you can determine if the command is present by taking the command name and appending '=?' to it, as shown below

```
AT+BLESTARTADV=?
```

If the command is present, the device will reply with **'OK'**. If the command is not present, the device will reply with **'ERROR'**.

```
AT+BLESTARTADV=?
OK\r\n
AT+MISSINGCMD=?
ERROR\r\n
```

# Write Command Mode '=xxx'

'Write' mode is used to assign specific value(s) to the command, such as changing the radio's transmit power level using the command we used above.

To write a value to the command, simply append an '=' sign to the command followed by any parameter(s) you wish to write (other than a lone '?' character which will be interpreted as test mode):

```
AT+BLEPOWERLEVEL=-8
```

If the write was successful, you will generally get an '**OK**' response on a new line, as shown below:

```
AT+BLEPOWERLEVEL=-8
OK\r\n
```

If there was a problem with the command (such as an invalid parameter) you will get an '**ERROR**' response on a new line, as shown below:

```
AT+BLEPOWERLEVEL=3
ERROR\r\n
```

**Note:** This particular error was generated because '3' is not a valid value for the AT+BLEPOWERLEVEL command. Entering '-4', '0' or '4' *would* succeed since these are all valid values for this command.

# Execute Mode

'Execute' mode will cause the specific command to 'run', if possible, and will be used when the command name is entered with no additional parameters.

```
AT+FACTORYRESET
```

You might use execute mode to perform a factory reset, for example, by executing the AT+FACTORYRESET command as follows:

```
AT+FACTORYRESET
OK\r\n
```

**NOTE:** Many commands that are meant to be read will perform the same action whether they are sent to the command parser in 'execute' or 'read' mode. For example, the following commands will produce identical results:

```
AT+BLEGETPOWERLEVEL
-4\r\n
OK\r\n
AT+BLEGETPOWERLEVEL?
-4\r\n
OK\r\n
```

If the command doesn't support execute mode, the response will normally be **'ERROR'** on a new line.

## Read Command Mode '?'

'Read' mode is used to read the current value of a command.

Not every command supports read mode, but you generally use this to retrieve information like the current transmit power level for the radio by appending a '?' to the command, as shown below:

```
AT+BLEPOWERLEVEL?
```

If the command doesn't support read mode or if there was a problem with the request, you will normally get an **'ERROR'** response.

If the command read was successful, you will normally get the read results followed by **'OK'** on a new line, as shown below:

```
AT+BLEPOWERLEVEL?
-4\r\n
OK\r\n
```

**Note:** For simple commands, 'Read' mode and 'Execute' mode behave identically.

# Standard AT

The following standard Hayes/AT commands are available on Bluefruit LE modules:

## AT

Acts as a ping to check if we are in command mode. If we are in command mode, we should receive the 'OK' response.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
AT
OK
```

## ATI

Displays basic information about the Bluefruit module.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** Displays the following values:

- Board Name
- Microcontroller/Radio SoC Name
- Unique Serial Number
- Core Bluefruit Codebase Revision
- Project Firmware Revision
- Firmware Build Date
- Softdevice, Softdevice Version, Bootloader Version (0.5.0+)

```
ATI
BLEFRIEND
nRF51822 QFAAG00
FB462DF92A2C8656
0.5.0
0.5.0
Feb 24 2015
S110 7.1.0, 0.0
```



```
OK
```

### Updates:

- Version **0.4.7+** of the firmware adds the chip revision after the chip name if it can be detected (ex. 'nRF51822 QFAAG00').
- Version **0.5.0+** of the firmware adds a new 7th record containing the softdevice, softdevice version and bootloader version (ex. 'S110 7.1.0, 0.0').

## ATZ

Performs a system reset.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
ATZ
OK
```

## ATE

Enables or disables echo of input characters with the AT parser

**Codebase Revision:** 0.3.0

**Parameters:** '1' = enable echo, '0' = disable echo

**Output:** None

```
# Disable echo support
ATE=0
OK
#Enable echo support
ATE=1
OK
```

## +++

Dynamically switches between DATA and COMMAND mode without changing the physical CMD/UART select switch.

When you are in COMMAND mode, entering '+++\n' or '+++\r\n' will cause the module to switch to DATA mode, and anything typed into the console will go direct to the BLUE UART service.

To switch from DATA mode back to COMMAND mode, simply enter '+++\\n' or '+++\\r\\n' again (be sure to include the new line character!), and a new 'OK' response will be displayed letting you know that you are back in COMMAND mode (see the two 'OK' entries in the sample code below).

**Codebase Revision:** 0.4.7

**Parameters:** None

**Output:** None

Note that +++ can also be used on the mobile device to send and receive AT command on iOS or Android, though this should always be used with care.

```
ATI
BLEFRIEND
nRF51822 QFAAG00
B122AAC33F3D2296
0.4.6
0.4.6
Dec 22 2014
OK
+++
OK
OK
```

# General Purpose

The following general purpose commands are available on all Bluefruit LE modules:

## AT+FACTORYRESET

Clears any user config data from non-volatile memory and performs a factory reset before resetting the Bluefruit module.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
AT+FACTORYRESET
OK
```

As of version 0.5.0+ of the firmware, you can perform a factory reset by holding the DFU button down for 10s until the blue CONNECTED LED lights up, and then releasing the button.

## AT+DFU

Forces the module into DFU mode, allowing over the air firmware updates using a dedicated DFU app on iOS or Android.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

The AT parser will no longer respond after the AT+DFU command is entered, since normal program execution effectively halts and a full system reset is performed to start the bootloader code

```
AT+DFU
OK
```

# AT+HELP

Displays a comma-separated list of all AT parser commands available on the system.

**Codebase Version:** 0.3.0

**Parameters:** None

**Output:** A comma-separated list of all AT parser commands available on the system.

The sample code below may not match future firmware releases and is provided for illustration purposes only

```
AT+HELP
AT+FACTORYRESET,AT+DFU,ATZ,ATI,ATE,AT+DBGMEMRD,AT+DBGNVMRD,AT+HWLEDPOLARITY,AT+HWLED,
AT+HWGETDIETEMP,AT+HWMODEPINPOLARITY,AT+HWMODEPIN,AT+HWGPIOMODE,AT+HWGPIO,AT+HWI
2CSCAN,AT+HWADC,AT+HWVBAT,AT+HWPWM,AT+HWPWRDN,AT+BLEPOWERLEVEL,AT+BLEGETADDRTYPE,
AT+BLEGETADDR,AT+BLEBEACON,AT+BLEGETRSSI,AT+GAPGETCONN,AT+GAPDISCONNECT,AT+GAPDE
VNAME,AT+GAPDELBONDS,AT+GAPINTERVALS,AT+GAPSTARTADV,AT+GAPSTOPADV,AT+GAPAUTOADV,AT
+GAPSETADVDATA,AT+BLEUARTTX,AT+BLEUARTRX,AT+GATTADDSERVICE,AT+GATTADDCHAR,AT+GATTC
HAR,AT+GATTLIST,AT+GATTCLEAR,AT+HELP
OK
```

# Hardware

The following commands allow you to interact with the low level HW on the Bluefruit LE module, such as reading or toggling the GPIO pins, performing an ADC conversion ,etc.:

## AT+HWADC

Performs an ADC conversion on the specified ADC pin

**Codebase Revision:** 0.3.0

**Parameters:** The ADC channel (0..7)

**Output:** The results of the ADC conversion

```
AT+HWADC=0
178
OK
```

## AT+HWGETDIETEMP

Gets the temperature in degree celcius of the BLE module's die. This can be used for debug purposes (higher die temperature generally means higher current consumption), but does not corresponds to ambient temperature and can nto be used as a replacement for a normal temperature sensor.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** The die temperature in degrees celcius

```
AT+HWGETDIETEMP
32.25
OK
```

## AT+HWGPIO

Gets or sets the value of the specified GPIO pin (depending on the pin's mode).

**Codebase Revision:** 0.3.0

**Parameters:** The parameters for this command change depending on the pin mode.

**OUTPUT MODE:** The following comma-separated parameters can be used when updating a pin that is set as an output:

- Pin numbers
- Pin state, where:
  - 0 = clear the pin (logic low/GND)
  - 1 = set the pin (logic high/VCC)

**INPUT MODE:** To read the current state of an input pin or a pin that has been configured as an output, enter the pin number as a single parameter.

**Output:** The pin state if you are reading an input or checking the state of an input pin (meaning only 1 parameter is supplied, the pin number), where:

- 0 means the pin is logic low/GND
- 1 means the pin is logic high/VCC

Trying to set the value of a pin that has not been configured as an output will produce an 'ERROR' response.

Some pins are reserved for specific functions on Bluefruit modules and can not be used as GPIO. If you try to make use of a reserved pin number an 'ERROR' response will be generated.

```
# Set pin 14 HIGH
AT+HWGPIO=14,1
OK

# Set pin 14 LOW
AT+HWGPIO=14,0
OK

# Read the current state of pin 14
AT+HWGPIO=14
0
OK

# Try to update a pin that is not set as an output
AT+HWGPIOMODE=14,0
OK
AT+HWGPIO=14,1
ERROR
```

## AT+HWGPIOMODE

This will set the mode for the specified GPIO pin (input, output, etc.).

**Codebase Revision:** 0.3.0

**Parameters:** This command one or two values (comma-separated in the case of two parameters being used):

- The pin number
- The new GPIO mode, where:
  - 0 = Input
  - 1 = Output
  - 2 = Input with pullup enabled
  - 3 = Input with pulldown enabled

**Output:** If a single parameters is passed (the GPIO pin number) the current pin mode will be returned.

Some pins are reserved for specific functions on Bluefruit modules and can not be used as GPIO. If you try to make use of a reserved pin number an 'ERROR' response will be generated.

```
# Configure pin 14 as an output
AT+HWGPIOMODE=14,0
OK

# Get the current mode for pin 14
AT+HWGPIOMODE=14
0
OK
```

## AT+HWI2CSCAN

Scans the I2C bus to try to detect any connected I2C devices, and returns the address of devices that were found during the scan process.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** A comma-separated list of any I2C address that were found while scanning the valid address range on the I2C bus, or nothing is no devices were found.

```
# I2C scan with two devices detected
AT+HWI2CSCAN
0x23,0x35
OK

# I2C scan with no devices detected
```

```
AT+HWI2CSCAN
OK
```

## AT+HWVBAT

Returns the main power supply voltage level in millivolts

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** The VBAT level in millivolts

```
AT+HWVBAT
3248
OK
```

## AT+HWRANDOM

Generates a random 32-bit number using the HW random number generator on the nRF51822 (based on white noise).

**Codebase Revision:** 0.4.7

**Parameters:** None

**Output:** A random 32-bit hexadecimal value (ex. '0x12345678')

```
AT+HWRANDOM
0x769ED823
OK
```

## AT+HWMODELED

Allows you to override the default behaviour of the MODE led (which indicates the operating mode by default).

**Codebase Revision:** 0.6.6

**Parameters:** LED operating mode, which can be one of the following values:

- **disable** or **DISABLE** or **0** - Disable the MODE LED entirely to save power
- **mode** or **MODE** or **1** - Default behaviour, indicates the current operating mode
- **hwuart** or **HWUART** or **2** - Toggles the LED on any activity on the HW UART bus (TX or RX)
- **bleuart** or **BLEUART** or **3** - Toggles the LED on any activity on the BLE UART Service (TX or RX characteristic)



- **spi** or **SPI** or **4** - Toggles the LED on any SPI activity
- **manual** or **MANUAL** or **5** - Manually sets the state of the MODE LED via a second comma-separated parameter, which can be **on**, **off**, or **toggle**.

**Output:** If run with no parameters, returns an upper-case string representing the current MODE LED operating mode from the fields above

```
# Get the curent MODE LED setting
AT+HWMODELED
MODE
OK

# Change the MODE LED to indicate BLE UART activity
AT+HWMODELED=BLEUART
OK

# Manually toggle the MODE LED
AT+HWMODELED=MANUAL,TOGGLE
OK
```

# Beacon

Adafruit's Bluefruit LE modules currently support the following 'Beacon' technologies:

- Beacon (Apple) via AT+BLEBEACON
- UriBeacon (Google) via AT+BLEURIBEACON (**deprecated**)
- Eddystone (Google) via AT+EDDYSTONE\*

Modules can be configured to act as 'Beacons' using the following commands:

## AT+BLEBEACON

**Codebase Revision:** 0.3.0

**Parameters:** The following comma-separated parameters are required to enable beacon mode:

- Bluetooth Manufacturer ID (uint16\_t)
- 128-bit UUID
- Major Value (uint16\_t)
- Minor Value (uint16\_t)
- RSSI @ 1m (int8\_t)

**Output:** None

```
# Enable Apple iBeacon emulation
# Manufacturer ID = 0x004C
AT+BLEBEACON=0x004C,01-12-23-34-45-56-67-78-89-9A-AB-BC-CD-DE-EF-F0,0x0000,0x0000,-59
OK
# Reset to change the advertising data
ATZ
OK

# Enable Nordic Beacon emulation
# Manufacturer ID = 0x0059
AT+BLEBEACON=0x0059,01-12-23-34-45-56-67-78-89-9A-AB-BC-CD-DE-EF-F0,0x0000,0x0000,-59
OK
# Reset to change the advertising data
ATZ
OK
```

AT+BLEBEACON will cause the beacon data to be stored in non-volatile config memory on the Bluefruit LE module, and these values will be persisted across system resets and power cycles. To remove or clear the beacon data you need to enter the 'AT+FACTORYRESET' command in command mode.

Entering Nordic Beacon emulation using the sample code above, you can see the simulated beacon in Nordic's 'Beacon Config' tool below:

The screenshot shows the 'Beacon config' interface. At the top, there's a blue header with a back arrow, the 'Beacon config' title, and a trash icon. Below the header, a search bar contains 'nRF Beacon'. The main content is divided into three sections: 'IDENTITY', 'NOTIFY', and 'STATUS'. The 'IDENTITY' section shows a UUID '01122334-4556-6778-899a-abbccddeeff0', MAJOR '0', and MINOR '0'. The 'NOTIFY' section shows an 'EVENT' of 'Near' with a mobile phone icon, and an 'ACTION' of 'Show Mona Lisa' with a small image of the Mona Lisa. The 'STATUS' section shows 'ENABLED' with a toggle switch currently in the 'OFF' position.

**BEACON CONFIG**

nRF Beacon


**IDENTITY**


UUID 01122334-4556-6778-899a-abbccddeeff0

MAJOR 0

MINOR 0

**NOTIFY**

EVENT Near 

ACTION Show Mona Lisa 

**STATUS**

ENABLED  OUI



# AT+BLEURIBEACON

Converts the specified URI into a [UriBeacon \(http://adafru.it/edk\)](http://adafru.it/edk) advertising packet, and configures the module to advertise as a UriBeacon (part of Google's [Physical Web \(http://adafru.it/ehZ\)](http://adafru.it/ehZ) project).

To view the UriBeacon URIs you can use one of the following mobile applications:

- Android 4.3+: [Physical Web \(http://adafru.it/edi\)](http://adafru.it/edi) on the Google Play Store
- iOS: [Physical Web \(http://adafru.it/edj\)](http://adafru.it/edj) in Apple's App Store

**Codebase Revision:** 0.4.7

**Parameters:** The URI to encode (ex. <http://www.adafruit.com/blog> (<http://adafru.it/ei0>))

**Output:** None of a valid URI was entered (length is acceptable, etc.).

```
AT+BLEURIBEACON=http://www.adafruit.com/blog
OK

# Reset to change the advertising data
ATZ
OK
```

If the supplied URI is too long you will get the following output:

```
AT+BLEURIBEACON=http://www.adafruit.com/this/uri/is/too/long
URL is too long
ERROR
```

If the URI that you are trying to encode is too long, try using a shortening service like [bit.ly](http://bit.ly), and encode the shortened URI.

UriBeacon should be considered deprecated as a standard, and EddyStone should be used for any future development. No further development will happen in the Bluefruit LE firmware around UriBeacon.

## AT+EDDYSTONEENABLE

This command will enable [Eddystone \(http://adafru.it/fSA\)](http://adafru.it/fSA) support on the Bluefruit LE module. Eddystone support must be enabled before the other related commands can be used.

**Codebase Revision:** 0.6.6

**Parameters:** 1 or 0 (1 = enable, 0 = disable)

**Output:** The current state of Eddystone support if no parameters are provided (1 = enabled, 0 = disabled)

```
# Enable Eddystone support
AT+EDDYSTONEENABLE=1
OK

# Check the current Eddystone status on the module
AT+EDDYSTONEENABLE
1
OK
```

## AT+EDDYSTONEURL

This command will set the URL for the [Eddystone-URL \(http://adafru.it/fSB\)](http://adafru.it/fSB) protocol.

**Codebase Revision:** 0.6.6

**Parameters:**

- The URL to encode (mandatory)
- An optional second parameter indicates whether to continue advertising the Eddystone URL even when the peripheral is connected to a central device
- Firmware **0.6.7** added an optional third parameter for the RSSI at 0 meters value. This should be measured by the end user by checking the RSSI value on the receiving device at 1m and then adding 41 to that value (to compensate for the signal strength loss over 1m), so an RSSI of -62 at 1m would mean that you should enter -21 as the RSSI at 0m. Default value is -18dBm.

**Output:** Firmware <= 0.6.6: none. With firmware >= **0.6.7** running this command with no parameters will return the current URL.

```
# Set the Eddystone URL to adafruit
```

```
AT+EDDYSTONEURL=http://www.adafruit.com
OK
```

```
# Set the Eddystone URL to adafruit and advertise it even when connected
AT+EDDYSTONEURL=http://www.adafruit.com,1
OK
```

# AT+EDDYSTONECONFIGEN

This command causes the Bluefruit LE module to enable the Eddystone URL config service for the specified number of seconds.

This command should be used in combination with the Physical Web application from Google, available for [Android \(http://adafru.it/edi\)](http://adafru.it/edi) or [iOS \(http://adafru.it/edj\)](http://adafru.it/edj). Run this command then select the 'Edit URL' option from the app to change the destination URL over the air.

**Codebase Revision:** 0.6.6

**Parameters:** The number of seconds to advertised the config service UUID

**Output:** None

```
# Start advertising the Eddystone config service for 5 minutes (300s)
AT+EDDYSTONECONFIGEN=300
OK
```

# BLE Generic

The following general purpose BLE commands are available on Bluefruit LE modules:

## AT+BLEPOWERLEVEL

Gets or sets the current transmit power level for the module's radio (higher transmit power equals better range, lower transmit power equals better battery life).

**Codebase Revision:** 0.3.0

**Parameters:** The TX power level (in dBm), which can be one of the following values (from lowest to higher transmit power):

- -40
- -20
- -16
- -12
- -8
- -4
- 0
- 4

**Output:** The current transmit power level (in dBm)

The updated power level will take affect as soon as the command is entered. If the device isn't connected to another device, advertising will stop momentarily and then restart once the new power level has taken affect.

```
# Get the current TX power level (in dBm)
AT+BLEPOWERLEVEL
0
OK

# Set the TX power level to 4dBm (maximum value)
AT+BLEPOWERLEVEL=4
OK

# Set the TX power level to -12dBm (better battery life)
AT+BLEPOWERLEVEL=-12
OK

# Set the TX power level to an invalid value
```

```
AT+BLEPOWERLEVEL=-3
ERROR
```

# AT+BLEGETADDRTYPE

Gets the address type (for the 48-bit BLE device address).

Normally this will be '1' (random), which means that the module uses a 48-bit address that was randomly generated during the manufacturing process and written to the die by the manufacturer.

Random does not mean that the device address is randomly generated every time, only that a one-time random number is used.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** The address type, which can be one of the following values:

- 0 = public
- 1 = random

```
AT+BLEGETADDRTYPE
1
OK
```

# AT+BLEGETADDR

Gets the 48-bit BLE device address.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** The 48-bit BLE device address in the following format: 'AA:BB:CC:DD:EE:FF'

```
AT+BLEGETADDR
E4:C6:C7:31:95:11
OK
```

# AT+BLEGETPEERADDR

Gets the 48-bit address of the peer (central) device we are connected to.

**Codebase Revision:** 0.6.5

**Parameters:** None



**Output:** The 48-bit address of the connected central device in hex format. The command will return **ERROR** if we are not connected to a central device.

Please note that the address returned by the central device is almost always a random value that will change over time, and this value should generally not be trusted. This command is provided for certain edge cases, but is not useful in most day to day scenarios.

```
AT+BLEGETPEERADDR
48:B2:26:E6:C1:1D
OK
```

## AT+BLEGETRSSI

Gets the RSSI value (Received Signal Strength Indicator), which can be used to estimate the reliability of data transmission between two devices (the lower the number the better).

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** The RSSI level (in dBm) if we are connected to a device, otherwise '0'

```
# Connected to an external device
AT+BLEGETRSSI
-46
OK

# Not connected to an external device
AT+BLEGETRSSI
0
OK
```

# BLE Services

The following commands allow you to interact with various GATT services present on Bluefruit LE modules when running in Command Mode.

## AT+BLEUARTTX

This command will transmit the specified text message out via the [UART Service \(http://adafru.it/iCn\)](http://adafru.it/iCn) while you are running in Command Mode.

**Codebase Revision:** 0.3.0

**Parameters:** The message payload to transmit. The payload can be up to 240 characters (since AT command strings are limited to a maximum of 256 bytes total).

**Output:** This command will produce an **ERROR** message if you are not connected to a central device, or if the internal TX FIFO on the Bluefruit LE module is full.

As of firmware release **0.6.2** and higher, AT+BLEUARTTX can accept a limited set of escape code sequences:

- \r = carriage return
- \n = new line
- \t = tab
- \b = backspace
- \\ = backward slash

As of firmware release **0.6.7** and higher, AT+BLEUARTTX can accept the following escape code sequence since AT+BLEUARTTX=? has a specific meaning to the AT parser:

- \? = transmits a single question mark

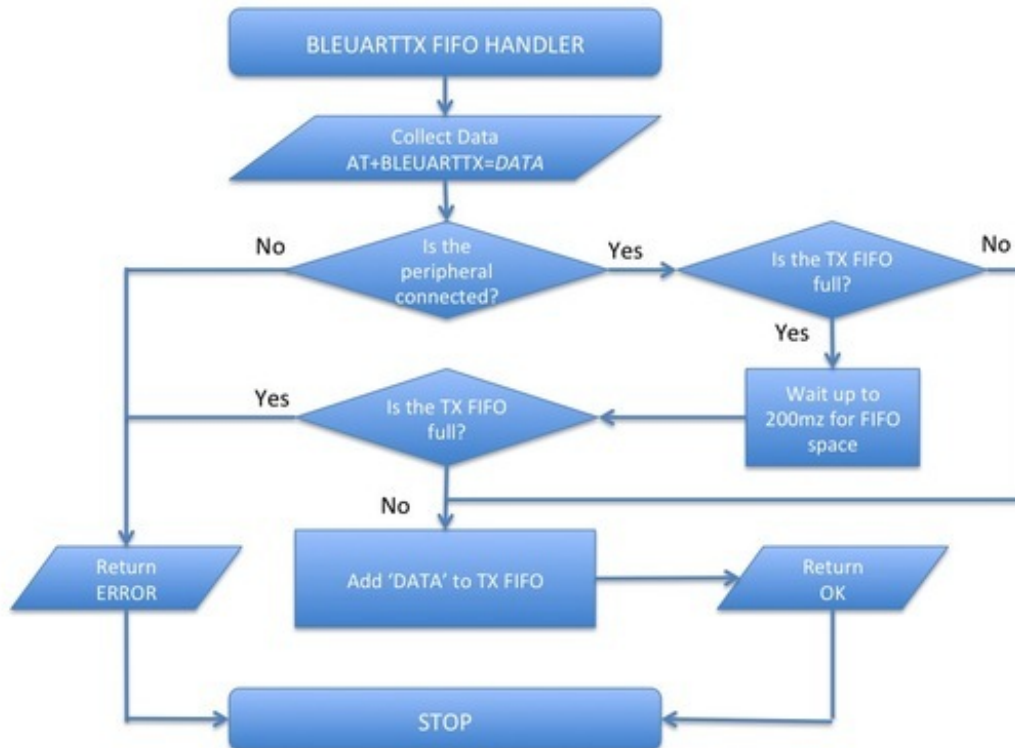
You must be connected to another device for this command to execute

```
# Send a string when connected to another device
AT+BLEUARTTX=THIS IS A TEST
OK

# Send a string when not connected
AT+BLEUARTTX=THIS IS A TEST
ERROR
```

## TX FIFO Buffer Handling

Starting with firmware version **0.6.7**, when the TX FIFO buffer is full a 200ms blocking delay will be used to see if any free space becomes available in the FIFO before returning ERROR. The exact process is detailed in the flow chart below:



Note: The TX FIFO full check will happen for each GATT transaction (of up to 20 bytes of data each), so large data transfers may have multiple 200ms wait states.

You can use the `AT+BLEUARTFIFO=TX` (<http://adafruit.it/id3>) command to check the size of the TX FIFO before sending data to ensure that you have enough free space available in the buffer.

The TX FIFO has the following size, depending on the firmware version used:

- Firmware  $\leq 0.6.6$ : **160 characters wide**
- Firmware  $\geq 0.6.7$ : **1024 characters wide**

It IS possible with large data transfers that part of the payload can be transmitted, and the command can still produce an ERROR if the FIFO doesn't empty in time in the middle of the payload transfer (since data is transmitted in maximum 20 byte chunks). If you need to ensure reliable data transfer, you should always check the TX FIFO size before sending data, which you

can do using the AT+BLEUARTFIFO command. If not enough space is available for the entire payload, add a SW delay until enough space is available. Any single AT+BLEUARTTX command can fit into the FIFO, but multiple large instances of this command may cause the FIFO to fill up mid transfer.

## AT+BLEUARTRX

This command will dump the [UART service \(http://adafru.it/iCn\)](http://adafru.it/iCn)'s RX buffer to the display if any data has been received from from the UART service while running in Command Mode. The data will be removed from the buffer once it is displayed using this command.

Any characters left in the buffer when switching back to Data Mode will cause the buffered characters to be displayed as soon as the mode switch is complete (within the limits of available buffer space, which is 1024 bytes on current black 32KB SRAM devices, or 160 bytes for the blue first generation BLEFriend board based on 16KB SRAM parts).

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** The RX buffer's content if any data is available, otherwise nothing.

You can also use the AT+BLEUARTFIFO=RX command to check if any incoming data is available or not.

```
# Command results when data is available
AT+BLEUARTRX
Sent from Android
OK

# Command results when no data is available
AT+BLEUARTRX
OK
```

## AT+BLEUARTFIFO

This command will return the free space available in the BLE UART TX and RX FIFOs. If you are transmitting large chunks of data, you may want to check if you have enough free space in the TX FIFO before sending, keeping in mind that individual GATT packets can contain up to 20 user bytes each.

**Codebase Revision:** 0.6.7

**Parameters:** Running this command with no parameters will return two comma-separated values

indicating the free space in the TX buffer, following by the RX buffer. To request a specific buffer, you can execute the command with either a "TX" or "RX" value (For example: "AT+BLEUARTFIFO=TX").

**Output:** The free space remaining in the TX and RX FIFO buffer if no parameter is present, otherwise the free space remaining in the specified FIFO buffer.

```
AT+BLEUARTFIFO
1024,1024
OK

AT+BLEUARTFIFO=TX
1024
OK

AT+BLEUARTFIFO=RX
1024
OK
```

## AT+BLEKEYBOARDEN

This command will enable GATT over HID (GoH) keyboard support, which allows you to emulate a keyboard on supported iOS and Android devices. By default HID keyboard support is disabled, so you need to set BLEKEYBOARDEN to 1 and then perform a system reset before the keyboard will be enumerated and appear in the Bluetooth preferences on your phone, where it can be bonded as a BLE keyboard.

**Codebase Revision:** 0.5.0

**Parameters:** 1 or 0 (1 = enable, 0 = disable)

**Output:** None

As of firmware version 0.6.6 this command is now an alias for AT+BLEHIDEN

You must perform a system reset (ATZ) before the changes take effect!

Before you can use your HID over GATT keyboard, you will need to bond your mobile device with the Bluefruit LE module in the Bluetooth preferences panel.

```
# Enable BLE keyboard support then reset
AT+BLEKEYBOARDEN=1
```

```
OK
ATZ
OK

# Disable BLE keyboard support then reset
AT+BLEKEYBOARDEN=0
OK
ATZ
OK
```

## AT+BLEKEYBOARD

Sends text data over the BLE keyboard interface (if it has previously been enabled via AT+BLEKEYBOARDEN).

Any valid alpha-numeric character can be sent, and the following escape sequences are also supported:

- \r - Carriage Return
- \n - Line Feed
- \b - Backspace
- \t - Tab
- \\ - Backslash

As of version 0.6.7 you can also use the following escape code when sending a single character ('AT+BLEKEYBOARD=?' has another meaning for the AT parser):

- \? - Question mark

**Codebase Revision:** 0.5.0

**Parameters:** The text string (optionally including escape characters) to transmit

**Output:** None

```
# Send a URI with a new line ending to execute in Chrome, etc.
AT+BLEKEYBOARD=http://www.adafruit.com\r\n
OK

# Send a single question mark (special use case, 0.6.7+)
AT+BLEKEYBOARD=\?
OK
```

## AT+BLEKEYBOARDCODE

Sends a raw hex sequence of USB HID keycodes to the BLE keyboard interface including key modifiers and up to six alpha-numeric characters.

This command accepts the following ascii-encoded HEX payload, matching the way HID over GATT sends keyboard data:

- **Byte 0:** Modifier
- **Byte 1:** Reserved (should always be 00)
- **Bytes 2..7:** Hexadecimal values for ASCII-encoded characters (if no character is used you can enter '00' or leave trailing characters empty)

After a keycode sequence is sent with the `AT+BLEKEYBOARDCODE` command, **you must send a second `AT+BLEKEYBOARDCODE` command with at least two 00 characters to indicate the keys were released!**

## Modifier Values

The modifier byte can have one or more of the following bits set:

- **Bit 0 (0x01):** Left Control
- **Bit 1 (0x02):** Left Shift
- **Bit 2 (0x04):** Left Alt
- **Bit 3 (0x08):** Left Window
- **Bit 4 (0x10):** Right Control
- **Bit 5 (0x20):** Right Shift
- **Bit 6 (0x40):** Right Alt
- **Bit 7 (0x80):** Right Window

**Codebase Revision:** 0.5.0

**Parameters:** A set of hexadecimal values separated by a hyphen ('-'). Note that these are HID scan code values, not standard ASCII values!

**Output:** None

HID key code values don't correspond to ASCII key codes! For example, 'a' has an HID keycode value of '04', and there is no keycode for an upper case 'A' since you use the modifier to set upper case values. For details, google 'usb hid keyboard scan codes', and see the example below.

A list of HID keyboard codes can be found [here \(http://adafru.it/cQV\)](http://adafru.it/cQV) (see section 7).

```
# send 'abc' with shift key --> 'ABC'
AT+BLEKEYBOARDCODE=02-00-04-05-06-00-00
OK
# Indicate that the keys were released (mandatory!)
AT+BLEKEYBOARDCODE=00-00
OK
```

# AT+BLEHIDEN

This command will enable GATT over HID (GoH) support, which allows you to emulate a keyboard, mouse or media control on supported iOS, Android, OSX and Windows 10 devices. By default HID support is disabled, so you need to set BLEHIDEN to 1 and then perform a system reset before the HID devices will be enumerated and appear in on your central device.

**Codebase Revision:** 0.6.6

**Parameters:** 1 or 0 (1 = enable, 0 = disable)

**Output:** None

You normally need to 'bond' the Bluefruit LE peripheral to use the HID commands, and the exact bonding process will change from one operating system to another.

If you have previously bonded to a device and need to clear the bond, you can run the AT+FACTORYRESET command which will erase all stored bond data on the Bluefruit LE module.

```
# Enable GATT over HID support on the Bluefruit LE module
AT+BLEHIDEN=1
OK

# Reset so that the changes take effect
ATZ
OK
```

# AT+BLEHIDMOUSEMOVE

Moves the HID mouse or scroll when position the specified number of ticks.

All parameters are signed 8-bit values (-128 to +127). Positive values move to the right or down, and origin is the top left corner.

**Codebase Revision:** 0.6.6

**Parameters:** X Ticks (+/-), Y Ticks (+/-), Scroll Wheel (+/-), Pan Wheel (+/-)

**Output:** None

```
# Move the mouse 100 ticks right and 100 ticks down
AT+BLEHIDMOUSEMOVE=100,100
OK
```



```
# Scroll down 20 pixels or lines (depending on context)
```

```
AT+BLEHIDMOUSEMOVE=,,20,
```

```
OK
```

```
# Pan (horizontal scroll) to the right (exact behaviour depends on OS)
```

```
AT+BLEHIDMOUSEMOVE=0,0,0,100
```

# AT+BLEHIDMOUSEBUTTON

Manipulates the HID mouse buttons via the specific string(s).

**Codebase Revision:** 0.6.6

**Parameters:** Button Mask String [L][R][M][B][F], Action [PRESS][CLICK][DOUBLECLICK][HOLD]

- L = Left Button
- R = Right Button
- M = Middle Button
- B = Back Button
- F = Forward Button
- If the second parameter (Action) is "HOLD", an optional third parameter can be passed specifying how long the button should be held in milliseconds.

**Output:** None

```
# Double click the left mouse button
```

```
AT+BLEHIDMOUSEBUTTON=L,doubleclick
```

```
OK
```

```
# Press the left mouse button down, move the mouse, then release L
```

```
# This is required to perform 'drag' then stop type operations
```

```
AT+BLEHIDMOUSEBUTTON=L
```

```
OK
```

```
AT+BLEHIDMOUSEMOVE=-100,50
```

```
OK
```

```
AT+BLEHIDMOUSEBUTTON=0
```

```
OK
```

```
# Hold the backward mouse button for 200 milliseconds (OS dependent)
```

```
AT+BLEHIDMOUSEBUTTON=B,hold,200
```

```
OK
```

# AT+BLEHIDCONTROLKEY

Sends HID media control commands for the bonded device (adjust volume, screen brightness, song

selection, etc.).

**Codebase Revision:** 0.6.6

**Parameters:** The HID control key to send, followed by an optional delay in ms to hold the button

The control key string can be one of the following values:

- System Controls (works on most systems)
  - BRIGHTNESS+
  - BRIGHTNESS-
- Media Controls (works on most systems)
  - PLAYPAUSE
  - MEDIANEXT
  - MEDIAPREVIOUS
  - MEDIASTOP
- Sound Controls (works on most systems)
  - VOLUME
  - MUTE
  - BASS
  - TREBLE
  - BASS\_BOOST
  - VOLUME+
  - VOLUME-
  - BASS+
  - BASS-
  - TREBLE+
  - TREBLE-
- Application Launchers (Windows 10 only so far)
  - EMAILREADER
  - CALCULATOR
  - FILEBROWSER
- Browser/File Explorer Controls (Firefox on Windows/Android only)
  - SEARCH
  - HOME
  - BACK
  - FORWARD
  - STOP
  - REFRESH
  - BOOKMARKS

You can also send a raw 16-bit hexadecimal value in the '0xABCD' format. A full list of 16-bit 'HID Consumer Control Key Codes' can be found [here \(http://adafru.it/cQV\)](http://adafru.it/cQV)(see section 12).

**Output:** Normally none.

If you are not bonded and connected to a central device, this command will return ERROR. Make sure you are connected and HID support is enabled before running these commands.

```
# Toggle the sound on the bonded central device
AT+BLEHIDCONTROLKEY=MUTE
OK

# Hold the VOLUME+ key for 500ms
AT+BLEHIDCONTROLKEY=VOLUME+,500
OK

# Send a raw 16-bit Consumer Key Code (0x006F = Brightness+)
AT+BLEHIDCONTROLKEY=0x006F
OK
```

# BLE GAP

**GAP** (<http://adafru.it/iCo>), which stands for the *Generic Access Profile*, governs advertising and connections with Bluetooth Low Energy devices.

The following commands can be used to configure the GAP settings on the BLE module.

You can use these commands to modify the advertising data (for ex. the device name that appears during the advertising process), to retrieve information about the connection that has been established between two devices, or the disconnect if you no longer wish to maintain a connection.

## AT+GAPGETCONN

Displays the current connection status (if we are connected to another BLE device or not).

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** 1 if we are connected, otherwise 0

```
# Connected
AT+GAPGETCONN
1
OK

# Not connected
AT+GAPGETCONN
0
OK
```

## AT+GAPDISCONNECT

Disconnects to the external device if we are currently connected.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
AT+GAPDISCONNECT
OK
```

# AT+GAPDEVNAME

Gets or sets the device name, which is included in the advertising payload for the Bluefruit LE module

**Codebase Revision:** 0.3.0

**Parameters:**

- None to read the current device name
- The new device name if you want to change the value

**Output:** The device name if the command is executed in read mode

Updating the device name will persist the new value to non-volatile memory, and the updated name will be used when the device is reset. To reset the device to factory settings and clean the config data from memory run the AT+FACTORYRESET command.

```
# Read the current device name
AT+GAPDEVNAME
UART
OK

# Update the device name to 'BLEFriend'
AT+GAPDEVNAME=BLEFriend
OK

# Reset to take effect
ATZ
OK
```

# AT+GAPDELBONDS

Deletes and bonding information stored on the Bluefruit LE module.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
AT+GAPDELBONDS
OK
```

# AT+GAPINTERVALS

Gets or sets the various advertising and connection intervals for the Bluefruit LE module.

Be extremely careful with this command since it can be easy to cause problems changing the intervals, and depending on the values selected some mobile devices may no longer recognize the module or refuse to connect to it.

**Codebase Revision:** 0.3.0

**Parameters:** If updating the GAP intervals, the following comma-separated values can be entered:

- Minimum connection interval (in milliseconds)
- Maximum connection interval (in milliseconds)
- Advertising interval (in milliseconds)
- Advertising timeout (in milliseconds)

Please note the following min and max limitations for the GAP parameters:

- **Absolute minimum connection interval:** 10ms
- **Absolute maximum connection interval:** 4000ms
- **Absolute minimum advertising interval:** 20ms
- **Absolute maximum advertising interval:** 10240ms
- **Absolute maximum advertising timeout:** 1023ms

If you only wish to update one interval value, leave the other comma-separated values empty (ex. ',,110,' will only update the third value, advertising interval).

**Output:** If reading the current GAP interval settings, the following comma-separated information will be displayed:

- Minimum connection interval (in milliseconds)
- Maximum connection interval (in milliseconds)
- Advertising interval (in milliseconds)
- Advertising timeout (in milliseconds)

Updating the GAP intervals will persist the new values to non-volatile memory, and the updated values will be used when the device is reset. To reset the device to factory settings and clean the config data from memory run the AT+FACTORYRESET command.

```
# Read the current GAP intervals
AT+GAPINTERVALS
20,100,100,30

# Update all values
AT+GAPINTERVALS=20,200,200,30
OK
```

```
# Update only the advertising interval
AT+GAPINTERVALS=,,150,
OK
```

## AT+GAPSTARTADV

Causes the Bluefruit LE module to start transmitting advertising packets if this isn't already the case (assuming we aren't already connected to an external device).

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
# Command results when advertising data is not being sent
AT+GAPSTARTADV
OK

# Command results when we are already advertising
AT+GAPSTARTADV
ERROR

# Command results when we are connected to another device
AT+GAPSTARTADV
ERROR
```

## AT+GAPSTOPADV

Stops advertising packets from being transmitted by the Bluefruit LE module.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Output:** None

```
AT+GAPSTOPADV
OK
```

## AT+GAPSETADVDATA

Sets the raw advertising data payload to the specified byte array (overriding the normal advertising data), following the guidelines in the [Bluetooth 4.0 or 4.1 Core Specification \(http://adafru.it/ddd\)](http://adafru.it/ddd).

In particular, **Core Specification Supplement (CSS) v4** contains the details on common advertising data fields like 'Flags' (Part A, Section 1.3) and the various Service UUID lists (Part A, Section 1.1). A list of all possible GAP Data Types is available on the Bluetooth SIG's [Generic Access Profile](http://adafru.it/cYs) (<http://adafru.it/cYs>) page.

The Advertising Data payload consists of [Generic Access Profile](http://adafru.it/cYs) (<http://adafru.it/cYs>) data that is inserted into the advertising packet in the following format: [U8:LEN] [U8:Data Type Value] [n:Value]

**WARNING:** This command requires a degree of knowledge about the low level details of the Bluetooth 4.0 or 4.1 Core Specification, and should only be used by expert users. Misuse of this command can easily cause your device to be undetectable by central devices in radio range.

**WARNING:** This command will override the normal advertising payload and may prevent some services from acting as expected.

To restore the advertising data to the normal default values use the AT+FACTORYRESET command.

For example, to insert the 'Flags' Data Type (Data Type Value 0x01), and set the value to 0x06/0b00000110 (BR/EDR Not Supported and LE General Discoverable Mode) we would use the following byte array:

```
02-01-06
```

- 0x02 indicates the number of bytes in the entry
- 0x01 is the '[Data Type Value](http://adafru.it/cYs)' and indicates that this is a **'Flag'**
- 0x06 (0b00000110) is the Flag value, and asserts the following fields (see Core Specification 4.0, Volume 3, Part C, 18.1):
  - **LE General Discoverable Mode** (i.e. anyone can discover this device)
  - **BR/EDR Not Supported** (i.e. this is a Bluetooth Low Energy only device)

If we also want to include two 16-bit service UUIDs in the advertising data (so that listening devices know that we support these services) we could append the following data to the byte array:

```
05-02-0D-18-0A-18
```

- 0x05 indicates that the number of bytes in the entry (5)
- 0x02 is the '[Data Type Value](http://adafru.it/cYs)' and indicates that this is an **'Incomplete List of 16-bit Service Class UUIDs'**
- 0x0D 0x18 is the first 16-bit UUID (which translates to **0x180D**, corresponding to the [Heart Rate](#)



[Service \(http://adafru.it/ddB\)](http://adafru.it/ddB)).

- 0x0A 0x18 is another 16-bit UUID (which translates to **0x180A**, corresponding to the [Device Information Service \(http://adafru.it/ecj\)](http://adafru.it/ecj)).

Including the service UUIDs is important since some mobile applications will only work with devices that advertise a specific service UUID in the advertising packet. This is true for most apps from Nordic Semiconductors, for example.

## Codebase Revision: 0.3.0

**Parameters:** The raw byte array that should be inserted into the advertising data section of the advertising packet, being careful to stay within the space limits defined by the Bluetooth Core Specification.

**Response:** None

```
# Advertise as Discoverable and BLE only with 16-bit UUIDs 0x180D and 0x180A
AT+GAPSETADVDATA=02-01-06-05-02-0d-18-0a-18
OK
```

The results of this command can be seen in the screenshot below, taken from a sniffer analyzing the advertising packets in Wireshark. The advertising data payload is highlighted in blue in the raw byte array at the bottom of the image, and the packet analysis is in the upper section:

```
Bluetooth Low Energy Link Layer
  Access Address: 0x8e89bed6
  Packet Header: 0x0f40 (PDU Type: ADV_IND, TxAdd=false, RxAdd=false)
  Advertising Address: e4:c6:c7:31:95:11 (e4:c6:c7:31:95:11)
  Advertising Data
    Flags
      Length: 2
      Type: Flags (0x01)
      000. .... = Reserved: 0x00
      ...0 .... = Simultaneous LE and BR/EDR to Same Device Capable (Host): false (0x00)
      .... 0... = Simultaneous LE and BR/EDR to Same Device Capable (Controller): false (0x00)
      .... .1.. = BR/EDR Not Supported: true (0x01)
      .... ..1. = LE General Discoverable Mode: true (0x01)
      .... ...0 = LE Limited Discoverable Mode: false (0x00)
    16-bit Service Class UUIDs (incomplete)
      Length: 5
      Type: 16-bit Service Class UUIDs (incomplete) (0x02)
      UUID 16: Heart Rate (0x180d)
      UUID 16: Device Information (0x180a)
  CRC: 0x93b900
```

```
0000 00 06 22 01 8b 17 06 0a 01 26 2b 00 00 97 02 00  ..*....&+....
0010 00 d6 be 89 8e 40 0f 11 95 31 c7 c6 e4 02 01 06  ....@...l....
0020 05 02 0d 18 0a 18 c9 9d 00  ....
```

# BLE GATT

**GATT** (<http://adafru.it/iCp>), which standards for the *Generic ATtribute Profile*, governs data organization and data exchanges between connected devices. One device (the peripheral) acts as a GATT Server, which stores data in *Attribute* records, and the second device in the connection (the central) acts as a GATT Client, requesting data from the server whenever necessary.

The following commands can be used to create custom GATT services and characteristics on the BLEFriend, which are used to store and exchange data.

Please note that any characteristics that you define here will automatically be saved to non-volatile FLASH config memory on the device and re-initialised the next time the device starts.

You need to perform a system reset via 'ATZ' before most of the commands below will take effect!

If you want to clear any previous config value, enter the '**AT+FACTORYRESET**' command before working on a new peripheral configuration.

## AT+GATTCLEAR

Clears any custom GATT services and characteristics that have been defined on the device.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Response:** None

```
AT+GATTCLEAR
OK
```

## AT+GATTADDSERVICE

Adds a new custom service definition to the device.

**Codebase Revision:** 0.3.0

**Parameters:** This command accepts a set of comma-separated key-value pairs that are used to define the service properties. The following key-value pairs can be used:

- **UUID:** The 16-bit UUID to use for this service. 16-bit values should be in hexadecimal format (0x1234).

- **UUID128:** The 128-bit UUID to use for this service. 128-bit values should be in the following format: 00-11-22-33-44-55-66-77-88-99-AA-BB-CC-DD-EE-FF

**Response:** The index value of the service in the custom GATT service lookup table. (It's important to keep track of these index values to work with the service later.)

Note: Key values are not case-sensitive

Only one UUID type can be entered for the service (either UUID or UUID128)

```
# Clear any previous custom services/characteristics
AT+GATTCLEAR
OK

# Add a battery service (UUID = 0x180F) to the peripheral
AT+GATTADDSERVICE=UUID=0x180F
1
OK

# Add a battery measurement characteristic (UUID = 0x2A19), notify enabled
AT+GATTADDCHAR=UUID=0x2A19,PROPERTIES=0x10,MIN_LEN=1,VALUE=100
1
OK
```

```
# Clear any previous custom services/characteristics
AT+GATTCLEAR
OK

# Add a custom service to the peripheral
AT+GATTADDSERVICE=UUID128=00-11-00-11-44-55-66-77-88-99-AA-BB-CC-DD-EE-FF
1
OK

# Add a custom characteristic to the above service (making sure that there
# is no conflict between the 16-bit UUID and bytes 3+4 of the 128-bit service UUID)
AT+GATTADDCHAR=UUID=0x0002,PROPERTIES=0x02,MIN_LEN=1,VALUE=100
1
OK
```

## AT+GATTADDCHAR

Adds a custom characteristic to the last service that was added to the peripheral (via

AT+GATTADDSERVICE).

AT+GATTADDCHAR must be run AFTER AT+GATTADDSERVICE, and will add the new characteristic to the last service definition that was added.

As of version 0.6.6 of the Bluefruit LE firmware you can now use custom 128-bit UUIDs with this command. See the example at the bottom of this command description.

### Codebase Revision: 0.3.0

**Parameters:** This command accepts a set of comma-separated key-value pairs that are used to define the characteristic properties. The following key-value pairs can be used:

- **UUID:** The 16-bit UUID to use for the characteristic (which will be inserted in the 3rd and 4th bytes of the parent service's 128-bit UUID). This value should be entered in hexadecimal format (ex. 'UUID=0x1234'). This value must be unique, and should not conflict with bytes 3+4 of the parent service's 128-bit UUID.
- **PROPERTIES:** The 8-bit characteristic properties field, as defined by the Bluetooth SIG. The following values can be used:
  - 0x02 - Read
  - 0x04 - Write Without Response
  - 0x08 - Write
  - 0x10 - Notify
  - 0x20 - Indicate
- **MIN\_LEN:** The minimum size of the values for this characteristic (in bytes, min = 1, max = 20, default = 1)
- **MAX\_LEN:** The maximum size of the values for the characteristic (in bytes, min = 1, max = 20, default = 1)
- **VALUE:** The initial value to assign to this characteristic (within the limits of 'MIN\_LEN' and 'MAX\_LEN'). Value can be an integer ("-100", "27"), a hexadecimal value ("0xABCD"), a byte array ("aa-bb-cc-dd") or a string ("GATT!").

**Response:** The index value of the characteristic in the custom GATT characteristic lookup table. (It's important to keep track of these characteristic index values to work with the characteristic later.)

Note: Key values are not case-sensitive

Make sure that the 16-bit UUID is unique and does not conflict with bytes 3+4 of the 128-bit service UUID

```
# Clear any previous custom services/characteristics
AT+GATTCLEAR
OK

# Add a battery service (UUID = 0x180F) to the peripheral
AT+GATTADDSERVICE=UUID=0x180F
1
OK

# Add a battery measurement characteristic (UUID = 0x2A19), notify enabled
AT+GATTADDCHAR=UUID=0x2A19,PROPERTIES=0x10,MIN_LEN=1,VALUE=100
1
OK
```

```
# Clear any previous custom services/characteristics
AT+GATTCLEAR
OK

# Add a custom service to the peripheral
AT+GATTADDSERVICE=UUID128=00-11-00-11-44-55-66-77-88-99-AA-BB-CC-DD-EE-FF
1
OK

# Add a custom characteristic to the above service (making sure that there
# is no conflict between the 16-bit UUID and bytes 3+4 of the 128-bit service UUID)
AT+GATTADDCHAR=UUID=0x0002,PROPERTIES=0x02,MIN_LEN=1,VALUE=100
1
OK
```

Version **0.6.6** of the Bluefruit LE firmware added the ability to use a new '**UUID128**' flag to add custom 128-bit UUIDs that aren't related to the parent service UUID (which is used when passing the 16-bit '**UUID**' flag).

To specify a 128-bit UUID for your customer characteristic, enter a value resembling the following syntax:

```
# Add a custom characteristic to the above service using a
# custom 128-bit UUID
AT+GATTADDCHAR=UUID128=00-11-22-33-44-55-66-77-88-99-AA-BB-CC-DD-EE-FF,PROPERTIES=0x02,MIN_
LEN=1,VALUE=100
1
OK
```

## AT+GATTCHAR

Gets or sets the value of the specified custom GATT characteristic (based on the index ID returned when the characteristic was added to the system via AT+GATTADDCHAR).

**Codebase Revision:** 0.3.0

**Parameters:** This function takes one or two comma-separated functions (one parameter = read, two parameters = write).

- The first parameter is the characteristic index value, as returned from the AT+GATTADDCHAR function. This parameter is always required, and if no second parameter is entered the current value of this characteristic will be returned.
- The second (optional) parameter is the new value to assign to this characteristic (within the MIN\_SIZE and MAX\_SIZE limits defined when creating it).

**Response:** If the command is used in read mode (only the characteristic index is provided as a value), the response will display the current value of the characteristics. If the command is used in write mode (two comma-separated values are provided), the characteristics will be updated to use the provided value.

```
# Clear any previous custom services/characteristics
AT+GATTCLEAR
OK

# Add a battery service (UUID = 0x180F) to the peripheral
AT+GATTADDSERVICE=UUID=0x180F
1
OK

# Add a battery measurement characteristic (UUID = 0x2A19), notify enabled
AT+GATTADDCHAR=UUID=0x2A19,PROPERTIES=0x10,MIN_LEN=1,VALUE=100
1
OK

# Read the battery measurement characteristic (index ID = 1)
AT+GATTCHAR=1
0x64
OK

# Update the battery measurement characteristic to 32 (hex 0x20)
AT+GATTCHAR=1,32
OK

# Verify the previous write attempt
AT+GATTCHAR=1
0x20
OK
```

# AT+GATTLIST

Lists all custom GATT services and characteristics that have been defined on the device.

**Codebase Revision:** 0.3.0

**Parameters:** None

**Response:** A list of all custom services and characteristics defined on the device.

```
# Clear any previous custom services/characteristics
AT+GATTCLEAR
OK

# Add a battery service (UUID = 0x180F) to the peripheral
AT+GATTADDSERVICE=UUID=0x180F
1
OK

# Add a battery measurement characteristic (UUID = 0x2A19), notify enabled
AT+GATTADDCHAR=UUID=0x2A19,PROPERTIES=0x10,MIN_LEN=1,VALUE=100
1
OK

# Add a custom service to the peripheral
AT+GATTADDSERVICE=UUID128=00-11-00-11-44-55-66-77-88-99-AA-BB-CC-DD-EE-FF
2
OK

# Add a custom characteristic to the above service (making sure that there
# is no conflict between the 16-bit UUID and bytes 3+4 of the 128-bit service UUID)
AT+GATTADDCHAR=UUID=0x0002,PROPERTIES=0x02,MIN_LEN=1,VALUE=100
2
OK

# Get a list of all custom GATT services and characteristics on the device
AT+GATTLIST
ID=01,UUID=0x180F
  ID=01,UUID=0x2A19,PROPERTIES=0x10,MIN_LEN=1,MAX_LEN=1,VALUE=0x64
ID=02,UUID=0x11,UUID128=00-11-00-11-44-55-66-77-88-99-AA-BB-CC-DD-EE-FF
  ID=02,UUID=0x02,PROPERTIES=0x02,MIN_LEN=1,MAX_LEN=1,VALUE=0x64
OK
```

# Debug

The following debug commands are available on Bluefruit LE modules:

Use these commands with care since they can easily lead to a HardFault error on the ARM core, which will cause the device to stop responding.

## AT+DBGMEMRD

Displays the raw memory contents at the specified address.

**Codebase Revision:** 0.3.0

**Parameters:** The following comma-separated parameters can be used with this command:

- The starting address to read memory from (in hexadecimal form, with or without the leading '0x')
- The word size (can be 1, 2, 4 or 8)
- The number of words to read

**Output:** The raw memory contents in hexadecimal format using the specified length and word size (see examples below for details)

```
# Read 12 1-byte values starting at 0x10000009
AT+DBGMEMRD=0x10000009,1,12
FF FF FF FF FF FF FF 00 04 00 00 00
OK

# Try to read 2 4-byte values starting at 0x10000000
AT+DBGMEMRD=0x10000000,4,2
55AA55AA 55AA55AA
OK

# Try to read 2 4-byte values starting at 0x10000009
# This will fail because the Cortex M0 can't perform misaligned
# reads, and any non 8-bit values must start on an even address
AT+DBGMEMRD=0x10000009,4,2
MISALIGNED ACCESS
ERROR
```

## AT+DBGNVMREAD

Displays the raw contents of the config data section of non-volatile memory





Returns the current stack size, to help detect stack overflow or detect stack memory usage when optimising memory usage on the system.

**Codebase Revision:** 0.4.7

**Parameters:** None

**Output:** The current size of stack memory in bytes

```
AT+DBGSTACKSIZE
1032
OK
```

## AT+DBGSTACKDUMP

Dumps the current stack contents. Unused sections of stack memory are filled with '0xCAFEFOOD' to help determine where stack usage stops.

This command is purely for debug and development purposes.

**Codebase Revision:** 0.4.7

**Parameters:** None

**Output:** The memory contents of the entire stack region

```
AT+DBGSTACKDUMP
0x20003800: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003810: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003820: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003830: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003840: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003850: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003860: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003870: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003880: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003890: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x200038A0: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x200038B0: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x200038C0: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x200038D0: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x200038E0: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x200038F0: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003900: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003910: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003920: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003930: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
0x20003940: CAFEF00D CAFEF00D CAFEF00D CAFEF00D
```

0x20003950: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003960: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003970: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003980: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003990: CAFE00D CAFE00D CAFE00D CAFE00D  
0x200039A0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x200039B0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x200039C0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x200039D0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x200039E0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x200039F0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A00: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A10: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A20: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A30: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A40: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A50: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A60: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A70: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A80: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003A90: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003AA0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003AB0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003AC0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003AD0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003AE0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003AF0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B00: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B10: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B20: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B30: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B40: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B50: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B60: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B70: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B80: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003B90: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003BA0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003BB0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003BC0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003BD0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003BE0: CAFE00D CAFE00D CAFE00D CAFE00D  
0x20003BF0: CAFE00D CAFE00D 00000000 CAFE00D  
0x20003C00: 00000004 20001D04 CAFE00D FFFFEF68  
0x20003C10: CAFE00D 00001098 CAFE00D CAFE00D  
0x20003C20: CAFE00D CAFE00D 00001006 200018D8  
0x20003C30: 00000001 200018D8 20001C50 00000004  
0x20003C40: 20001BB0 000134A5 0000100D 20001D28  
0x20003C50: 00000006 00000006 20001C38 20001D44

```
0x20003C60: 20001C6C 20001D44 00000006 00000005
0x20003C70: 20001D38 00000005 20001D38 00000000
0x20003C80: 00000001 00012083 200018C8 000013D3
0x20003C90: 00550000 00000001 80E80000 4FC40000
0x20003CA0: 000080E8 00000009 60900000 000080E8
0x20003CB0: 60140000 20002764 0009608F 000080E8
0x20003CC0: 80000000 000080E8 00000000 00129F5F
0x20003CD0: 00000000 0001E4D9 80E80000 200018C8
0x20003CE0: 200018D4 00000000 80E80000 000000FF
0x20003CF0: 0000011C 0001BCE1 0000203A 0001BC1D
0x20003D00: 00000000 0001BC1D 80E80000 0001BCE1
0x20003D10: 0000011C 0001BDA9 80E80000 0001BDA9
0x20003D20: 0000011C FFFFFFF9 008B8000 0001BC1D
0x20003D30: 00000048 00000010 0000A000 00000009
0x20003D40: 0001E326 00000001 80E80000 51538000
0x20003D50: 000080E8 0001E9CF 00000000 00000009
0x20003D60: 61C78000 000080E8 00000048 00000504
0x20003D70: 0000A1FC 0002125C 00000000 000080E8
0x20003D80: 00000000 0012A236 00000000 0001E4D9
0x20003D90: 000080E8 00000009 00004998 000080E8
0x20003DA0: 622C8000 0012A29B 00000042 0001E479
0x20003DB0: 40011000 000185EF 00006E10 00000000
0x20003DC0: 00000000 00000004 0000000C 00000000
0x20003DD0: 62780000 00018579 2000311B 0001ACDF
0x20003DE0: 00000000 20003054 20002050 00000001
0x20003DF0: 20003DF8 0002085D 00000001 200030D4
0x20003E00: 00000200 0001F663 00000001 200030D4
0x20003E10: 00000001 2000311B 0001F631 00020A6D
0x20003E20: 00000001 00000000 0000000C 200030D4
0x20003E30: 2000311B 00000042 200030D4 00020AD7
0x20003E40: 20002050 200030D4 20002050 00020833
0x20003E50: 20002050 20003F1B 20002050 0001FF89
0x20003E60: 20002050 0001FFA3 00000005 20003ED8
0x20003E70: 20002050 0001FF8B 00000010 00020491
0x20003E80: 00000001 0012A54E 00000020 00022409
0x20003E90: 00000000 20002050 200030D4 0001FF8B
0x20003EA0: 00021263 00000005 0000000C 20003F74
0x20003EB0: 20003ED8 20002050 200030D4 00020187
0x20003EC0: 20003ED4 20003054 00000000 20003F75
0x20003ED0: 00000008 20003F64 00000084 FFFFFFFF
0x20003EE0: FFFFFFFF 00000008 00000001 00000008
0x20003EF0: 20302058 2000311B 0001F631 00020A6D
0x20003F00: 20002050 00000000 0000000C 200030D4
0x20003F10: 32002050 32303032 00323330 000258D7
0x20003F20: 20002050 200030D4 20002050 00020833
0x20003F30: 00000000 20002050 00000020 000001CE
0x20003F40: 20003F40 200030D4 00000004 0001ED83
0x20003F50: 200030D4 20003F60 000001D6 000001D7
0x20003F60: 000001D8 00016559 0000000C 00000000
```

```
0x20003F70: 6C383025 00000058 200030D4 FFFFFFFF
0x20003F80: 1FFF4000 00000028 00000028 000217F8
0x20003F90: 200020C7 000166C5 000166AD 00017ED9
0x20003FA0: FFFFFFFF 200020B8 2000306C 200030D4
0x20003FB0: 200020B4 000180AD 1FFF4000 200020B0
0x20003FC0: 200020B0 200020B0 1FFF4000 0001A63D
0x20003FD0: CAFEF00D CAFEF00D 200020B4 00000002
0x20003FE0: FFFFFFFF FFFFFFFF 1FFF4000 00000000
0x20003FF0: 00000000 00000000 00000000 00016113
OK
```

# History

This page tracks additions or changes to the AT command set based on the firmware version number (which you can obtain via the 'ATI' command):

## Version 0.6.7

The following AT commands were added in the 0.6.7 release:

- **AT+BLEUARTFIFO**  
Returns the number of free bytes available in the TX and RX FIFOs for the Bluetooth UART Service.

The following commands were changed in the 0.6.7 release:

- **AT+BLEUARTTX**  
If the TX FIFO is full, the command will wait up to 200ms to see if the FIFO size decreases before exiting and returning an ERROR response due to the FIFO being full.
- **AT+BLEURIBEACON**  
This command will go back to using the old (deprecated) UriBeacon UUID (0xFED8), and only the AT+EDDYSTONEURL command will use the newer Eddystone UUID (0xFEAA).
- **AT+BLEKEYBOARD** and **AT+BLEUARTTX**  
These commands now accept '\?' as an escape code since 'AT+BLEKEYBOARD=?' has another meaning for the AT parser. To send a single question mark the following command should be used: 'AT+BLEKEYBOARD=\?' or 'AT+BLEUARTTX=\?'
- **AT+EDDYSTONEURL**  
This command now accepts an optional third parameter for RSSI at 0m value (default is -18dBm).  
Running this command with no parameters ('AT+EDDYSTONEURL\r\n') will now return the current URL.

Key bug fixes in this release:

- The FIFO handling for the Bluetooth UART Service was improved for speed and stability, and the TX and RF FIFOs were increased to 1024 bytes each.
- An issue where a timer overflow was causing factory resets every 4 hours or so has been resolved.
- Fixed a problem with the GATT server where 'value\_len' was being incorrectly parsed for integer values in characteristics where 'max\_len' >4

## Version 0.6.6

The following AT commands were added in the 0.6.6 release:

- **AT+EDDYSTONEURL**  
Update the URL for the beacon and switch to beacon mode
- **AT+EDDYSTONEENABLE**  
Enable/disable beacon mode using the configured url
- **AT+EDDYSTONECONFIGEN**  
Enable advertising for the the Eddystone configuration service for the specified number of seconds
- **AT+HWMODELED**  
Allows the user to override the default MODE LED behaviour with one of the following options: DISABLE, MODE, HWUART, BLEUART, SPI, MANUAL
- **AT+BLECONTROLKEY**  
Allows HID media control values to be sent to a bonded central device (volume, screen brightness, etc.)
- **AT+BLEHIDEN**  
Enables or disables BLE HID support in the Bluefruit LE firmware (mouse, keyboard and media control)
- **AT+BLEMOUSEMOVE**  
To move the HID mouse
- **AT+BLEMOUSEBUTTON**  
To set the state of the HID mouse buttons

The following commands were changed in the 0.6.6 release:

- **AT+BLEKEYBOARDEN** - Now an alias for **AT+BLEHIDEN**
- **AT+GATTADDCHAR** - Added a new UUID128 field to allow custom UUIDs

Key bug fixes in this release:

- Fixed issues with long beacon URLs
- Fixed big endian issue in `at+blebeacon` for major & minor number

Known issues with this release:

- Windows 10 seems to support a limited number of characteristics for the DIS service. We had to disable the Serial Number characteristic to enable HID support with windows 10.

## Version 0.6.5

The following AT commands were added in the 0.6.5 release:

- **AT+BLEGETPEERADDR** (<http://adafru.it/iCq>)

The following commands were changed in the 0.6.5 release:

- Increased the UART buffer size (on the nRF51) from 128 to 256 bytes
- `+++` now responds with the current operating mode
- Fixed a bug with **AT+GATTCHAR** values sometimes not being saved to NVM
- Fixed a bug with **AT+GATTCHAR** `max_len` value not being taken into account after a reset

(min\_len was always used when repopulating the value)

## Version 0.6.2

This is the first release targeting **32KB SRAM parts (QFAC)**. 16KB SRAM parts can't be used with this firmware due to memory management issues, and should use the earlier 0.5.0 firmware.

The following AT commands were changed in the 0.6.2 release:

- [AT+BLEUARTTX](http://adafru.it/iCr) (<http://adafru.it/iCr>)  
Basic escape codes were added for new lines, tabs and backspace
- [AT+BLEKEYBOARD](http://adafru.it/iCr) (<http://adafru.it/iCr>)  
Also works with OS X now, and *may* function with other operating systems that support BLE HID keyboards

## Version 0.5.0

The following AT commands were added in the 0.5.0 release:

- [AT+BLEKEYBOARDEN](http://adafru.it/iCr) (<http://adafru.it/iCr>)
- [AT+BLEKEYBOARD](http://adafru.it/iCr) (<http://adafru.it/iCr>)
- [AT+BLEKEYBOARDCODE](http://adafru.it/iCr) (<http://adafru.it/iCr>)

The following AT commands were changed in the 0.5.0 release:

- [ATI](http://adafru.it/iCs) (<http://adafru.it/iCs>)  
The SoftDevice, SoftDevice version and bootloader version were added as a new (7th) record. For Ex: "S110 7.1.0, 0.0" indicates version 7.1.0 of the S110 softdevice is used with the 0.0 bootloader (future boards will use a newer 0.1 bootloader).

Other notes concerning 0.5.0:

Starting with version 0.5.0, you can execute the **AT+FACTORYRESET** command at any point (and without a terminal emulator) by holding the DFU button down for 10 seconds until the blue CONNECTED LED starts flashing, then releasing it.

## Version 0.4.7

The following AT commands were added in the 0.4.7 release:

- [+++](http://adafru.it/iCs) (<http://adafru.it/iCs>)
- [AT+HWRANDOM](http://adafru.it/iCt) (<http://adafru.it/iCt>)
- [AT+BLEURIBEACON](http://adafru.it/iCu) (<http://adafru.it/iCu>)
- [AT+DBGSTACKSIZE](http://adafru.it/iCv) (<http://adafru.it/iCv>)
- [AT+DBGSTACKDUMP](http://adafru.it/iCv) (<http://adafru.it/iCv>)



The following commands were changed in the 0.4.7 release:

- [ATI](#)  
(<http://adafru.it/iCs>) The chip revision was added after the chip name. Whereas ATI would previously report 'nRF51822', it will now add the specific HW revision if it can be detected (ex 'nRF51822 QFAAG00')

## Version 0.3.0

- First public release

# Command Examples

The following code snippets can be used when operating in Command Mode to perform specific tasks.

## Heart Rate Monitor Service

The command list below will add a [Heart Rate](http://adafru.it/ddB) service to the BLEFriend's attribute table, with two characteristics:

- [Heart Rate Measurement](http://adafru.it/ddD)
- [Body Sensor Location](http://adafru.it/eck)

```
# Perform a factory reset to make sure we get a clean start
AT+FACTORYRESET
OK

# Add the Heart Rate service entry
AT+GATTADDSERVICE=UUID=0x180D
1
OK

# Add the Heart Rate Measurement characteristic
AT+GATTADDCHAR=UUID=0x2A37, PROPERTIES=0x10, MIN_LEN=2, MAX_LEN=3, VALUE=00-40
1
OK

# Add the Body Sensor Location characteristic
AT+GATTADDCHAR=UUID=0x2A38, PROPERTIES=0x02, MIN_LEN=1, VALUE=3
2
OK

# Create a custom advertising packet that includes the Heart Rate service UUID
AT+GAPSETADVDATA=02-01-06-05-02-0d-18-0a-18
OK

# Reset the device to start advertising with the custom payload
ATZ
OK

# Update the value of the heart rate measurement (set it to 0x004A)
AT+GATTCHAR=1,00-4A
OK
```

## Python Script

The following code performs the same function, but has been placed inside a Python wrapper using [PySerial](http://adafru.it/cLU) (<http://adafru.it/cLU>) to show how you can script actions for the AT parser.

```
import io
import sys
import serial
import random
from time import sleep

filename = "hrm.py"
ser = None
serio = None
verbose = True # Set this to True to see all of the incoming serial data

def usage():
    """Displays information on the command-line parameters for this script"""
    print "Usage: " + filename + " <serialPort>\n"
    print "For example:\n"
    print " Windows : " + filename + " COM14"
    print " OS X   : " + filename + " /dev/tty.usbserial-DN009WNO"
    print " Linux  : " + filename + " /dev/ttyACM0"
    return

def checkargs():
    """Validates the command-line arguments for this script"""
    if len(sys.argv) < 2:
        print "ERROR: Missing serialPort"
        usage()
        sys.exit(-1)
    if len(sys.argv) > 2:
        print "ERROR: Too many arguments (expected 1).\"
        usage()
        sys.exit(-2)

def errorhandler(err, exitonerror=True):
    """Display an error message and exit gracefully on "ERROR\r\n" responses"""
    print "ERROR: " + err.message
    if exitonerror:
        ser.close()
        sys.exit(-3)

def atcommand(command, delays=0):
    """Executes the supplied AT command and waits for a valid response"""
    serio.write(unicode(command + "\n"))
```

```

if delays:
    sleep(delays/1000)
rx = None
while rx != "OK\r\n" and rx != "ERROR\r\n":
    rx = serio.readline(2000)
    if verbose:
        print unicode(rx.rstrip("\r\n"))
# Check the return value
if rx == "ERROR\r\n":
    raise ValueError("AT Parser reported an error on " + command.rstrip() + "")

if __name__ == '__main__':
    # Make sure we received a single argument (comPort)
    checkargs()

    # This will automatically open the serial port (no need for ser.open)
    ser = serial.Serial(port=sys.argv[1], baudrate=9600, rtscts=True)
    serio = io.TextIOWrapper(io.BufferedRWPair(ser, ser, 1),
                             newline='\r\n',
                             line_buffering=True)

    # Add the HRM service and characteristic definitions
    try:
        atcommand("AT+FACTORYRESET", 1000) # Wait 1s for this to complete
        atcommand("AT+GATTCLEAR")
        atcommand("AT+GATTADDSERVICE=UUID=0x180D")
        atcommand("AT+GATTADDCHAR=UUID=0x2A37, PROPERTIES=0x10, MIN_LEN=2, MAX_LEN=3, VALUE=0
0-40")
        atcommand("AT+GATTADDCHAR=UUID=0x2A38, PROPERTIES=0x02, MIN_LEN=1, VALUE=3")
        atcommand("AT+GAPSETADVDATA=02-01-06-05-02-0d-18-0a-18")
        # Perform a system reset and wait 1s to come back online
        atcommand("ATZ", 1000)
        # Update the value every second
        while True:
            atcommand("AT+GATTCHAR=1,00-%02X" % random.randint(50, 100), 1000)
    except ValueError as err:
        # One of the commands above returned "ERROR\r\n"
        errorHandler(err)
    except KeyboardInterrupt:
        # Close gracefully on CTRL+C
        ser.close()
        sys.exit()

```

The results of this script can be seen below in the 'HRM' app of Nordic's nRF Toolbox application:

Please note that nRF Toolbox will only display HRM data if the value changes, so you will need to update the Heart Rate Measurement characteristic at least once after opening the HRM app and

connecting to the BLEFriend





# Field Updates

The BLEFriend module includes a special 'DFU' bootloader that allows you to update the firmware over the air using a compatible device (such as a recent iPhone or iPod or a BLE-enabled Android device running Android 4.3 or later).

The benefit of this bootloader is that you can reprogram the flash contents of the MCU without having to purchase a HW debugger, using nothing but your tablet or phone to update the flash memory contents of the BLEFriend.

You can update the Firmware over the air but not over the USB/UART connection!

## Requirements

In order to perform over the air field updates of the firmware on the nRF51822 based Bluefruit LE modules, you will need access to the following resources:

- A Bluetooth Low Energy enabled iOS device (iPad 3rd generation or later, iPhone 5 or later, or a recent iPod Touch) or a BLE enabled Android device (running Android 4.3 or higher, for example the Nexus 4, Nexus 5, and the Nexus 7 2013)
- The [Bluefruit LE Connect app for Android](http://adafru.it/f4G) (<http://adafru.it/f4G>) (for Android devices)
- The [Bluefruit LE Connect app for iOS](http://adafru.it/f4H) (<http://adafru.it/f4H>) (for iOS devices)

To update using your Android or iOS device, continue on to the appropriate page in this guide.

While the DFU (Device Firmware Update) code running on the modules has several safety features (CRC packet checks, caching and testing the entire firmware image before writing it, etc.) this procedure isn't without risk, however small. There is a small possibility you can brick your device in DFU mode, requiring access to a HW debugger like the J-Link to recover it.

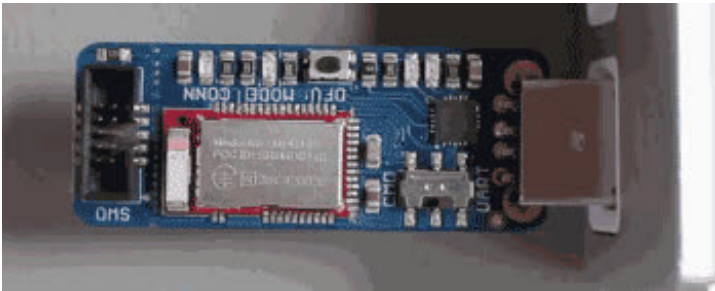
## Forcing DFU Mode

Performing firmware updates from within the Bluefruit LE Connect app will automatically cause the board to reset into DFU mode, but there may be situations where you need to force the device into DFU mode as well.

To force the device into DFU mode (to enable firmware updates on devices that are locked up from a bad Arduino sketch, for example) press and hold the **DFU** button when inserting the device if a button is available, or by setting the **DFU** pin to **GND** when powering the device up (depending on the exact board you are using).

# DFU Mode Confirmation

You will know that you are in DFU mode because the MODE LED will blink at a constant rate:



## DFU Timeout

By default, the DFU code has a **5-minute timeout**. After 5 minutes in DFU mode, the device will revert back to the normal user code if any user code is present on the device. To return back to DFU mode, you will need to hold down the DFU button and reset the device via a power cycle.

Once you're in DFU mode, continue on to the iOS or Android pages ahead.

## Firmware Images

Bluefruit LE Connect will automatically download the appropriate firmware image for you, but if you need direct access to them the latest Bluefruit LE firmware images are always available in our Github repo at [https://github.com/adafruit/Adafruit\\_BluefruitLE\\_Firmware](https://github.com/adafruit/Adafruit_BluefruitLE_Firmware) (<http://adafru.it/edX>)



# DFU on iOS

## Install Bluefruit LE Connect

The first step to enable DFU support on your iOS device is to install our free [Bluefruit LE Connect](http://adafru.it/f4H) (<http://adafru.it/f4H>) application, available in the App Store.

This should work on an iPhone or iPad less than a few years old since Apple was very early in adding Bluetooth Low Energy support to their devices.

The Bluefruit LE Connect application will manage the firmware updates for you, including downloading the appropriate firmware image from our Github firmware repo, resetting the board into DFU mode, and displaying the version number once the update is complete (as detailed in the video below).

## Update Process

Follow the video below to update your nRF51822 based Bluefruit LE module in a few simple clicks:

# DFU on Android (4.3+)

## Install Bluefruit LE Connect

The first step to enable DFU support on your Android device is to install our free [Bluefruit LE Connect](http://adafru.it/f4G) (<http://adafru.it/f4G>) application, available in the Play Store.

This application will manage the firmware updates for you, including downloading the appropriate firmware image from our Github firmware repo.

## Verified Devices

You can perform a field update of your nRF51822 based Bluefruit LE module on most recent Android devices, though Bluetooth Low Energy support was only added to version 4.3, with some important stability updates in 4.4.

Make sure you are running at least Android 4.4 or higher and have a BLE radio inside your phone.

We've tested DFU updates with the following devices:

- Nexus 6 (Android 6.0.1)
- Nexus 4 (Android 4.4.4)
- Nexus 7 - 2013 (Android 4.4.4)
- LG G4 (Android 5.1)

**Note:** The 2012 edition of the Nexus 7 won't work since it doesn't support BLE.

## Update Process

Follow the video below to see how to update the firmware on your device via a few easy clicks!

# BLE Sniffer

Using a special firmware image provided by Nordic Semiconductors and the open source network analysis tool Wireshark, the BLEFriend can be converted into a low cost Bluetooth Low Energy sniffer.

Since nRF-Sniffer is a passive solution that is simply scanning packets over the air, there is the possibility of missing packets using this tool (or any other passive sniffing solution). In order to capture as many packets as possible, be sure to run the sniffer on a USB bus that isn't busy and avoid running it in a virtual machine since this can introduce significant latency over USB.

## Select the Sniffer Target

The nRF-Sniffer can only sniff one device at a time, so the first step is getting the sniffer running and then selecting the device that you want to debug.

Start nRF-Sniffer by running the ble-sniffer\_win executable (for example: ble-sniffer\_win\_1.0.1\_1111\_Sniffer.exe).

This will try to detect the device running the nRF-Sniffer firmware over a UART COM port.

If the board isn't detected right away type **'f'** to erase any previous com port settings, or try removing and then re-inserting the sniffer while the console application is running.

Once the sniffer is found, you should see a list of all BLE devices that were detected in listening range:

```

BLE Sniffer 1.0.1

Commands:
l          List the devices available for sniffing.
arrow keys Navigate the device list. Use ENTER to select.
[#] or ENTER Select a device to sniff from list.
e          Like ENTER, but sniffer will only follow advertisements.
w          Start Wireshark, the primary viewer for the sniffer.
x/q       Exit
c          Display filter: Nearest devices (RSSI > -50 dBm).
v          Display filter: Nearest devices (RSSI > -70 dBm).
b          Display filter: Nearest devices (RSSI > -90 dBm).
a          Remove display filter.
p          Passkey entry
o          OOB key entry
h          Define new adv hop sequence.
s          Get support
u          Launch User Guide (pdf)
CTRL-R    Re-program firmware onto board

Available devices:

# public name          RSSI          device address
-----
[ ] 0 ""               -90 dBm      14:99:e2:05:29:cf  public
[ ] 1 ""               -65 dBm      68:48:98:b8:e5:2b  public
[ ] 2 ""               -46 dBm      e4:c6:c7:31:95:11  random

Scanning for devices.

Sent Key value to sniffer

```

In this particular case, we'll select device number 2, which is a BLEFriend running the standard UART firmware.

Type the device number you want to sniff (in this case '2'), and you should see the device highlighted in the list, similar to the image below:

```

BLE Sniffer 1.0.1

BTLE Plugin version  SUN rev. 1111

Commands:
l          List the devices available for sniffing.
arrow keys Navigate the device list. Use ENTER to select.
[#] or ENTER Select a device to sniff from list.
e          Like ENTER, but sniffer will only follow advertisements.
w          Start Wireshark, the primary viewer for the sniffer.
x/q       Exit
c          Display filter: Nearest devices (RSSI > -50 dBm).
v          Display filter: Nearest devices (RSSI > -70 dBm).
b          Display filter: Nearest devices (RSSI > -90 dBm).
a          Remove display filter.
p          Passkey entry
o          OOB key entry
h          Define new adv hop sequence.
s          Get support
u          Launch User Guide (pdf)
CTRL-R    Re-program firmware onto board

Available devices:

# public name          RSSI          device address
-----
[ ] 0 ""               -90 dBm      14:99:e2:05:29:cf  public
[ ] 1 ""               -90 dBm      68:48:98:b8:e5:2b  public
-> [X] 2 ""             -46 dBm      e4:c6:c7:31:95:11  random

Sniffing device 2 - ""

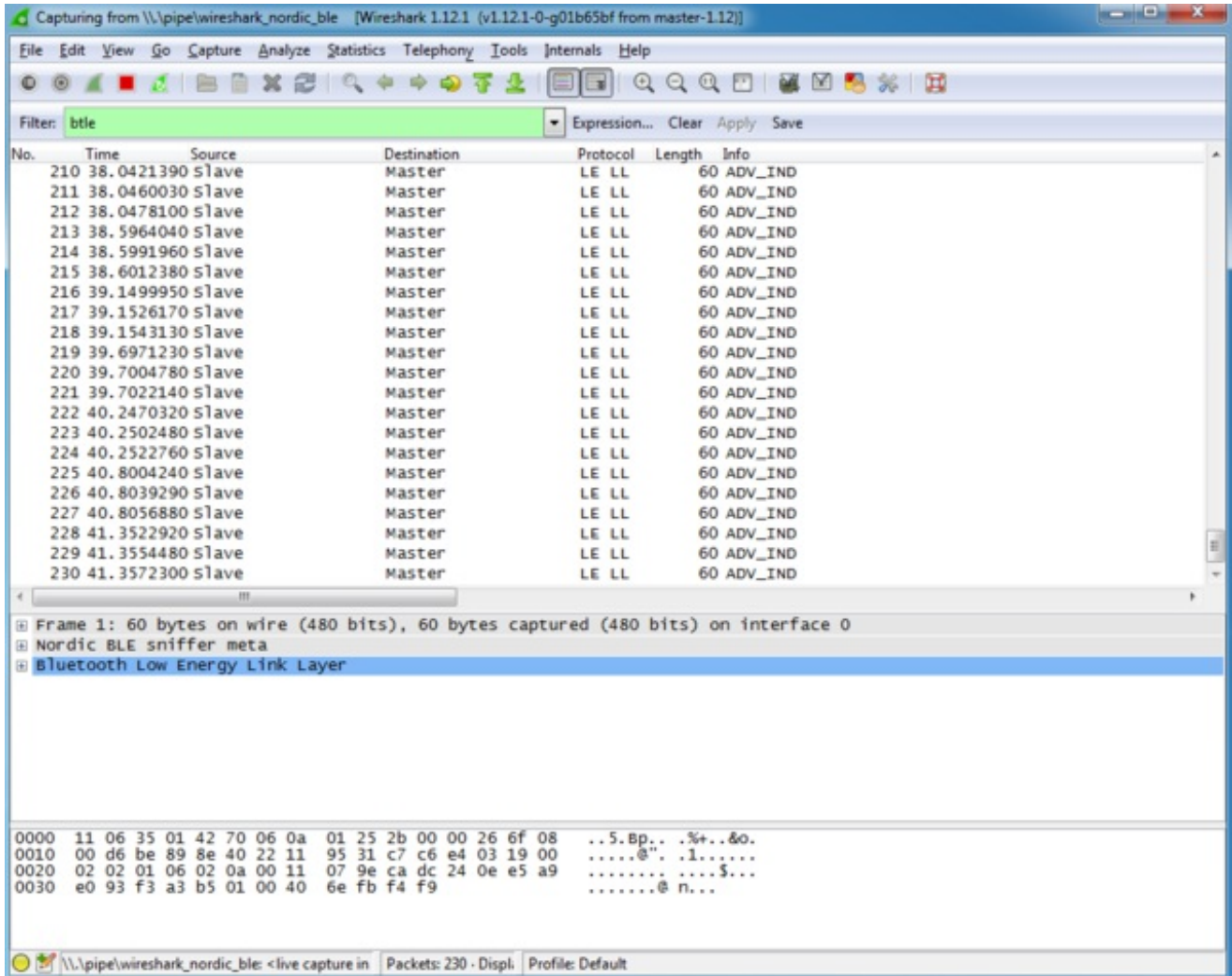
```

At this point you can type 'w', which will try to open wireshark and start pushing data out via a dedicate

pipe created by the nRF-Sniffer utility.

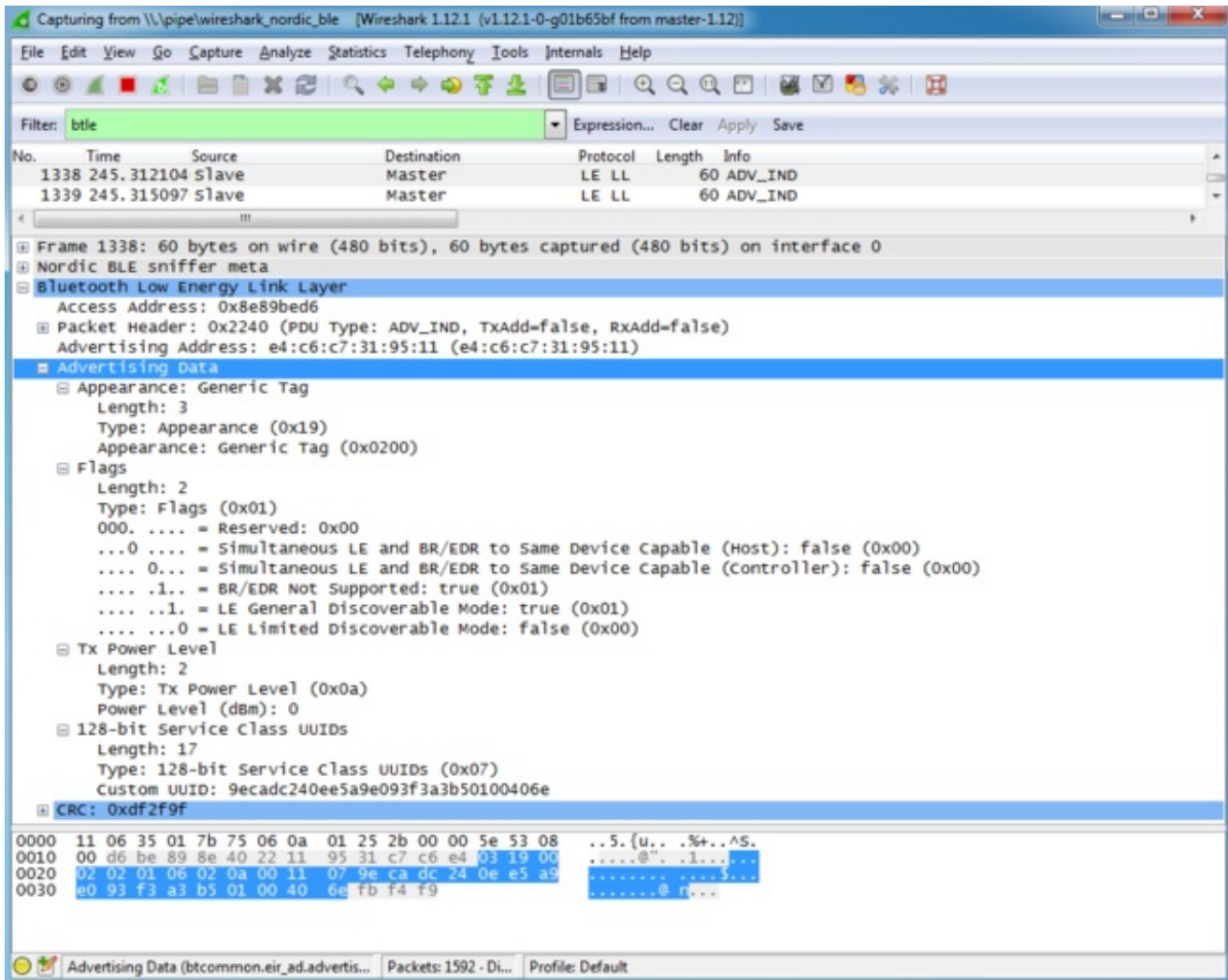
# Working with Wireshark

Once Wireshark has loaded, you should see the advertising packets streaming out from the selected BLE device at a regular interval, as shown in the image below:



One of the key benefits of WireShark as an analysis tool is that it understands the raw packet formats and provides human-readable displays of the raw packet data.

The main way to interact with BLE data packets is to select one of the packets in the main window, and then expand the **Bluetooth Low Energy Link Layer** treeview item in the middle of the UI, as shown below:



Clicking on the **Advertising Data** entry in the treeview will highlight the relevant section of the raw payload at the bottom of the screen, but also provides human readable information about the payload that can save you a lot of time trying to debug or reverse engineer a device.

We can see, for example, that the device is advertising itself as a Bluetooth Low Energy only device ('BR/EDR Not Supported'), with a TX Power Level of 0dBm, and a single service is being advertised using a 128-bit UUID (the UART service in this case).

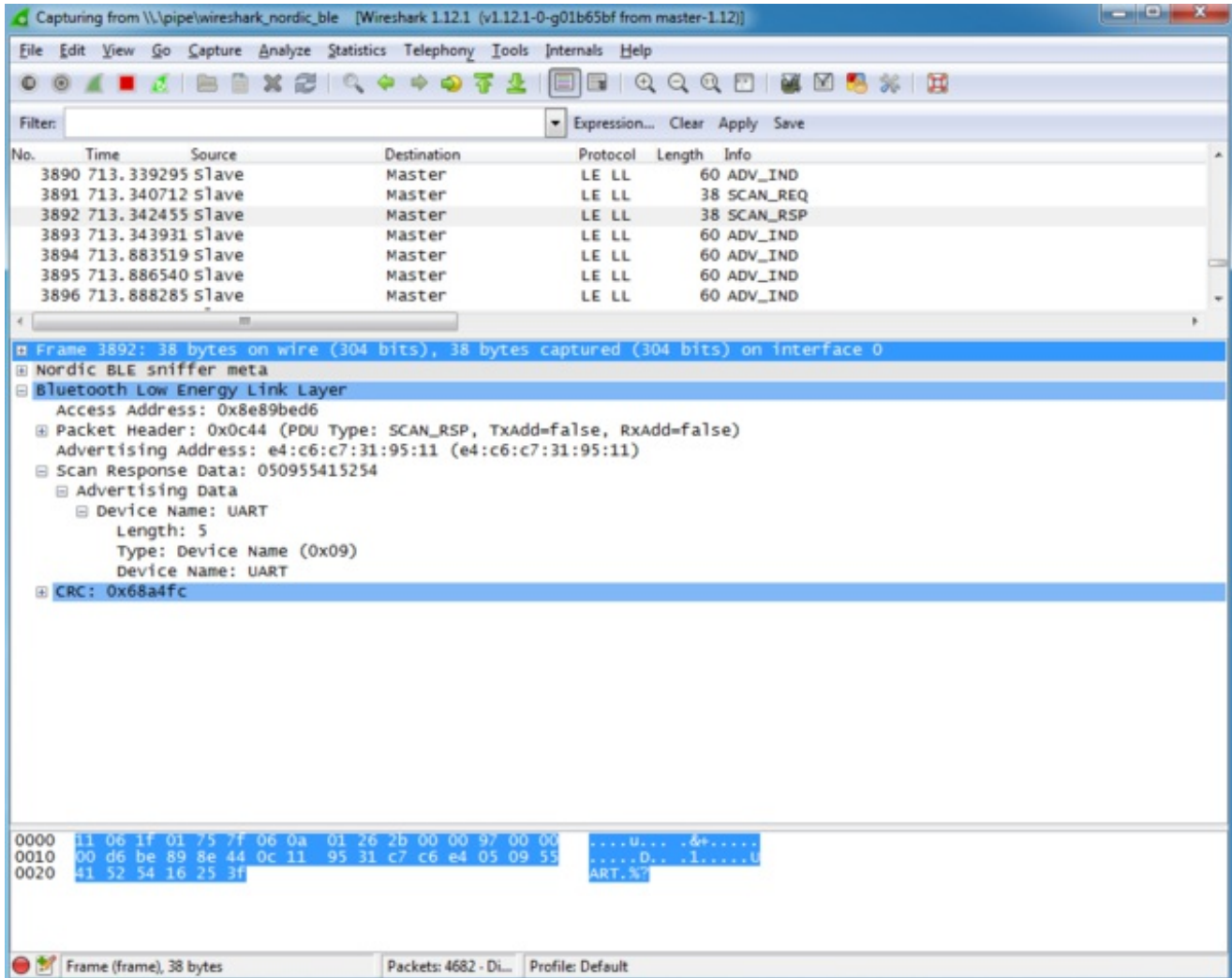
## Capturing Exchanges Between Two Devices

If you wish to sniff data being exchanged between two BLE devices, you will need to establish a connection between the original device we selected above and a second BLE device (such as an iPhone or an Android tablet with BLE capabilities).

The nRF-Sniffer firmware is capable of listening to all of the exchanges that happen between these devices, but can not connect with a BLE peripheral or central device itself (it's a purely passive device).

# Scan Response Packets

If you open up **nRF UART** on an Android or iOS device, and click the **Connect** button, the phone or tablet will start scanning for devices in range. One of the side effects of this scanning process is that you may spot a new packet in Wireshark on an irregular basis, the 'SCAN\_REQ' and 'SCAN\_RSP' packets:



The **Scan Response** is an optional second advertising packet that some Bluetooth Low Energy peripherals use to provide additional information during the advertising phase. The normal mandatory advertising packet is limited to 31 bytes, so the Bluetooth SIG includes the possibility to request a second advertising payload via the **Scan Request**.

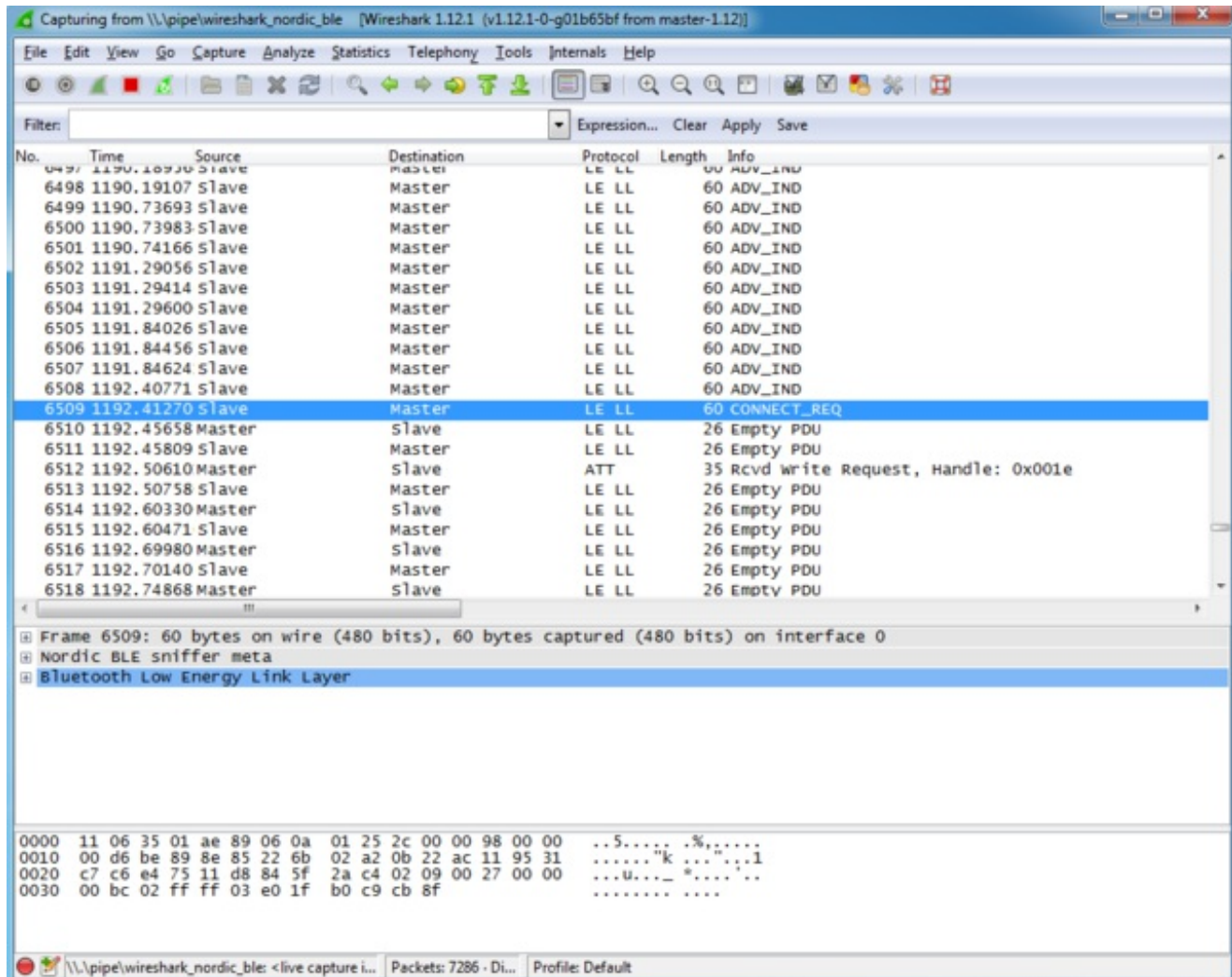
You can see both of these transactions in the image above, and the **Device Name** that is included in the Scan Response payload (since the 128-bit UART Service UUID takes up most of the free space in the main advertising packet).

For more information on Scan Responses and the advertising process in Bluetooth Low Energy see our [Introduction to Bluetooth Low Energy Guide \(http://adafru.it/iCo\)](http://adafru.it/iCo).

# Connection Request

Once we click on the **UART** device in **nRF UART**, the two device will attempt to connect to each other by means of a **Connection Request**, which is initiated by the central device (the phone or tablet).

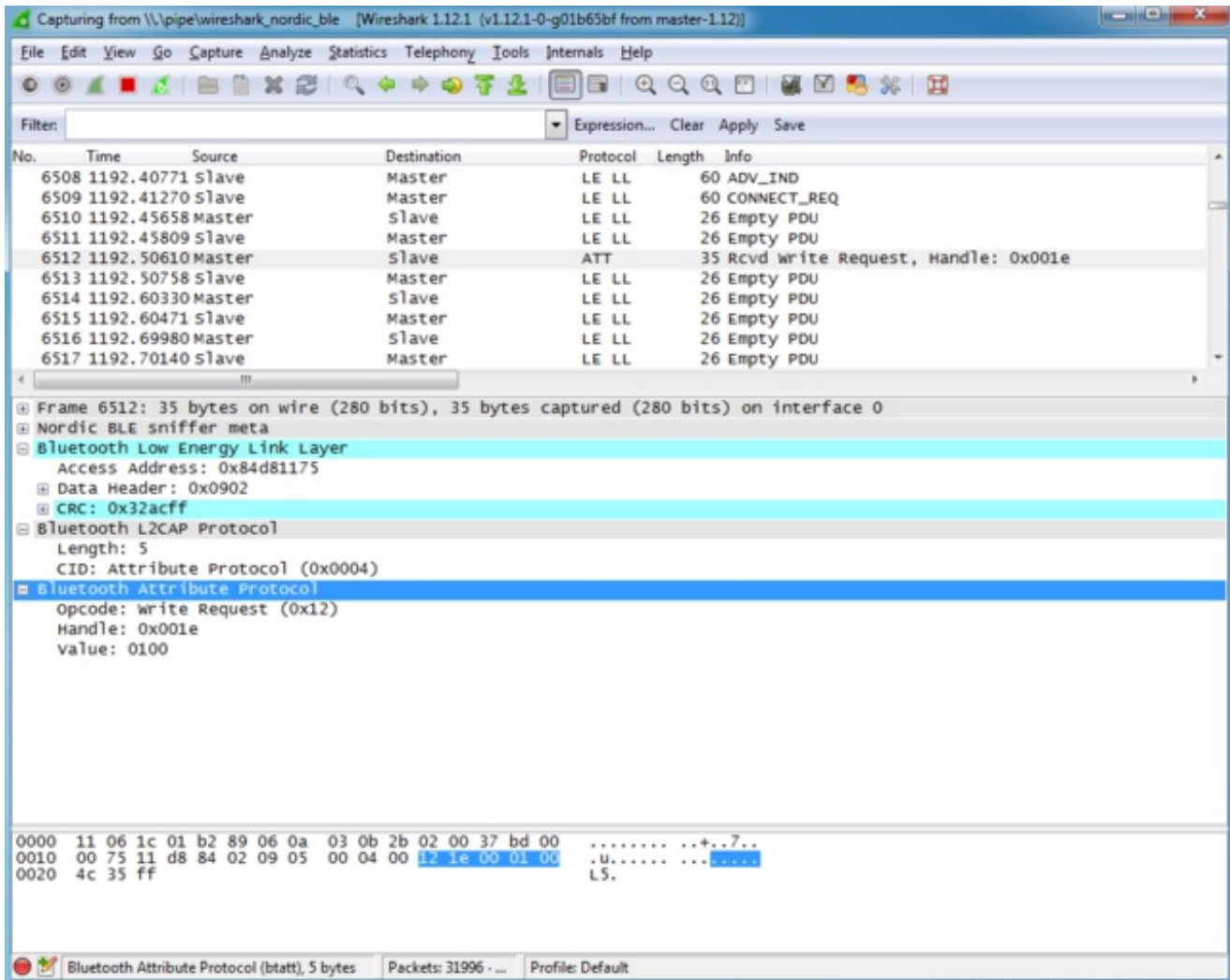
We can see this **CONNECT\_REQ** in the timeline in the image below:



# Write Request

Once the connection has been established, we can see that the **nRF UART** application tries to write data to the BLEFriend via a **Write Request** to handle '0x001E' (which is the location of an entry in the attribute table since everything in BLE is made up of attributes).





What this write request is trying to do is enable the 'notify' bit on the [UART service's TX characteristic](http://adafru.it/iCn) (0x001E is the handle for the CCCD or 'Client Characteristic Configuration Descriptor' (<http://adafru.it/ecl>)). This bit enables an 'interrupt' of sorts to tell the BLEFriend that we want to be alerted every time there is new data available on the characteristic that transmits data from the BLEFriend to the phone or tablet.

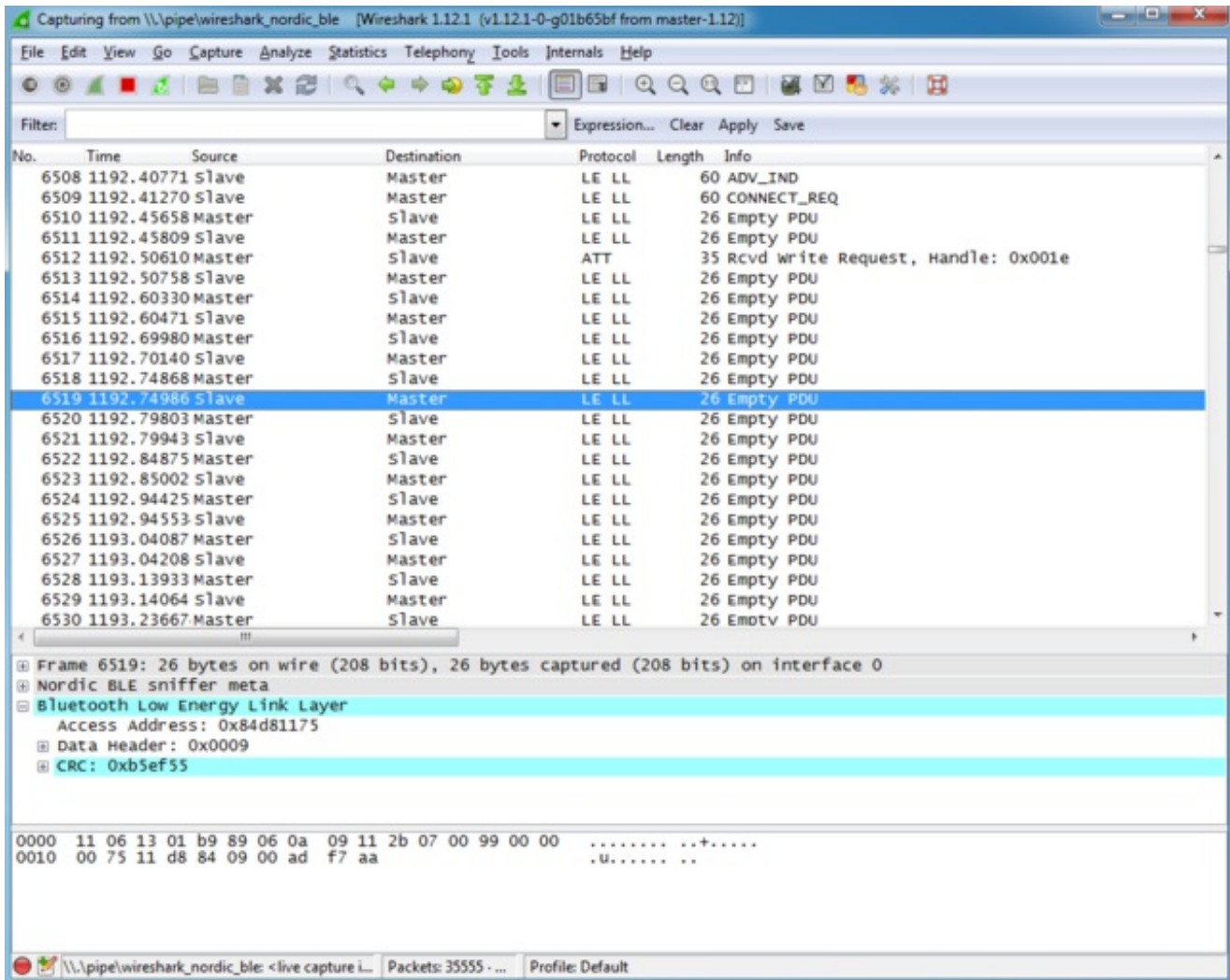
## Regular Data Requests

At this point you will start to see a lot of regular **Empty PDU** requests. This is part of the way that Bluetooth Low Energy works.

Similar to USB, all BLE transaction are initiated by the bus 'Master', which is the central device (the tablet or phone).

In order to receive data from the bus slave (the peripheral device, or the BLEFriend in this particular case) the central device sends a 'ping' of sorts to the peripheral at a delay known as the 'connection interval' (not to be confused with the one-time connection highlighted earlier in this tutorial).

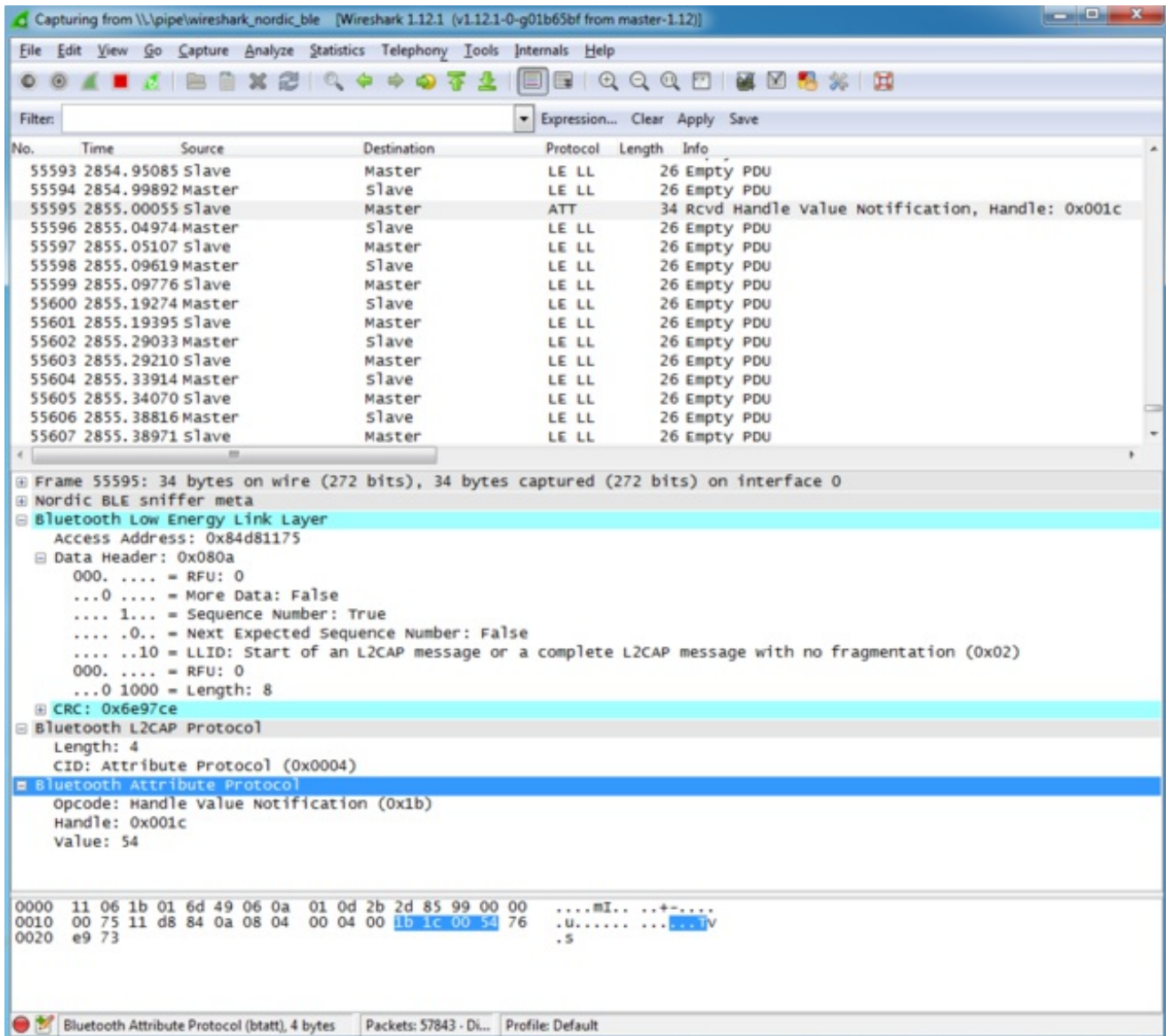
We can see pairs of transaction that happen at a reasonably consistent interval, but no data is exchanged since the BLEFriend (the peripheral) is saying 'sorry, I don't have any data for you':



## Notify Event Data

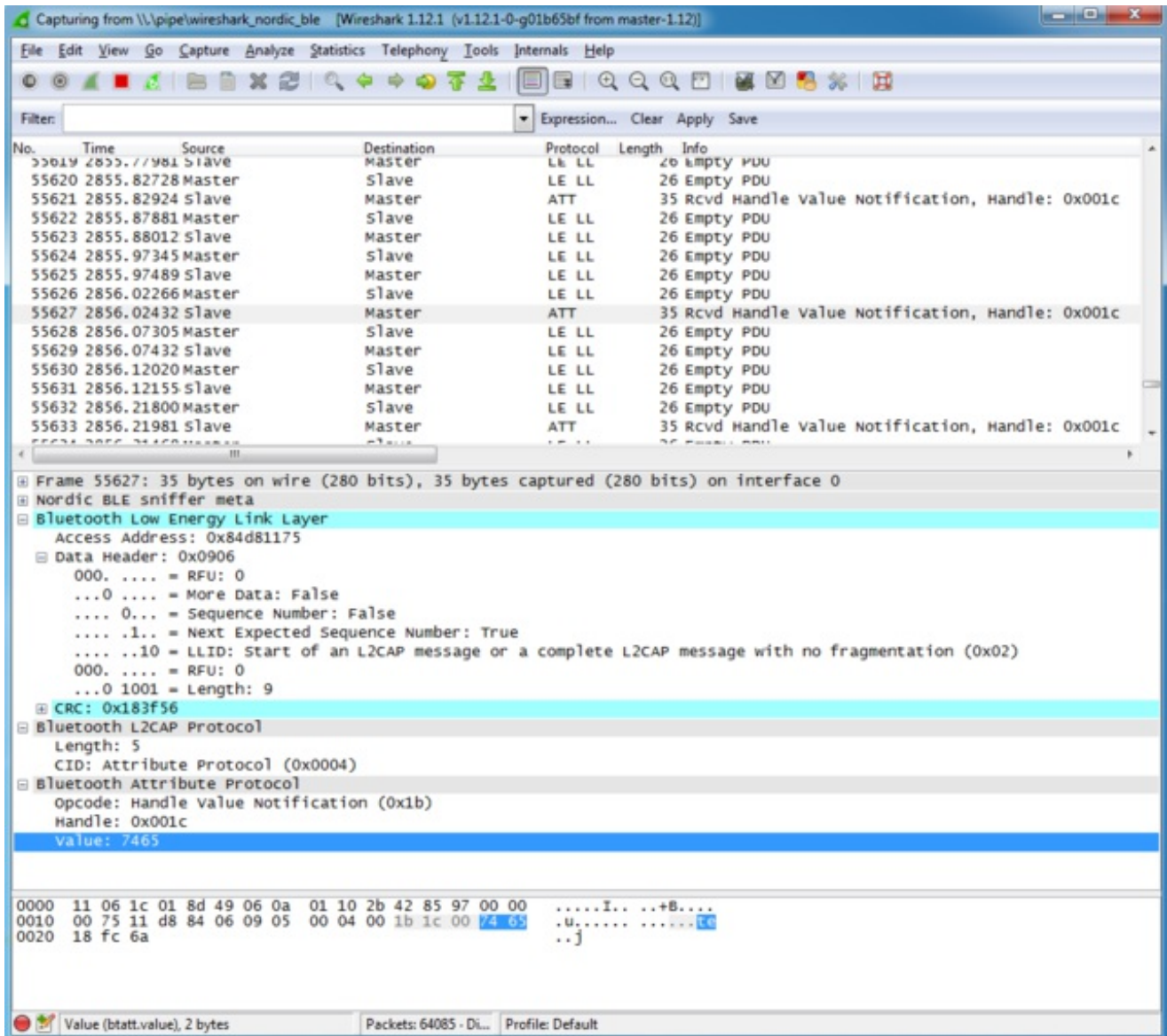
To see an actual data transaction, we simply need to enter some text in our terminal emulator SW which will cause the BLEFriend to send the data to **nRF UART** using the UART service.

Entering the string 'This is a test' in the terminal emulator, we can see the first packet being sent below (only the 'T' character is transmitted because the packets are sent out faster than we enter the characters into the terminal emulator):

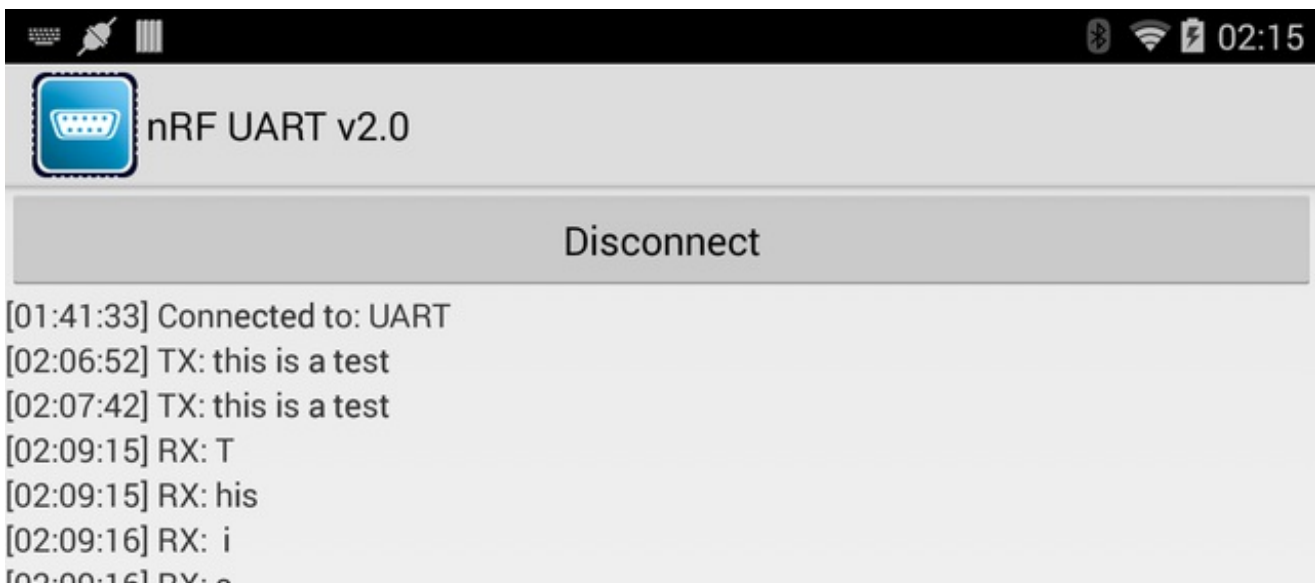


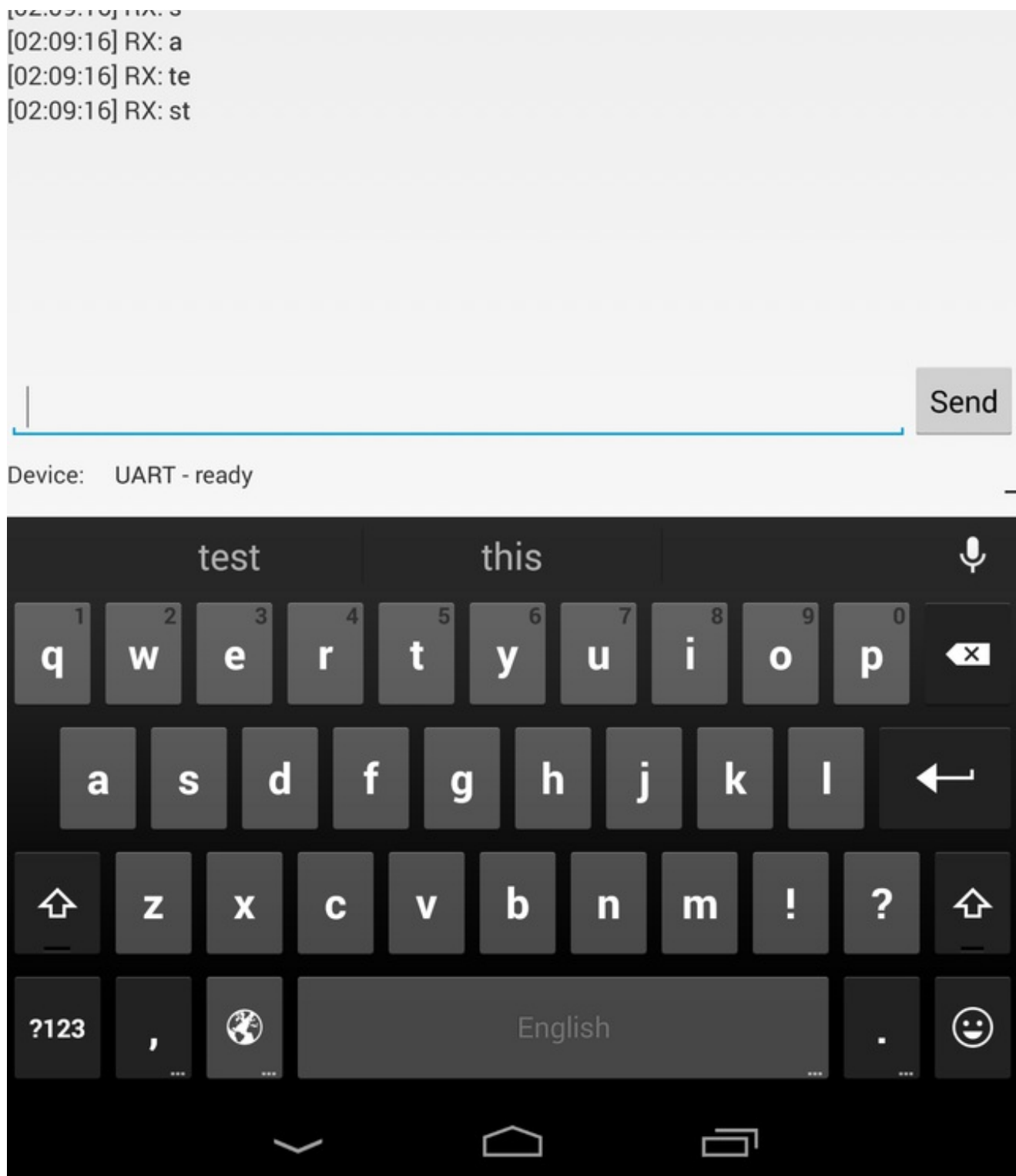
What this 4-byte 'Bluetooth Attribute Protocol' packet is actually saying is that attribute 0x001C (the location of the TX characteristic in the attribute table) has been updated, and the new value is '0x54', which corresponds to the letter 'T'.

Scrolling a bit further down we can see an example where more than one character was sent in a single transaction ('te' in this case):



The results of this transaction in the nRF UART application can be seen below:





## Closing Wireshark and nRF-Sniffer

When you're done debugging, you can save the session to a file for later analysis, or just close Wireshark right away and then close the nRF-Sniffer console window to end the debug session.

# Moving Forward

A sniffer is an incredibly powerful and valuable tool debugging your own hardware, reverse engineering existing BLE peripherals, or just to learn the ins and outs of how Bluetooth Low Energy actually works on the a packet by packet level.

You won't learn everything there is to know about BLE in a day, but a good book on BLE, a copy of the Bluetooth 4.1 Core Specification and a sniffer will go a long way to teaching you most of the important things there is to know about BLE in the real world.

# GATT Service Details

Data in Bluetooth Low Energy is organized around units called 'GATT Services (<http://adafru.it/iCp>)' and 'GATT Characteristics'. To expose data to another device, you must instantiate at least one service on your device.

Adafruit's Bluefruit LE Pro modules support some 'standard' services, described below (more may be added in the future).

## UART Service

The UART Service is the standard means of sending and receiving data between connected devices, and simulates a familiar two-line UART interface (one line to transmit data, another to receive it).

The service is described in detail on the dedicated [UART Service \(http://adafru.it/iCn\)](http://adafru.it/iCn) page.

# UART Service

**Base UUID:** 6E400001-B5A3-F393- E0A9- E50E24DCCA9E

This service simulates a basic UART connection over two lines, TXD and RXD.

It is based on a proprietary UART service specification by Nordic Semiconductors. Data sent to and from this service can be viewed using the nRFUART apps from Nordic Semiconductors for Android and iOS.

This service is available on every Bluefruit LE module and is automatically started during the power-up sequence.

## Characteristics

Nordic's UART Service includes the following characteristics:

Name	Mandatory	UUID	Type	R	W	N	I
TX	Yes	0x0002	U8[20]	X			
RX	Yes	0x0003	U8[20]	X	X		

R = Read; W = Write; N = Notify; I = Indicate

Characteristic names are assigned from the point of view of the Central device

### TX (0x0002)

This characteristic is used to send data back to the sensor node, and can be written to by the connected Central device (the mobile phone, tablet, etc.).

### RX (0x0003)

This characteristic is used to send data out to the connected Central device. Notify can be enabled by the connected device so that an alert is raised every time the TX channel is updated.



# Software Resources

To help you get your Bluefruit LE module talking to other Central devices, we've put together a number of open source tools for most of the major platforms supporting Bluetooth Low Energy.

## Bluefruit LE Client Apps and Libraries

Adafruit has put together the following mobile or desktop apps and libraries to make it as easy as possible to get your Bluefruit LE module talking to your mobile device or laptop, with full source available where possible:

### Bluefruit LE Connect (<http://adafru.it/f4G>) (Android/Java)

Bluetooth Low Energy support was added to Android starting with Android 4.3 (though it was only really stable starting with 4.4), and we've already released [Bluefruit LE Connect to the Play Store](http://adafru.it/f4G) (<http://adafru.it/f4G>).

The full [source code](http://adafru.it/fY9) (<http://adafru.it/fY9>) for Bluefruit LE Connect for Android is also available on Github to help you get started with your own Android apps. You'll need a recent version of [Android Studio](http://adafru.it/fYa) (<http://adafru.it/fYa>) to use this project.



### Adafruit Bluefruit LE Connect

Adafruit Industries Education

★★★★★ 47

PEGI 3

This app is compatible with some of your devices.

Installed

### Bluefruit LE Connect (<http://adafru.it/f4H>) (iOS/Swift)

Apple was very early to adopt Bluetooth Low Energy, and we also have an iOS version of the [Bluefruit LE Connect](http://adafru.it/f4H) (<http://adafru.it/f4H>) app available in Apple's app store.

The full [Swift source code](http://adafru.it/ddv) (<http://adafru.it/ddv>) for Bluefruit LE Connect for iOS is also available on Github. You'll need XCode and access to Apple's developer program to use this project.

## Adafruit Bluefruit LE Connect

[View More by This Developer](#)

By Adafruit Industries

Open iTunes to buy and download apps.



[View in iTunes](#)

This app is designed for both iPhone and iPad

### Description

Wirelessly connect your iOS device to Adafruit Bluefruit LE modules for control & communication with your projects.

Features:

[Adafruit Industries Web Site](#) > [Adafruit Bluefruit LE Connect Support](#) >

[...More](#)

### What's New in Version 1.7

- Apple Watch support with Color Picker and Control Pad
- Brightness Slider added to Color Picker
- Bugfixes for XML parsing in DFU mode

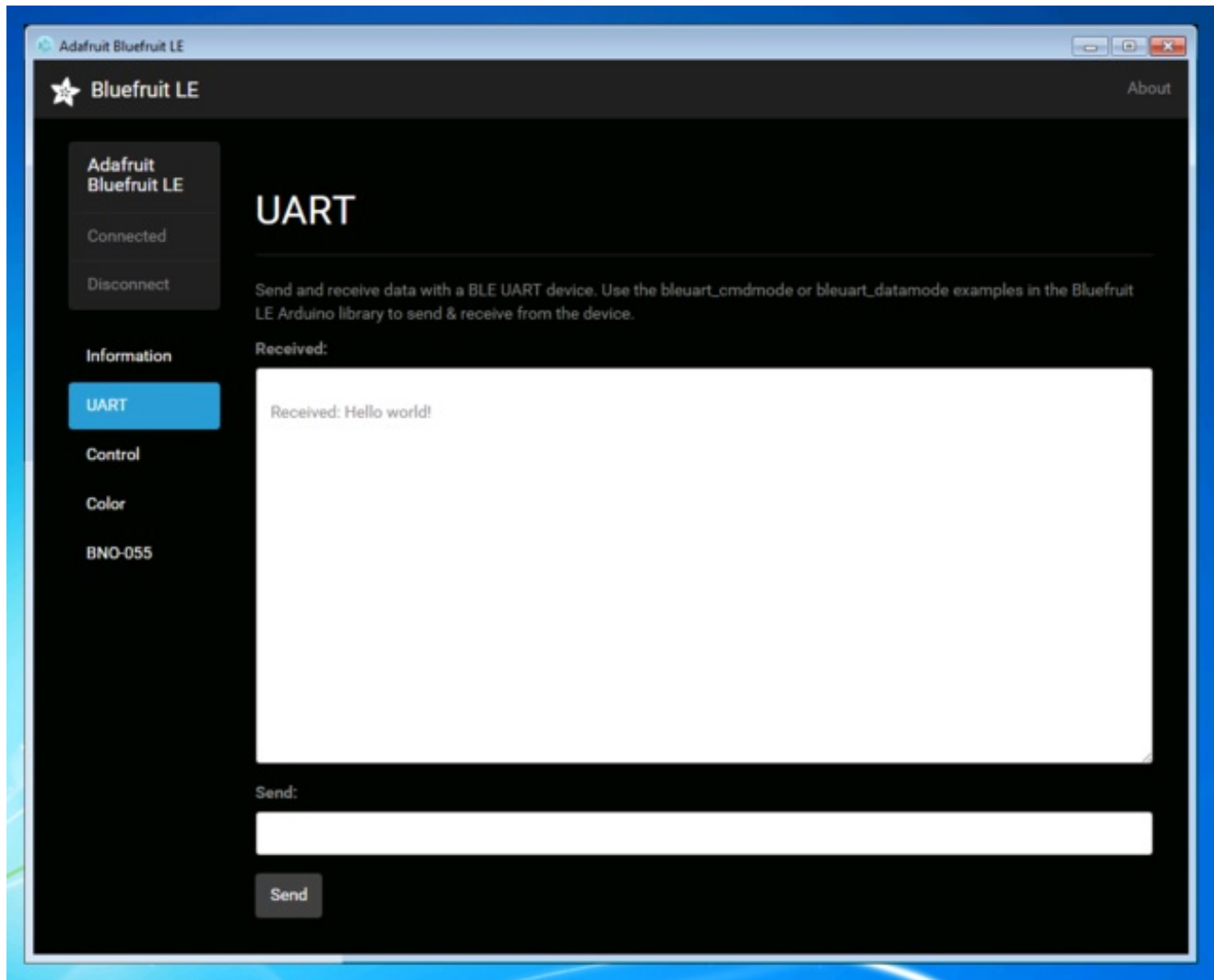
## ABLE (<http://adafru.it/ijB>) (Cross Platform/Node+Electron)

ABLE (<http://adafru.it/ijB>) (Adafruit Bluefruit LE Desktop) is a cross-platform desktop application based on Sandeep Misty's [noble library](http://adafru.it/ijC) (<http://adafru.it/ijC>) and the [Electron](http://adafru.it/ijD) (<http://adafru.it/ijD>) project from Github (used by Atom).

It runs on OS X, Windows 7+ and select flavours of Linux (Ubuntu tested locally). Windows 7 support is particularly interesting since Windows 7 has no native support for Bluetooth Low Energy but the noble library talks directly to [supported Bluetooth 4.0 USB dongles](http://adafru.it/1327) (<http://adafru.it/1327>) to emulate BLE on the system (though at this stage it's still in early BETA and drops the connection and takes more care to work with).

This app allows you to collect sensor data or perform many of the same functionality offered by the mobile Bluefruit LE Connect apps, but on the desktop.

The app is still in BETA, but full [source](http://adafru.it/ijE) (<http://adafru.it/ijE>) is available in addition to the easy to use [pre-compiled binaries](http://adafru.it/ijB) (<http://adafru.it/ijB>).



## Bluefruit LE Python Wrapper (<http://adafru.it/fQF>)

As a proof of concept, we've played around a bit with getting Python working with the native Bluetooth APIs on OS X and the latest version of Bluez on certain Linux targets.

There are currently example sketches showing how to retrieve BLE UART data as well as some basic details from the Device Information Service (DIS).

This isn't an actively support project and was more of an experiment, but if you have a recent Macbook or a Raspberry Pi and know Python, you might want to look at [Adafruit\\_Python\\_BluefruitLE](http://adafru.it/fQF) (<http://adafru.it/fQF>) in our github account.

## Debug Tools

If your sense of adventure gets the better of you, and your Bluefruit LE module goes off into the weeds, the following tools might be useful to get it back from unknown lands.

These debug tools are provided purely as a convenience for advanced users for device recovery purposes, and are not recommended unless you're OK with potentially bricking your board. Use them at your own risk.

## AdaLink (<http://adafru.it/fPq>) (Python)

This command line tool is a python-based wrapper for programming ARM MCUs using either a [Segger J-Link](http://adafru.it/fYU) (<http://adafru.it/fYU>) or an [STLink/V2](http://adafru.it/ijF) (<http://adafru.it/ijF>). You can use it to reflash your Bluefruit LE module using the latest firmware from the [Bluefruit LE firmware repo](http://adafru.it/edX) (<http://adafru.it/edX>).

Details on how to use the tool are available in the readme.md file on the main [Adafruit\\_AdaLink](http://adafru.it/fPq) (<http://adafru.it/fPq>) repo on Github.

Completely reprogramming a Bluefruit LE module with AdaLink would require four files, and would look something like this (using a JLink):

```
adalink nrf51822 --programmer jlink --wipe
--program-hex "Adafruit_BluefruitLE_Firmware/softdevice/s110_nrf51_8.0.0_softdevice.hex"
--program-hex "Adafruit_BluefruitLE_Firmware/bootloader/bootloader_0002.hex"
--program-hex "Adafruit_BluefruitLE_Firmware/0.6.7/blefriend32/blefriend32_s110_xxac_0_6_7_150917_blefriend32.hex"
--program-hex "Adafruit_BluefruitLE_Firmware/0.6.7/blefriend32/blefriend32_s110_xxac_0_6_7_150917_blefriend32_signature.hex"
```

You can also use the AdaLink tool to get some basic information about your module, such as which SoftDevice is currently programmed or the IC revision (16KB SRAM or 32KB SRAM) via the --info command:

```
$ adalink nrf51822 -p jlink --info
Hardware ID : QFACA10 (32KB)
Segger ID   : nRF51822_xxAC
SD Version  : S110 8.0.0
Device Addr : ****.*.*.*.*.*.*.*
Device ID   : *****
```

## Adafruit nRF51822 Flasher (<http://adafru.it/fVL>) (Python)

Adafruit's nRF51822 Flasher is an internal Python tool we use in production to flash boards as they go through the test procedures and off the assembly line, or just testing against different firmware releases when debugging.

It relies on AdaLink or OpenOCD beneath the surface (see above), but you can use this command line tool to flash your nRF51822 with a specific SoftDevice, Bootloader and Bluefruit firmware combination.

It currently supports using either a Segger J-Link or STLink/V2 via AdaLink, or [GPIO on a Raspberry Pi](#) (<http://adafru.it/fVL>) if you don't have access to a traditional ARM SWD debugger. (A pre-built version of OpenOCD for the RPi is included in the repo since building it from scratch takes a long time on the original RPi.)

We don't provide active support for this tool since it's purely an internal project, but made it public just in case it might help an adventurous customer debrick a board on their own.

```
$ python flash.py --jtag=jlink --board=blefriend32 --softdevice=8.0.0 --bootloader=2 --firmware=0.6.7
jtag      : jlink
softdevice : 8.0.0
bootloader : 2
board     : blefriend32
firmware  : 0.6.7
Writing Softdevice + DFU bootloader + Application to flash memory
adalink -v nrf51822 --programmer jlink --wipe --program-hex "Adafruit_BluefruitLE_Firmware/softdevice/s110_nrf51
_8.0.0_softdevice.hex" --program-hex "Adafruit_BluefruitLE_Firmware/bootloader/bootloader_0002.hex" --program-
hex "Adafruit_BluefruitLE_Firmware/0.6.7/blefriend32/blefriend32_s110_xxac_0_6_7_150917_blefriend32.hex" --p
rogram-hex "Adafruit_BluefruitLE_Firmware/0.6.7/blefriend32/blefriend32_s110_xxac_0_6_7_150917_blefriend32
_signature.hex"
...
```

# BLE FAQ

Can I talk to Classic Bluetooth devices with a Bluefruit LE modules?

No. Bluetooth Low Energy and 'Classic' Bluetooth are both part of the same Bluetooth Core Specification -- defined and maintained by the Bluetooth SIG -- but they are completely different protocols operating with different physical constraints and requirements. The two protocols can't talk to each other directly.

Can my Bluefruit LE module connect to other Bluefruit LE peripherals

No, the Bluefruit LE firmware from Adafruit is currently peripheral only, and doesn't run in Central mode, which would cause the module to behave similar to your mobile phone or BLE enabled laptop.

At some point we might consider a new firmware image offering this, but since 98% of the uses cases for BLE involved running as a peripheral we've concentrated all of our development effort there for now.

Why are none of my changes persisting when I reset with the sample sketches?

In order to ensure that the Bluefruit LE modules are in a known state for the Adafruit demo sketches, most of them perform a factory reset at the start of the sketch.

This is useful to ensure that the sketch functions properly, but has the side effect of erasing any custom user data in NVM and setting everything back to factory defaults every time your board comes out of reset and the sketch runs.

To disable factory reset, open the demo sketch and find the **FACTORYRESET\_ENABLE** flag and set this to '0', which will prevent the factory reset from happening at startup.

If you don't see the 'FACTORYRESET\_ENABLE' flag in your .ino sketch file, you probably have an older version of the sketches and may need to update to the latest version via the Arduino library manager.

Do I need CTS and RTS on my UART based Bluefruit LE Module?

Using CTS and RTS isn't strictly necessary when using HW serial, but they should both be used with SW serial, or any time that a lot of data is being transmitted.

The reason behind the need for CTS and RTS is that the UART block on the nRF51822 isn't very robust, and early versions of the chip had an extremely small FIFO meaning that the UART peripheral was quickly overwhelmed.

Using CTS and RTS significantly improves the reliability of the UART connection since these two pins tell the device on the other end when they need to wait while the existing buffered data is processed.

To enable CTS and RTS support, go into the BluefruitConfig.h file in your sketch folder and simply assign an appropriate pin to the macros dedicated to those functions (they may be set to -1 if they aren't currently being used).

Enabling both of these pins should solve any data reliability issues you are having with large

commands, or when transmitting a number of commands in a row.

How can I update to the latest Bluefruit LE Firmware?

The easiest way to keep your Bluefruit LE modules up to date is with our [Bluefruit LE Connect app for Android](http://adafru.it/f4G) (<http://adafru.it/f4G>) or [Bluefruit LE Connect for iOS](http://adafru.it/f4H) (<http://adafru.it/f4H>). Both of these apps include a firmware update feature that allows you to automatically download the latest firmware and flash your Bluefruit LE device in as safe and painless a manner as possible. You can also roll back to older versions of the Bluefruit LE firmware using these apps if you need to do some testing on a previous version.

Which firmware version supports 'xxx'?

We regularly release [Bluefruit LE firmware images](http://adafru.it/edX) (<http://adafru.it/edX>) with bug fixes and new features. Each AT command in this learning guide lists the minimum firmware version required to use that command, but for a higher level overview of the changes from one firmware version to the next, consult the [firmware history page](http://adafru.it/iCw) (<http://adafru.it/iCw>).

Does my Bluefruit LE device support ANCS?

ANCS is on the roadmap for us (most likely in the 0.7.x release family), but we don't currently support it since there are some unusual edge cases when implementing it as a service.

My Bluefruit LE device is stuck in DFU mode ... what can I do?

If your device is stuck in DFU mode for some reason and the firmware was corrupted, you have several options.

First, try a factory reset by holding down the DFU button for about 10 seconds until the CONN LED starts flashing, then release the DFU button to perform a factory reset.

If this doesn't work, you may need to reflash your firmware starting from DFU mode, which can be done in one of the following ways:

## Bluefruit LE Connect (Android)

- Place the module in DFU mode (constant LED blinky)
- Open Bluefruit LE Connect
- Connect to the 'DfuTarg' device
- Once connected, you will see a screen with some basic device information. Click the '...' in the top-right corner and select **Firmware Updates**
- Click the **Use Custom Firmware** button
- Select the appropriate .hex and .init files (copied from the [Bluefruit LE Firmware repo](http://adafru.it/edX) (<http://adafru.it/edX>)) ... for the BLEFRIEND32 firmware version 0.6.7, this would be:
  - Hex File: blefriend32\_s110\_xxac\_0\_6\_7\_150917\_blefriend32.hex
  - Init File: blefriend32\_s110\_xxac\_0\_6\_7\_150917\_blefriend32\_init.dat
- Click **Start Update**

Unfortunately, the iOS app doesn't yet support custom firmware updates from DFU mode yet, but we will get this into the next release.

## Nordic nRF Toolbox

You can also use Nordic's nRF Toolbox application to update the firmware using the OTA bootloader.

On **Android**:

- Open nRF Toolbox (using the latest version)
- Click the **DFU** icon
- Click the **Select File** button
- Select **Application** from the radio button list, then click **OK**
- Find the appropriate .hex file (ex. 'blefriend32\_s110\_xxac\_0\_6\_7\_150917\_blefriend32.hex')
- When asked about the '**Init packet**', indicate **Yes**, and select the appropriate \*\_init.dat file (for example: 'blefriend32\_s110\_xxac\_0\_6\_7\_150917\_blefriend32\_init.dat').
- Click the **Select Device** button at the bottom of the main screen and find the **DfuTarg** device, clicking on it
- Click the **Upload** button, which should now be enabled on the home screen
- This will begin the DFU update process which should cause the firmware to be updated or restored on your Bluefruit LE module

On **iOS**:

- Create a .zip file containing the .hex file and init.dat file that you will use for the firmware update. For example:
  - Rename 'blefriend32\_s110\_xxac\_0\_6\_7\_150917\_blefriend32.hex' to **application.hex**
  - Rename 'blefriend32\_s110\_xxac\_0\_6\_7\_150917\_blefriend32\_init.dat' to **application.dat**
- Upload the **.zip file** containing the application.hex and application.dat files to your iPhone using iTunes, as described [here \(http://adafru.it/iCx\)](http://adafru.it/iCx)
- Open the nRF Toolbox app (using the latest version)
- Click the **DFU** icon
- Click the **Select File** text label
- Switch to **User Files** to see the .zip file you uploaded above
- Select the .zip file (ex. blefriend32\_065.zip)
- On the main screen select **Select File Type**
- Select **application**
- On the main screen select **SELECT DEVICE**
- Select **DfuTarg**
- Click the **Upload** button which should now be enabled
- This will begin the DFU process and your Bluefruit LE module will reset when the update is complete
- If you get the normal 2 or 3 pulse blinky pattern, the update worked!

## Adafruit\_nRF51822\_Flasher

As a last resort, if you have access to a Raspberry Pi, a Segger J-Link or a STLink/V2, you can also try manually reflashing the entire device, as described in the [FAQ above \(http://adafru.it/iCy\)](http://adafru.it/iCy), with further details on the [Software Resources \(http://adafru.it/iCz\)](http://adafru.it/iCz) page.

How do I reflash my Bluefruit LE module over SWD?



Reflashing Bluefruit LE modules over SWD (ex. switching to the sniffer firmware and back) is **at your own risk and can lead to a bricked device, and we can't offer any support for this operation!** You're on your own here, and there are unfortunately 1,000,000 things that can go wrong, which is why we offer two separate Bluefruit LE Friend boards -- the sniffer and the normal Bluefruit LE Friend board with the non-sniffer firmware, which provides a bootloader with fail safe features that prevents you from ever bricking boards via OTA updates.

### **AdaLink (SWD/JTAG Debugger Wrapper)**

Transitioning between the two board types (sniffer and Bluefruit LE module) is unfortunately not a risk-free operation, and requires external hardware, software and know-how to get right, which is why it isn't covered by our support team.

That said ... if you're determined to go down that lonely road, and you have a [Segger J-Link \(http://adafru.it/fYU\)](http://adafru.it/fYU) (which is what we use internally for production and development), or have already erased your Bluefruit LE device, you should have a look at [AdaLink \(http://adafru.it/fPq\)](http://adafru.it/fPq), which is the tool we use internally to flash the four files required to restore a Bluefruit LE module. (Note: recent version of AdaLink also support the cheaper [STLink/V2 \(http://adafru.it/2548\)](http://adafru.it/2548), though the J-Link is generally more robust if you are going to purchase a debugger for long term use.)

The mandatory Intel Hex files are available in the [Bluefruit LE Firmware repo \(http://adafru.it/edX\)](http://adafru.it/edX). You will need to flash:

- An appropriate bootloader image
- An appropriate SoftDevice image
- The Bluefruit LE firmware image
- The matching signature file containing a CRC check so that the bootloader accepts the firmware image above (located in the same folder as the firmware image)

The appropriate files are generally listed in the [version control .xml file \(http://adafru.it/fPr\)](http://adafru.it/fPr) in the firmware repository.

If you are trying to flash the sniffer firmware (at your own risk!), you only need to flash a single .hex file, which you can find [here \(http://adafru.it/fYV\)](http://adafru.it/fYV). The sniffer doesn't require a SoftDevice image, and doesn't use the fail-safe bootloader -- which is why changing is a one way and risky operation if you don't have a supported SWD debugger.

### **Adafruit\_nF51822\_Flasher**

We also have an internal python tool available that sits one level higher than AdaLink (referenced above), and makes it easier to flash specific versions of the official firmware to a Bluefruit LE module. For details, see the [Adafruit\\_nRF51822\\_Flasher \(http://adafru.it/fVL\)](http://adafru.it/fVL) repo.

Can I access BETA firmware releases?

The latest versions of the Bluefruit LE Connect applications for iOS and Android allow you to optionally update your Bluefruit LE modules with pre-release or BETA firmware.

This functionality is primarily provided as a debug and testing mechanism for support issues in the forum, and should only be used when trying to identify and resolve specific issues with your modules!

## Enabling BETA Releases on iOS

- Make sure you have at least **version 1.7.1** of Bluefruit LE Connect
- Go to the Settings page
- Scroll to the bottom of the Settings page until you find **Bluefruit LE**
- Click on the Bluefruit LE icon and enable the **Show beta releases** switch
- You should be able to see any BETA releases available in the firmware repo now when you use Bluefruit LE Connect

## Enabling BETA Releases on Android

- Make sure you have the latest version of Bluefruit LE Connect
- Open the Bluefruit LE Connect application
- Click the "... " icon in the top-right corner of the app's home screen
- Select **Settings**
- Scroll down to the **Software Updates** section and enable **Show beta releases**
- You should be able to see any BETA releases available in the firmware repo now when you use Bluefruit LE Connect

Why can't I see my Bluefruit LE device after upgrading to Android 6.0?

In Android 6.0 there were [some important security changes](http://adafruit.it/jcU) that affect Bluetooth Low Energy devices. If location services are unavailable (meaning the GPS is turned off) you won't be able to see Bluetooth Low Energy devices advertising either. See [this issue](http://adafruit.it/jcV) for details.

Be sure to enable location services on your Android 6.0 device when using Bluefruit LE Connect or other Bluetooth Low Energy applications with your Bluefruit LE modules.

What is the theoretical speed limit for BLE?

This depends on a variety of factors, and is determined by the capabilities of the central device (the mobile phone, etc.) as much as the peripheral.

Taking the HW limits on the nRF51822 into account (max 6 packets per connection interval, and a minimum connection interval of 7.5ms) you end up with the following theoretical limits on various mobile operating systems:

- **iPhone 5/6 + IOS 8.0/8.1**  
 $6 \text{ packets} * 20 \text{ bytes} * 1/0.030 \text{ s} = 4 \text{ kB/s} = 32 \text{ kbps}$
- **iPhone 5/6 + IOS 8.2/8.3**  
 $3 \text{ packets} * 20 \text{ bytes} * 1/0.030 \text{ s} = 2 \text{ kB/s} = 16 \text{ kbps}$
- **iPhone 5/6 + IOS 8.x with nRF8001**  
 $1 \text{ packet} * 20 \text{ bytes} * 1/0.030 \text{ s} = 0.67 \text{ kB/s} = 5.3 \text{ kbps}$
- **Nexus 4**  
 $4 \text{ packets} * 20 \text{ bytes} * 1/0.0075 \text{ s} = 10.6 \text{ kB/s} = 84 \text{ kbps}$
- **Nordic Master Emulator Firmware (MEFW) with nRF51822 0.9.0**  
 $1 \text{ packet} * 20 \text{ bytes} * 1/0.0075 = 2.67 \text{ kB/s} = 21.33 \text{ kbps}$
- **Nordic Master Emulator Firmware (MEFW) with nRF51822 0.11.0**

6 packets \* 20 bytes \* 1/0.0075 = 16 kB/s = 128 kbps

There are also some limits imposed by the Bluefruit LE firmware, but we are actively working to significantly improve the throughput in the upcoming 0.7.0 release, which will be available Q1 2015.

The above figures are useful as a theoretical maximum to decide if BLE is appropriate for your project or not.