# AN0886: Happy Gecko Low Energy USB Overview

More USB peripherals are being connected to things with batteries or are powered by batteries.

Systems are not just a guaranteed 100 mA any longer. Because of this, MCUs with good energy consumption begin to look more attractive in the USB space, especially when those USB interface MCUs aren't the only element in the system. In some of these systems, most of the power is consumed just communicating over USB. On the EFM32HG devices, Silicon Labs has implemented techniques to reduce the amount of power consumed by the USB module and system-level hooks that can reduce the overall power consumption of the entire device.

This document discusses these features and how they can be leveraged to reduce system power consumption in a USB application. Note that this document assumes some familiarity with USB transfer types and terms.

KEY POINTS

- Most of the energy in low energy USB systems is consumed in the USB communcation.
- The low energy USB features of the EFM32HG Happy Gecko family can dramatically reduce this USB energy consumption.
- The device can use low power modes when idle to further reduce device energy consumption.
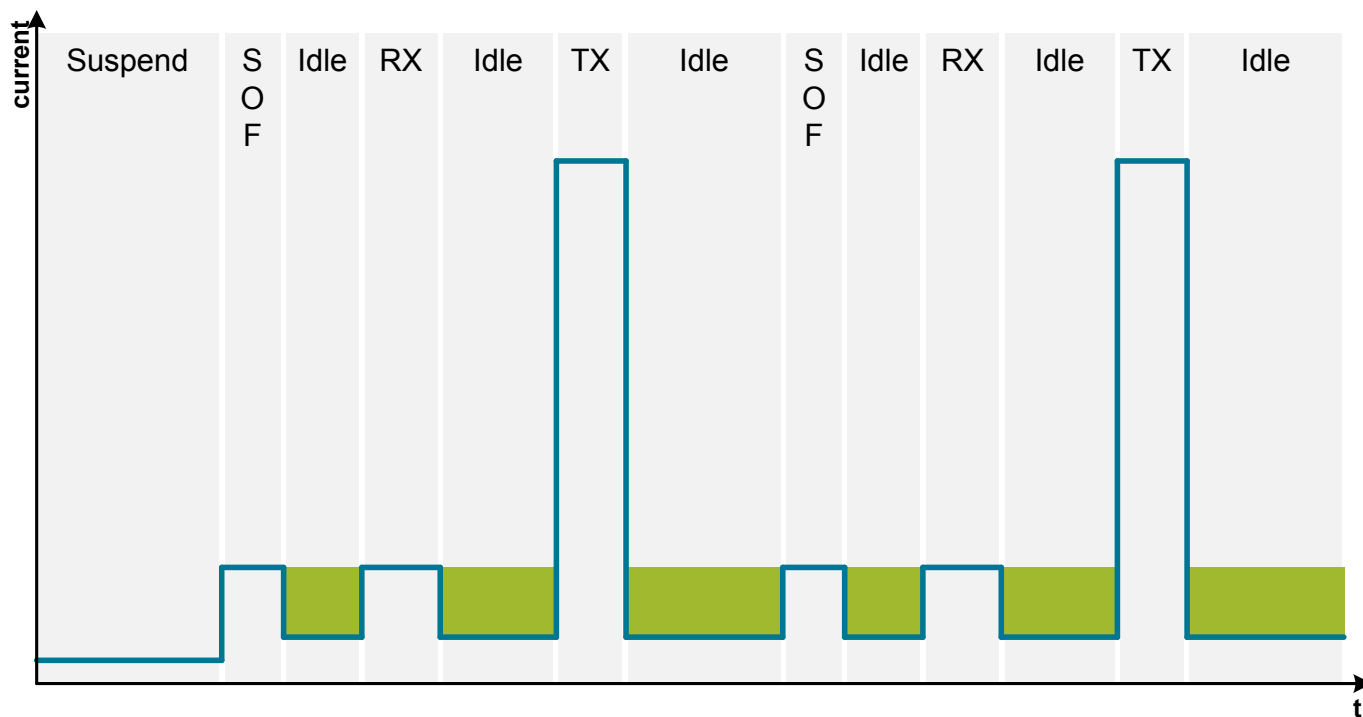
Current reduction

1. Taking Advantage of Bus Idle Times

USB traffic is inherently bursty. Full-speed frames occur every millisecond, and the frame is shared amongst all the devices connected to the bus. From a single end-node's perspective, this generally means that much of the frame will be spent talking to other devices. Normal USB devices stay fully operational during this entire frame, even if they aren't actively communicating on the bus.
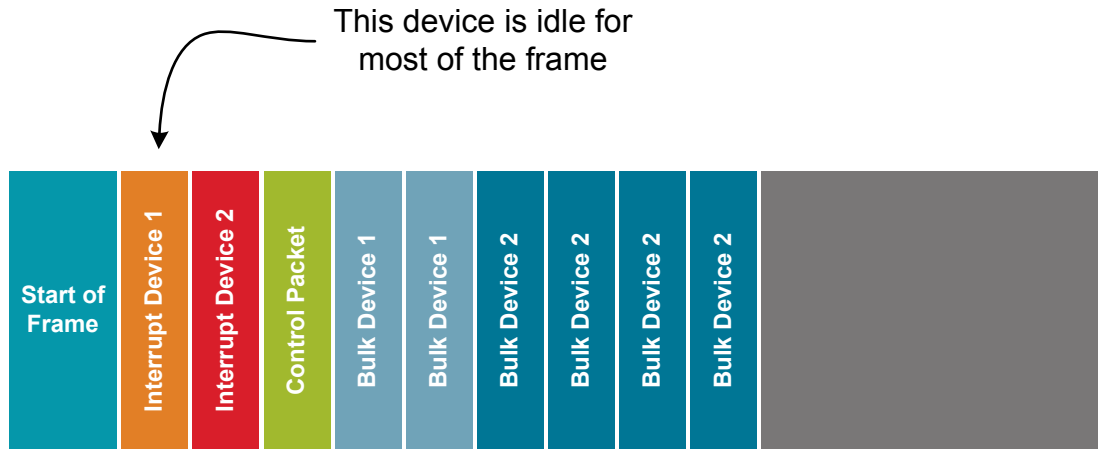

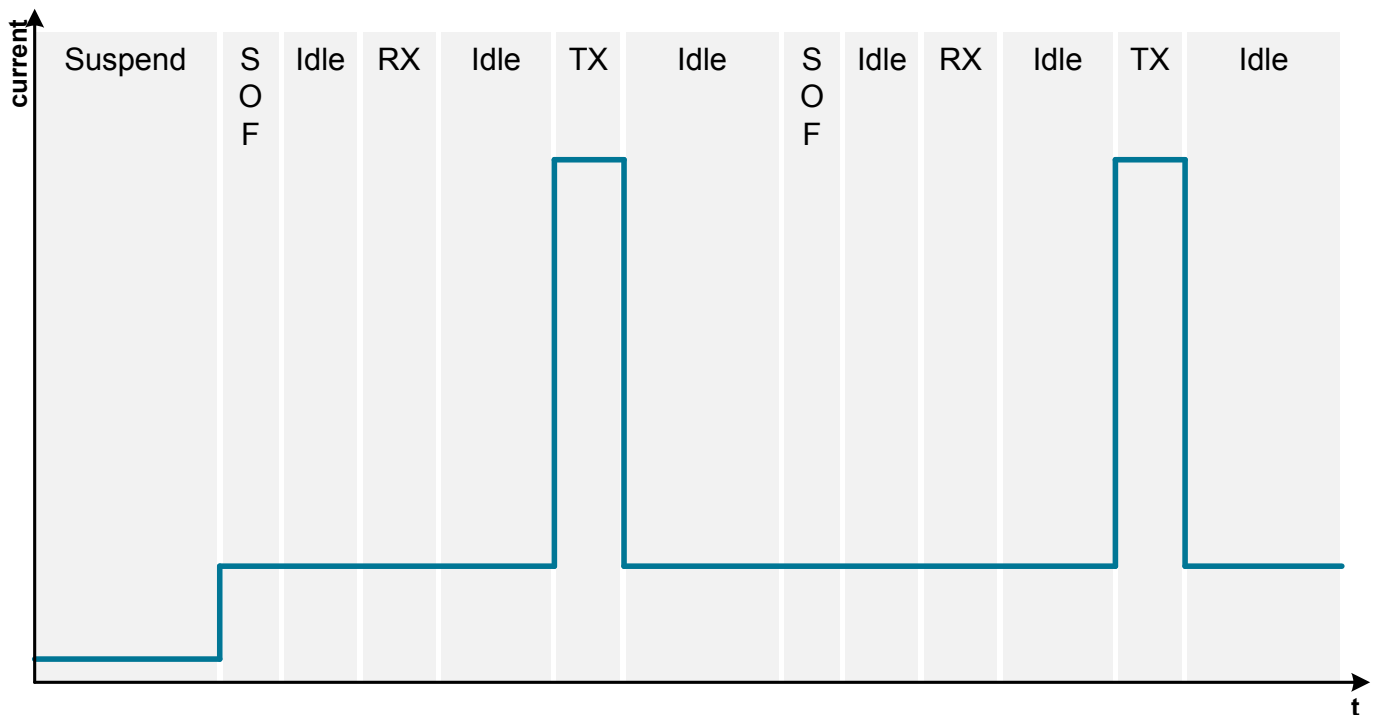**Figure 1.1. Example Full-Speed USB Frame**

Figure 1.2. Example Standard Full-Speed USB Device Energy Consumption

Instead, the EFM32HG Happy Gecko devices use two mechanisms to reduce the overall energy consumed during standard USB bus traffic whenever the device USB transceiver is idle:

- Reducing transceiver energy consumption and disabling the PHY.
- Gating the clock to the USB peripheral.

Happy Gecko devices use USB Low Energy Mode (LEM) whenever the bus is idle. This enables the EFM32HG Happy Gecko family to lower the overall energy consumption of the system.
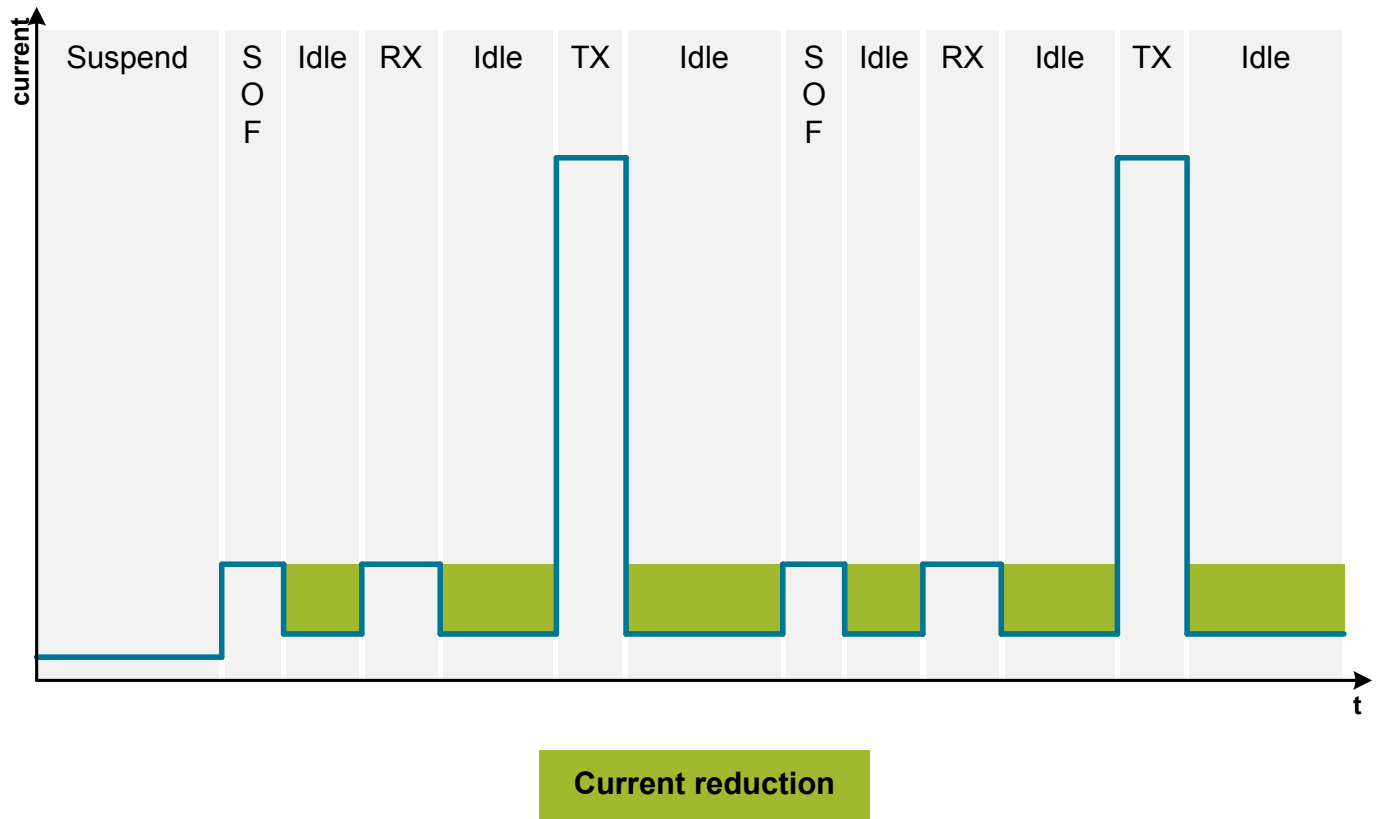

Figure 1.3. Example EFM32HG Happy Gecko Full-Speed USB Energy Consumption

2. Bus-Loading Examples

The more the device is idle on the bus, the more the USB Low Energy Mode features reduce energy consumption. This means that low transfer-rate USB transfer types like Interrupt transfers (i.e., HID) will conserve more energy with the USB Low Energy Mode features enabled than high transfer-rate USB transfer types like Bulk transfers.

2.1 Bulk Transfers

Bulk transfers are usually the least energy-friendly, as there is always activity when a device is engaged with the driver. Typically, the low-level bulk driver will just fill the bus with requests, and using up the bandwidth available as a Bulk endpoint means little to no energy savings. However, Bulk data transfers tend to be bursty, and the low-energy techniques help applications during times when the device is active while there is no traffic on the bus.
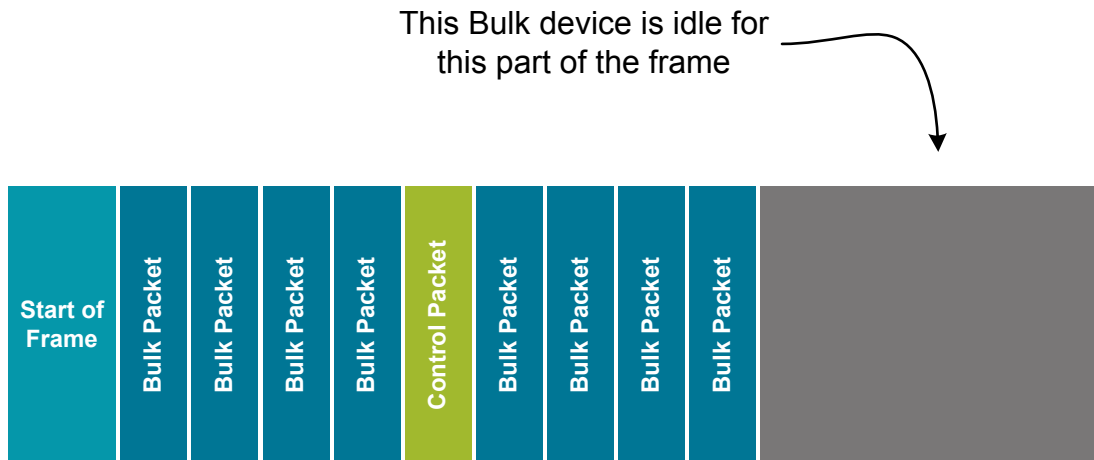

Figure 2.1. Example Bulk Device Traffic

Enabling low-energy when NAKing OUTs in the EFM32HG USB transceiver creates gains in some lower-bandwidth Bulk out scenarios. Reducing IN data requests from the host will also have a positive impact on energy consumption as well. In other words, if the host sends requests for the device less frequently when a data stream isn't active, this helps reduce the device energy consumption with the transceiver low energy features enabled. In PC-based systems, however, it may not be possible to control the number of IN packets sent to the device from the application level, as it is controlled by low-level host USB drivers.

2.2 Isochronous Transfers

The USB Low Energy Mode benefit for Isochronous devices is potentially higher than for Bulk devices. In this case, the energy savings will directly relate to the bandwidth used by the audio or video device. For example, a 16-bit 48 kHz audio device supporting two channels (left and right) and playback only will require 192 bytes per Full-Speed frame, or 3 packets. The device will be idle the rest of the frame and will be able to stay in a lower power mode.
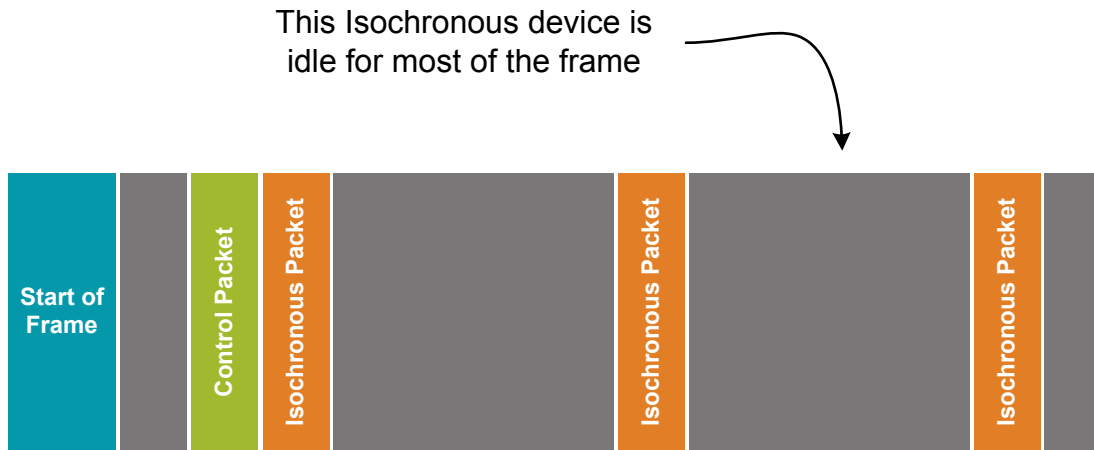
Figure 2.2. Example Isochronous Device Traffic

2.3 Interrupt Transfers

Interrupt transfers are the lowest bandwith of all the USB transfer types, with 64 bytes per millisecond in Full-Speed systems. These types of transfers are therefore able to make the most use of the USB Low Energy Mode features, since the device is idle most of the time in each frame. Reducing the USB host polling rate of the device and the number of bytes sent per packet may also help reduce energy consumption.
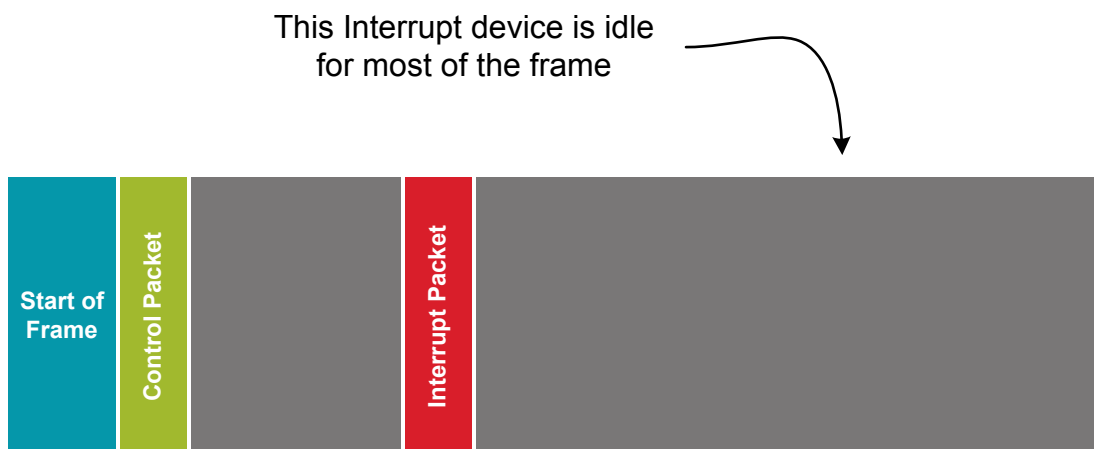
Figure 2.3. Example Interrupt Device Traffic

3. System-Level Savings

In addition to the Low Energy USB features themselves, the EFM32HG devices have additional ways to save power in the system.

3.1 Oscillator Management

The USHFRCO is a high-frequency, precision oscillator that runs at 24 or 48 MHz. Using this oscillator only for USB in the system will reduce the overall energy consumption of the device, since the oscillator can be gated when not needed by the USB transceiver.

3.2 EMU Energy Mode Management

If the core is not performing other tasks between USB packets, the system can take advantage of the EMU energy modes (EM1-EM4) available on the EFM32HG devices to reduce system energy consumption. This can be a significant percentage of the device or system current consumption.

4. USB Low Energy Mode Example

The USB LEM HID Keyboard demo for the EFM32HG devices demonstrates the USB LEM features discussed in this document. The example uses the Low Energy Mode on Bus Idle Enable feature in the USB transceiver to reduce power consumption (LEMOSCCTRL = 1). In addition, the example switches to EM1 in the main loop whenever it's not sampling the buttons (every 50 ms) to further reduce the device power consumption.

Table 4.1. USB LEM HID Keyboard Current Consumption Comparison

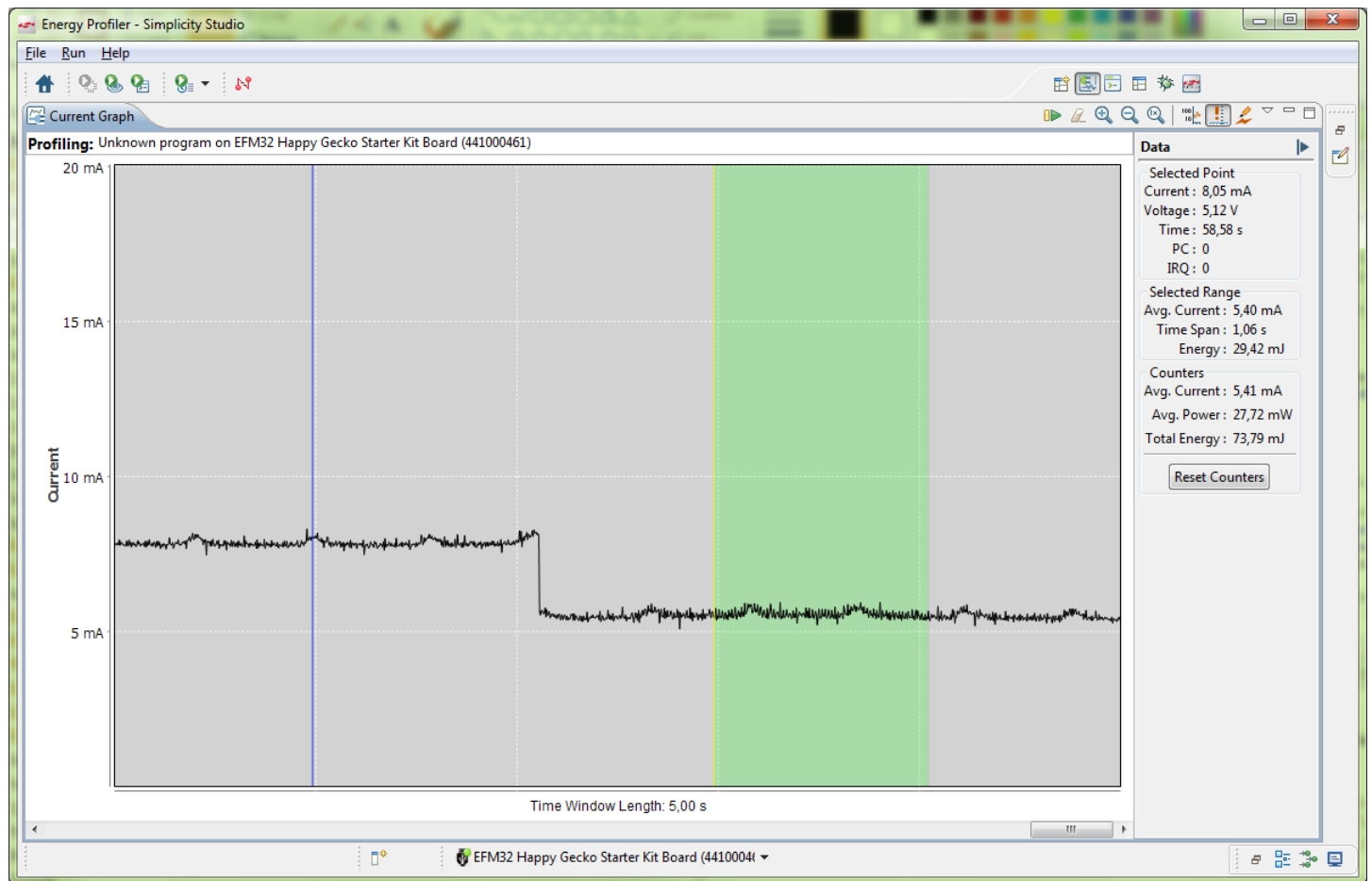| Example Settings		Current Consumption (mA)	% Energy Saved Compared to No Low-Energy Options
USB Low Energy Mode	EM1 in Main Loop		
Off	Off	8.76	—
Off	On	8.29	5.4%
On	Off	6.2	29.2%
On	On	5.8	33.8%

Figure 4.1. Using Advanced Energy Monitoring (AEM) with the EFM32HG USB LEM HID Keyboard Demo

After downloading the latest version of Simplicity Studio and installing using the [**Full**] or [**EFM32**] options:

1. Provide power to the board by connecting the DBG USB connector to the PC using the provided USB cable.
2. Move the switch to the AEM position.
3. Click the [**Refresh detected hardware**] button and select the EFM32HG Happy Gecko Starter Kit under [**Detected Hardware**].
4. Click the [**Demos**] tile under [**Tools**] to load the available demos.
5. Click the [**SLSTK3400A_usbdhidkbd**] demo and click [**Start**] to download and run the demo.

6. If using the demo with Energy Profiler, move the switch to the USB position to view the current consumption for the entire system.

To view and debug the source code for the USB LEM HID Keyboard demo:

1. Click the [**Software Examples**] tile under [**Software and Kits**].

2. In the wizard, select the EFM32HG Happy Gecko Starter Kit and click [**Next**].

3. Select the [**SLSTK3400A_usbdhidkbd**] from the list under the [**Demos**] folder and click [**Next**].

4. Click [**Finish**].

5. Click the [**Debug**] button in the IDE to build and download the code to the hardware.

6. Click the [**Resume**] button to start running the example.

7. Connect the device USB connector on the board to the PC.

   • Pressing PB0 will output characters as a USB keyboard.

   • Pressing PB1 toggles between normal and low-energy USB configurations, as indicated by the starter kit LCD display. The energy consumption in these modes can be viewed using Energy Profiler.

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