

# Measuring the Dynamic Current of nRF8001

### nAN-27

## Application Note v1.0

This document describes how you measure the dynamic current of nRF8001 using a series resistor and oscilloscope while running a heart rate sensor demo.

Understanding the peak current and average current of a device is necessary for maximizing battery lifetime. Battery size and lifetime are important factors in battery driven applications. Smaller batteries allow for smaller applications, while low average current helps maximize battery lifetime. Their limited peak current capabilities are an important factor when avoiding large reservoir capacitors.

When nRF8001 is in active mode the peak current draw can be significantly higher than the average current draw. Depending on the operation it is performing, the current draw of the nRF8001 varies between a few  $\mu$ A in idle mode to several mA in active mode.



### 1 Test setup

The following tools are needed in order for you to perform the test:

- nRF8001 Development Kit (DK)
- nRF8001 Software Development Kit (SDK)
- nRFgo Starter Kit
- nRFgo Studio
- Oscilloscope

#### 1.1 Hardware setup

To measure the dynamic current follow these steps:

- 1. Remove the **nRF Current Measurement** jumper (P4) on the nRF2735 board and wire a  $10 \Omega$  resistor across it. It is important the series resistor is placed close to the VDD connection of the nRF8001 module.
- 2. Use two channels on a digital storage oscilloscope to measure the voltage drop over the resistor.
- **Note:** Make sure there are no large capacitors between the series resistor and the nRF8001 module. A large capacitor will smooth the current waveform, making it difficult to see the different states.

For more information regarding the test setup, please refer to our White Paper, *nRF Performance Test Guidelines* at www.nordicsemi.com.



Figure 1 Test setup



#### 1.2 Firmware setup

The necessary firmware is included in the nRF8001 SDK. It is available on your computer after you install nRFgo Studio and the nRF8001 SDK.

#### 1.2.1 Programming the nRF8200

Program the nRF8200 in nRFgo Studio with the precompiled HEX file for the heart rate sensor demo.

- 1. Connect the nRFgo Motherboard and open nRFgo Studio.
- 2. Click the **Browse** button next to the File to program field.

nRFgo Studio - Programming device on nRF Module	connector on	board 0			
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Module - nRF8200					
nRF ISP Motherboard connector					
Bootloaders					
	][				
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Figure 2 nRFgo Studio start up



3. Select heart\_rate\_sensor\_nrf8200.hex which is found in \\NordicSemiconductor\nRF8001SDK vN.N\Precompiled\_hex\ and click Open.

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		alert_notif_application_nrf8200.hex	22.12.2011 18:30	HEX File	31 KB		
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Figure 3 HEX file location

4. Click **Program** once the file appears in the File to program field.

🔀 nRFgo Studio - Programming device on nRF Module connector or	n b	oard 0	(an and	-			x
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Figure 4 Programming the nRF8200 with the HEX file



#### 1.2.2 Master Control Panel setup

The Master Control Panel is part of the nRF8001 SDK and is used to initiate the Master Emulator dongle. If the destination folder was not changed upon installation, the Master Control Panel can be found in the Start Menu. When started, a device discovery is performed as seen in *Figure 5*.

1. Select the Nordic HRM V1.0 device and click Select device.

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File Help Master emulator (n	RF2739)				
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- Scan for devices					
Stop discovery					
Discovered devic	es				
Address	Bonded	Addr. type	Adv. type	Adv. data	Scan rsp.
EE2A7B55FD0C	False	Random	Connectable	Flags:GeneralDiscoverable, BrEdrNotSupported ServicesMoreAvailableUuid16:0x180D CompleteLocalName:Nordic HRM V1.	0
Select device					
	_				
Delete bond info					
Log					
[09:52:27.5] Devic	e address: 0x29	CD0099FF56			
[09:52:27.5] Contro	oller version: cor	ntroller.0.9.1553	6		
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Figure 5 Master control panel device discovery



- Click Service discovery and then click Enable Services.
   A list of available services on nRF8001 are shown in the Service Discovery window. The heart rate dummy data is updated every second as shown in the Log window.

Master Control Panel					
File Help					
Master emulator (nRF2739)					
006103C2   006103C2 connected Reset					
Device info Device address: EE2A7855ED0C. Bonded: False					
A-1					
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Service Discovery					
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- Characteristic Declaration, Properties: Notify, Characteristic UUID: 0X2A37					
ClientCharacteristicConfiguration CharacteristicConfigurationBits: Notification (	0001)				
- Characteristic Declaration, Properties: Read, Characteristic UUID: 0x2A38					
Heart Rate Sensor Location, Value: 03					
- Characteristic Declaration, Properties: Write, Characteristic UUID: 0x2A39					
Heart Rate Control Point, Value: (no value)					
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Figure 6 Master Control Panel - Service Discovery



- 4. To adjust the default connection interval, select **File** and then **Options.** Change the interval from 20 ms to 1000 ms.
- 5. Connection supervision timeout should be changed to a minimum of six times the connection interval.
- 6. Enable the new settings by disconnecting and then reconnecting the device.

N Options	
File	
Connection parameters Scanning	Security
Connection scan interval	250 ms
Connection scan window	
10	200 ms
Connection interval	
0	1000 ms
Connection slave latency	
0	0
Connection supervision timeout	
-0	6000 ms
ОК	Cancel

Figure 7 Setting connection interval



### 2 Measurement analysis

The top line on the graph from the oscilloscope shows the current and the bottom line shows VDD\_PA as a reference. VDD\_PA goes high when the TX is on. The x axis is divided into 1ms intervals and the y axis is divided into 5 mA intervals.



#### Figure 8 Current waveform

**Note:** An analysis of the current waveform and detailed analysis of the dynamic current consumption can be found in the *nRF8001 Product Specification*.





*Figure 9 Current consumption over time* 

A breakdown of the different states in a single connection event can be seen in *Figure 9* as referred to in the *nRF8001 Product Specification*.



Figure 10 Current consumption

*Figure 10* shows that the two correspond well when the curve in segment C from *Figure 9* is overlaid with the curve in *Figure 8* on page 8.



Using the markers on the oscilloscope, you can read the following currents:

Markers	Current
I <sub>Wake up, MCU LL</sub>	3.8mA
I <sub>Standby</sub>	0.9mA
I <sub>RX</sub>	13.5mA
I <sub>TX</sub>	12.5mA
I <sub>MCU LL</sub>	3.5mA
I <sub>MCU host</sub>	5.0mA

#### Table 1 Current measurement

**Note:**  $I_{Idle}$  and  $I_{Sleep}$  cannot be measured using this method because the voltage drop over the resistor will be too small for an exact reading. An ampere meter must be inserted instead of the 10  $\Omega$  resistor.



### Liability disclaimer

Nordic Semiconductor ASA reserves the right to make changes without further notice to the product to improve reliability, function or design. Nordic Semiconductor ASA does not assume any liability arising out of the application or use of any product or circuits described herein.

### Life support applications

Nordic Semiconductor's products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Nordic Semiconductor ASA customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Nordic Semiconductor ASA for any damages resulting from such improper use or sale.

### **Contact details**

For your nearest dealer, please see http://www.nordicsemi.com. Information regarding product updates, downloads, and technical support can be accessed through your My Page account on our homepage.

 
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### **Revision History**

Date	Version	Description
November 2012	1.0	First release