AN12898

JN5189-Power Consumption Analysis

Rev. 1 — 01/2021 Application Note

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1 Introduction

This application note describes the power consumption analysis on a DK6 board with a JN5189 module fitted.

To perform low-power measurements, the DK6 board is modified. This minimizes the leaking current and allows to measure very low currents. The modifications are described in the *IoT-ZTB-DK006 Development Kit User Guide* (document UM11393) chapter 7.

As a reference for the measurements, the power-down and active currents are presented in the data sheet. They are compared to the measurements results.

Firstly, the power-down and RF-static currents are measured using the Customer Module Evaluation Tool (CMET/AN1242).

Secondly, they are measured from a profile based on a Zigbee event.

The CMET version is 2038 and its radio driver version is 2085. The static measurements are based on this radio driver.

The Zigbee event currents are based on the radio driver 2088. The software is a part of the SDK.

Figure 1. DK6 board with JN5189 module

2 Power consumption measurement

2.1 Test setup description

2.1.1 Hardware configuration

The test setup is composed of:

- One JN5189 module on a mezzanine board
- One modified DK6 board, as described in IoT-ZTB-DK006 Development Kit user guide UM11393

The test equipment chosen is a source/measure unit SMU (Keysight B2902A for instance). It is a power supply capable of measuring low currents.

Test setup block diagram is shown in Figure 2.

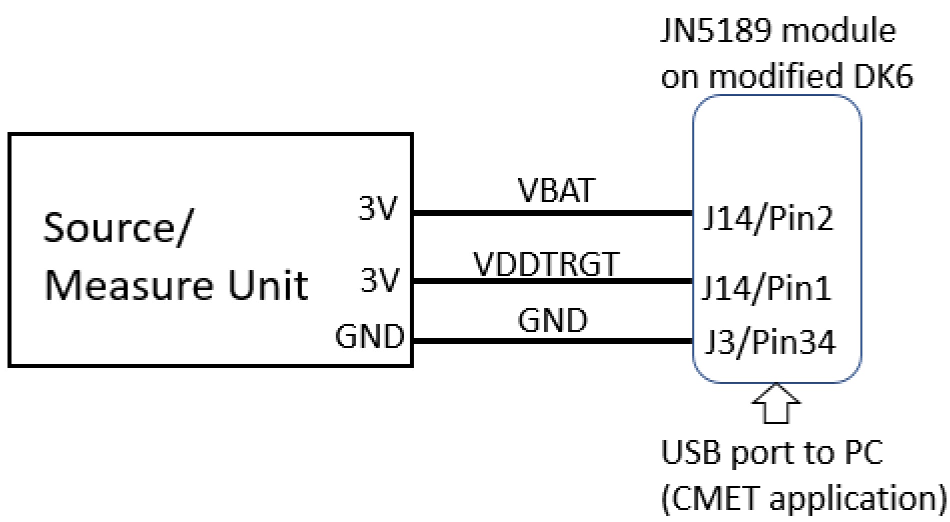
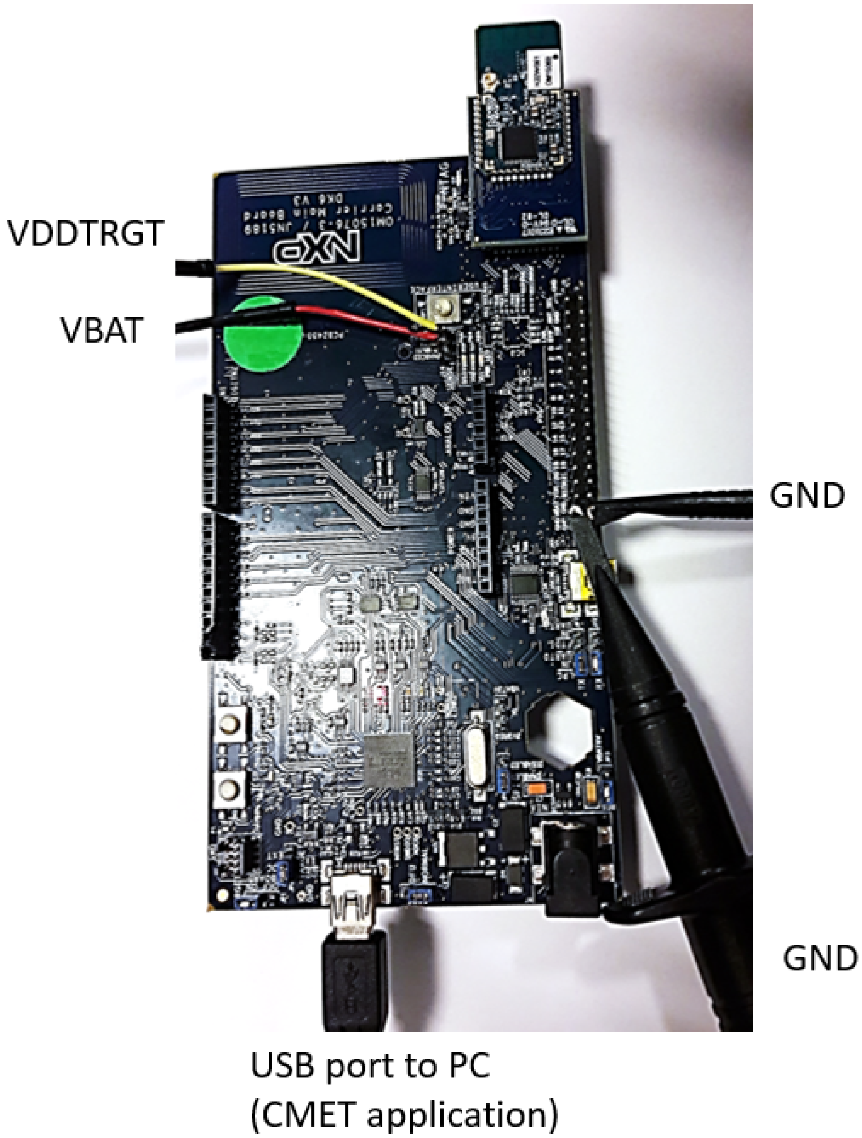


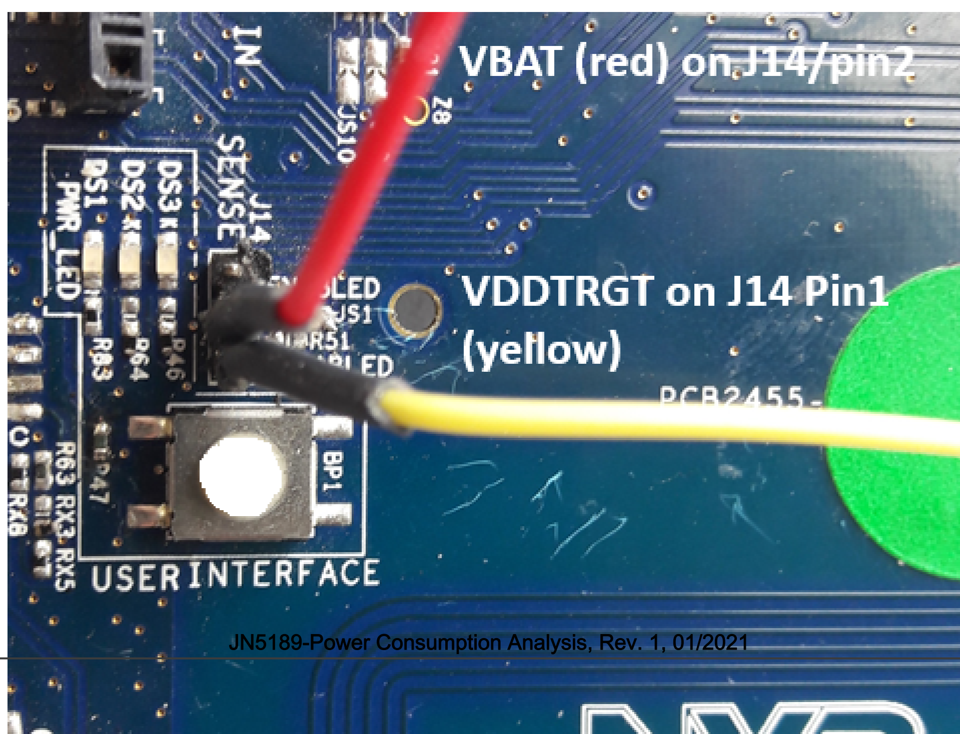
Figure 2. Test setup block diagram for static measurements

The VBAT supplies the JN5189 device under the test while the VDDTRGT is used to supply the rest of the board. The purpose is to measure the current on the JN5189 independently of the board consumption.

From a supply standpoint, VBAT = VDDTRGT.

The test connections are shown in Figure 3.


VDDTRGT
VBAT
GND
GND
USB port to PC
(CMET application)


VBAT (red) on J14/pin2
VDDTRGT on J14 Pin1
(yellow)
USER INTERFACE

2.1.2 Software configuration

CMET is the software tool used for the power consumption measurement. It can be downloaded from the NXP website (CMET/AN1242).

As described in *High Performance M68HC11 System Design Using The WSI PSD4XX and PSD5XX Families* (document AN1242), the low-power modes are shown in Table 1.

Table 1. Power down currents description

Power mode	CPU	CPU clock	RAM	Wake-up source
PM_DEEP_DOWN	OFF	OFF	OFF	Hardware reset, I/O event
PM_DOWN	OFF	OFF	Variable size Retention	HW reset, I/O event, wake-up timer
PM_SLEEP	ON	OFF	ON	Any interrupt

For this test, the CMET version used is shown in Figure 4.

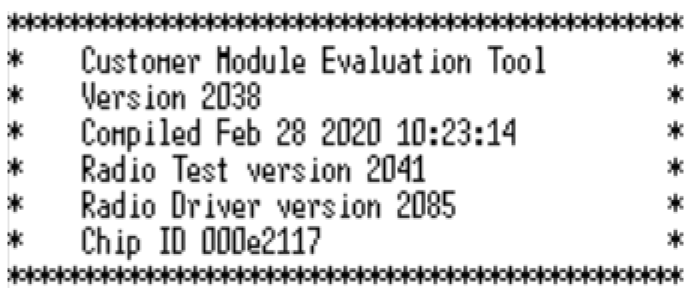


Figure 4. CMET version

2.2 Power consumption in low-power modes

The power-down and deep power-down modes are covered by these measurements.

The currents measured with the CMET are shown in Table 2.

Table 2. CMET current measurements

Symbol	Parameter	Conditions	Type (datasheet)	Measure with CMET @VBAT 3 V	Units
IDD	Supply current	Deep power-down (everything is powered off, wakeup on hardware reset only)	250	235	nA
		Deep power-down-IO (everything is powered off, wakeup on hardware reset only or an event on any of the 22 GPIOs and the NTAG interrupt)	350	360	nA
		Power-down (wakeup on hardware reset or an IO event, wake-up timer on, 32 kHz FRO on, no SRAM retention)	800	880	nA

Table continues on the next page...

Table 2. CMET current measurements (continued)

Symbol	Parameter	Conditions	Type (datasheet)	Measure with CMET @VBAT 3 V	Units
		Power-down-4K (wakeup on hardware reset or an IO event, wake-up timer on, 32 kHz FRO on, with 4 KB SRAM retention)	1025	1085	nA
		Power-down-8K (wakeup on hardware reset or an IO event, wake-up timer on, 32 kHz FRO on, with 8 KB SRAM retention)	1120	1170	nA

2.3 Power consumption in the Active mode

The RF currents are measured with the CMET and the results are shown in Table 3.

Table 3. Active current results with CMET

Parameter	Conditions	Requirement typical @Vbat 3 V (CPU current not included)	CMET measurement @Vbat 3 V (CPU current included)	Units
Supply current	Radio in RX mode (IEEE 802.15.4)	4.30	6.84	mA
	Radio in TX mode (IEEE 802.15.4), output power 0 dBm	7.36	10.15	mA
	Radio in TX mode (IEEE 802.15.4), output power +3 dBm	9.44	12.21	mA
	Radio in TX mode (IEEE 802.15.4), output power +10 dBm	20.28	21.75	mA

NOTE

The gap compared to the data sheet is due to the CPU current that is already a part of the CMET measurements.

3 Power profile measurement

3.1 Hardware prerequisites

The setup is composed of the IOTZTB-DK006 kit content: a control bridge, a light node, and a switch device made of the JN5189 fitted on a DK6 board. Similarly to the previous chapters, the DK6 of the switch device is modified for power measurement.

The JN5189 fitted on a modified DK6 board is called “the switch device” further on in this document.

The block diagram of the test setup is shown in Figure 5.

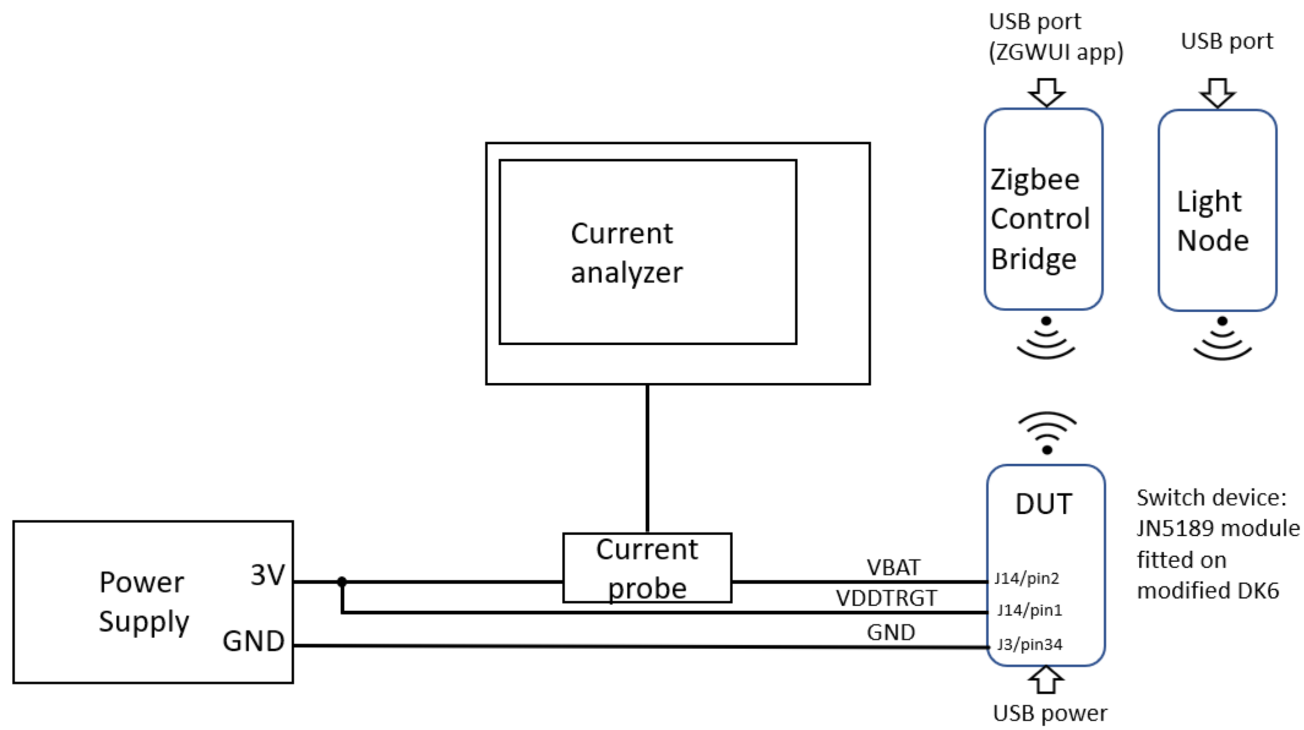


Figure 5. Test setup block diagram

The modified DK6 with the JN5189 module fitted is shown in Figure 6.

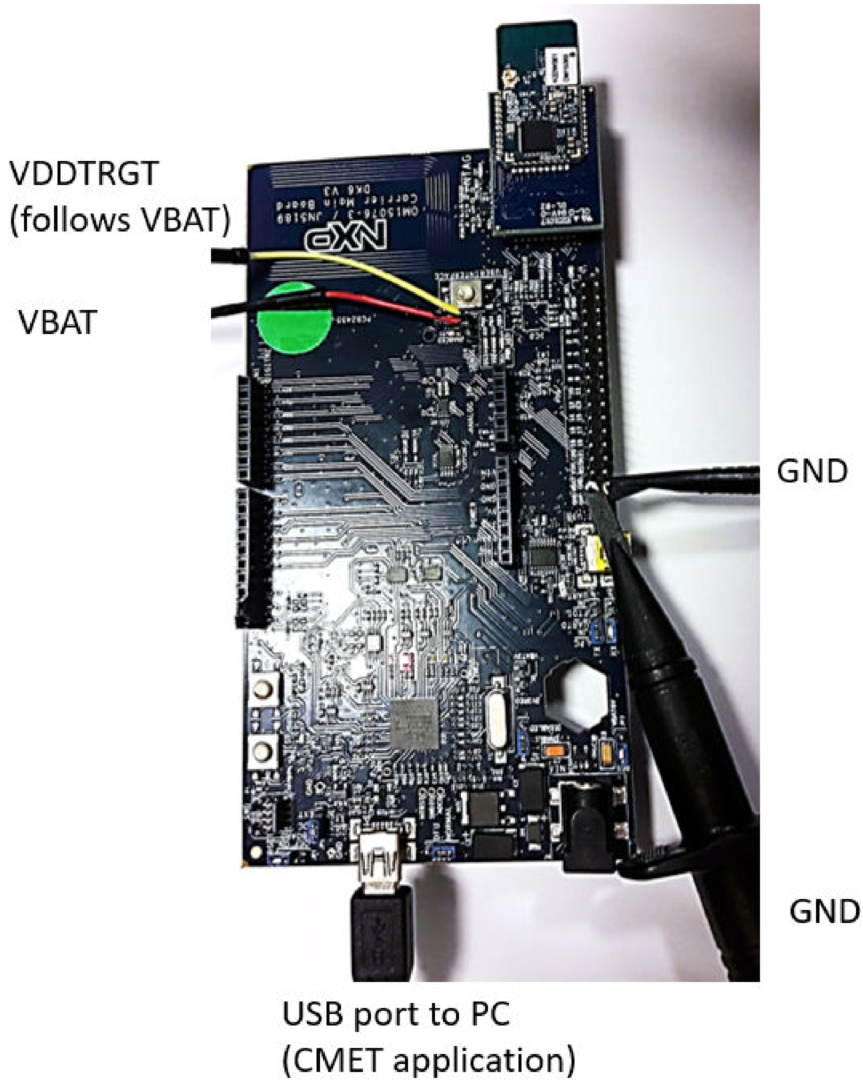


Figure 6. Modified DK6 and JN5189 module fitted

The Zigbee control bridge and the light node are shown in Figure 7 and Figure 8.

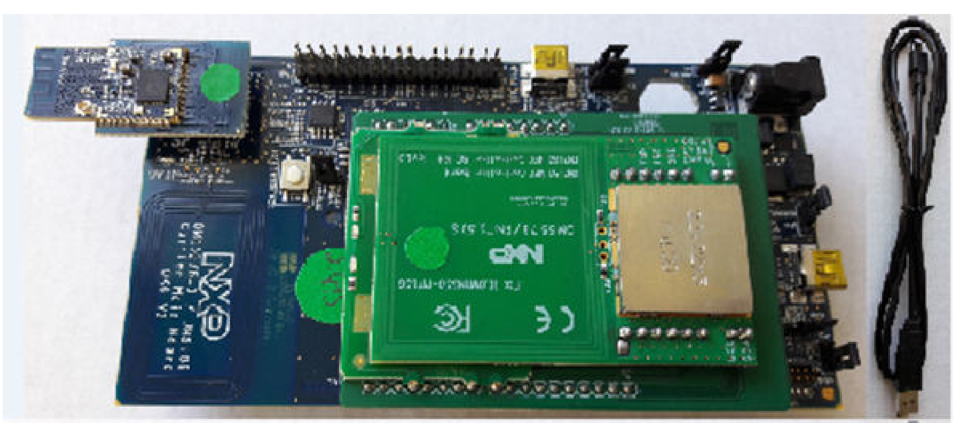


Figure 7. Zigbee control bridge

The test setup is shown in Figure 9.

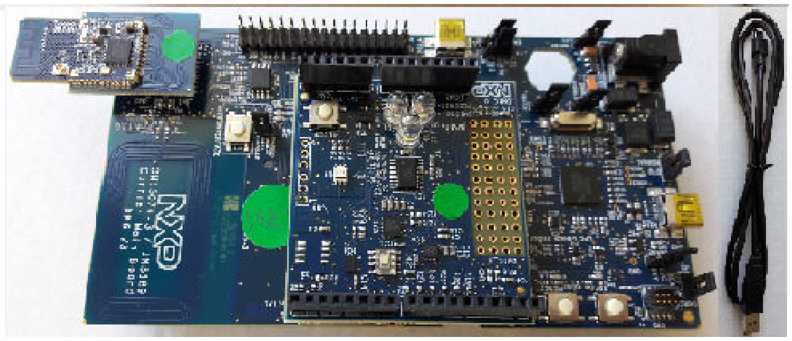


Figure 8. Light node

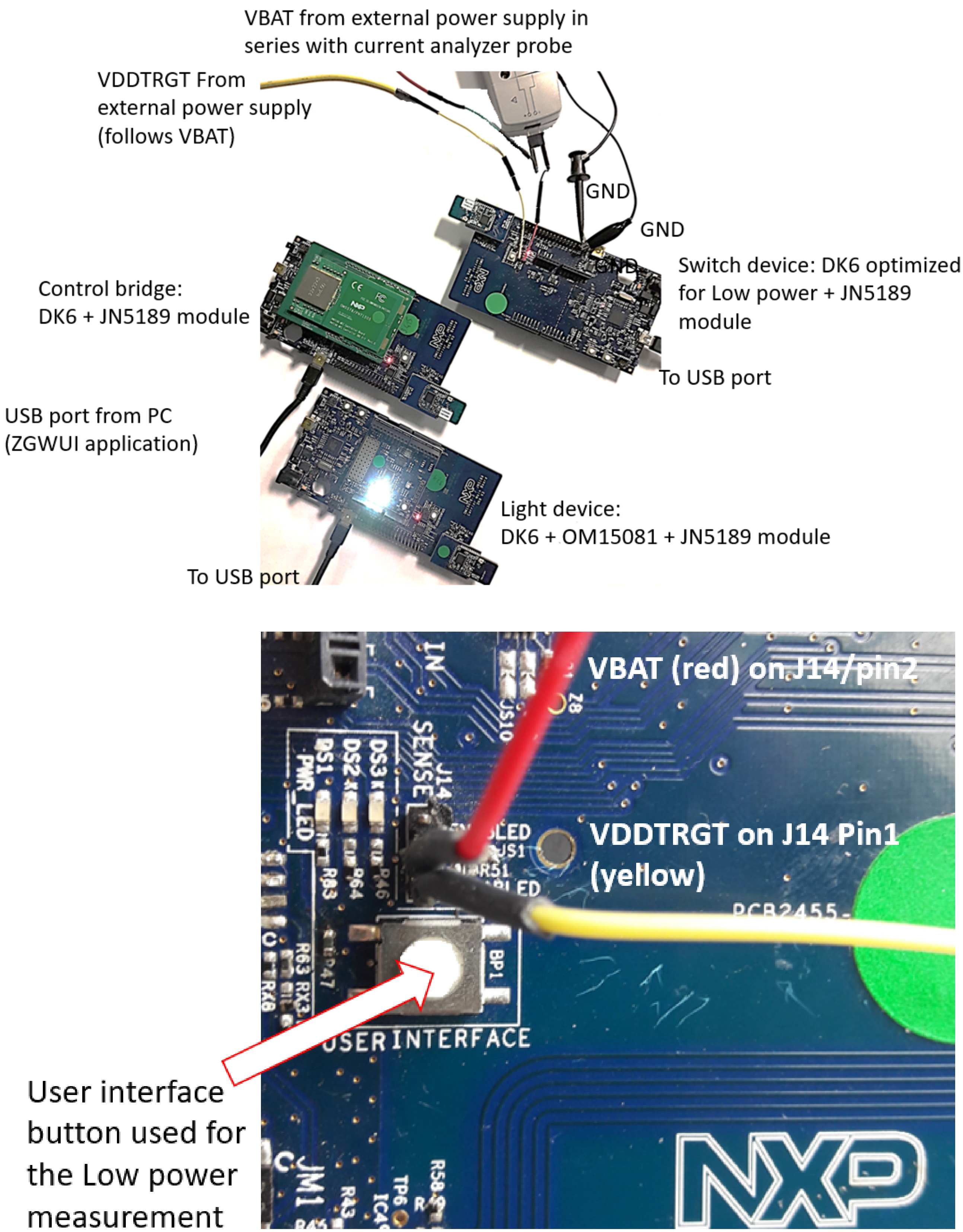


Figure 9. Test setup

3.2 Software configuration

A flash programmer is necessary to program the binary file into the flash memory of the device. The instructions are described in the JN-SW-4407 application note, which is in the *tools* folder of the SDK.

The control bridge is configured using the instructions shown in document AN1247. The AN1223-Zigbee-IoT-Gateway-Control-Bridge (ZGWUI) must be installed on the PC to connect the control bridge.

The light node is configured using the instructions in document AN1244.

The switch device is configured using the instructions in document JN-AN-1245. The switch used in this example has the following parameters, which are described in document JN-AN-1245:

- DIO_TOGGLE=1
- DK6_TEST=1

The other settings for the next measurements are as follows:

- Payload: 37 B
- RAM size: 4 KB
- TX output power: 10 dBm
- Radio driver version: 2088

NOTE

After the binary files are programmed into the device memory and before the procedure described in Measurement procedure, all the devices must be unplugged from their USB ports or any external power supplies.

NOTE

The DC-DC is always enabled in this measurement.

3.3 Use case description

A basic use case of a ZigBee network application is chosen as an example.

A light node joins a ZigBee network and it is controlled by a switch device via a control bridge. The control bridge is logging the communication events thanks to the ZGWUI application on a PC.

3.4 Measurement procedure

3.4.1 Joining the network

The switch device must join the network to control the light node.

The ZGWUI application is used to start the network and it joins the devices.

The joining procedure is as follows:

1. Start the ZGWUI application on the PC.
2. In the "Settings" menu, select the COM port that corresponds to the control bridge, as shown in Figure 10 and Figure 11.

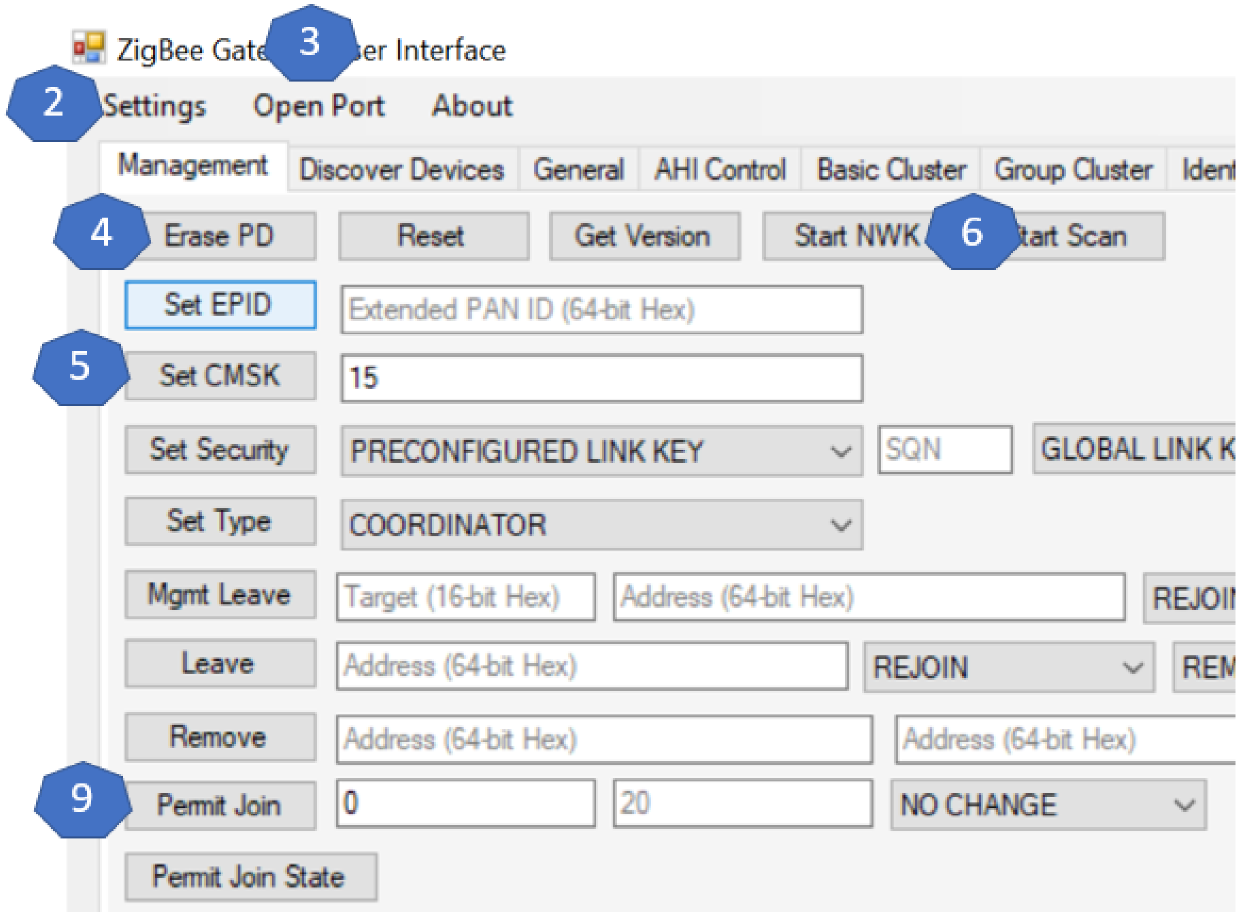


Figure 10. ZigBee interface

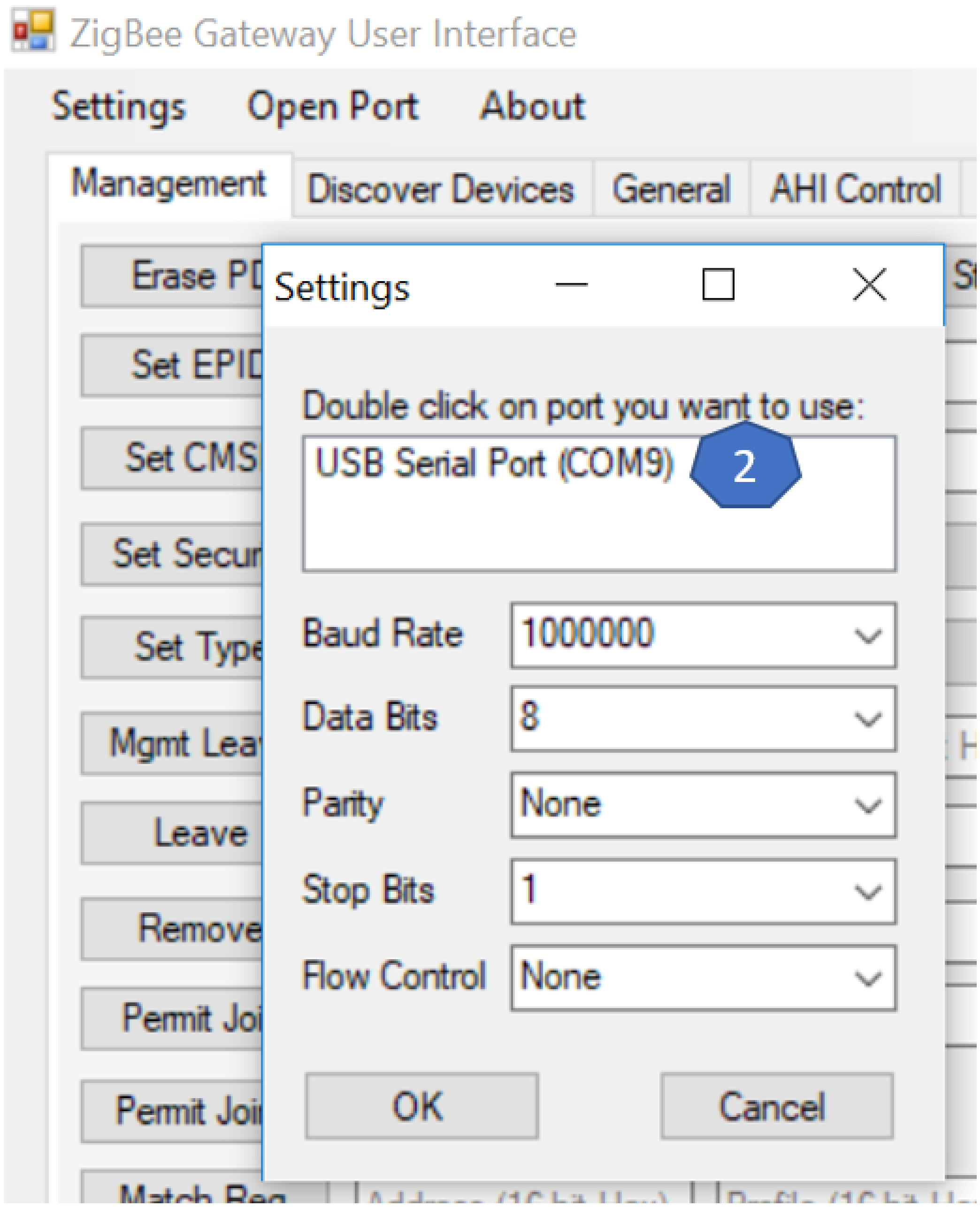


Figure 11. ZigBee settings

3. Select "Open port".
4. Erase the PD.
5. Set the channel in the CMSK field and select "Set CMSK". Type "15".
6. Start the NWK.
7. Connect the switch device to a USB port and to an external power supply (as shown in Hardware prerequisites).
8. Power on the external power supply.
9. In the ZGWUI, in the "Permit Join" field, type "0" into the first one and "20" into the second one. Select "Permit Join".
10. The switch device joins the network and can be verified in the log message on the ZGWUI, as shown in Figure 12.

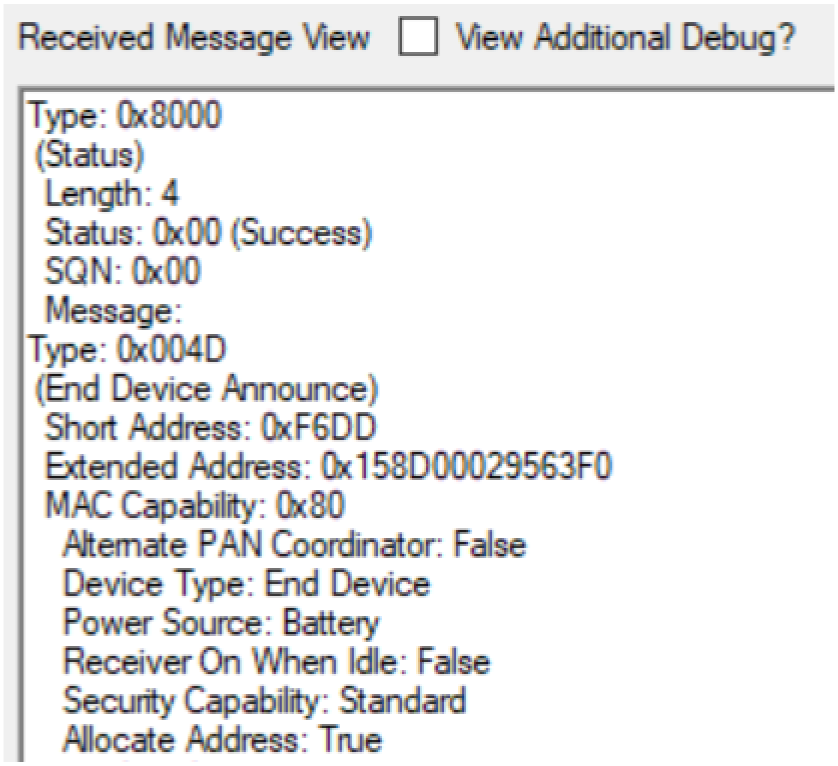


Figure 12. ZGWUI log message

11. Power on the light node by connecting it to a USB port.

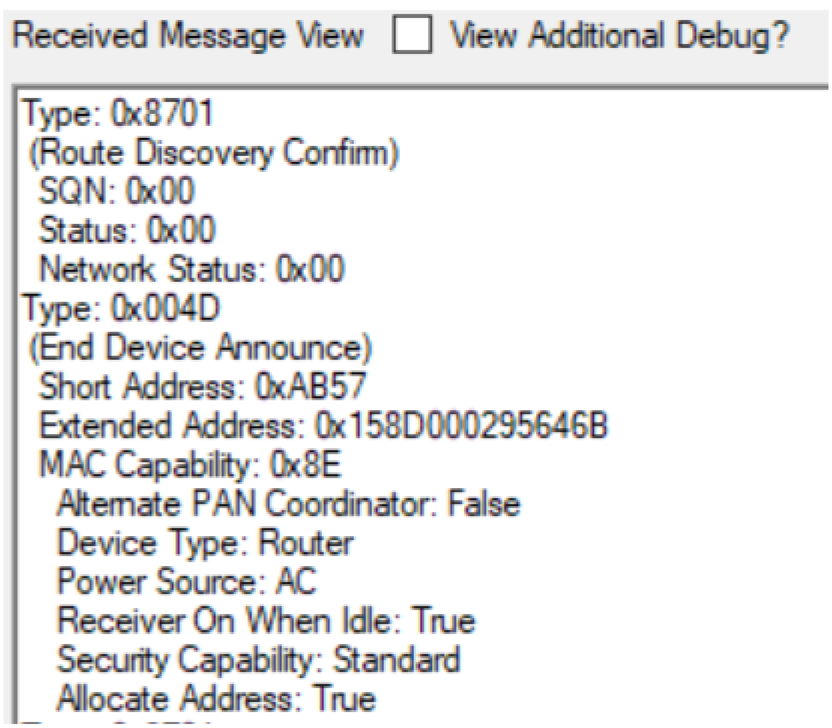


Figure 13. Powering the light node

12. The light node flashes until it joins the network, as shown in Figure 13. Then the light is always ON.

The power consumption can be observed when the switch device joins the network, as shown in Figure 14.

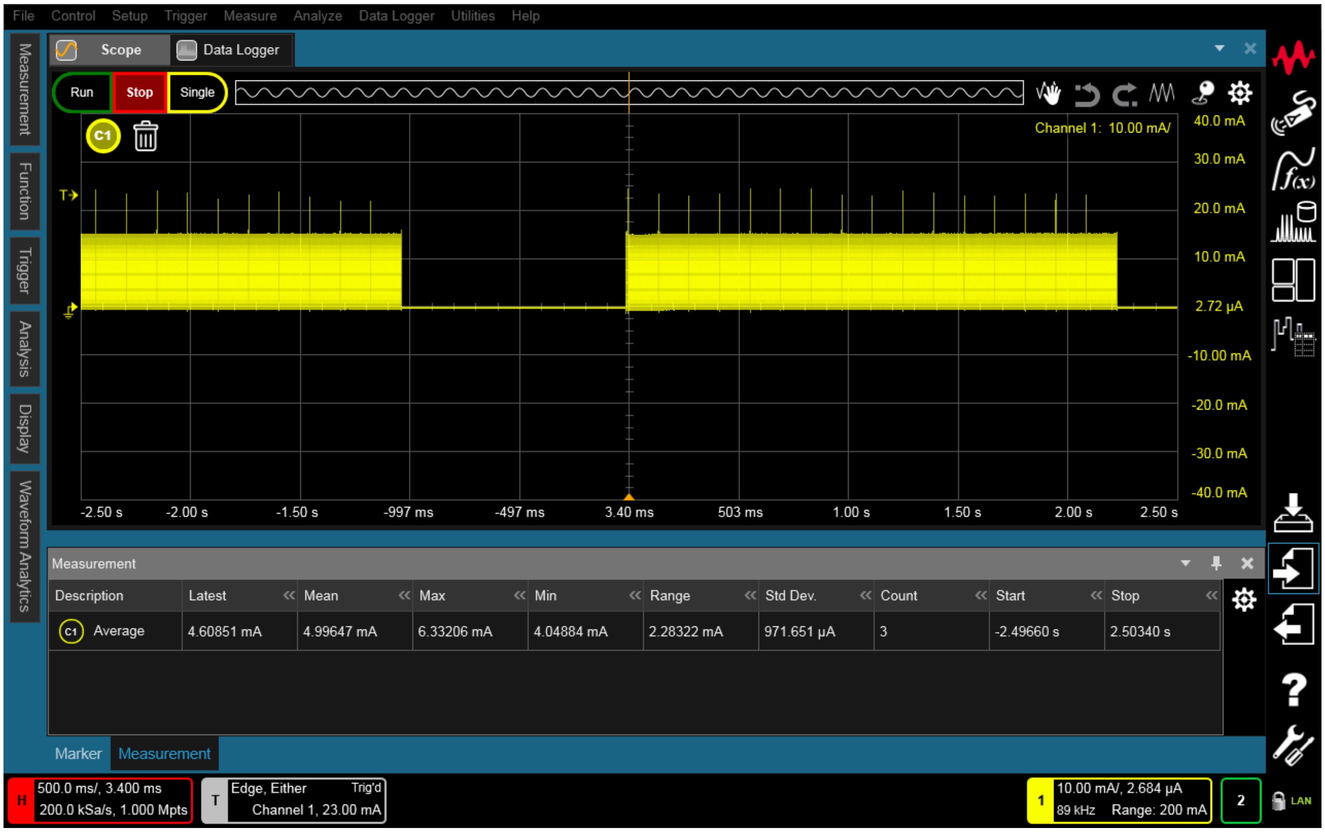


Figure 14. Joining power profile

The ZGWUI session must stay active for the next steps in the following chapters.

3.4.2 Binding the switch to the light node

When the switch device has joined the network, it is necessary to bind it to the light node. To do so, perform the following steps in the same ZGWUI session as in the previous chapter:

1. On the light node, push the reset button (SW4 on DK6 board) three times:

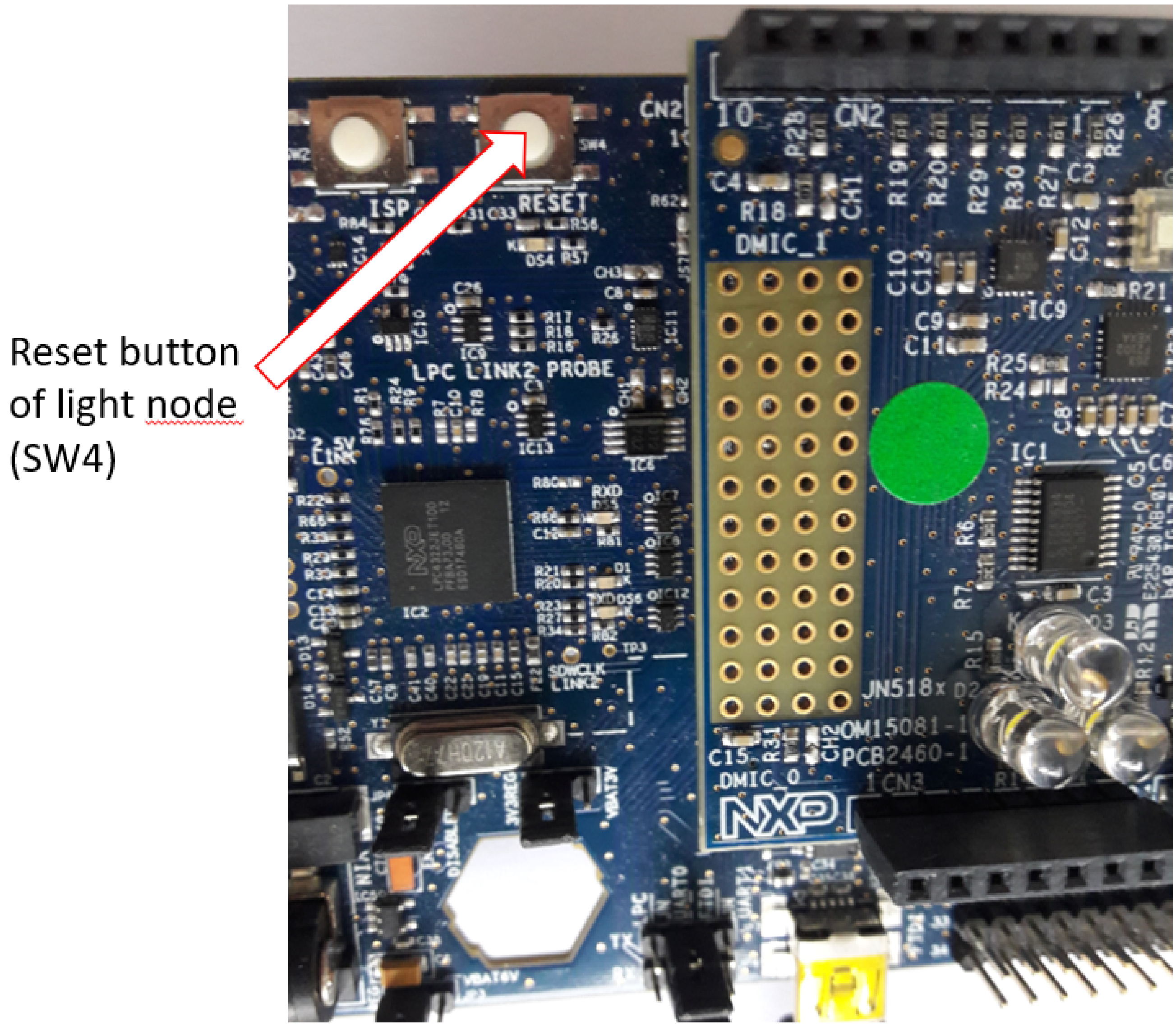


Figure 15. Light node: reset button location

1. The light node starts to flash.
2. On the switch device, press the user interface button (BP1) and release it. The light node LEDs stop flashing and stay ON.

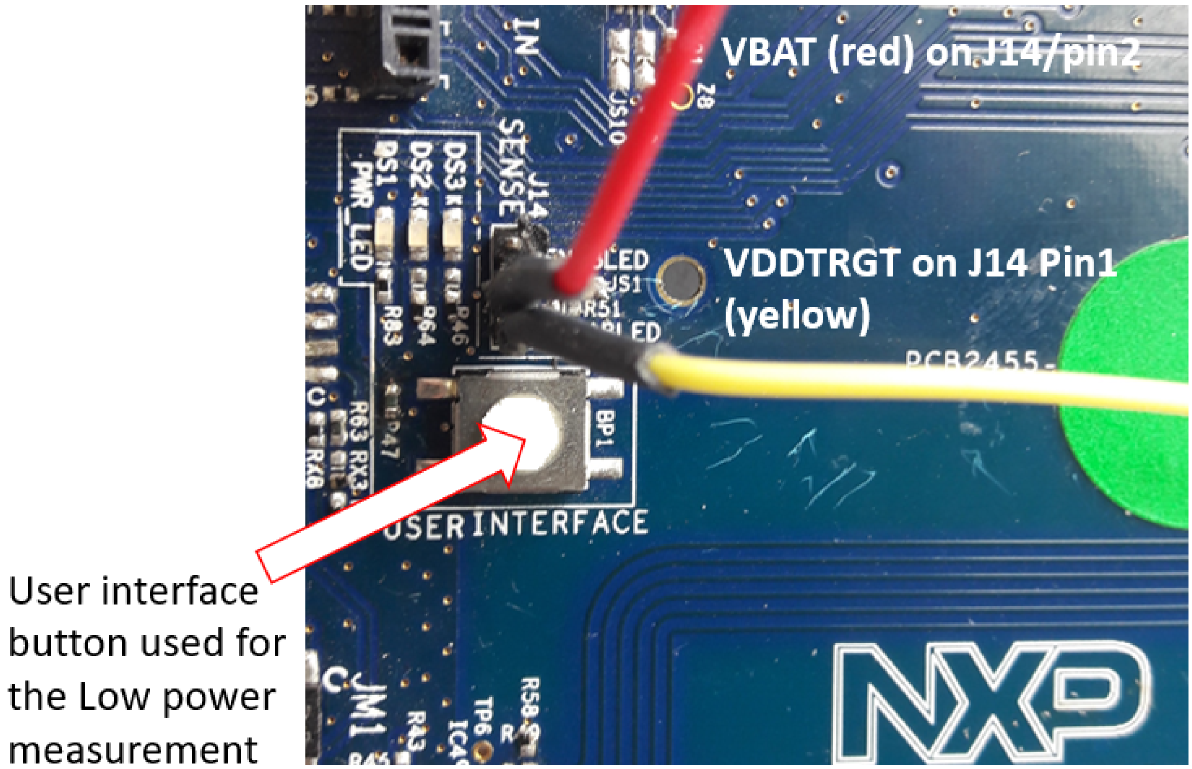


Figure 16. Switch device: user interface button location

3. The switch device and the light node are bound and the switch device can control the light node according to Table 4.

Table 4. Light node rules

User interface button on the switch device	Result on the light node
Push 2n+1, n = 0, 1, 2..	Light OFF
Push 2n, n = 0, 1, 2..	Light ON

The power profile is observed at the binding time (Figure 17).

Figure 17. Binding power profile

The sniffing trace of a binding event is shown in Figure 18.

Packet Type	PAN Src	PAN Dst	MAC Src	MAC Dst	MAC Seq	NWK Src	NWK Dst
Bind Request		0xE1E9	0x0000	0x4EF4	176	0x0000	0x4EF4
Acknowledgement					176		
Acknowledgement		0xE1E9	0x4EF4	0x0000	153	0x4EF4	0x0000
Acknowledgement					153		
Bind Response		0xE1E9	0x4EF4	0x0000	154	0x4EF4	0x0000
Acknowledgement					154		
Data Request		0xE1E9	0x4EF4	0x0000	155		
Acknowledgement					155		
Transport Key		0xE1E9	0x0000	0x4EF4	177	0x0000	0x4EF4
Acknowledgement					177		
Verify Key		0xE1E9	0x4EF4	0x0000	156	0x4EF4	0x0000
Acknowledgement					156		
Link Status		0xE1E9	0x0000	0xFFFF	178	0x0000	0xFFFC
Data Request		0xE1E9	0x4EF4	0x0000	157		
Acknowledgement					157		
Acknowledgement		0xE1E9	0x0000	0x4EF4	179	0x0000	0x4EF4
Acknowledgement					179		
Data Request		0xE1E9	0x4EF4	0x0000	158		
Acknowledgement					158		
Bind Request		0xE1E9	0x0000	0x4EF4	180	0x0000	0x4EF4
Acknowledgement					180		
Acknowledgement		0xE1E9	0x4EF4	0x0000	159	0x4EF4	0x0000
Acknowledgement					159		
NWK Address Request		0xE1E9	0x4EF4	0x0000	160	0x4EF4	0xFFFD
Acknowledgement					160		
Bind Response		0xE1E9	0x4EF4	0x0000	161	0x4EF4	0x0000
Acknowledgement					161		

Figure 18. Binding sniffer trace

3.4.3 Switching on the light node with the switch device

When the user pushes the user interface button of the switch device, the device goes through the following three phases:

1. Waking up from the sleep mode
2. Transmitting data
3. Going back to the sleep mode

In this case, the power profile can be measured as shown in Figure 19.

Figure 19. Light-on event power profile

The shape of the current profile is the same when pushing the user interface button again to switch the light off.

The sniffer trace of a light-on event is as below:

Stack	Packet Type	PAN Src	PAN Dst	MAC Src	MAC Dst	MAC Seq	NWK Src	NWK Dst
ZigBee	On/Off: On		0xE1E9	0x4EF4	0x0000	200	0x4EF4	0x13BE
ZigBee	Acknowledgement					200		
ZigBee	On/Off: On		0xE1E9	0x0000	0x13BE	49	0x4EF4	0x13BE
ZigBee	Acknowledgement					49		

Figure 20. Light-on event sniffer trace

The power profile is then processed as shown in Figure 21.

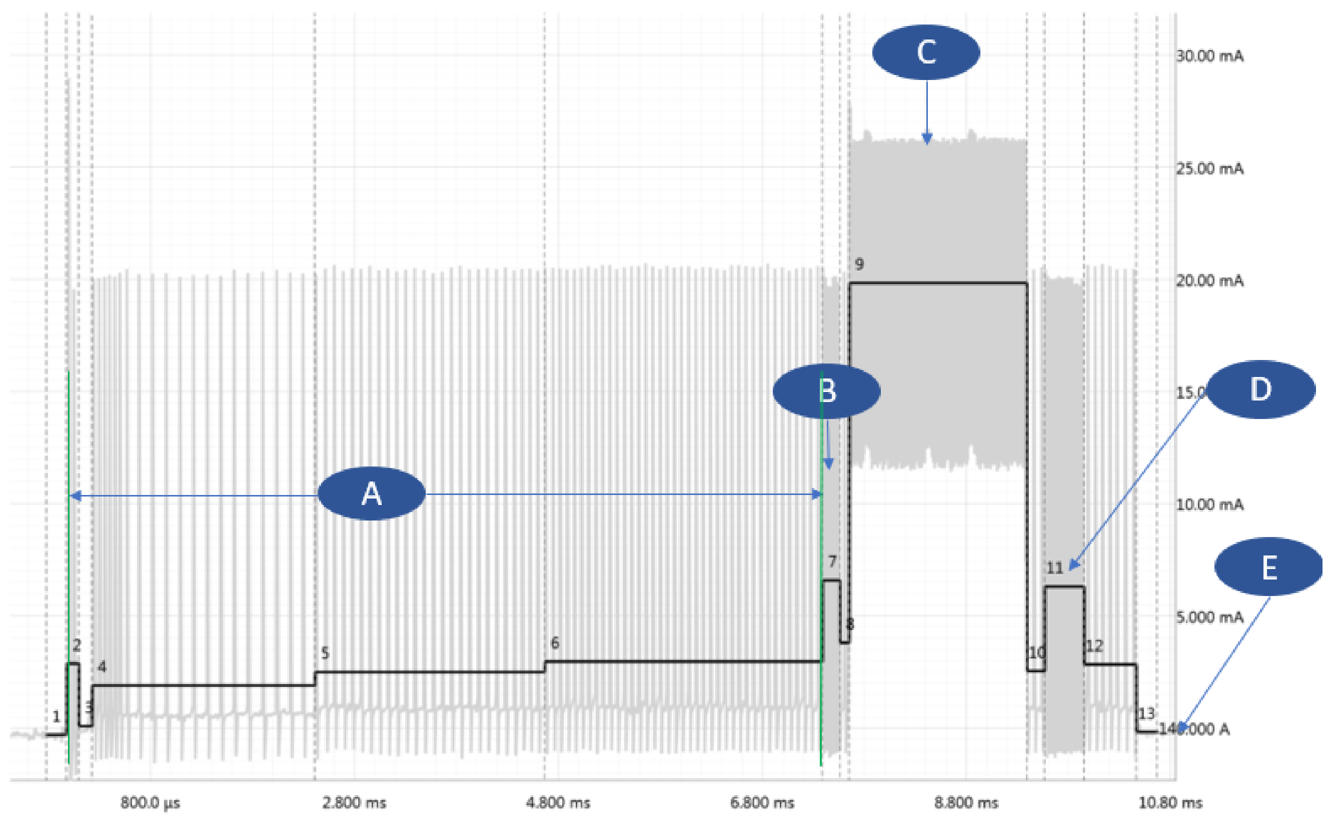


Figure 21. Current profile of a ZigBee event

The power consumption is analyzed for several Vbat voltages, as shown in Table 5.

Table 5. Current measurements from a ZigBee profile

Step#	CPU	Radio	Mode	Current @ 2.6 V	Current @ 3.0 V	Current @ 3.6 V	Duration
A	Start	OFF	Initialization	2.5 mA	2.4 mA	2.4 mA	7.6 ms
B	ON	RX ON	RX Cal- CCA	6.6 mA	6.5 mA	5.9 mA	172 µs
C	ON	TX ON	10 dBm	22.6 mA	19.8 mA	16.9 mA	1.7 ms
D	ON	RX ON	Wait for Ack	6.7 mA	6.3 mA	5.7 mA	387 µs
E	ON	OFF	PD Mode 0	2.70 µA	2.73 µA	2.85 µA	NA

4 Conclusion

This application note provides a step by step approach to measure low-power performances of the JN5189. The measurements are based on the Zigbee events that can be replicated using the development kit (IOTZTB-DK006).

The total energy consumed is in line with the specifications, which makes the JN5189 particularly suitable for low-power applications.

5 Revision history

Table 6. Revision history

Rev	Date	Description
1	01/2021	Typos corrected in Software configuration and Binding the switch to the light node.
0	09/2020	Initial version

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Date of release: 01/2021
Document identifier: AN12898