ANR020 PROTEUS-III

REMOTE GPIO CONTROL - HOW TO

VERSION 1.0

JULY 10, 2020

Revision history

Manual version	Notes	Date
1.0	• Initial version	July 2020

Abbreviations and abstract

Abbreviation	Name	Description
CS	Checksum	Byte wise XOR combination of the preceding fields.
I/O	Input/output	Pinout description.
Payload		The intended message in a frame / package.
RF	Radio frequency	Describes wireless transmission.
UART	Universal Asynchronous Receiver Transmitter	Allows the serial communication with the module.
[HEX] 0xhh	Hexadecimal	All numbers beginning with 0x are hexadecimal numbers. All other numbers are decimal, unless stated otherwise.

Contents

1 Introduction

The Proteus-III is a Bluetooth® LE module based on the nRF52 Nordic Semiconductors SoC which presents various Bluetooth® LE and low power features. It provides a command based UART interface that allows the configuration and control of the Proteus-III by simple commands. Besides the commands needed for configuration and radio data transmission, various commands are provided to use the so called remote GPIO feature.
This feature allows to write and read up to 6 GPIOs of the Proteus-III via Bluetooth® LE connection. With help of this, simple applications, like switches or digital level detectors, can be realized with the Proteus-III without the need of connecting a host controller to it.

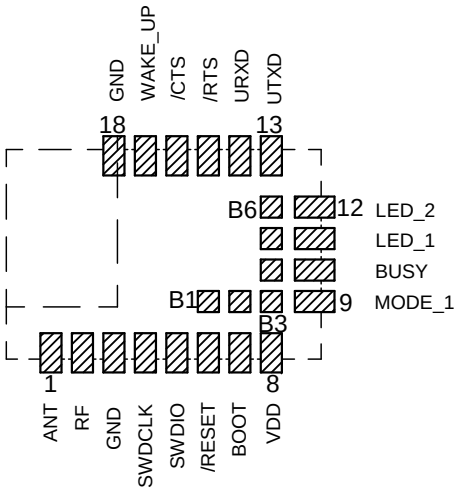
This application note describes which steps have to be run to switch a GPIO and how to read the pin level of a GPIO via remote connection. First or all a general description follows, then in the `Examples` section it is demonstrated how the GPIOs can be controlled by a second Proteus-III radio module or by smart phone.

1.1 Supported GPIOs

The supported GPIOs are identified by so called GPIO_IDs, that are used in the commands for GPIO control. The following GPIOs of the Proteus-III are supported for remote and local access.

No	GPIO_ID	Supported functions
B1	1	Input, Output
B2	2	Input, Output
B3	3	Input, Output
B4	4	Input, Output
B5	5	Input, Output
B6	6	Input, Output

Table 1: Supported GPIO_IDs



2 General description

This chapter is based on a test setup with two Proteus-III radio modules. "Module 1" is the one, whose GPIOs are configured and controlled. It can be run without host controller. "Module 2" is the remote device which sends the commands for GPIO control via radio to "Module 1". It must be controlled via host controller "Host 2" to send the correct commands. Instead of the remote Proteus-III "Module 2", another remote device such as a smart phone can also be used.

Chapter 3.1 contains an example, where the Proteus-III "Module 1" is controlled by another Proteus-III "Module 2". Chapter 3.2 shows the example, where the Proteus-III "Module 1" is controlled by a smart phone.

The full description of the necessary UART commands can be found in the Proteus-III manual, where the radio commands are described in detail in the application note "ANR009 Proteus-III Advanded Developer Guide".

2.1 Remote GPIO configuration

To use the remote GPIO control feature of the Proteus-III "Module 1", the GPIOs of interest must be configured first. This configuration defines the GPIO function of the pin. Either an output pin, or an input pin with/without pull resistor.

To do so, the remote device "Module 2" must setup a Bluetooth® LE connection to the radio module "Module 1" and send a `CMD_GPIO_REMOTE_WRITECONFIG_REQ` command via Bluetooth® LE thereafter (see figure 1).
The configuration is stored in flash memory, such that it is retained even after a device restart.
It can be read back by the remote device "Module 2" using the `CMD_GPIO_REMOTE_READCONFIG_REQ` command (see figure 2).

After the configuration has been done, the configured GPIOs are ready to be controlled.

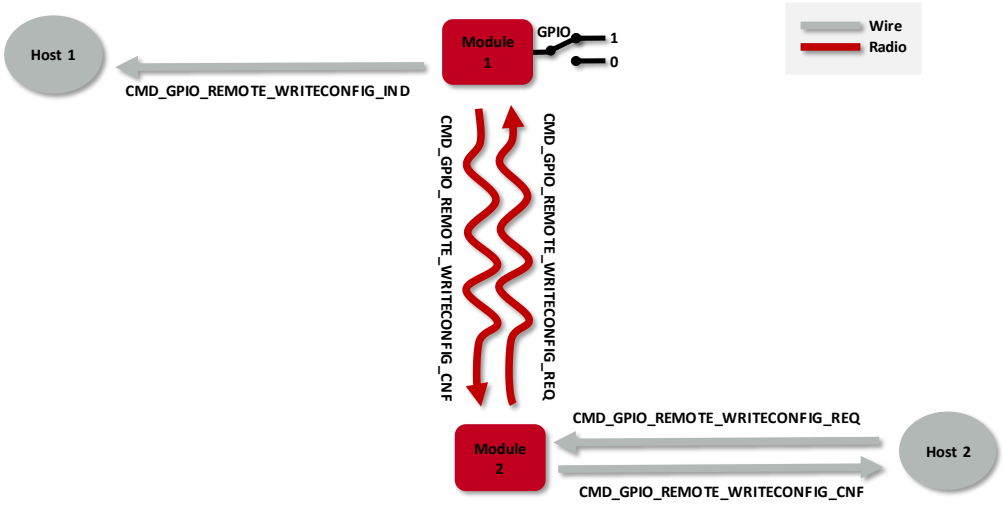


Figure 1: Configure the local GPIOs via remote device host

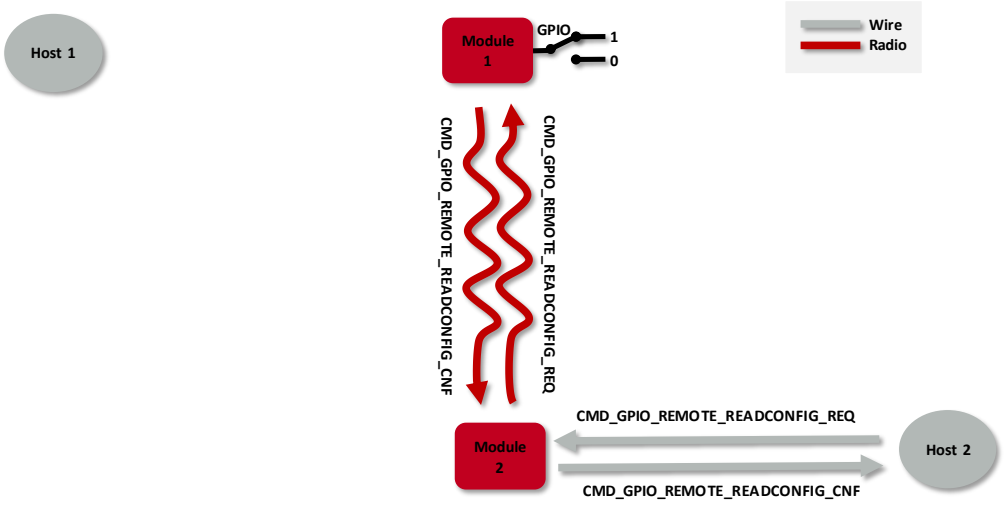


Figure 2: Read the configuration of the local GPIOs via remote device host

2.1.1 Local GPIO configuration

In case no host controller is connected to "Module 1", please go to the next chapter `Remote control`.

In case a host controller is connected to "Module 1", both, writing and reading the GPIO configuration can be done locally using the commands `CMD_GPIO_LOCAL_WRITECONFIG_REQ` and `CMD_GPIO_LOCAL_READCONFIG_REQ` (see figure 3 and figure 4). In this case, the host controller of "Module 1" must send the respective commands via UART to the "Module 1".

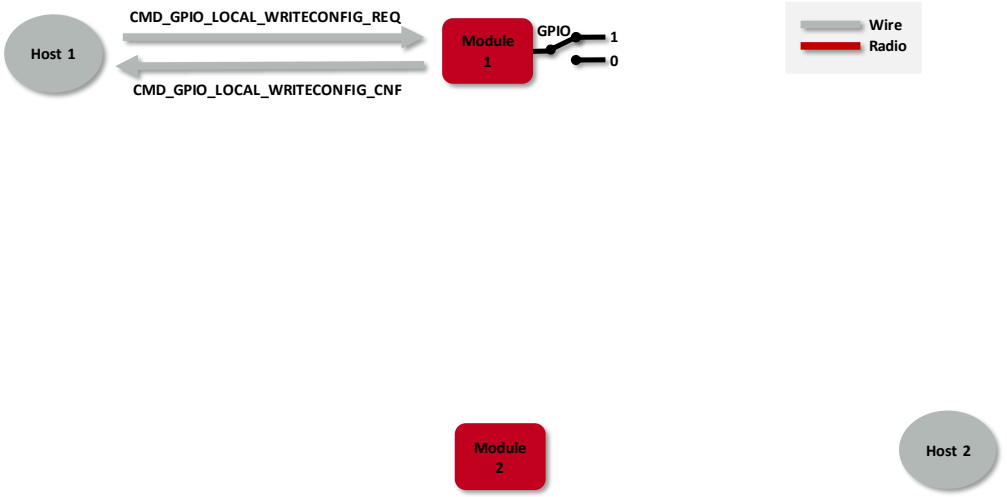


Figure 3: Configure the local GPIOs via local host

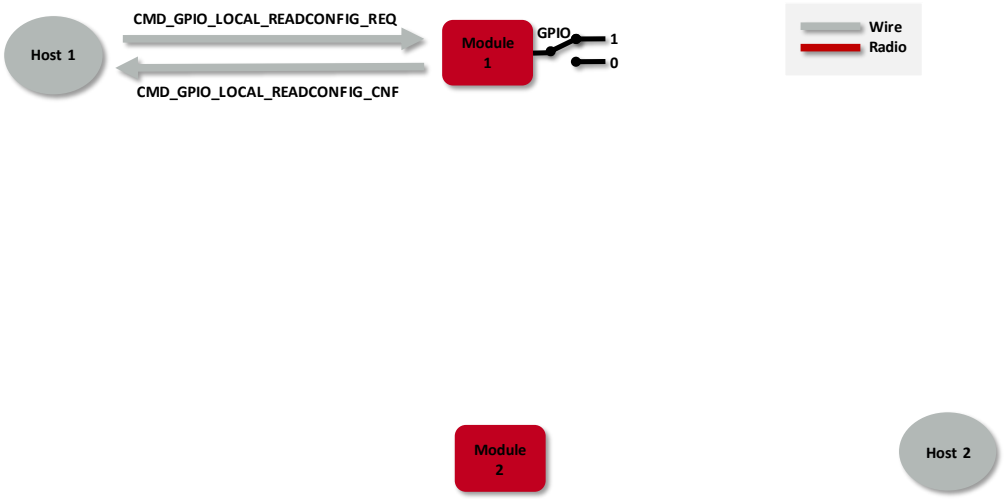


Figure 4: Read the configuration of the local GPIOs via local host

2.2 Remote control

To control a GPIO via remote device, first setup a Bluetooth® LE connection to the radio module "Module 1" and send the respective commands, `CMD_GPIO_REMOTE_WRITE_REQ` for setting GPIO output values (see figure 5), or `CMD_GPIO_REMOTE_READ_REQ` for reading GPIO values (see figure 6).
In case a host controller is connected to "Module 1", each time the GPIOs are written to via remote connection, the local host is informed using a `CMD_GPIO_REMOTE_WRITE_IND` message.

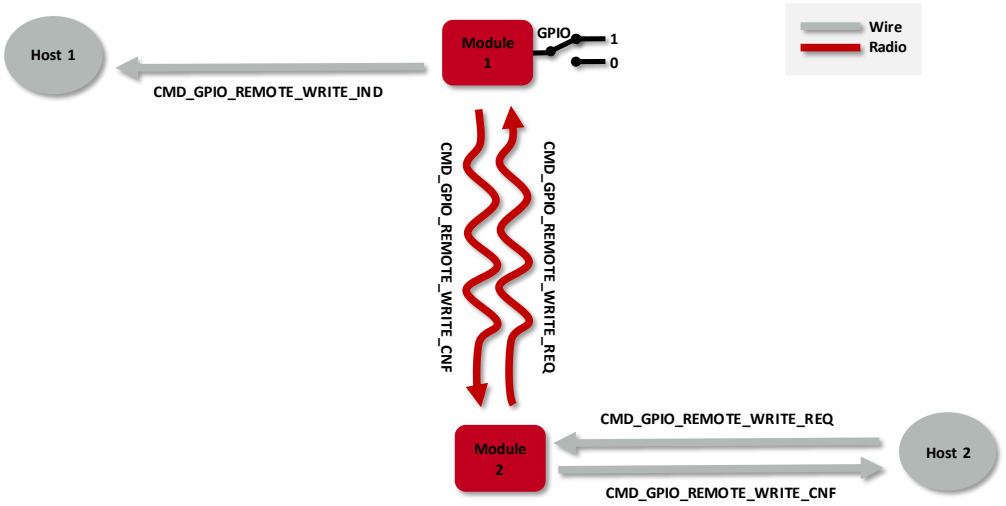


Figure 5: Set the output value of a GPIO via remote device

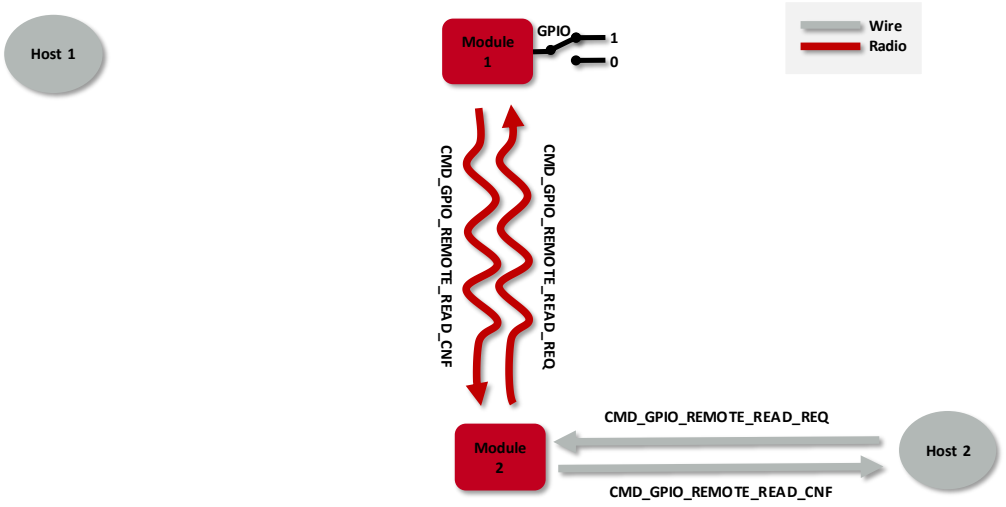


Figure 6: Read the input value of a GPIO via remote device

2.2.1 Local control

In case a host controller is connected to "Module 1", it also can write and read the GPIO status of the radio module "Module 1". To do so, the host controller must send the respective commands, `CMD_GPIO_LOCAL_WRITE_REQ` to set GPIO output values (see figure 7), or `CMD_GPIO_LOCAL_READ_REQ` to read GPIO values (see figure 8). Each time the GPIOs are written to via local host, the connected remote device is informed using a `CMD_GPIO_LOCAL_WRITE_IND` message.

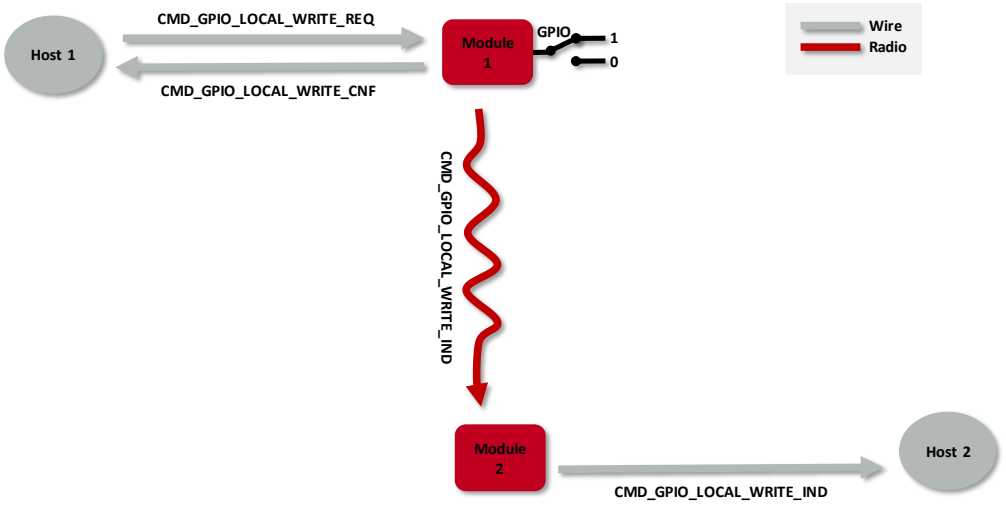


Figure 7: Set the output value of a GPIO via host controller

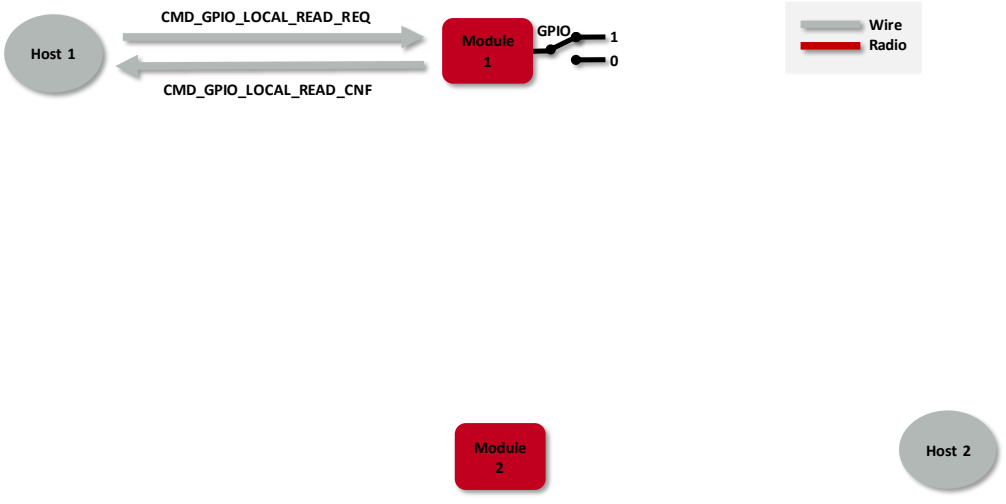


Figure 8: Read the input value of a GPIO via host controller

3 Examples

The below commands are in hexadecimal notation. The arrow in the left column describes, whether it's a message from host to radio module, or vice versa. A request command is always sent from host to module (⇒). An indication, confirmation or response message is always sent from module to host (⇐).

3.1 Example 1: Control "Module 1" by "Module 2"

This chapter describes how to setup a Bluetooth® LE connection between two Proteus-III radio modules, and how to configure and control the GPIOs of one of both modules via Bluetooth® LE connection.
The setup is as shown above, where "Module 1" is the one, whose GPIOs are switched via radio. It can run without host controller. "Module 2" is the one whivh must be connected to a host controller "Host 2", to send the corresponding configuration and control commands.

For demonstration purpuses, two Proteus-III evaluation boards are appropriate. As "host" a Windows computer including the terminal program *hterm* can be taken. The USB connector of the Proteus-III evaluation board allows an easy connection to the Windows computer.

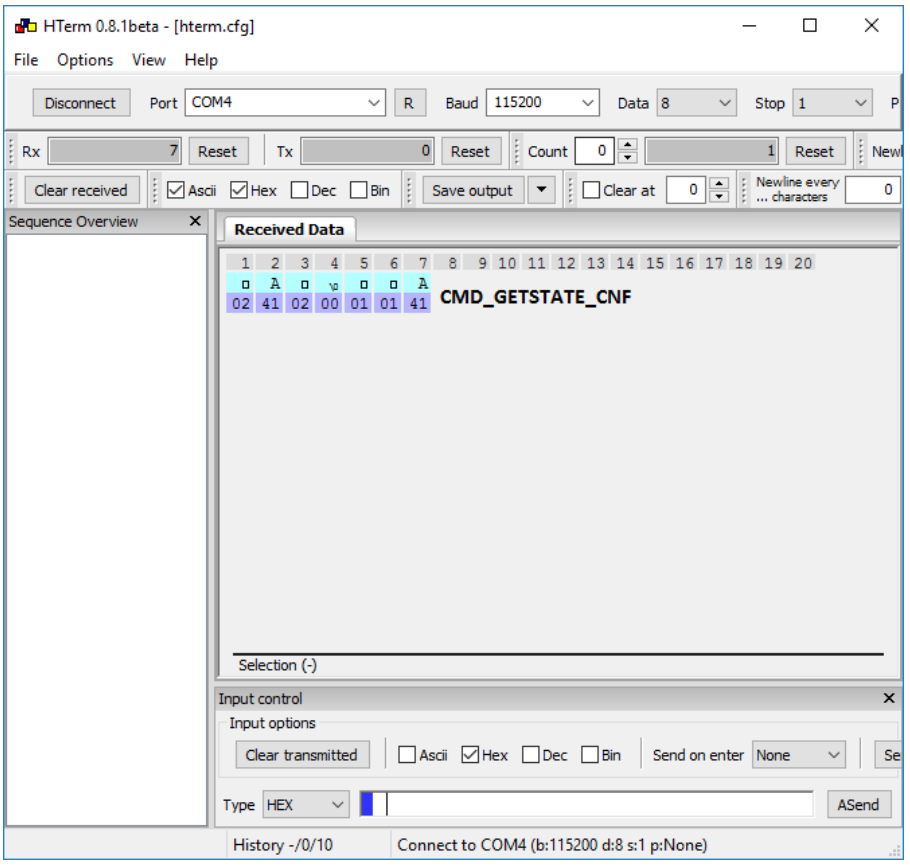


Figure 9: The terminal program hterm

Hint: Please note that the Würth Elektronik eiSos's tool Smart Commander (version 1.0.1.0 or newer) also includes the function to control the GPIOs of the Proteus-III. This tool allows

to generate the commands, that are shown below, by clicking the corresponding buttons in the Smart Commander GUI menu. This tool will be not used in this example.

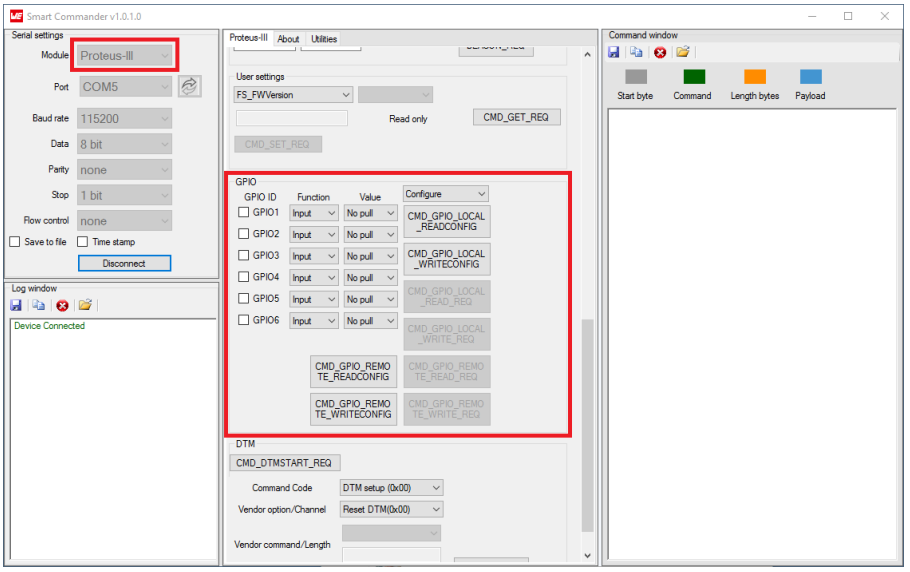


Figure 10: The Würth Elektronik eiSos's tool Smart Commander

3.1.1 Boot-up and connection setup

1. Power-up the modules and make their UARTs accessible by the host(s) (115200 Baud, 8n1). After the power-up or after reset the following sequence is sent from the module to the host.

Info	Module 1	Module 2
⇐ Response `CMD_GETSTATE_CNF`: Module 1 started in `ACTION_IDLE` mode.	02 41 02 00 01 01 41	
⇐ Response `CMD_GETSTATE_CNF`: Module 2 started in `ACTION_IDLE` mode.		02 41 02 00 01 01 41

2. Request the MAC address `FS_BTMAC` of both modules.

Info	Module 1	Module 2
⇒ Request `CMD_GET_REQ` with settings index 4		02 10 01 00 04 17
⇐ Response `CMD_GET_CNF`: `FS_BTMAC` of Module 2 is 0x55 0x00 0x00 0xDA 0x18 0x00		02 50 07 00 00 55 00 00 DA 18 00 C2
⇒ Request `CMD_GET_REQ` with settings index 4	02 10 01 00 04 17	
⇐ Response `CMD_GET_CNF`: `FS_BTMAC` of Module 1 is 0x11 0x00 0x00 0xDA 0x18 0x00	02 50 07 00 00 11 00 00 DA 18 00 86	

3. Connect Module 2 to Module 1 via Bluetooth®.

Info	Module 1	Module 2
⇒ Request CMD_CONNECT_REQ with FS_BTMAC of Module 1		02 06 06 00 11 00 00 DA 18 00 D1
⇐ Response CMD_CONNECT_CNF: Request understood, try to connect now		02 46 01 00 00 45
⇐ Indication CMD_CONNECT_IND: Physical connection established successfully to module with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00		02 86 07 00 00 11 00 00 DA 18 00 50
⇐ Indication CMD_CONNECT_IND: Physical connection established successfully to module with FS_BTMAC 0x55 0x00 0x00 0xDA 0x18 0x00	02 86 07 00 00 55 00 00 DA 18 00 14	
⇐ Indication CMD_CHANNELOPEN_RSP: Channel opened successfully to module with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00 and maximum payload size of 0xF3 (243 Bytes) per packet		02 C6 08 00 00 11 00 00 DA 18 00 F3 E3
⇐ Indication CMD_CHANNELOPEN_RSP: Channel opened successfully to module with FS_BTMAC 0x55 0x00 0x00 0xDA 0x18 0x00 and maximum payload size of 0xF3 (243 Bytes) per packet	02 C6 08 00 00 55 00 00 DA 18 00 F3 A7	

4. Now the Bluetooth® LE connection is open, and the configuration and control of the GPIOs of "Module 1" can be done.

3.1.2 Configure and control a GPIO as output

If the Bluetooth® LE connection has been setup, as shown in chapter 3.1.1, the following steps can be run to configure the GPIO *B1* with GPIO_ID 1 as output pin.

1. First of all configure the GPIO *B1* with GPIO_ID 1 as output pin with default level LOW.

Info	Module 1	Module 2
⇒ Request CMD_GPIO_REMOTE_WRITECONFIG_REQ: Configure GPIO *B1* (GPIO_ID 1) as output with default level LOW		02 28 04 00 03 01 02 00 2E
⇐ Response CMD_GPIO_REMOTE_WRITECONFIG_CNF: GPIO with GPIO_ID 1 has been configured successfully		02 68 04 00 00 02 01 00 6D
⇐ Indication CMD_GPIO_REMOTE_WRITECONFIG_IND: GPIO with GPIO_ID 1 has been configured to output LOW by remote device	02 A8 04 00 03 01 02 00 AE	

2. Read the current configuration

Info	Module 1	Module 2
⇒ Request CMD_GPIO_REMOTE_READCONFIG_REQ:		02 2C 00 00 2E
⇐ Response CMD_GPIO_REMOTE_READCONFIG_CNF: GPIO with GPIO_ID 1 has been configured to output LOW, GPIO_ID 2 - 6 are not configured		02 6C 14 00 00 03 01 02 00 02 02 00 02 03 00 02 04 00 02 05 00 02 06 00 7E

3. Switch the GPIO *B1* with GPIO_ID 1 to HIGH.

Info	Module 1	Module 2
⇒ Request CMD_GPIO_REMOTE_WRITE_REQ: Set the GPIO *B1* (GPIO_ID 1) to HIGH		02 29 03 00 02 01 01 2A
⇐ Response CMD_GPIO_REMOTE_WRITE_CNF: GPIO with GPIO_ID 1 has been successfully		02 69 04 00 00 02 01 00 6C
⇐ Indication CMD_GPIO_REMOTE_WRITE_IND: GPIO with GPIO_ID 1 has been set to HIGH by remote device	02 A9 03 00 02 01 01 AA	

4. Read the current state of the GPIO *B1* with GPIO_ID 1.

Info	Module 1	Module 2
⇒ Request CMD_GPIO_REMOTE_READ_REQ: Read the state of GPIO *B1* (GPIO_ID 1)		02 2A 02 00 01 01 2A
⇐ Response CMD_GPIO_REMOTE_READ_CNF: GPIO with GPIO_ID 1 is HIGH		02 6A 04 00 00 02 01 01 6E

5. Switch the GPIO *B1* with GPIO_ID 1 again to LOW.

Info	Module 1	Module 2
⇒ Request CMD_GPIO_REMOTE_WRITE_REQ: Set the GPIO *B1* (GPIO_ID 1) to LOW		02 29 03 00 02 01 00 2B
⇐ Response CMD_GPIO_REMOTE_WRITE_CNF: GPIO with GPIO_ID 1 has been set successfully		02 69 04 00 00 02 01 00 6C
⇐ Indication CMD_GPIO_REMOTE_WRITE_IND: GPIO with GPIO_ID 1 has been set to LOW by the remote device	02 A9 03 00 02 01 00 AB	

3.1.3 Configure and control a GPIO as input

If the Bluetooth® LE connection has been setup, as shown in chapter 3.1.1, the following steps can be run to configure the GPIO *B1* with GPIO_ID 1 as input pin.

1. First of all configure the GPIO *B1* with GPIO_ID 1 as input pin with default level LOW.

Info	Module 1	Module 2
⇒ Request `CMD_GPIO_REMOTE_WRITECONFIG_REQ`: Configure GPIO *B1* (GPIO_ID 1) as input with pull down resistor		02 28 04 00 03 01 01 01 2C
⇐ Response `CMD_GPIO_REMOTE_WRITECONFIG_CNF`: GPIO with GPIO_ID 1 has been configured successfully		02 68 04 00 00 02 01 00 6D
⇐ Indication `CMD_GPIO_REMOTE_WRITECONFIG_IND`: GPIO with GPIO_ID 1 has been configured to input with pull down resistor by the remote device	02 A8 04 00 03 01 01 01 AE	

2. Read the current configuration

Info	Module 1	Module 2
⇒ Request `CMD_GPIO_REMOTE_READCONFIG_REQ`:		02 2C 00 00 2E
⇐ Response `CMD_GPIO_REMOTE_READCONFIG_CNF`: GPIO with GPIO_ID 1 has been configured to input with pulldown, GPIO_ID 2 - 6 are not configured		02 6C 14 00 00 03 01 01 01 02 02 00 02 03 00 02 04 00 02 05 00 02 06 00 7C

3. Leave the GPIO *B1* open and read the current state of the GPIO *B1* with GPIO_ID 1.

Info	Module 1	Module 2
⇒ Request `CMD_GPIO_REMOTE_READ_REQ`: Read the state of GPIO *B1* (GPIO_ID 1)		02 2A 02 00 01 01 2A
⇐ Response `CMD_GPIO_REMOTE_READ_CNF`: GPIO with GPIO_ID 1 is LOW		02 6A 04 00 00 02 01 00 6F

4. Now, apply a HIGH signal to the GPIO *B1* and read the current state of the GPIO *B1* with GPIO_ID 1.

Info	Module 1	Module 2
⇒ Request `CMD_GPIO_REMOTE_READ_REQ`: Read the state of GPIO *B1* (GPIO_ID 1)		02 2A 02 00 01 01 2A
⇐ Response `CMD_GPIO_REMOTE_READ_CNF`: GPIO with GPIO_ID 1 is HIGH		02 6A 04 00 00 02 01 01 6E

3.2 Example 2: Control "Module 1" by smart phone

This chapter describes how to setup a Bluetooth® LE connection between a smart phone and a Proteus-III radio module, and how to configure and control the GPIOs of the Proteus-III "Module 1" via the Bluetooth® LE connection.
"Module 1" itself can run without host controller as its GPIOs are controlled via radio. For demonstration purposes, we here again use a Proteus-III evaluation board, which is connected to a Windows computer including the terminal program *hterm*, which is the host "Host 1".

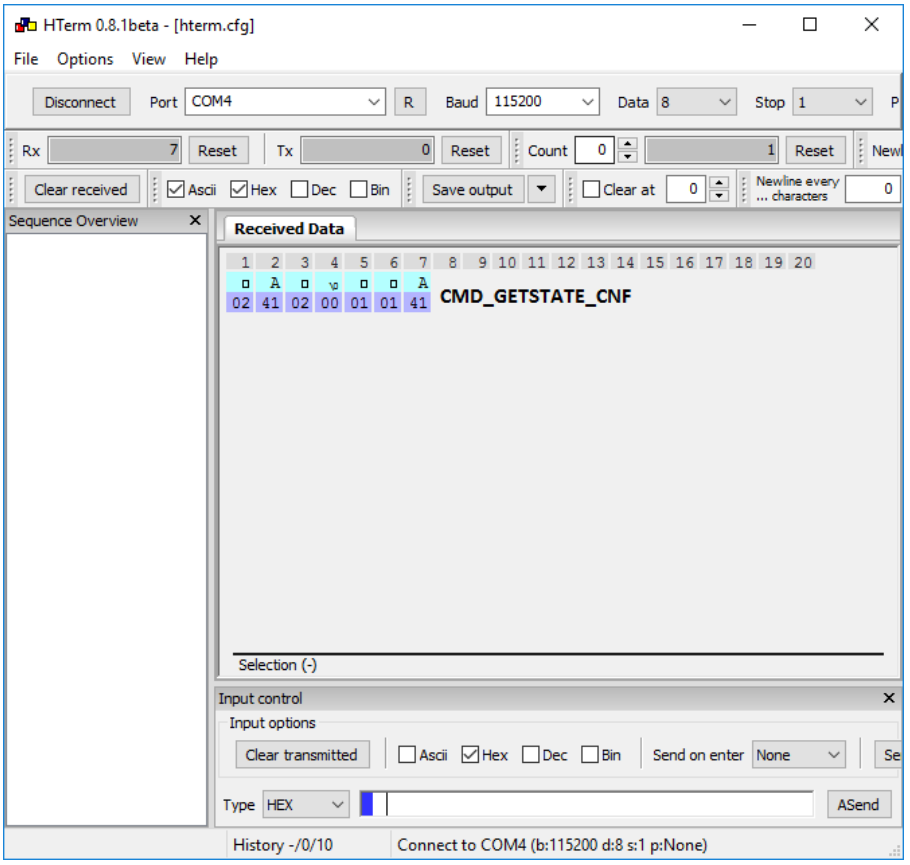


Figure 11: The terminal program hterm

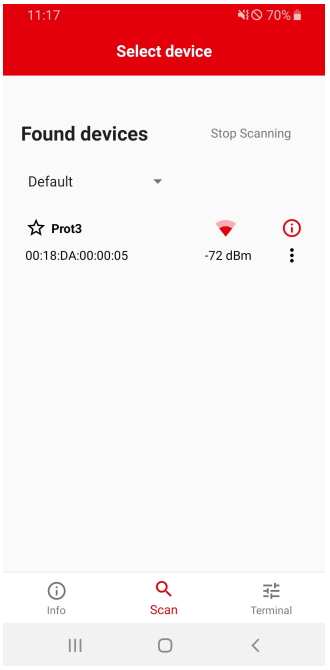
Instead of "Module 2" we here use an Android smart phone including the app "Proteus Connect", which allows the operation with all radio modules from the Proteus series. Besides the functions for connection setup and data transmission, this app contains the functions of GPIO configuration and control, which we will focus on in this chapter.

3.2.1 Boot-up and connection setup

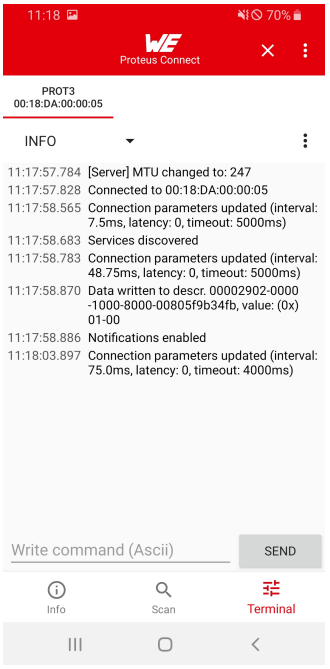
- Connect the Proteus evaluation board to a PC using an USB cable.
- Open a terminal program using the Proteus default UART settings (115200 Baud, 8n1).
- Press the reset button on the Proteus evaluation board. The Proteus module outputs a `CMD_GETSTATE_CNF` to indicate that it is ready for operation.

Info	Module 1
⇐ Response `CMD_GETSTATE_CNF`: Module 1 started in `ACTION_IDLE` mode.	02 41 02 00 01 01 41

- Then open the "Proteus Connect" app and press "Scan". As soon as the Proteus-III appears in the scan list, click on it to start the connection setup.



- In the app a new window pops up, which shows the connection setup steps in its log window.



- On the radio module side, the Proteus-III outputs its connection setup related messages.

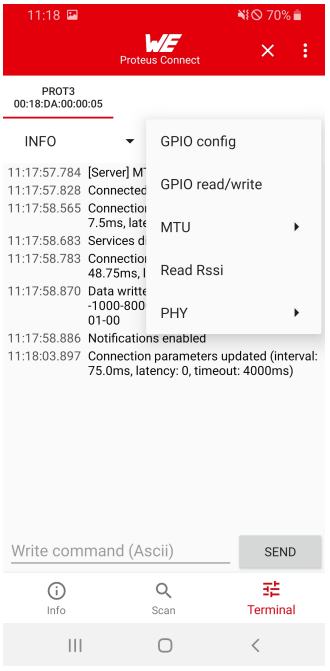
Info	Module 1
⇐ Indication `CMD_CONNECT_IND`: Physical connection established successfully to device with `FS_BTMAC` 0x55 0x00 0x00 0xDA 0x18 0x00	02 86 07 00 00 55 00 00 DA 18 00 14
⇐ Indication `CMD_CHANNELOPEN_RSP`: Channel opened successfully to device with `FS_BTMAC` 0x55 0x00 0x00 0xDA 0x18 0x00 and maximum payload size of 0xF3 (243 Bytes) per packet	02 C6 08 00 00 55 00 00 DA 18 00 F3 A7

- Now the Bluetooth® LE connection is open, and the configuration and control of the GPIOs of "Module 1" can be done.

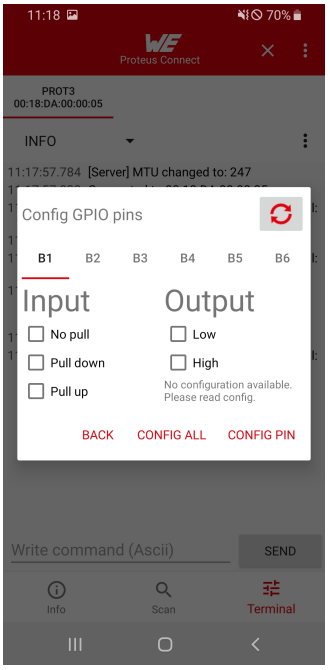
3.2.2 Configure and control a GPIO as output

If the Bluetooth® LE connection has been setup, as shown in chapter `3.2.1`, the following steps can be run to configure the GPIO *B1* with GPIO_ID 1 as output pin.

1. First of all configure the GPIO *B1* with GPIO_ID 1 as output pin with default level LOW. To do so, press the "..."-menu button and then "GPIO config" .



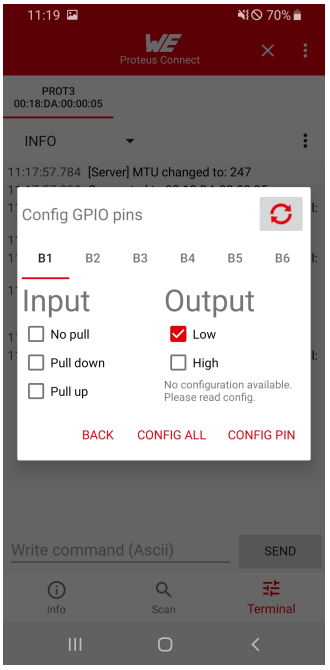
2. A menu opens, which allows the configuration of the GPIOs. First of all, press on the refresh button to read the current pin configuration of the radio module.



3. Pressing this button sends a `CMD_GPIO_REMOTE_READCONFIG_REQ` message (02 2C) to the radio module, which responds with a `CMD_GPIO_REMOTE_READCONFIG_CNF` message (02 6C 02 01 00 02 02 00 02 03 00 02 04 00 02 05 00 02 06 00), which states that all pins with GPIO_ID 1 to 6 are not configured.

Please note that the format of the radio commands differs from the formnat of the UART commands. The documentation of the radio command format for configuration and control of the GPIOs can be found in application note "ANR009 Proteus-III Advanded Developer Guide".

4. Now select pin *B1* with output LOW in the app and press "CONFIG PIN".

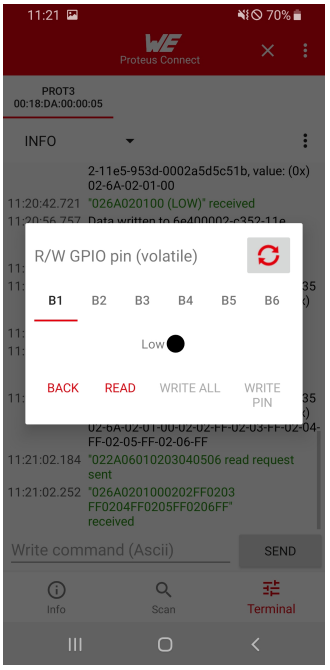


5. Pressing this button sends a `CMD_GPIO_REMOTE_WRITECONFIG_REQ` message (02 28 03 01 02 00 / configure GPIO with GPIO_ID 1 to output LOW) to the radio module, which responds with a `CMD_GPIO_REMOTE_WRITECONFIG_CNF` message (02 68 02 01 00 / configured GPIO with GPIO_ID 1 successfully).

6. On the radio module side, the Proteus-III outputs the corresponding indication message

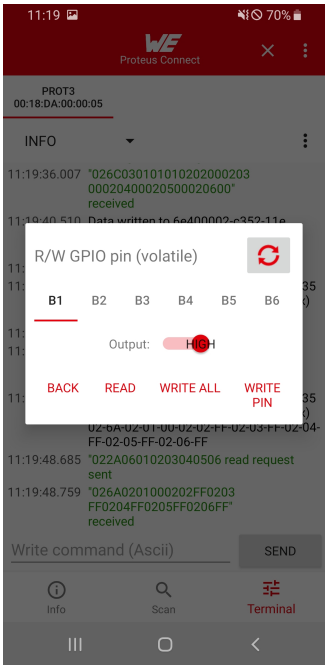
Info	Module 1
⇐ Indication `CMD_GPIO_REMOTE_WRITECONFIG_IND`: The GPIO with GPIO_ID 1 has been configured to output LOW by the remote device	02 A8 04 00 03 01 02 00 AE

7. Now, go to the sub menu "GPIO read/write" and press the refresh button to read all GPIO states.



8. Pressing this button sends a `CMD_GPIO_REMOTE_READ_REQ` message (02 2A 06 01 02 03 04 05 06 / request state of GPIO_ID 1 to 6) to the radio module, which responds with a `CMD_GPIO_REMOTE_READ_CNF` message (02 6A 02 01 00 02 02 FF 02 03 FF 02 04 FF 02 05 FF 02 06 FF), which states that the GPIO with GPIO_ID 1 is LOW, but the GPIOs with GPIO_ID 2 to 6 are not configured.

9. Next, press "B1", move the slider to HIGH and press "WRITE PIN" to set the GPIO with GPIO_ID 1 to HIGH.



10. Pressing these buttons sends a `CMD_GPIO_REMOTE_WRITE_REQ` message (02 29 02 01 01 / set the GPIO with GPIO_ID 1 to HIGH) to the radio module, which responds with

a CMD_GPIO_REMOTE_WRITE_CNF message (02 69 02 01 00), which states that the GPIO with GPIO_ID 1 has been set successfully.

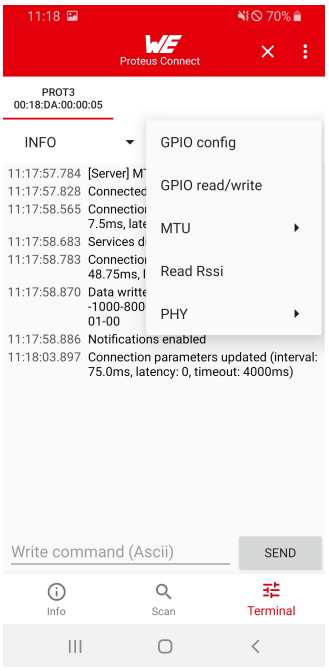
11. On the radio module side, the Proteus-III outputs the corresponding indication message

Info	Module 1
⇐ Indication CMD_GPIO_REMOTE_WRITE_IND: The GPIO with GPIO_ID 1 has been set to HIGH by the remote device	02 A9 03 00 02 01 01 AA

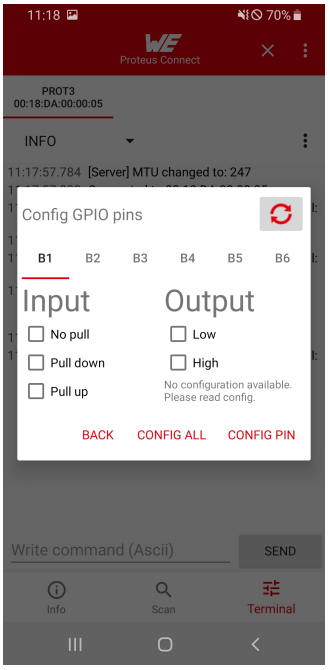
3.2.3 Configure and control a GPIO as input

If the Bluetooth® LE connection has been setup, as shown in chapter 3.2.1, the following steps can be run to configure the GPIO *B1* with GPIO_ID 1 as input pin.

1. First of all configure the GPIO *B1* with GPIO_ID 1 as input pin with pull down resistor. To do so, press the "..."-menu button and then "GPIO config" .



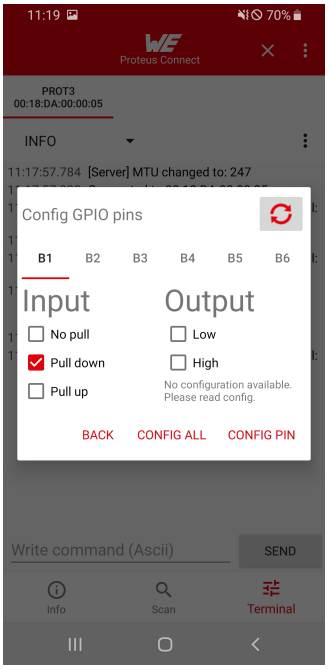
2. A menu opens, which allows the configuration of the GPIOs. First of all, press on the refresh button to read the current pin configuration of the radio module.



3. Pressing this button sends a `CMD_GPIO_REMOTE_READCONFIG_REQ` message (02 2C) to the radio module, which responds with a `CMD_GPIO_REMOTE_READCONFIG_CNF` message (02 6C 02 01 00 02 02 00 02 03 00 02 04 00 02 05 00 02 06 00), which states that all pins with GPIO_ID 1 to 6 are not configured.

Please note that the format of the radio commands differs from the UART command format. The documentation of the radio command format for configuration and control of the GPIOs can be found in application note "ANR009 Proteus-III Advanded Developer Guide".

4. Now select pin *B1* with input pull down in the app and press "CONFIG PIN".

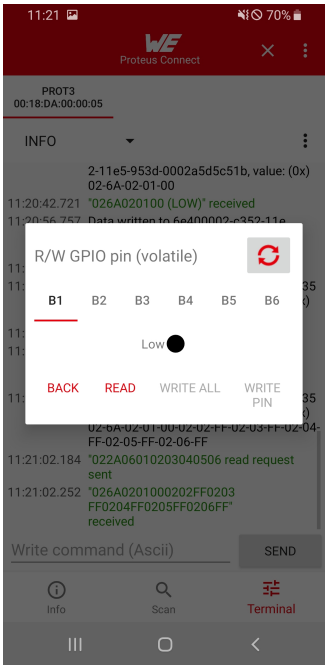


5. Pressing this button sends a `CMD_GPIO_REMOTE_WRITECONFIG_REQ` message (02 28 03 01 01 01 / configured GPIO with GPIO_ID 1 to input pull down) to the radio module, which responds with a `CMD_GPIO_REMOTE_WRITECONFIG_CNF` message (02 68 02 01 00 / configured GPIO with GPIO_ID 1 successfully).

6. On the radio module side, the Proteus-III outputs the corresponding indication message

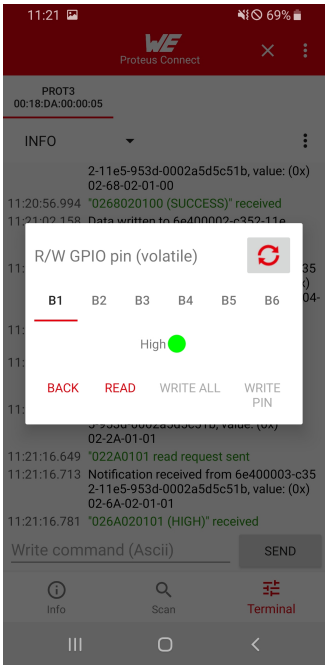
Info	Module 1
⇐ Indication `CMD_GPIO_REMOTE_WRITECONFIG_IND`: The GPIO with GPIO_ID 1 has been configured to input pull down by the remote device	02 A8 04 00 03 01 01 01 AC

7. Now, go to the sub menu "GPIO read/write" and press the refresh button to read all GPIO states.



8. Pressing this button sends a `CMD_GPIO_REMOTE_READ_REQ` message (02 2A 06 01 02 03 04 05 06 / request state of GPIO_ID 1 to 6) to the radio module, which responds with a `CMD_GPIO_REMOTE_READ_CNF` message (02 6A 02 01 00 02 02 FF 02 03 FF 02 04 FF 02 05 FF 02 06 FF), which states that the GPIO with GPIO_ID 1 is LOW, but the GPIOs with GPIO_ID 2 to 6 are not configured.

9. Apply a HIGH signal to the pin by connecting VCC to it. Then press "B1" and press "READ PIN" to read the GPIO with GPIO_ID 1.



10. Pressing these buttons sends a `CMD_GPIO_REMOTE_READ_REQ` message (02 2A 01 01 / read the GPIO with GPIO_ID 1 to the radio module, which responds with a

CMD_GPIO_REMOTE_READ_CNF message (02 6A 02 01 01), which states that the GPIO with GPIO_ID 1 is HIGH.

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