

Simucube Wireless Button Plate Module v1

1. System overview

The Simucube wireless button plate module enables a user to connect their sim wheels to the Simucube force feedback controller without messy cables. The concept is that sim-wheel buttons and incremental encoders are connected to a button plate logic transmitter module, which communicates to Simucube force feedback controller's wireless adapter via Bluetooth. The Simucube controller then communicates these button- and encoder state changes via USB to the user's PC.

Basic operating principle:

- Button plate manufacturers integrate the wireless button plate module in their designs simply by plugging the module to their PCB connector board and configuring the module with provided button plate configuration tool. The button plate configuration tool is introduced later in this document.
- Customers connect the wireless button plate to their Simucube controller by simply pressing both paddle shifters simultaneously
- The original Simucube version needs an add-on receiver board (Simucube Wireless Adapter, sold separately) to interface with these wireless button plate transmitter modules. Simucube 2 has this receiver module embedded in its design.

A wireless button plate module is shown in Figure 1. A physical system overview is shown in Figure 2 and Figure 3.

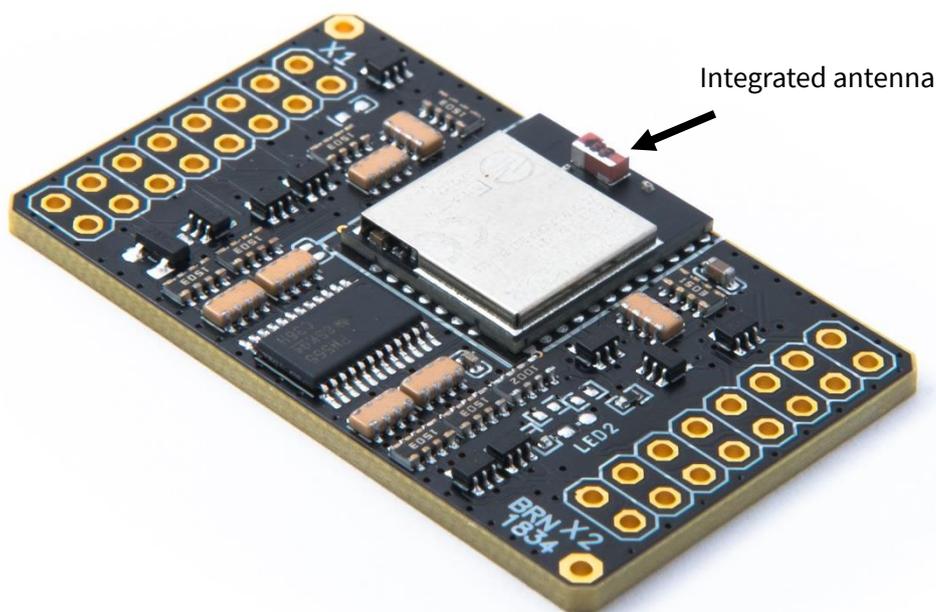


Figure 1 : A wireless button plate module with an integrated antenna

Simucube Wireless Button Plate Module

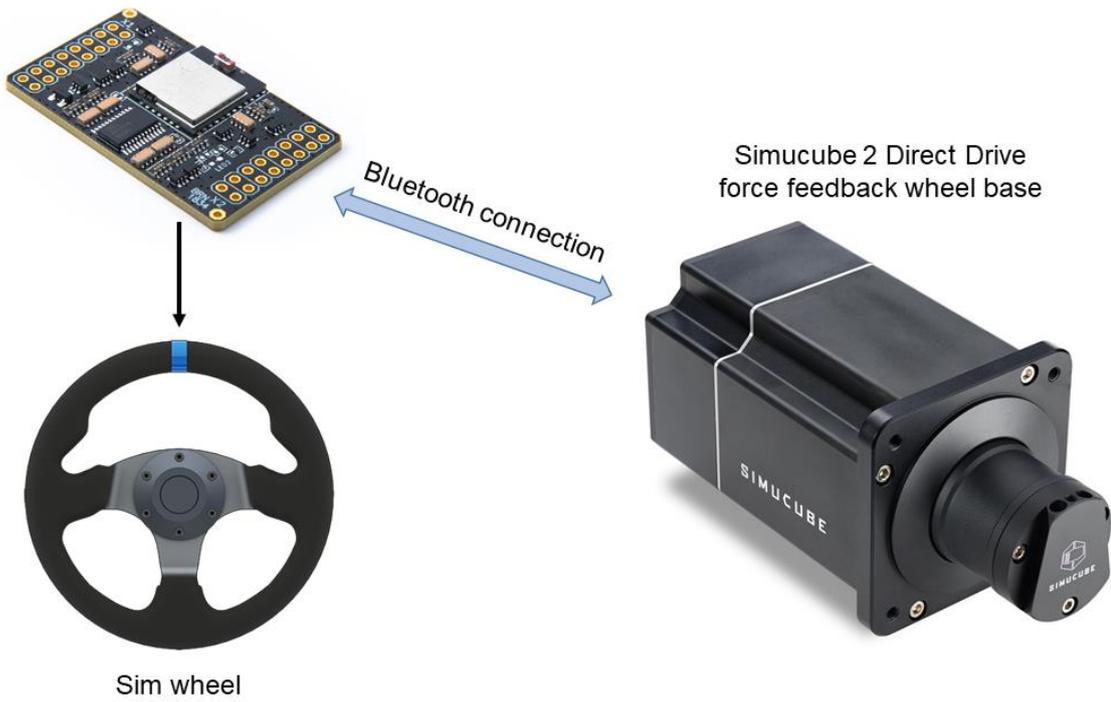


Figure 2 : Wireless wheel system overview with Simucube 2

Simucube Wireless Button Plate Module

Simucube Wireless Adapter

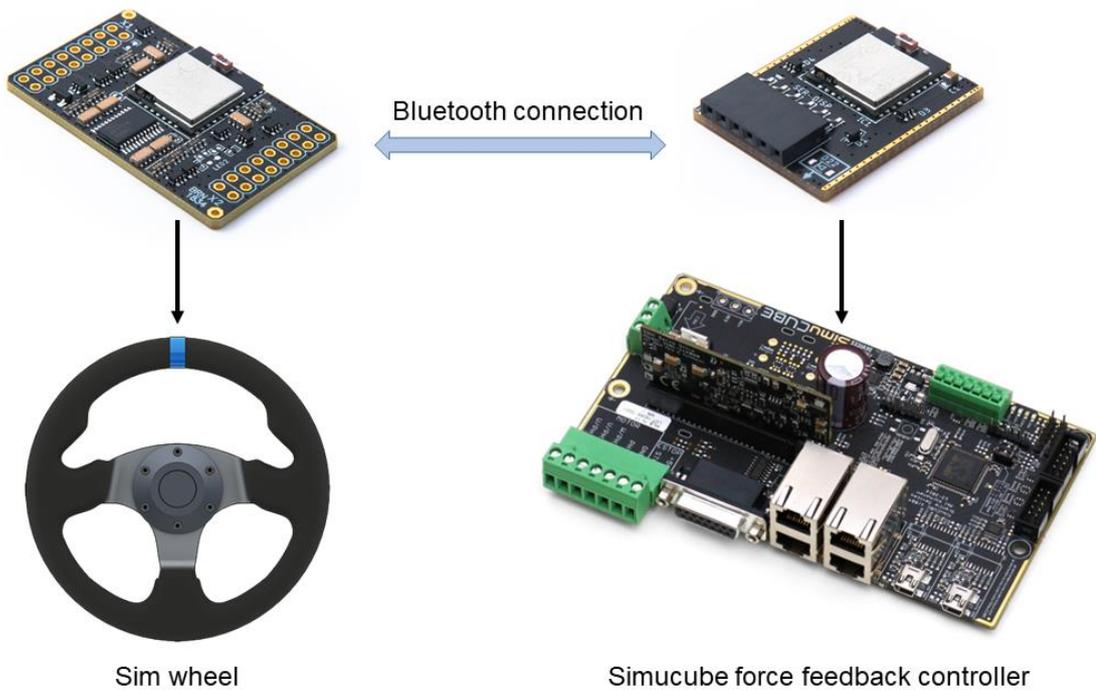


Figure 3 : Wireless wheel system overview with the original Simucube

2. Wireless button plate module

The wireless button plate module consists of a Bluetooth low-energy module and supporting peripheral components for allowing a total of 28 digital inputs, as well as controlling a status led. The main function of the module is to wirelessly communicate input device state-change data to the Simucube controller.

The wireless button plate module is designed and built to consume a frugal amount of energy, be as compact and simple possible, whilst still serving the needs of wheel-manufacturers and sim-users. The low current-consumption of the module makes continuous use of many months possible on just two AAA batteries.

2.1. Operation logic

Wireless button plate modules can be turned on by simply connecting an appropriate power supply to them. After power-on, a module enters discovery mode and announces itself to the Simucube controller's wireless adapter for 30 seconds. Discovery mode can also be activated by pressing both paddle shifters simultaneously.

Note that keeping the paddle shifters pressed, will keep discovery mode active. The Simucube controller's wireless adapter can establish a connection only while the wireless button plate module is in discovery mode.

When connecting a wireless button plate module to a Simucube controller for the first time, it is required to manually select the wireless button plate module from the list provided by Simucube configuration software.

Thereafter, a connection will be established automatically when pressing both paddle shifters simultaneously. After establishing a connection, all input-events coming from the button plate module, will be transmitted to the Simucube controller's wireless adapter.

The connection between a wireless button plate and a Simucube controller can be closed by pressing both paddle shifters for 5 seconds. After closing the connection in this way, the button plate module waits 5 seconds before it can be set to the discovery mode again. It is also needed to release and press again at least one paddle shifter to activate the discovery mode again after those 5 seconds.

The wireless button plate module will enter sleep mode if it is not connected to a Simucube controller. A module can be woken up by power down/up or by pressing both paddle shifters again.

The wireless button plate module status changes are shown by a blinking status LED in a following manner:

1. Discovery mode: continuous blinking at a high frequency
2. Connected to a Simucube controller: 3 blinks at a medium frequency
3. Disconnected from Simucube controller: 10 blinks at a slow frequency

2.2. Input devices

The wireless button plate logic module has 28 pins for input devices. The first two pins are fixed and must be connected to the paddle shifters. Every sim-wheel based on this wireless button plate module must have two paddle shifters connected to these pins, because they are used for putting the module in discovery mode, allowing subsequent connection to the Simucube controller's wireless adapter.

Push buttons for different purposes can be connected to any of the other pins, but incremental encoders can only be connected to ENCXX pins. The first encoder should be connected to pins ENC1A and ENC1B, the second to ENC2A and ENC2B, etc. The pin names and functions are listed in Table 1. The device pin order is shown later in this document, in Figure 6.

Table 1: Input pins

Pin	Usage	Pin	Usage	Pin	Usage	Pin	Usage
PADDLE1	Paddle shifter (left)	ENC3B	Encoder / Button	BTN3	Button	BTN10	Button
PADDLE2	Paddle shifter (right)	ENC4A	Encoder / Button	BTN4	Button	BTN11	Button
ENC1A	Encoder / Button	ENC4B	Encoder / Button	BTN5	Button	BTN12	Button
ENC1B	Encoder / Button	ENC5A	Encoder / Button	BTN6	Button	BTN13	Button
ENC2A	Encoder / Button	ENC5B	Encoder / Button	BTN7	Button	BTN14	Button
ENC2B	Encoder / Button	BTN1	Button	BTN8	Button	BTN15	Button
ENC3A	Encoder / Button	BTN2	Button	BTN9	Button	BTN16	Button

The supported input devices for the wireless button plate module are currently limited to push buttons and 2-bit incremental encoders. However, it is possible to configure push buttons to support different roles. A push button can be used as a simple push button, SHIFT-button, or as a torque-off button.

When a SHIFT-button is active, it changes the function of all other inputs by shifting them 16 or 32 steps depending on the amount of input pins used in the button plate. As an example, SHIFT plus button 5 would have it function as button 37, and so forth. If a torque-off button is mapped to the button plate, the servo-motor torque can be switched on and off by pressing that button.

With regards to incremental encoders, different brands may produce different amount of state changes per detent/step. Currently, the wireless button plate module supports encoders with 1, 2 or 4 state changes per detent.

2.3. A wireless button plate module as a part of a sim wheel

The wireless button plate module is meant to be used as a module in custom circuit boards. **The operating voltage specification of the wireless button plate module is between 2.4 – 3.8 V.** A power-switch between a module and its power supply is recommended. The recommended power supply types for the module is a single 3 V lithium-, or 2 x 1.5 V alkaline batteries in series.

The module consumes less than 1 μA current in sleep mode, which means that it doesn't need to be shut down, except for long-term storing. However, keeping even one paddle shifter pressed will prevent the module from staying in the most energy saving sleep mode. It is therefore strongly suggested to switch the power off in any situation where paddle shifters may be pressed for a long time.

Every input device pin is connected to the button plate logic module in a similar fashion. The pins have 150 k Ω pull-up resistors and 10 nF capacitors for low pass filtering the state changes. All input devices must either connect the input pin to a common ground or leave it floating, depending on the input device state. All input pins are totally independent from each other, so it is possible to use all of them at the same time.

The input pin connection diagram is shown in the Figure 4 and the pin order in Figure 6. A status led can be connected directly between the status led pin and the common ground.

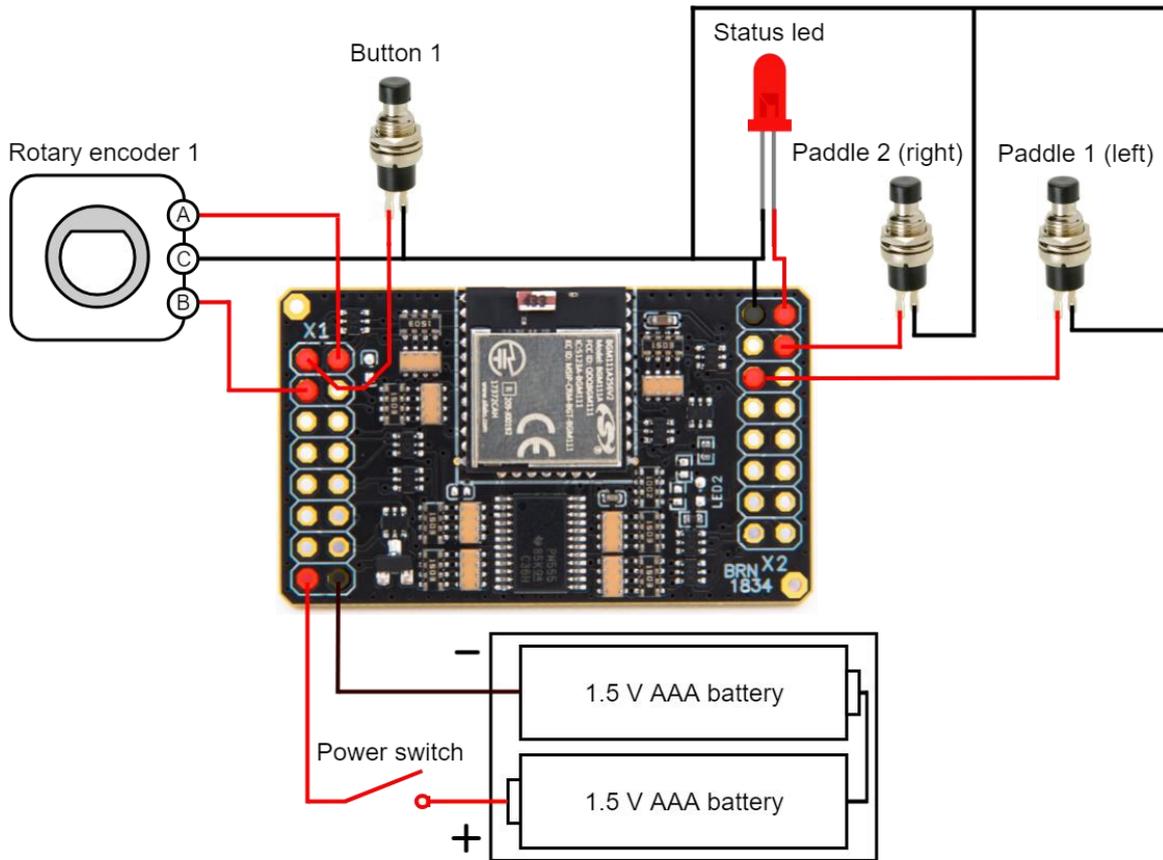


Figure 4 : Wireless button plate module connection to power supply, status led and input devices. The black wires are connected to the common ground (GND)

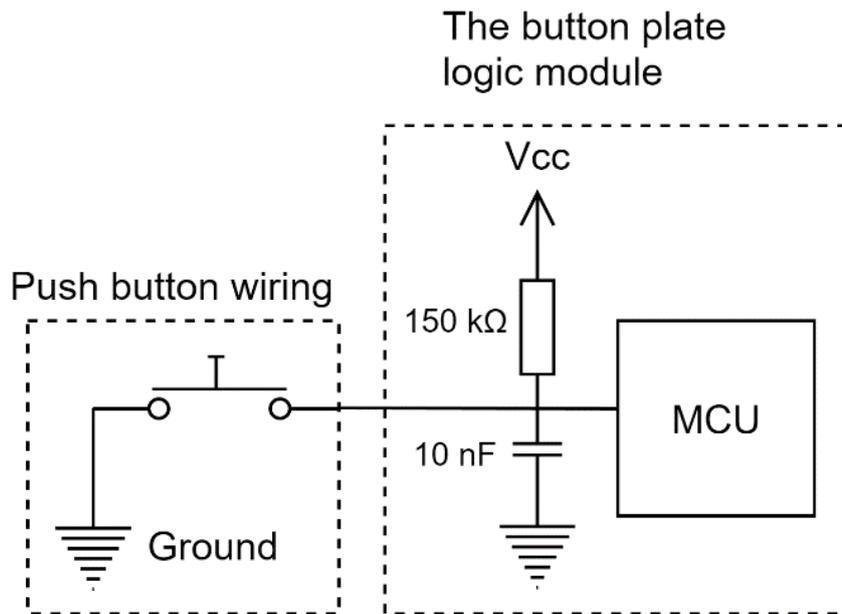
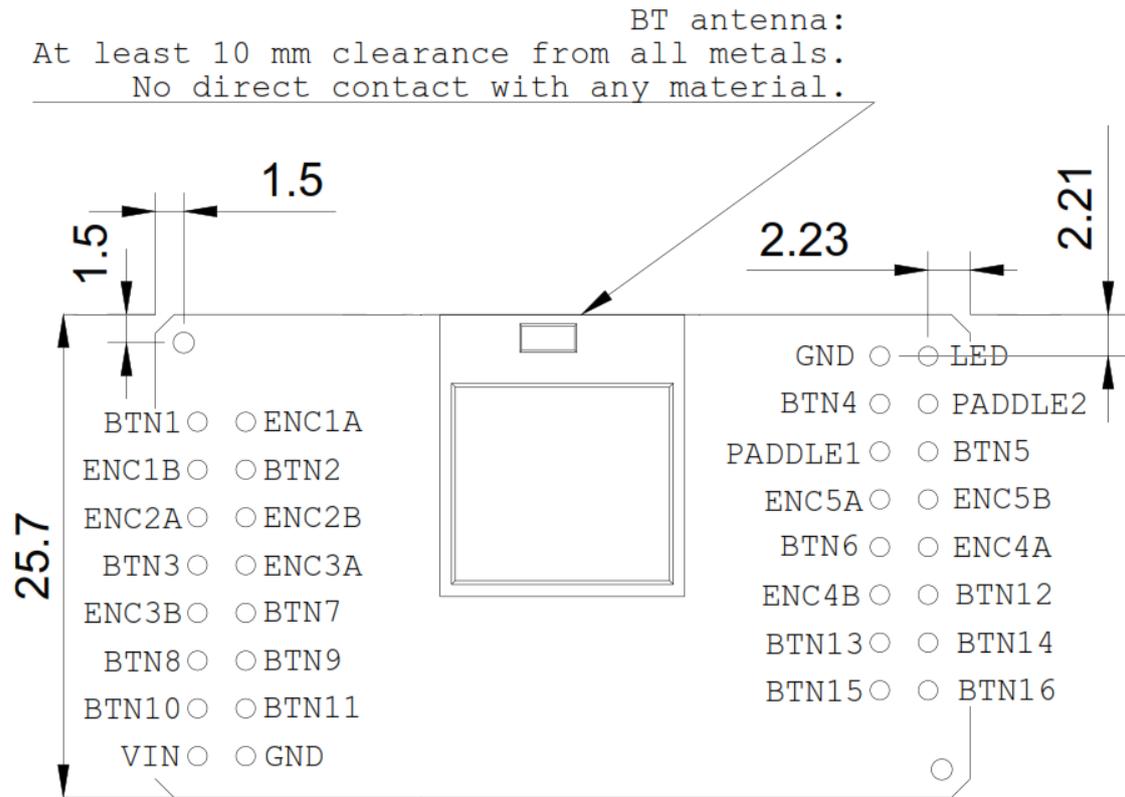


Figure 5 : Input device connection



Headers and 1.1 mm holes are symmetrically on both sides.

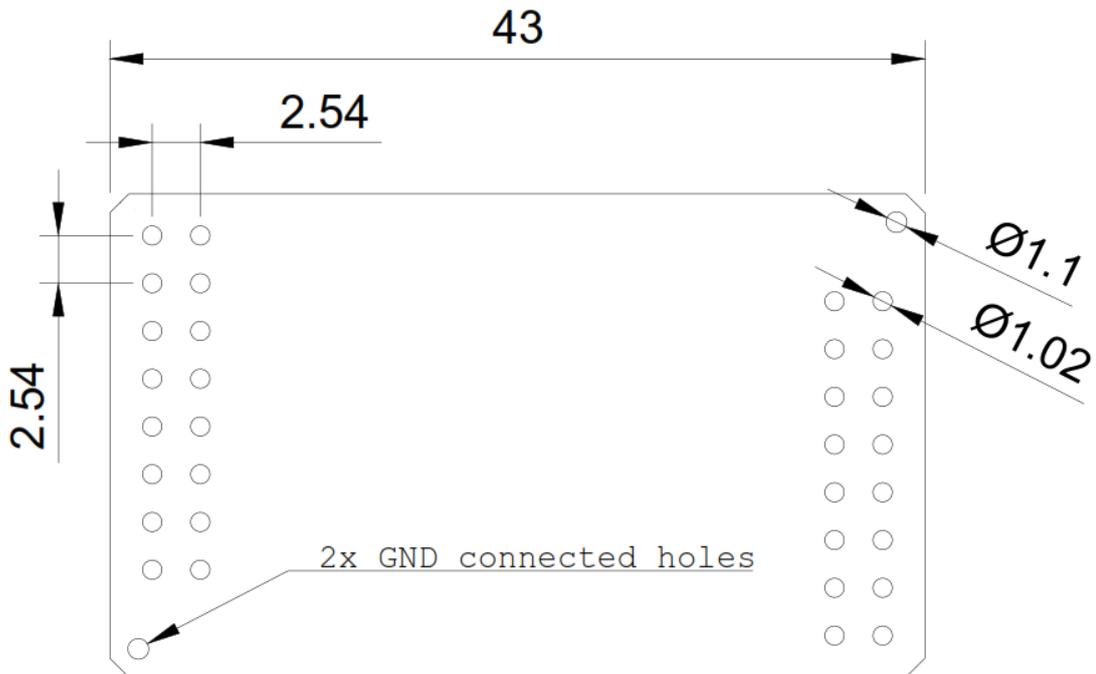


Figure 6 : The wireless button plate module input pins and physical dimensions in millimeters

2.4. Module with an integrated antenna

The original wireless button plate module type has an integrated antenna for easy usage. When mounting the module inside a wheel, special care must be taken locating the module. Avoid metal materials near the integrated antenna, as it will degrade the RF-performance. Plastic materials can be closer to the module, provided it is not touching it.

If metal objects are too close though, it might interfere with communications. **The minimum recommended distance of metal and/or conductive enclosures is 10 mm in any direction from the antenna.** The position of the antenna is shown in Figure 1.

Another connection-related requirement is to make way to allow radiating the signal between the wireless button plate module and the wireless adapter of Simucube controller. This simply means that the button plate enclosure on the wheel should not be constructed of conductive material only, there must be a window or hole close to the antenna. This is not a problem with plastic or other non-conductive case materials but may cause problems in fully enclosed metal or carbon fiber cases.

When soldering the module directly to another circuit board, the circuit board must be designed such that there is no copper or any other conductive material near the antenna.

2.5. Module with an external antenna connector

A wireless button plate module variant with an external antenna connector has been designed to allow placing the antenna outside of the button plate casing. **This module variant needs an external antenna to work properly.** It has a male U.FL connector (shown in Figure 7) for connecting an antenna to it.



Figure 7: A male U.FL connector

There are few requirements for the antenna:

- The antenna must have an U.FL connector for connecting it to the module
- The antenna must be meant for 2.4 GHz frequency
- The button plate module is approved with a standard 2.14 dBi dipole antenna. The antenna gain must not exceed 2.14 dBi. (FCC regulations)
- If an adapter cable is used between a button plate module and an external antenna, the antenna must be connected to the adapter cable using a RP-SMA connector (FCC regulations). An adapter cable with U.FL and RP-SMA connectors is shown in Figure 8



Figure 8: U.FL - RP-SMA adapter cable

2.6. Recommendations about placing input devices to pins

Instructions for connecting input devices to certain pins have been written to standardize input device wirings between different sim wheel models. This has been done to make it possible to swap sim wheels without remapping all input device functions in game every time. These instructions have been written assuming that the bluetooth chip of the logic module points upwards and towards the player.

Basis to the instructions:

- Every sim wheel should have two paddle shifters
- All input devices except paddles are used with thumbs
- Sim wheel input device layout can coarsely be separated to four parts: right top, right bottom, left top and left bottom
- It does not matter if there is an encoder or two separate buttons for tuning some value
- Usage of all input pins except the paddles is optional. Use just as many as needed

Paddle shifters

Connect the left paddle to the PADDLE1 pin and the right paddle to the PADDLE2 pin

Encoders

If a sim wheel has encoder or two +/- buttons for tuning some value at

- Right bottom: use encoder 4 pins
- Right top: use encoder 5 pins
- Left bottom: use encoder 3 pins
- Left top: use encoder 1 pins

If two buttons are used instead of an encoder, connect ENCXA pin for the button meant for increasing a value and the ENCXB pin for decreasing it.

Buttons

The button numbers are listed in the order in which they should be connected. The button nearest to the player's thumb comes first, etc.

- Right bottom: 16, 14, 15, 13
- Right top: 4, 5, 6, 12
- Left bottom: 10, 8, 11, 9
- Left top: 1, 2, 3, 7

If there is need for more than 4 buttons in any corner, the last unused pins of other corners may be used next.

3. Reference breakout board

A reference breakout board has been designed to allow connecting the wireless button plate module to a power supply and peripheral input devices. The breakout board will not be sold, but its design files will be published to enable sim-wheel manufacturer to produce them if they want.

The design and cad files, together with more information about the reference board will be provided as separate documents. The reference board is shown in Figure 9. The reference breakout board has been designed so that it fits inside the standard 70mm bolt circle.

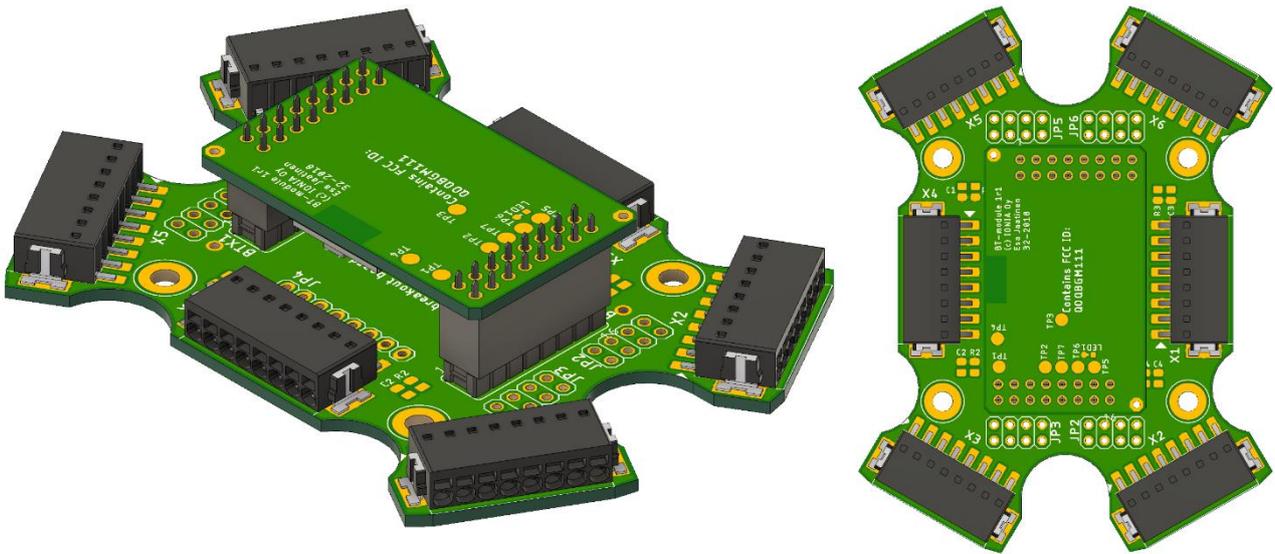


Figure 9 : The reference breakout board for the wireless button plate module

4. Wireless button plate module configurator

A configuration tool will be provided for sim-wheel manufacturers for configuring the wireless button plate modules. The configuration tool allows the manufacturers to save information about the connected input devices, to the module.

When connecting a wireless sim-wheel to a Simucube controller, Simucube reads this configuration and uses it for interpreting the signals from the button plate. Every wireless button plate module must be configured with this tool before use.

The configuration tool consists of a custom Bluetooth USB hardware device, as well as the software application. The software application is shown in Figure 10. It will allow you to:

- Scan and list nearby wireless button plates
- Establish connection to button plates, one by one
- Load and save input device configurations from files
- Load and save input device configurations from button plate modules
- Test functionality of input devices
- Read and write device name
- Read device battery voltage

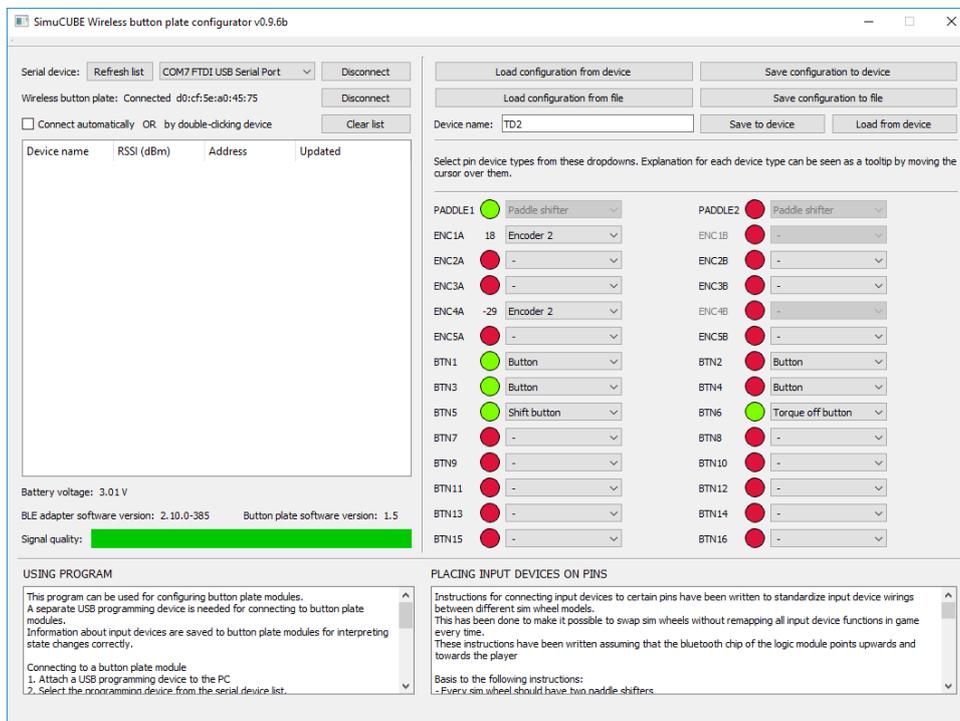


Figure 10: The button plate configurator user interface

5. Known issues

1. The status led stops blinking if the discovery mode is continued over 50 seconds by pressing the paddle shifters. The button plate module stays normally in the discovery mode, but the led doesn't blink anymore. The status led continues working normally after leaving the discovery mode.
2. The button plate module needs unbelievably little amount of energy in the sleep mode (below 100 nA). If the battery power is switched off during the sleep mode, the capacitors on the board have enough energy for running the sleep mode for up to a minute. If the battery power is switched on before the energy in the capacitor has been consumed, the module stays in the sleep mode, and therefore it doesn't enter the discovery mode automatically. However, the discovery mode can be entered normally by pressing both paddle shifters simultaneously.

This problem can be avoided by connecting the power switch so that it shorts the module VIN and GND pins when the battery power is turned off.

6. Product change log

3.4.2020:

- ESD protection diodes have been changed to prevent possible current leak when using higher than 3.3 V supply voltage
- Input pin low-pass filter cutoff frequency has been increased from 100 Hz to 500 Hz by changing capacitance of filtering capacitors from 10 nF to 2.2 nF
- A 2.2 μ F capacitor has been added between the voltage supply pins to smooth voltage changes caused by current consumption spikes

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7. Document change log

Version 1.0 11.10.2018

- Initial document

Version 1.1 25.10.2018

- Chapter 2.4. Added recommendations about placing input devices to different pins
- Chapter 2.1. After closing the connection between a wireless button plate and a Simucube controller by pressing paddles for 5 seconds, the button plate module does not start advertising in the next 5 seconds
- Chapter 4. Updated the Figure 9

Version 1.2 30.1.2019

- Added a chapter for known issues

Version 1.3 23.4.2019

- Fixed unclear figure about button plate module pins

Version 1.4 21.11.2019

- Added information about the wireless button plate variant with an external antenna connector
- Added figure “Wireless wheel system overview with Simucube 2”
- Removed notes about wireless button plate module with female pin headers

Version 1.5 3.4.2020

- Added product change log