

# **sepioo S1 Module – Integration Manual**

Graz, 10.10.2023

This document describes how to integrate sepioo S1 module including all the requirements related to it.

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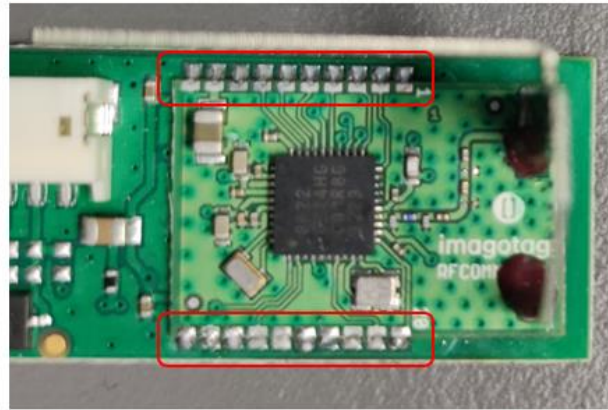
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# Mechanical Integration

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Max. Dimensions of the module: 13 x 23 x 3,1 mm

The module needs to be attached to a host PCB by soldering using the castellated holes on the sides of the PCB of the module (see red marking in the picture below). Pin assignment is described in the HW/FW chapter. 3D data of the module can be requested from the module provider on demand.

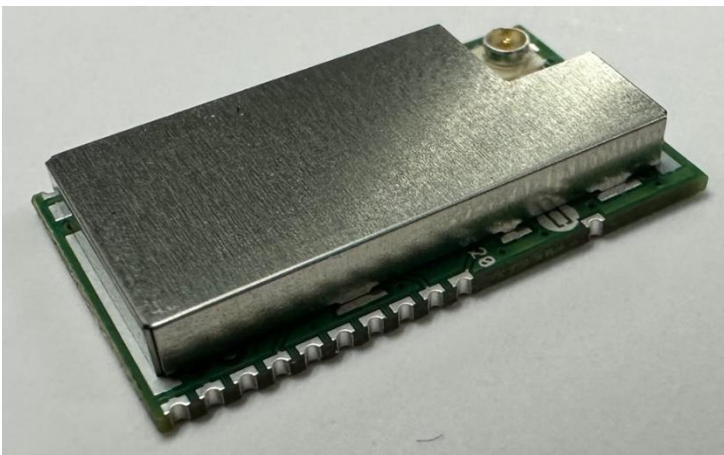


*Figure 1: Image soldering situation*

## **Mechanical integration requirements**

- The PCB ground must **not** be connected directly to the casing material
- The module has to have a minimum distance of 10 mm to the metal casing.
- Furthermore, the module has to have at least 25 mm distance to batteries.
- The module antenna needs to be reachable by electromagnetic waves, meaning it is not allowed to be mounted behind metal or liquids. Instead, the host system cover must be some kind of plastic to cover the opening in the metal in front of the antenna. A typical plastic with a permittivity of  $\sim 2.5$  should be used.
- The antenna needs to be connected to the module via connector – details can be found in Antenna chapter

## **sep100 S1 module - 3D view:**



*Figure 2: Image module*

## Dimension details

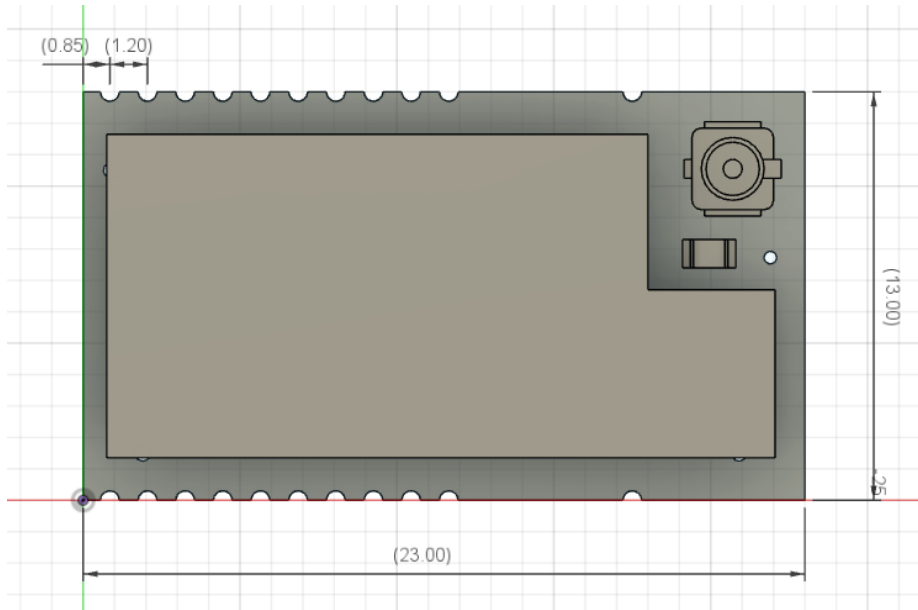


Figure 3: Top view sepioo S1 module

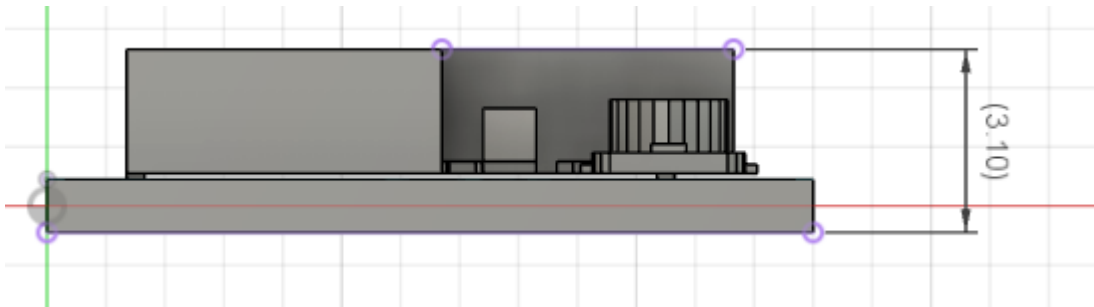


Figure 4: Front view of sepioo S1 module

# Antenna

The sepioo S1 module has been tested and certified with reference external antennas attached to the modules U.F.L connector (see list below).

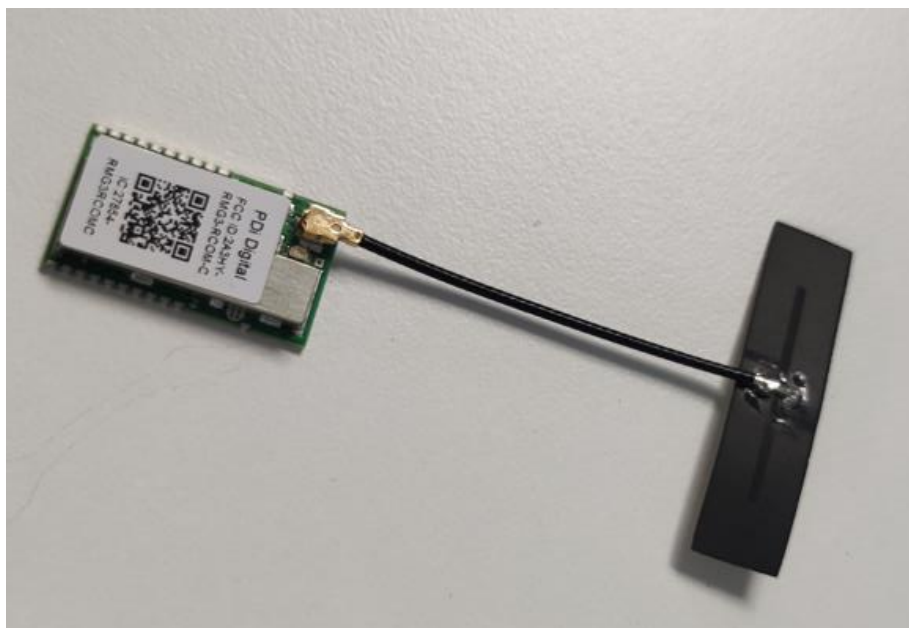


Figure 5: Module with external reference antenna

## General antenna requirements

- **Type:** dipole
- **Impedance:** 50 Ohm
- **Bandwidth:** 2.4 – 2.5 GHz
- **Max. gain:** 3.3 dBi
- **Polarization:** linear
- **Connector:** U.FL (equivalent to IPEX MHF1)

## Qualified antennas

Table 1: Qualified antennas

Antenna description	Type	Max. Gain	Bandwidth	Impedance	Form factor	Polarization
molex, 2196110100, WiFi6e Low Gain Flex Antenna, 100 mm	dipole	2,5 dBi	2.4-2.5 GHz	50 $\Omega$	35x15x0.2 mm <sup>3</sup>	Linear
Linx, ANT-W63-FPC2-ccc-100 100 mm	dipole	3,2 dBi	2.4-2.5 GHz	50 $\Omega$	42x12x0.2 mm <sup>3</sup>	Linear
Kyocera, 1003893FT, BT Tunable FPC 2.4 GHz EmbeddedAntenna, 100 mm	dipole	3,3 dBi	2.4-2.49 GHz	50 $\Omega$	40x8x0.1 mm <sup>3</sup>	Linear
OPO-2.4/2.5 50 mm	dipole	3,25 dBi	2.4-2.5 GHz	50 $\Omega$	35x9x0.2 mm <sup>3</sup>	Linear

Any external antenna of the same general type and of equal or less directional gain compared to the one listed above in table 1 and having similar in-band and out-of-band characteristics, can be used in the regulatory areas that have modular radio approvals, such as USA and Canada, as long as spot-check testing of the host is performed to verify that no performance changes compromising compliance have been introduced.

In countries applying the ETSI standard, where manufacturers issue a self-declaration of conformity before placing products in the market, like in the EU countries, the radiated emissions are always tested with the end product, where antennas with higher gain compared to the qualified antennas may violate some of the regulatory limits.

In case an external antenna is used having non similar in-band and out-of-band characteristics, but still with less than or equal to the maximum gain listed in the table above, it can be added to the grant/certificate by a permissive change (FCC and ISSED). All products using an external antenna having more gain than the qualified antennas require a full new end-product certification.

In any case, when using an antenna not listed here in this document the manufacturer needs to be informed, even in case gain, in-band and out-of-band characteristics are covered by the antennas listed.

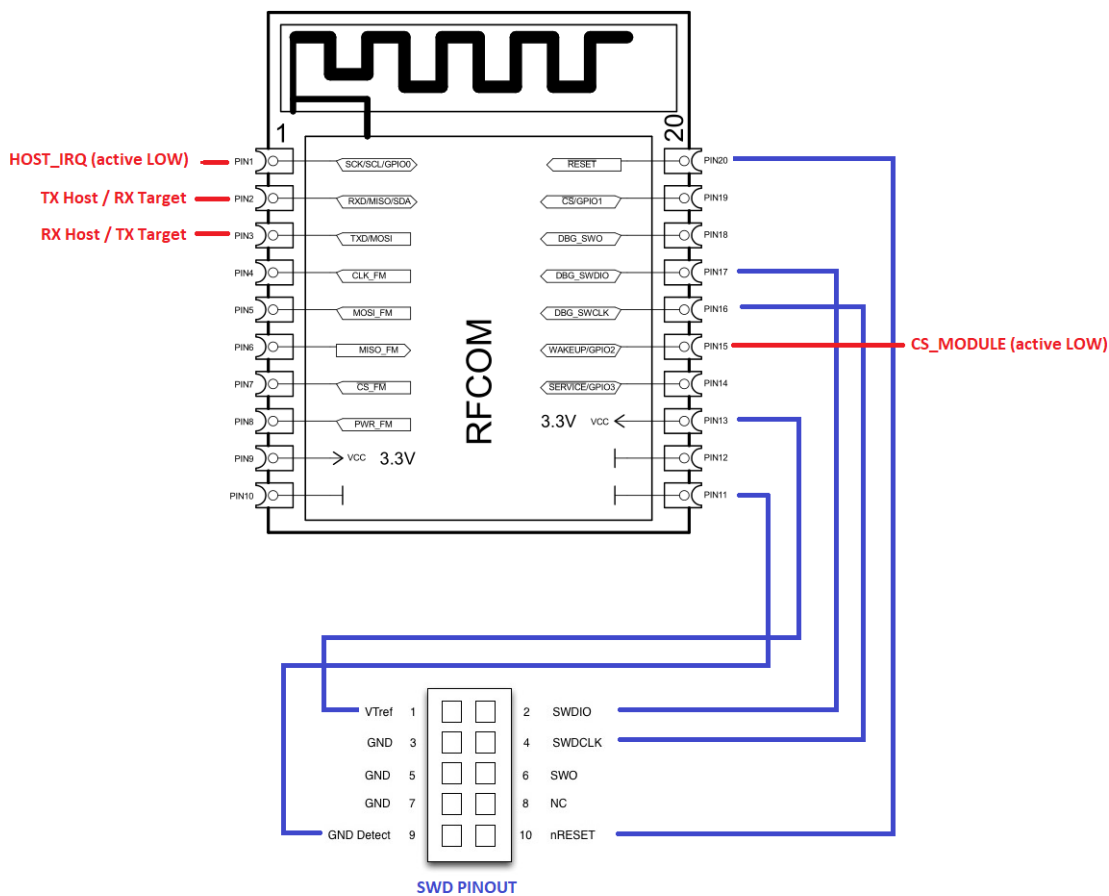


Figure 6: Pinout

### Flashing

To flash the Module with the SEGGER Flasher (ARM) connect the module via the SWD pins shown in blue in Figure 1RFCOMM001A pinout.

An external power supply (3.3V) is also needed as the SEGGER flasher does not provide power.

Start "ARMFirmwareFlasher.exe" and select a firmware hex file via the drop-down menu:

**"File – Open firmware file"**

Enter a Label ID (must match a Label ID in the pool-file.csv) and press **START**.

After a successful flash operation, the notification windows should turn green and PASS appears.

After successfully flashing the module be sure to reboot it, i.e. reconnect power supply or trigger reset via the reset pin (pull LOW).

### Operation

For communicating one must first pull PIN 15 (WAKEUP/GPIO2) low and wait for the "RDY\r" response from the module. After this the module is ready to receive commands for approximately two seconds. A timeout will occur if this time is exceeded.

All available commands are listed below including a short example and the expected result.

# UART COMMANDS

---

## **Command "RES\r":**

Function: resets the module

Returns: "ACK\r"

## **Command "SVN\r":**

Function: returns the SVN-revision of the firmware (like FW version)

Returns: "ACK 9403\r"

9403 => 0x0394 in decimal = 916 => SVN revision 916.

## **Command "FIB\r":**

Function: returns very detailed firmware information.

Returns: "ACK 0000000003200203100094038524A74A0020000000D001000000C002FFFF0BF1\r"

## **Command "RID\r":**

Function: returns the unique ID (=address) of the module.

Returns: "ACK 0012FFA5\r"

0012FFA5 => 0xA5FF1200 => the unique ID of the module is A5FF1200.

## **Command "SEV <1-byte event-type><4-byte data>\r":**

Function: sends a high-priority event to the access-point backend.

### **<1-byte event-type>:**

specifies the "type" of the event (see PKT\_EVENT\_TYPES).

PKT\_EVENT\_TYPE\_NONE = 0x00, // no event

PKT\_EVENT\_TYPE\_BUTTON\_1\_PRESSED = 0x01, // event "button 1 was pressed"

PKT\_EVENT\_TYPE\_BUTTON\_2\_PRESSED = 0x02, // event "button 2 was pressed"

PKT\_EVENT\_TYPE\_BUTTON\_1\_AND\_2\_PRESSED = 0x03, // event "button 1+2 was pressed"

PKT\_EVENT\_TYPE\_SIMPLE\_NFC\_EVENT = 0x04

// ... add more event types here (up to 0xFF)

**<4-byte data>:** 4-byte payload.

### **Example: "SEV 04AABBCCDD\r"**

Format: 04 => event type 0x04

AABBCCDD => 0xAA,0xBB,0xCC,0xDD payload that will be sent to the access-point.

Returns: "ACK\r"

Notes: Events are reserved for critical messages and should be used seldomly.

Sending too many events will cause congestion of the network,

therefore the use should be limited to high-priority or critical messages.

Only a single event can be active at a given time.

To monitor the status and successful/failed delivery, use the

"Get Event Status" command (EVS).



### **Command "EVS\r":**

Function: returns the status of the event-transmission.

Returns: "ACK 000A0104AABBCCDD\r"

Format:

offset 0: flag indicating if event is active

offset 1: number of retries left

offset 2: result of previous event (see SYNC\_EVENT\_RESULT)

SYNC\_EVENT\_RESULT\_NOT\_AVAILABLE = 0 // result is not available

SYNC\_EVENT\_RESULT\_EVENT\_CONFIRMED = 1 // event was confirmed

SYNC\_EVENT\_RESULT\_EVENT\_TIMEOUT = 2 // event has timed out

offset 3: event type (see PKT\_EVENT\_TYPES)

PKT\_EVENT\_TYPE\_NONE = 0x00 // no event

PKT\_EVENT\_TYPE\_BUTTON\_1\_PRESSED = 0x01 // event "button 1 was pressed"

PKT\_EVENT\_TYPE\_BUTTON\_2\_PRESSED = 0x02 // event "button 2 was pressed"

PKT\_EVENT\_TYPE\_BUTTON\_1\_AND\_2\_PRESSED = 0x03 // event "button 1+2 was pressed"

PKT\_EVENT\_TYPE\_SIMPLE\_NFC\_EVENT = 0x04

// ... add more event types here (up to 0xFF)

// offset 4-7: event data payload (4 bytes)

### **Command "RSC <1-byte user-SET-config ID>\r":**

Function: reads a user-SET-config register and returns the 12-bits data.

This config was SET by the access-point backend system.

<1-byte user-SET-config ID>: specifies the config-register to read.

Example: "RSC 00\r"

00 => 0x02 => use user-SET-config #0

Returns: "ACK BC0A\r"

BC0A => 0x0ABC => 12 bits of config data => 0xABC

Notes: Config-registers can be set/read the access-point backend system.

ATTENTION! Only 12 bits can be SET by the access-point!

However, 4 bytes can be READ by the access-point!

So, the RSC and WGC commands differ in their function!

### **Command "WGC <1-byte user-GET-config ID><4-byte data>\r":**

Function: writes a 4-byte value to a user-GET-config register.

<1-byte config-ID>: specifies the config-register to write.

<4-byte data>: 4 byte payload.

This config can be READ by the access-point backend system.

Note that the value will not be transferred to the access-point,

it's the access-point backend system's task to regularly read

all configs of interest. This method does not cause a congestion of the network and is the preferred way of providing data to the access-point backend.

Example: "WGC 02AABBCCDD\r"

02 => 0x02 = use user-GET-config #1.

AABBCCDD => 0xAA,0xBB,0xCC,0xDD payload that will be written.

Returns: "ACK\r"

Notes: Config-registers can be set/read the the access-point backend system.

ATTENTION! 4 bytes can be READ by the access-point!

However only 12 bits can be SET by the access-point!

So, the RSC and WGC commands differ in their function!

### **Command "EHI <32bit host interrupt configs\r":**

Function: Enables interrupts to signal host about certain events.

Check "interrupt\_commands.py" for details about what interrupts to active and the according command string.

Example: "EHI 00010000\r"

"Host enables IRQ when [user-SET-config #0] will be written."

NOTE: this could to be configured after startup once.

Returns: "ACK\r"

### **Command "GHI\r":**

Function: Prints currently active IRQ flags.

Example: "GHI\r"

Returns: "ACK 00010000\r"

IRQ flag [user-SET-config #0 was written] is set.

### **Command "CHI\r":**

Function: Host wants to clear IRQ flag.

Example: "EHI 00010000\r"

host wants to clear IRQ flag, user-SET-config #0 was written."

Returns: "ACK\r"

Notes: After an interrupt was caught and handled, PIN 1 (GPIO0) is still low, one must manually clear the active interrupt in order to reset PIN 1 to a HIGH state again.  
To clear all active interrupts, use the "CHI FFFFFFFF\r" command which will clear everything.

### **Command "ERF\r":**

Function: Enables output of modulated or unmodulated carrier

Example: "ERF 0107\r"

Enabled output of unmodulated carrier on channel 7

Returns: "ACK\r"

Notes: The first bytes describe the mode :  
(00 = disable radio; 01 = output unmodulated carrier; 02 = output modulated carrier) The second bytes describes the channel to use (0x00 – 0x0B)

**This command is only used for certification/testing purposes.**

### **Command "RUD\r":**

Function: Reads USERDATA previously received via AUX page

Example: "RUD 00003100\r"

Reads 0x100 (256) bytes of USERDATA from address 0x00003

Returns: 2 bytes length + requested data + 2 bytes checksum

Notes: Every packet is transmitted with a two byte length information in the beginning and a checksum at the end for validating the requested data.

This command allows to read a maximum of 4095 bytes per request in address range of 0x00000 to 0xFFFFF (1048575), although an error will be thrown if the address is out of range.

### Error responses "ERR <2-byte error-code>\r":

Function: any function may respond with a 2-byte error code.

Example: "ERR 0200\r"

0200 => 0x0002 => ERR\_COMMAND\_TIMEOUT.

List of error-codes:

ERR_NONE	= 0 // no error - all OK!
ERR_UNSPECIFIC	= 1 // a generic error (not a specific one) occurred
ERR_COMMAND_TIMEOUT	= 2 // host-MCU didn't send a command on time (=timeout)
ERR_COMMAND_BUFFER_FULL	= 3 // buffer for receiving commands was full
ERR_COMMAND_RECEIVE_ABORTED	= 4 // host-MCU command reception was aborted
ERR_COMMAND_LENGTH_INVALID	= 5 // host-MCU command had invalid length
ERR_COMMAND_UNKNOWN	= 6 // command is unknown
ERR_PARAMETER_LENGTH_INVALID	= 7 // parameter had invalid length
ERR_PARAMETER_FORMAT_INVALID	= 8 // parameter had invalid format
ERR_COMMAND_NOT_IMPLEMENTED	= 9 // command is not implemented
ERR_EVENT_IS_ACTIVE	= 10 // an EVENT is still active
ERR_USER_CONFIG_ID_INVALID	= 11 // user-config ID is invalid
ERR_RFOUT	= 12, // rf output config is invalid
ERR_READ_USERDATA	= 13 // error while transmitting payload

## EXAMPLE USAGE CHARTS

In order to talk with the module, pull the /CS\_MODULE pin LOW and wait for the module to respond with “RDY\r”. After that one can issue a command terminated with '\r' <CARRIAGE RETURN> char. The module will just answer with a simple “ACK\r”, depending on the command followed with desired information (e.g. SVN). See Figure 2 example of simple commands.

If a command is not recognized (command not known, typo, wrong parameters, timeout, etc.) the label will respond with an Error followed by the Error code (e.g. ERR 0200 = ERR\_COMMAND\_TIMEOUT.) see Figure 3 error responses

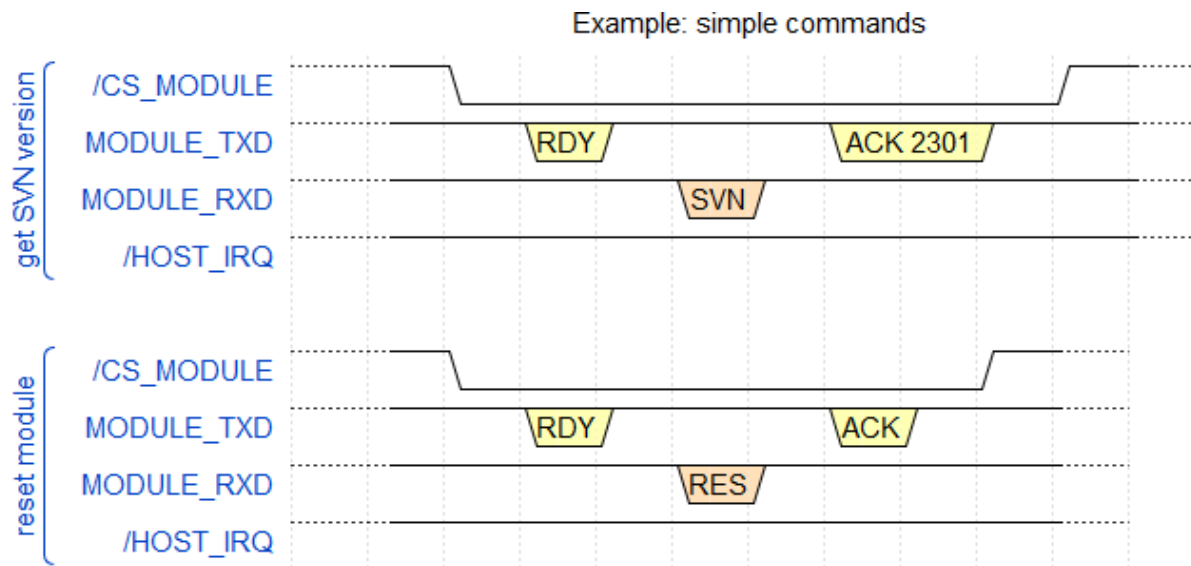


Figure 7: example of simple commands

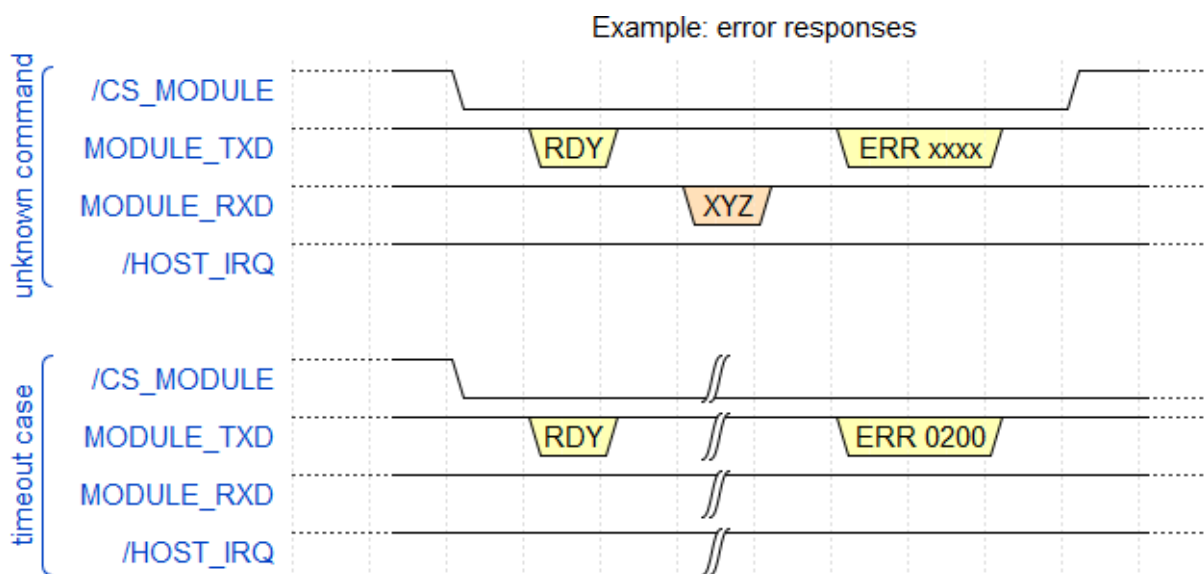


Figure 8: error responses

In order to enable host interrupts, use the command “EHI” followed by the desired interrupts to enable. A tool to provide help on how to select interrupts and the corresponding command is provided (see interrupt\_command.py). see Figure 4 enable host interrupts.

There is no need to enable an interrupt again once it was activated.

To disable the interrupt again, issue an “EHI 00000000\r” command to disable ALL interrupts or select a specific interrupt to disable (again see interrupt\_command.py for help)

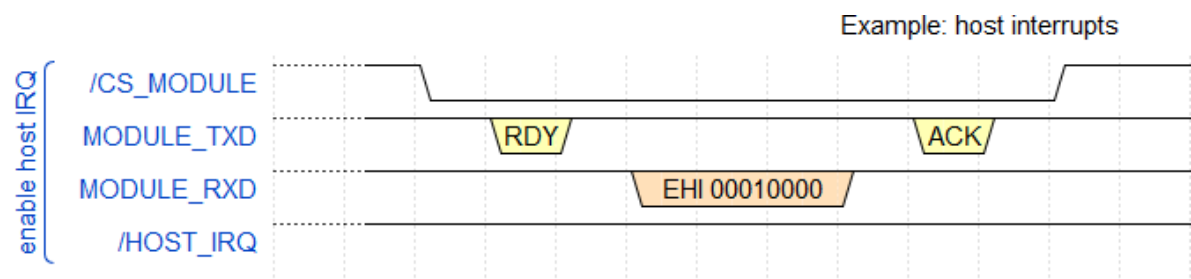


Figure 9: enable host interrupts

After an interrupt was enabled (e.g. set\_config #0 was written) the module will pull the /HOST\_IRQ pin LOW. After that the host can communicate with the module (read set\_config, ...).

It is important to clear the active interrupt flag again to allow the /HOST\_IRQ to go HIGH again.

To do this one can simply clear ALL active interrupts (CHI FFFFFFFF\r) or ask for the currently active interrupts (“GHI\r”) and just clear those. see Figure 5 handle host interrupts and clear active flags.

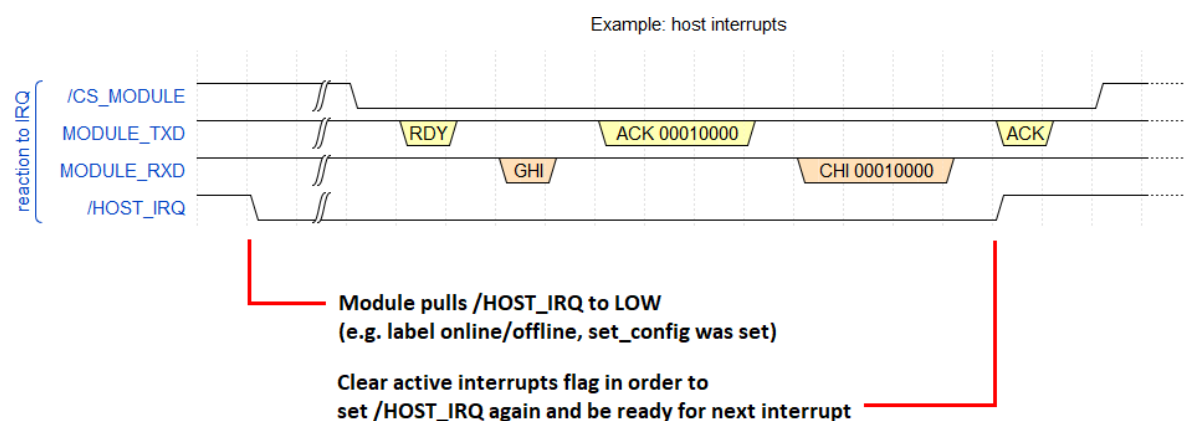


Figure 10: handle host interrupts and clear active flags

## Canada/ISED PRODUCT LABELING

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The Host Marketing Name (HMN) shall be indicated on the exterior of the host product or on the product packaging, or in the product literature, which shall be supplied with the host product or readily available online.

The host product shall be properly labelled to identify the modules within the host product.

The ISED certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the ISED certification number for the module, preceded by the word "contains" or similar wording expressing the same meaning, as follows:

Contains IC: 27854-RMG3RCOMC

In addition to containing other required statements specified elsewhere in this standard or in the applicable RSS, user manuals for licence-exempt radio apparatus shall contain the following text, or an equivalent notice, that shall be displayed in a conspicuous location, either in the user manual or on the device, or both in both English and French:

*This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:*

*(1) This device may not cause interference.*

*(2) This device must accept any interference, including interference that may cause undesired operation of the device.*

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

*(2) L'appareil ne doit pas produire de brouillage;*

*(3) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

## RF EXPOSURE

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The module is an exempt RF device. It can be used in hosts for portable and mobile applications and for fixed installation. This module can not be used for medical implants.

The module can be connected to an external antenna via UFL connector – see table with qualified antennas above.

RF integration specifications:

- Usable bands:
  - SES imagotag protocol: 2404,053 MHz – 2479,285 MHz
    - Channels 0-10 available
  - BLE protocol (GFSK mit 1Mbit/s): 2401 – 2481 MHz
    - Channels 0-39 (additionally 2401 MHz, 2402 MHz, 2403 MHz, 2481 MHz) available
- Transmission power of  $\leq 10$  dBm

The host integrator must comply with the following requirements:

- The PCB ground must not be connected directly to the casing material
- The module has to have a minimum distance of 10 mm to the metal casing.
- Furthermore, the module has to have at least 25 mm distance to batteries.
- The module antenna needs to be reachable by electromagnetic waves, meaning it is not allowed to be mounted behind metal or liquids. Instead, the host system cover must be some kind of plastic to cover the opening in the metal in front of the antenna. A typical plastic with a permittivity of  $\sim 2.5$  should be used.
- The usage of the module is permitted only in case the host integrator complies with all RF exposure requirements.
- RF Exposure: The host device must maintain a minimum separation distance between antenna and user. The minimum separation distance can for example be maintained with an appropriate distance between antenna and outer casing in the host device.

## USA / FCC VERIFICATION TEST REQUIREMENTS

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To ensure that no out-of-complaint emissions as a composite result from any stray host signals being reradiated out of compliance to 15B under SDoC or Certification it needs to be confirmed by a Spurious Emission Test and spot checks of the module integrated into the host device.

The host device needs to comply with the conducted limits for unintentional radiators according to <https://www.ecfr.gov/current/title-47/chapter-I/subchapter-A/part-15/subpart-B/section-15.107> as well as the host needs to comply with the radiated limits for unintentional radiators according to <https://www.ecfr.gov/current/title-47/chapter-I/subchapter-A/part-15/subpart-B/section-15.109>.

### **Spurious Emission Test**

For spurious emission tests, the host integrator can use the standard FW (the FW that the module is delivered with).

As described in detail in the FW integration chapter of this document there is a dedicated UART command implemented for spurious emission testing – **command “ERFv”**. With this command modulated or unmodulated carriers can be emitted within the 2.4GHz spectrum by the module on the configured channels accordingly.



## USA / FCC COMPLIANCE

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The following rules are applicable to this modular transmitter:

- 1.1307 Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.
- 2.1033 Application for certification.
- 15.209 Radiated emission limits; general requirements.
- 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz.
- 15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz.

This modular transmitter is only FCC authorized for the Part 15 FCC transmitter rules listed in the grant. The host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the limited modular transmitter grant of certification.

A host product shall use a physical label stating "Contains Transmitter Module FCC ID: 2A3HY-RMG3-RCOM-C," or "Contains FCC IDs: 2A3HY-RMG3-RCOM-C, XYZMODEL," or shall use e-labeling."

The antenna(s) used for this transmitter must not transmit simultaneously with any other antenna or transmitter, except in accordance with FCC multi-transmitter product procedures.

The device shall bear the following statement in a conspicuous location on the device:

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

When the device is so small or for such use that it is impracticable to label it with the statement specified in a font that is four-point or larger, and the device does not have a display that can show electronic labeling, then the information required by this paragraph shall be placed in the user manual and must also either be placed on the device packaging or on a removable label attached to the device.

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

A compliance information statement that includes the following items (Section 2.1077(a)) must be supplied with the product at the time of marketing or importation:

- Identification of the product, e.g., trade name, model, etc.
- A statement that the product complies with the rules, as applicable; and
- The name and address, and telephone number, or internet contact information of the responsible party's (as defined in Section 2.909(b)) contact located in the United States.

Further to Section 2.1077(c), the compliance information must be provided in a form that an end-user can reasonably be expected to have the capability to access, such as the instruction manual, a separate product insert, computer disk, web page, or the device's own electronic screen. Compliance information may be provided electronically as permitted in Section 2.935. "

Devices authorized under the SDoC procedure have the option to use the FCC logo to indicate compliance with the FCC rules,<sup>12</sup> and the logo may be included in the instruction materials or as part of an e-label.

The FCC logo shall only be used on a product that has been tested, evaluated, and found to be compliant in accordance with the SDoC procedures. The use of the FCC logo on the device does not mitigate the requirement to provide a means to uniquely identify the product or to provide the required compliance information statement. The FCC logo cannot be used on products that are exempt from an authorization by rule (e.g., Section 15.103 exempt devices, or Section 15.3 incidental radiators) unless the SDoC procedure has been fully applied for the product.

In addition, this module is not permitted for any application where end users can insert a module into any open host platform.