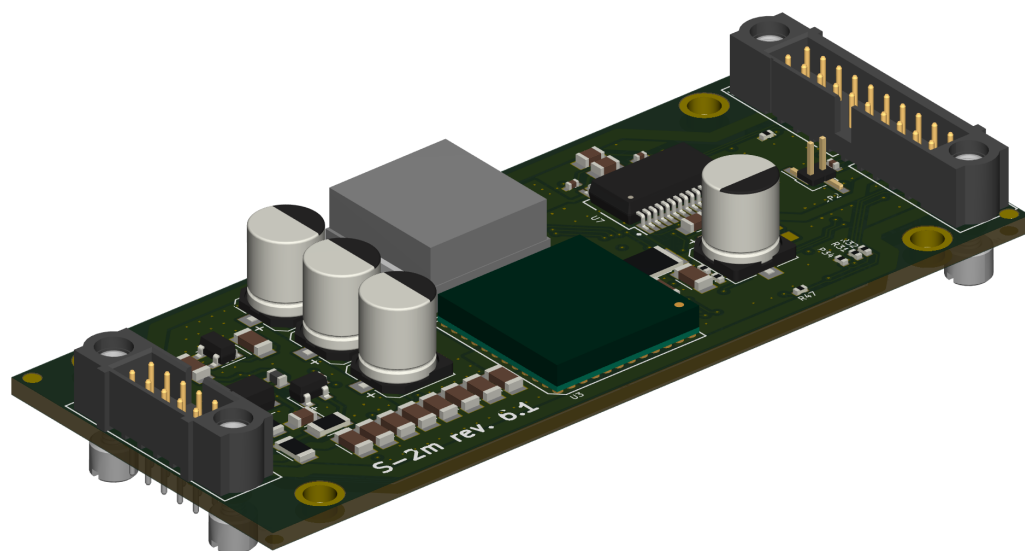




S-2M DRIVER USER MANUAL



Version number 1.1.0
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CONTACT INFORMATION

Avenue des Pâquiers 1
2072 St-Blaise
Switzerland

Telephone:	+41 32 729 9510
Fax:	+41 32 729 9519
Email:	info@alpeslasers.ch
Web site:	http://www.alpeslasers.ch

DOCUMENT VERSION

This is Version 1.1.0 of the S-2m manual, published on 2026/05/07, superseding version 1.0.2 of the manual, published on January 11th, 2024. The following modifications have been applied since the publication of version 1.0.0:

Publication date	Version number	Changes
2022/06/30	1.0.0	Original release
2023/02/17	1.0.1	§ 7.3 modified to clarify maximum 50 ms pulse length and parameter definition.
2024/01/11	1.0.2	§ 7.3 modified to add warning that internal and external clocks are not synced.
2026/05/07	1.1.0	<ul style="list-style-type: none">- Added documentation for the new External Trigger operating modes.- Updated all relevant sections to reflect Hardware Revision 6.1.

Preface

This manual serves is intended for personnel using the S-2m pulser to drive ALPES LASERS QCLs. Its purpose is to serve as a reference for the mechanical and electronic configuration and provide the customer with sufficient information to carry out normal operation. The specifications provided herein refer to the output of the electronic driver, not to a detected optical signal of a QCL. This manual should be used in conjunction with the QCL datasheet and the separate QCL operation manual. It is not intended to replace or supersede any local directive. Table 1 summarizes the content of each section.



CAUTION:

All personnel must read and understand this manual before attempting to operate ALPES LASERS QCLs and the associated electronic devices. Failure to follow safety instructions could result in death or serious injury.

Chapter	Content
1. Introduction	General description
2. Specifications	Table of values
3. Mechanical Interface	Drawings and mounting instructions
4. Electrical Interface	Pinout and system assembly
5. Graphical User Interface	Software instructions
6. Safety interlocks, external modulation and security	Description of interlocks with schematics
7. Modes of Operation	Descriptions and graphs of the internal pulsing modes
8. Non-volatile Memory	Information stored on the S-2m card
9. Built-in Test	Information retrieved in the BIT
10. Communication Protocol	Overview and data packet structure
11. Environmental Specifications	Description of ESS testing
11. Troubleshooting	Quick checks, Symptom–Cause–Test–Fix table, and STATUS-bit

Table 1: Structure of the S-2m User Manual.

Typesetting conventions

- Table 2 gives a list of the acronyms used in this manual.
- A *boxed item* indicates a button to push (hw) or click (sw)

Acronym	Full name
BIT	Built-In Test
GUI	Graphical User Interface
HHL	High Heat Load (QCL package)
MCU	Microcontroller unit
PCB	Printed Circuit Board
QCL	Quantum Cascade Laser
S-2m	ALPES LASERS QCL pulser driver
TC-3	Temperature Controller
TEC	ThermoElectric Cooler (Peltier junction)

Table 2: Acronyms used in this manual.

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1. Introduction

The S-2m pulser driver is designed to provide fast, high impedance electrical current pulses to non-linear current-driven devices. It is a ruggedized version of the ALPES LASERS S-2 pulser driver, and was designed for use with high-power HHL-packaged QCLs. The general driver capabilities are:

- Producing power for the QCL
- Producing modulation to the QCL
- Transfer TEC current from the main system to the internal QCL TEC
- Transfer thermistor signal to the main system
- Provide safety interlocks to prevent inadvertent laser activation
- Communication with the main system or maintenance software

The S-2m driver can be directly controlled by a computer, with drivers available for Windows.

To provide maximum flexibility for integrating into the customer device, the S-2m pulser is provided as a connectorized PCB, as shown in Fig. 1.1. A conformal parylene coating is applied for electronic protection.

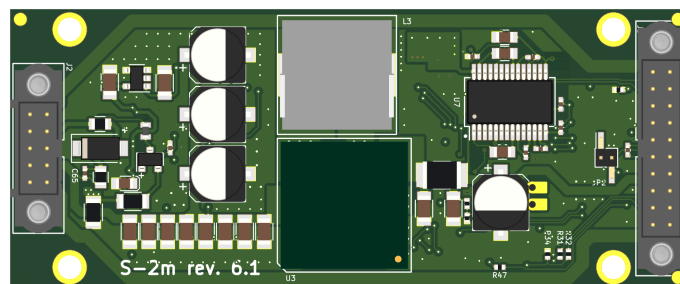


Figure 1.1: S-2m pulser PCB card.

2. Specifications

2.0.1 Laser Drive Pulse Characteristics

Specification	Min	Typ	Max	Unit
Peak current output ¹	0	-	8	A
Avg. current output	0	-	3	A
Output voltage	0.8	-	25	V
Pulse width	300 ns	-	4.2 s	-
Sync pulse width	300 ns	-	4.2 s	-
Pulse repetition frequency	0.24 Hz	-	1 MHz	-
Rise time	1	1.94	3	V/ns
Fall time	1	2.14	3	V/ns

Table 2.1: S-2m Laser Drive Pulse Characteristics.

2.0.2 Input / Output Signals Characteristics

Specification	Min	Typ	Max	Unit
I/O Input Low voltage	-0.3	0	0.8	V
I/O Input High voltage	2.5	3.3	5	V
Ext. Trigger pulse width	40	-	-	ns
Power supply voltage range	9	18	28	V
RS232 RX/TX	3.3	-	12	V
Output voltage modulation bandwidth	20	-	1000	Hz

Table 2.2: S-2m input signals specifications.

¹For output currents ≥ 4 A, the power supply voltage must be higher than the laser output voltage.

2.0.3 Settings Characteristics

Specification	Min	Typ	Max	Unit
Pulse width increment	-	10	-	ns
Sync pulse width increment	-	10	-	ns
Pulse repetition period resolution	-	10	-	ns
Number of pulse repetition	0	-	65536	-
Current measurement resolution	-	1	-	mA
Voltage setting resolution	-	10	-	mV

Table 2.3: S-2m settings specifications.

In standard pulsing mode, also referred to "internal" mode, the S-2m pulser can generate a maximum peak current ≥ 8 A and a maximum average current ≥ 3.0 A. The maximum values can vary between S-2m cards, and in general depend on the duty cycle as well as on the selected operation mode when the output mode is not "internal." The maximum peak current as function of duty cycle is depicted in Fig. 2.1. These values represent the maximum allowable user input for the "Peak current limit" in the GUI, with higher attempted input values automatically reduced to the corresponding value from the figure for the selected mode and duty cycle combination.

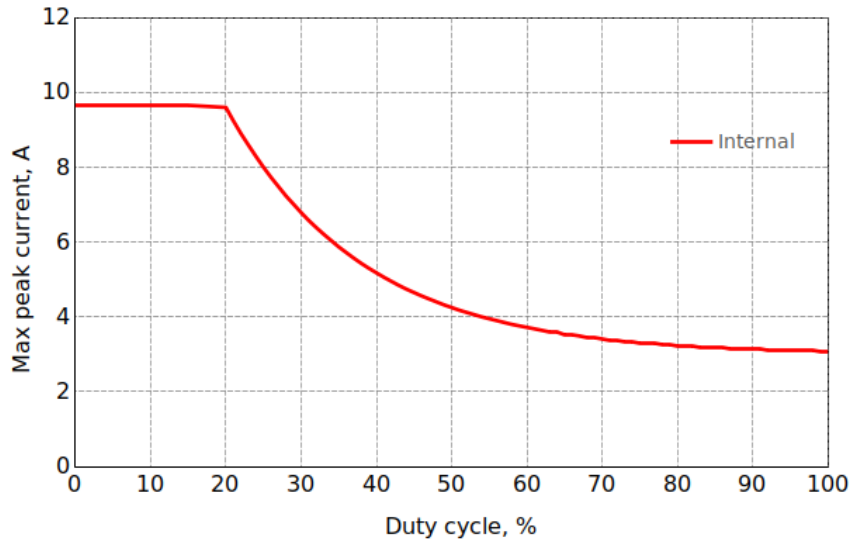


Figure 2.1: ALPES LASERS S-2m pulser maximum peak current as a function of duty cycle.

3. Mechanical interface

3.1 Drawings

All dimensions in the drawings provided are in mm.

3.1.1 S-2m driver PCB

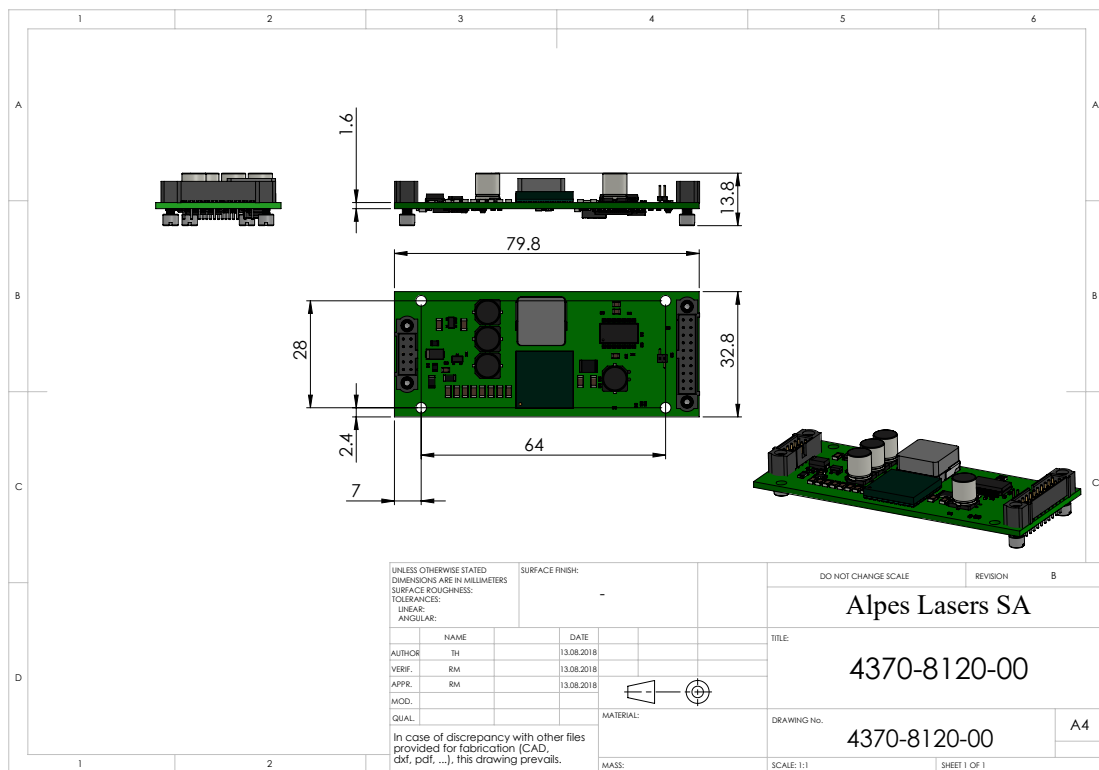


Figure 3.1: S-2m driver PCB. Through-hole spacing 64 mm.

3.1.2 S2m-HHL interface

C-S2m-HHL flex cable

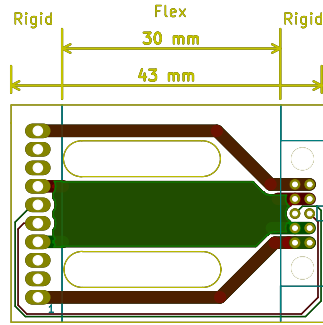


Figure 3.2: C-S2m-HHL flex cable for attaching the HHL package to the S-2m PCB

HHL package with C-S2m-HHL flex cable

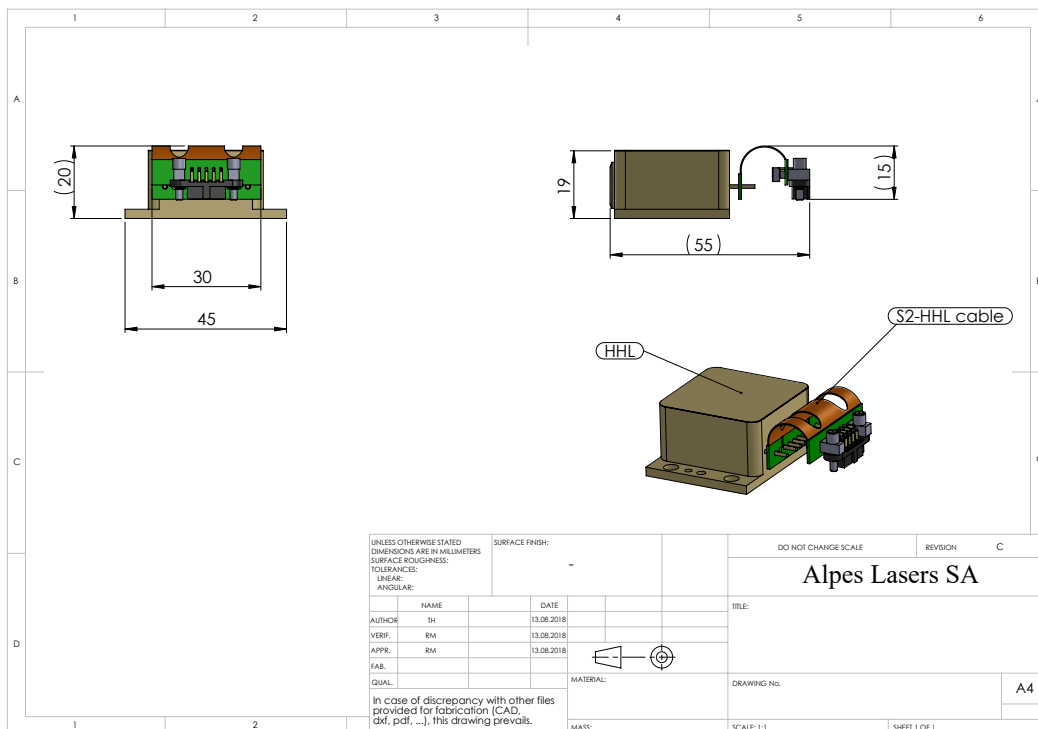


Figure 3.3: HHL-packaged QCL with flex cable for attachment to the S-2m

3.1.3 HHL - S-2m assembly

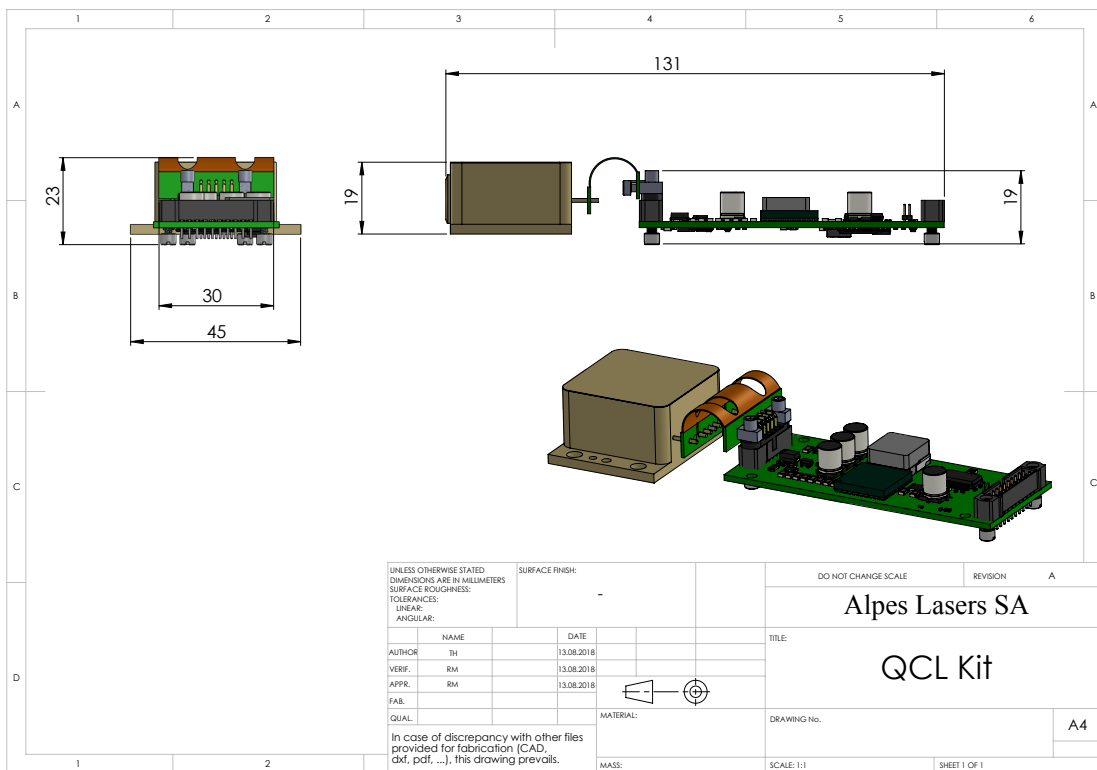


Figure 3.4: HHL-packaged QCL attached to the S-2m driver with a C-S2m-HHL cable

4. Electrical interface

This chapter describes the electrical pinouts and cable connections for the ALPES LASERS S-2m laser driver. For reference, the "back" or "input" end refers to the 20-pin end of the S-2m PCB connecting to external instruments such as the temperature controller and computer, whereas "front" or "output" end refers to the 10-pin end connecting to the laser. The general system components are depicted in Fig. 4.1.



CAUTION:

Do not apply more than 5 V on any external input other than the power supply and RS232 lines. There is a risk of damaging the S-2m pulser.

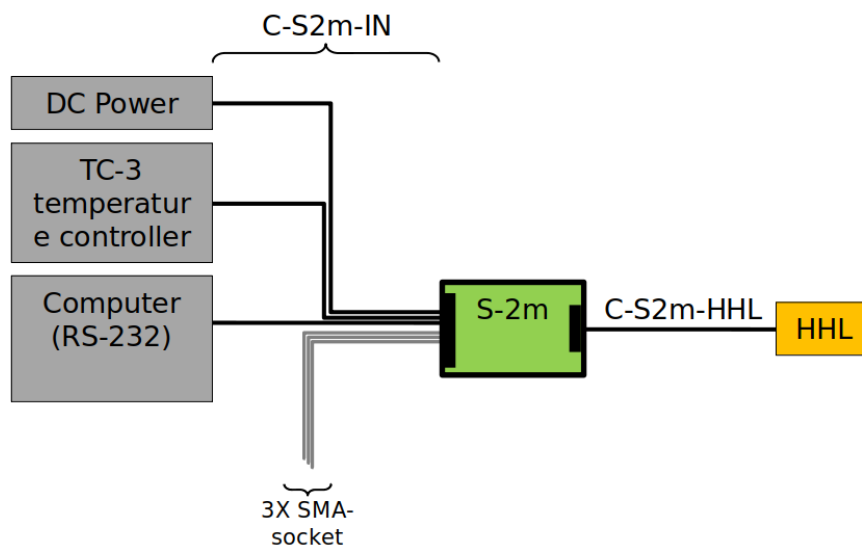


Figure 4.1: Block diagram of system components: power supply, temperature controller TC-3, computer, C-S2m-IN cable, S2-m driver, C-S2-m-HHL cable, and the HHL-packaged QCL. The C-S2m-IN cable splits into 6 outputs from the S2-m PCB, 3 of which are terminated with SMA-Socket plugs. See Sec. 4.3 for details.

4.1 S-2m Input Pinout

The back pinout of the S-2m is shown in Table 4.1 and Fig. 4.2.

Pin	Name	Direction	Description
1	TEC+	-	Power + of the TEC
2	RS-232 Ground ¹	-	Communication Ground
3	Ground	-	Ground
4	Ground	-	Short to pin 3
5	T_SENSOR-EXT	Output	Temp. sensor negative line
6	T_SENSOR+EXT	Output	Temp. sensor positive line
7	IN_V_SUPPLY+	Input	Short to pin 8
8	IN_V_SUPPLY+	Input	DC power +
9	IN_MOD_DIRECT	Input	External modulation input
10	TEC-	Input	Power - of the TEC
11	TEC+	Input	Short to pin 1
12	OUT_RS232_TX	Output	Communication transmit line
13	IN_RS232_RX	Input	Communication receive line
14	MULTI_IN_OUT ²	Input/Output	- Microcontroller status Output - Ext. trigger Input - Sync Pulse Output
15	OUT_LASER_ON	Output	Output status: 3.3 V when output is enabled, 0 V when output is OFF
16	IN_VREG_INTERLOCK	Input	Laser voltage interlock
17	MCU_OUT_INTERLOCK	Input	Microcontroller output interlock
18	IN_SAFETY	Input	Interlock
19	IN_ARM	Input	Interlock
20	TEC-	Input	Short to pin 10

Table 4.1: S-2m input (instrument end) pinout.

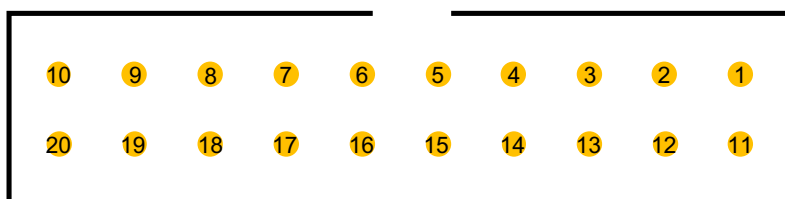


Figure 4.2: S-2m input end pin numbering. Refer to Table 4.1 for pin descriptions.

¹Pin 2 is by default connected to Pin 3 by the zero-ohm resistor R43, so that the whole PCB by default has a single ground. R43 may be desoldered from the PCB to float the communication ground. See Fig. 4.3 for the board location.

²Only available for hardware revision ≥ 6.1 . Otherwise, this pin act as "Microcontroller status output" only

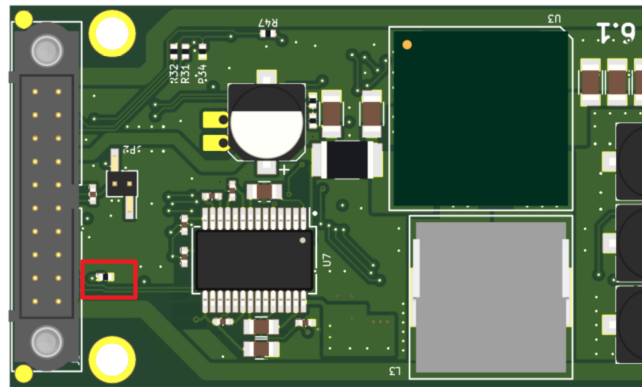


Figure 4.3: Zero-ohm link R43 may be desoldered from the PCB if an isolated communication ground is desired.

4.2 S-2m Output Pinout

The front pinout of the S-2m is shown in Table 4.2 and Fig. 4.4.

Pin	Name	Description
1	TEC-	Power - of the TEC
2	Laser+	Laser voltage +
3	T_SENSOR-	Temp. sensor negative line
4	Laser-	Laser voltage -
5	TEC+	Power + of the TEC
6	TEC-	Short to pin 1
7	Laser+	Short to pin 2
8	T_SENSOR+	Temp. sensor positive line
9	Laser-	Short to pin 4
10	TEC+	Short to pin 5

Table 4.2: S-2m output (laser end) pinout

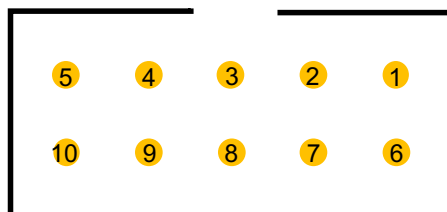


Figure 4.4: S-2m output (laser end) pin numbering

4.3 C-S2m-IN cable

The C-S2m-IN cable provides the connections from the power supply and external instruments to the 20-pin input connector on the S2-m PCB. Unless otherwise indicated in the pinout of Table 4.3.1 below, the pairs are not shielded.

4.3.1 Instrument end of cable

Temperature controller

Connector: DB-15 Male
 Cable type: 4 wires 24AWG
 Length: 1.4 m (55 in.)
 Label: TEC

DB-15 pin	Descr.	S-2m pin
1	TEC+	1
2	n/c	-
3	TEC-	10
4	n/c	-
5	Earth gnd (shielded)	-
6	Earth gnd (shielded)	-
7	T Sensor+	6
8	T Sensor-	5
9	n/c	-
10	n/c	-
11	n/c	-
12	n/c	-
13	n/c	-
14	n/c	-
15	n/c	-

Communication

Connector: DB-9 Female
 Cable type: 3 wires 24AWG
 Length: 1.4 m (55 in.)
 Label: RS232

DB-9 pin	Descr.	S-2m pin
1	n/c	-
2	RS232 TX	12
3	RS232 RX	13
4	n/c	-
5	RS232 GND	2
6	n/c	-
7	n/c	-
8	n/c	-
9	n/c	-

Power supply

Connector: 2.1 mm DC jack
 Cable type: 2 wires 24AWG
 Length: 0.3 m (12 in.)
 Label: POWER

Pin	Descr.	S-2m pin
PIN	DC Power+	8
RING	DC Power-	4

4.3.2 S-2m end of cable



Figure 4.5: C-S2m-IN cable connector (female) to the S-2m input (male), Sec. 4.1.

Pin	S-2m Pin Name	Length	Connection to / Terminal
1	TEC+	1.4 m	Temperature controller
2	RS232_GND	1.4 m	Computer
3	GND		
4	DC power-	0.3 m	Power supply, 2.1 mm DC jack
5	T_SENSOR-EXT	1.4 m	Temperature controller
6	T_SENSOR+EXT	1.4 m	Temperature controller
7	IN_V_SUPPLY+	-	No wire
8	IN_V_SUPPLY+	0.3 m	Power supply, 2.1 mm DC jack
9	IN_MOD_DIRECT	15 cm	SMA-socket Label: IN MOD DIRECT
10	TEC-	1.4 m	Temperature controller
11	TEC+	-	No wire
12	OUT_RS232_TX	1.4 m	Computer
13	IN_RS232_RX	1.4 m	Computer
14	MULTI_IN_OUT	15 cm	SMA-socket Label: MULTI_IN_OUT
15	OUT_LASER_ON	15 cm	SMA-socket Label: OUT LASER ON
16	IN_VREG_INTERLOCK	15 cm	No wire
17	MCU_OUT_INTERLOCK	15 cm	No wire
18	IN_SAFETY	15 cm	No wire
19	IN_ARM	15 cm	No wire
20	TEC-	-	No wire

Table 4.3: C-S2m-IN cable with connector to the S-2m input

4.4 C-S2m-HHL cable

The C-S2m-HHL cable provides a 30 mm flexible bridge between the S-2m PCB output and the HHL pins, as depicted in [3.1.2](#).

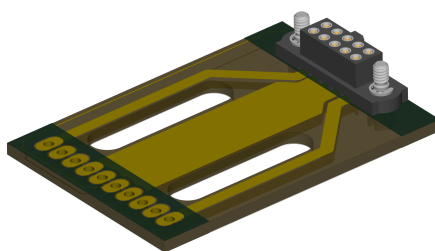


Figure 4.6: 30mm C-S2m-HHL cable

HHL Pin	Name	S-2m Output Pin
1	TEC -	1, 6
2	(No pin)	
3	nc	
4	Laser +	2, 7
5	T sensor -	3
6	T sensor +	8
7	Laser -	4, 9
8	nc	
9	nc	
10	TEC +	5, 10

Table 4.4: C-S2m-HHL pin connections

4.4.1 Impedance matching



CAUTION:

The laser output pulse is a high-power, fast-edge and high frequency signal. Particular care must be taken with the impedance matching of the output line between the S-2m and the laser.

Impedance discontinuities (e.g., long cables, adapters, connectors, or unterminated lines) can generate reflections that lead to voltage and current overshoot at the controller output and/or at the laser input. This may cause unstable pulse shapes and, in the worst case, overstress the output stage and damage the system. To minimize reflections and ensure safe operation:

- Use the recommended cable for the output pulse line.
- Keep the output cable **as short as practical**.
- Avoid additional adapters, extensions, or impedance transitions.

5. Graphical User Interface

This section describes how to program the S-2m pulser with the provided GUI.

With the S-2m powered on and connected to the computer via the C-S2m-IN cable, open the S-2m control software: a dialog similar to the one shown in figure 5.1 will appear. The top line of the dialog box shows a drop-down menu for the port connection. Click to search for connected ports if necessary, then tick the box next to "connect" to start communication with the S-2m card. An active connection is indicated by "ok" appearing to the right of "connect." If no ports appear after the scan, ensure all drivers are installed, e.g. for the RS232-USB serial adapter.

5.1 General operation

1. Enter the desired repetition period, pulse width, and peak current limit using the dialog box. The corresponding frequency and duty cycle are calculated automatically.
 - These parameters are adjustable even if the output is off
 - Pulse width and repetition period can be adjusted in 10 ns increments
 - *Note:* If the pulse width is set to a value larger than the repetition period, the current will be on continuously.
 - *Note:* The **Peak current limit [A]** line displays the maximum allowed peak current for the current duty cycle and repetition rate. If this value is exceeded during operation, the driver will shut down in order to protect the laser.
2. Click to set the values. The values displayed on the right will update accordingly under **Actual:** to the right of the input box, as shown in Fig. 5.2.
3. Select an output mode from the dropdown box to enter the mode-specific pulse width(s) and amplitude(s). Refer to the laser datasheet for the voltage setpoints. Details of the various output modes are given in Ch. 7 *Modes of operation*.
 - Output voltage can be adjusted in 10 mV increments
 - Two voltage values separated by a / appear under "Actual." These indicate the Set value / Real-time measured value.

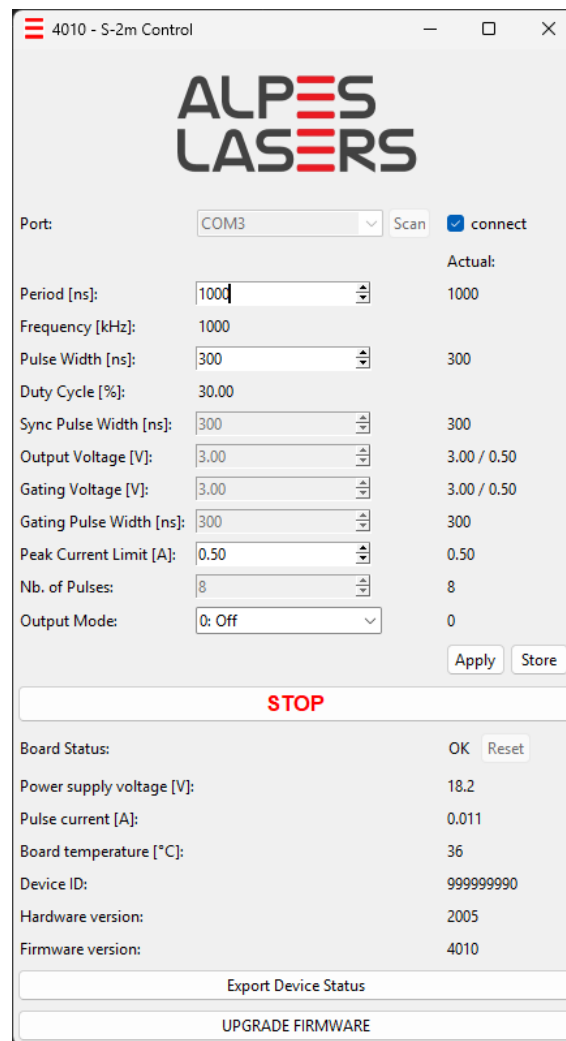


Figure 5.1: Dialog Box for internal control.

4. Click on `apply` to start the selected operating mode with the defined settings, or on `store` to simultaneously start pulsing and save the current settings permanently in the driver.
5. Click on `Export Device Status` to export a JSON file containing the current S-2m status, device information, settings, measurements, and diagnostic data.

IMPORTANT:

By default, the S-2m pulser is powered up with the settings stored during the last session, including automatic pulse generation at power up if the stored output mode is other than OFF. The S-2m driver should only be used with its paired HHL-QCL to avoid the card's stored parameters exceeding the setpoints of another laser.

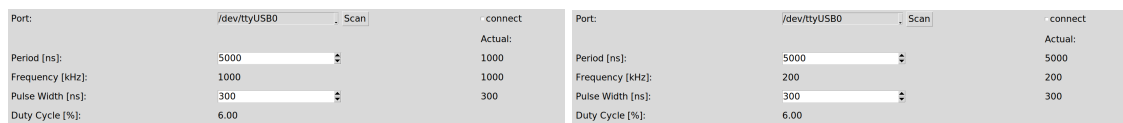


Figure 5.2: The set value appears under **Actual**, which changes upon clicking `apply`, as shown here for changing the pulse repetition period.

Below the `apply` and `store` buttons, several informational values are displayed. Values like the Hardware version and Device ID are static, while others like the Power supply voltage and the Board temperature [°C] are measured. *When pulsing*, the measured value of the **Pulse current [A]** is displayed at the bottom of the GUI screen, indicating the current measured in the output ON state. This measured Pulse current value is indicative only, accurate for pulse widths >300 ns and above the minimum measurable value, which can be as high as 0.15 A in some conditions.

5.2 Software

5.2.1 Graphical User Interface (GUI) download

A bundled package including the graphical user interface (GUI) and firmware is available for updating and operating the S-2m. The latest release can be downloaded from the Alpes Lasers GitHub repository at:

<https://github.com/alpeslasers/s2m-gui-release>

5.2.2 Python driver

The S-2m pulser can also be driven using a pure Python driver which can be integrated into another software at the user's convenience. The python driver containing the functions to perform all the capabilities of the GUI can be downloaded from the The Python Package Index: <https://pypi.org/project/sdeux/>.

Note: ALPES LASERS offers this Python driver for convenience only. Software support will not be provided.

Example of Python communication

The Python library of the S-2m may be used to write applications. A basic example is provided here:

```
import time
from sdeux.auto_detect import init_driver
from sdeux.serial_handler import S2SerialHandler

if __name__ == '__main__':
    th = S2SerialHandler('/dev/ttyUSB0')
    th.open()
    s2 = init_driver(th)
    s2.set_up()
    print(s2.info)
    print(s2.settings)
    s2.set_settings(pulsing_mode='internal',
                   voltage=5.0,          # applied voltage
                   pulse_period=1000,    # in nanoseconds
                   pulse_width=500,     # in nanoseconds
                   current_limit=3.0)    # amps
    time.sleep(1.0) # wait a bit for measure averaging
    s2.reload_info()
    s2.reload_settings()
    print(s2.info)
    print(s2.settings)
    th.close()
```

The sdeux library is available from The Python Package Index.

6. Safety interlocks, external modulation and security

6.1 Interlocks

The safety interlocks built into the S-2m driver card are implemented as part of the hardware, and thus are not defeatable by software settings. The safety interlocks are not accessible from the C-S2M-IN cable (as described in Ch. 4): the C-S2M-IN cable already provides a build-in connection for the interlocks.

For an advanced direct operation of the S-2m card without the C-S2M-IN cable, the GND pin must be grounded, and the 3 interlocks held at +3.3 V or +5 V:

- IN_VREG_INTERLOCK Gates the main voltage regulator chip on the driver card, effectively the DC power supply. Schematized in Fig. 6.1.
- IN_ARM Interlock for the main gate driver. Schematized in Fig. 6.3
- IN_SAFETY Interlock for the safety gate driver. Schematized in Fig. 6.3

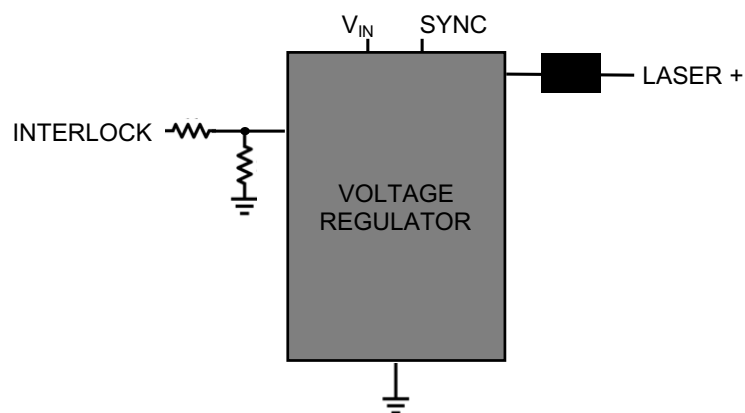


Figure 6.1: Simplified IN_VREG_INTERLOCK connection schematic

Note: the MCU_OUT_INTERLOCK output provides +3.3V and can be used to enable the interlocks. This is how the C-S2M-IN cable enables all interlocks.

Note: It is also possible to short the MCU_OUT_INTERLOCK with IN_VREG_INTERLOCK by connecting the jumper "JP2" directly on the driver PCB. The two pins are located near the input end of the PCB, as shown in Fig. 6.2.

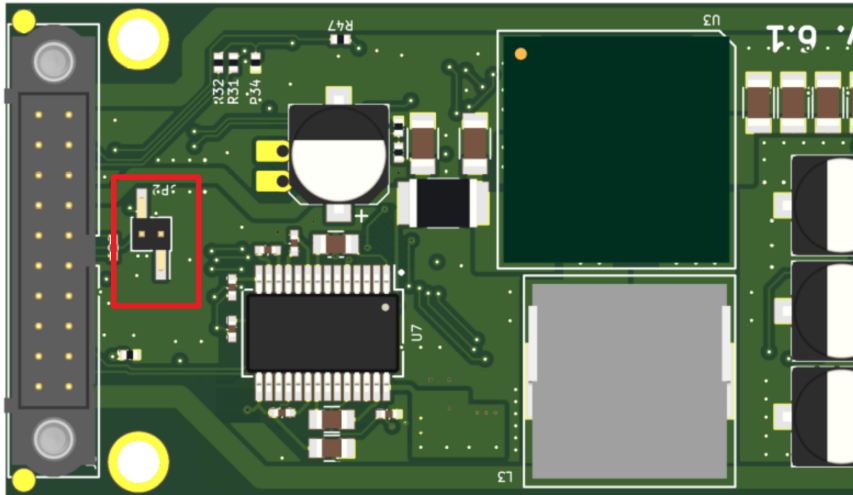


Figure 6.2: Jumper to short IN_VREG_INTERLOCK with MCU_OUT_INTERLOCK

The pulse settings defined in the GUI are output from the microcontroller and input to the driver. The driver itself consists of two identical arms, referred to as SAFETY and ARM, both of which must be enabled for laser output. When this is the case, the OUT_LASER_ON pin effectively provides a TTL signal with the modulation input to the transistor drivers. Fig. 6.3 depicts the parallel driver chips, OUT_LASER_ON signal, as well as the optional external modulation input IN_MOD_DIRECT as described in Sec. 7.3 below.

Figs. 6.4 and 6.5 depict the OFF/ON switching time measured for the ARM and SAFETY arms of the driver circuit.

6.2 Security Features

An LED indicator on the back side of the PCB turns from green (ready) to red in normal operation when the S-2m is running. The LED also turns red in case of status errors: a power supply outside the specified range, triggering an Overvoltage or Undervoltage status, or Overcurrent as defined by the current limit set in the GUI. In these cases, the microcontroller no longer outputs to the driver circuit, and the voltage on the green MCU OUT cable which serves as a status indicator switches from 0 V

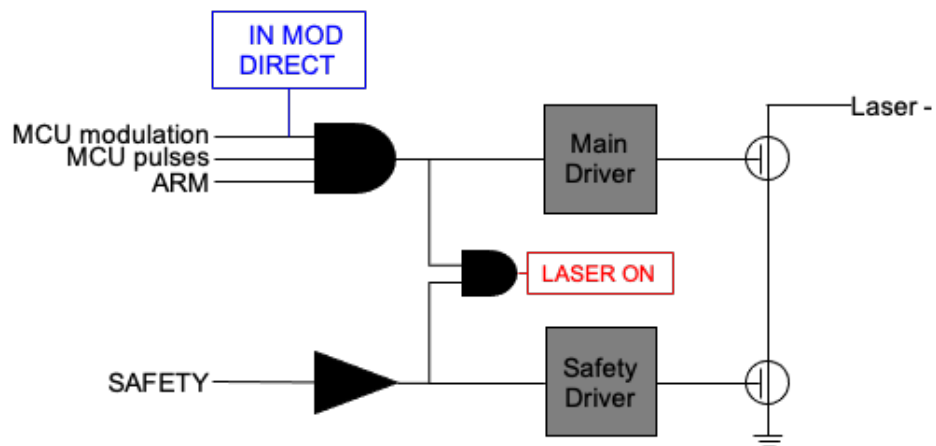


Figure 6.3: Simplified driver connection schematic

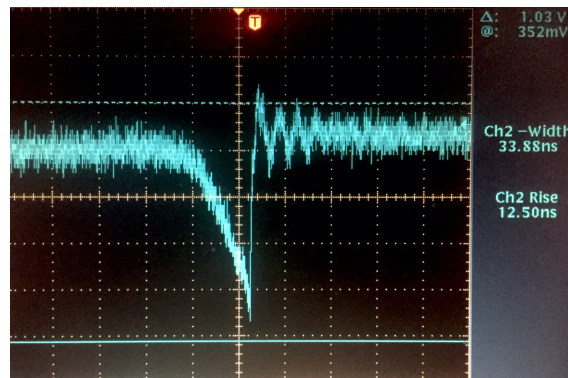


Figure 6.4: ARM interlock response time: ON 13 ns, OFF 34 ns

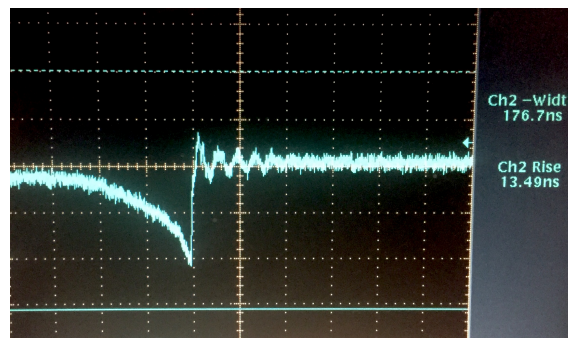


Figure 6.5: SAFETY interlock response time: ON 13 ns, OFF 177 ns

(normal operation) to +3.3 V (status error/no MCU output). The status must be reset via the RESET_STATUS_FLAG before operation can resume.

As an additional security feature, the S-2m will shut down if the pulse length is longer than 50 ms to avoid overheating the QCL.



WARNING:
 Internal pulses must be disabled during external control and vice-versa. Enabling internal and external pulses simultaneously might result in damages to the laser and the pulser.

Red LED Status	Green LED Status	Board status
Off	Off	Turned off
Off	On	Ready
On	Off	Error
On	On	Pulsing

Table 6.1: Board status depending on the LED indications

6.2.1 Status Errors

In case of an error or fault, the **red LED** turns on and the **green LED** turns off. The error conditions are defined as follows:

- **Boot fail:** A critical error occurred during initialization.
- **Undervoltage:** The power supply voltage dropped below 6 V.
- **Overcurrent:** The average current exceeded the user-defined maximum for more than 100 ms.
- **Overvoltage:** The power supply voltage exceeded 28 V.
- **Overtemperature:** The CPU temperature exceeded 85 degree C.
- **Fast overcurrent:** The current exceeded $1.25 \times$ the user-defined maximum during a pulse.
- **Out-of-pulse overcurrent:** A current greater than 0 mA was detected outside of a pulse.

7. Modes of operation

The S-2m's pulsing schemes are described here.

The IN_MOD_DIRECT SMA-socket cable must be disconnected for all other modes other than "External Gating".

7.1 Off

No pulsing, but the S-2m is ready to receive instruction and will still react if an error occurs (by example an under-voltage or an over-temperature).

7.1.1 Connections

Name	Connection	Function	Direction
IN_MOD_DIRECT	No	N/A	N/A
OUT_LASER_ON	No	N/A	N/A
MULTI_IN_OUT	Yes (optional)	MCU status	Output

Table 7.1: Pin Connections Description.

7.1.2 Parameters Used in the GUI

Only the following GUI parameters are applied in the current firmware revision. Other parameters available in the GUI are not relevant for this configuration.

Parameter	Description	Unit
Output Mode	0: Off	N/A

Table 7.2: List of GUI parameters used by the system.

7.2 Pulsing

Standard pulsing mode with configurable pulse width and duty cycle in the GUI and a configurable TTL synchronization pulse. See figure 7.1

7.2.1 Connections

Name	Connection	Function	Direction
IN_MOD_DIRECT	Must be disconnected	N/A	N/A
OUT_LASER_ON	Yes (optional)	TTL image of the laser pulses	Output
MULTI_IN_OUT	Yes (optional)	Sync TTL signal	Output

Table 7.3: Pin Connections Description.

7.2.2 Synchronization pulses

In pulsing mode (1: Pulsing), MULTI_IN_OUT behaves as a configurable TTL synchronization pulse **aligned with the falling edge** of OUT_LASER_ON.

7.2.3 Parameters Used in the GUI

Only the following GUI parameters are applied in the current firmware revision. Other parameters available in the GUI are not relevant for this configuration.

Parameter	Description	Unit
Output Mode	1: Pulsing	N/A
Period	Pulses period	ns
Pulse Width	Pulses length	ns
Sync Pulse Width	Sync Pulses length	ns
Output Voltage	Pulses voltage	V
Peak Current Limit	Pulses current limit	A

Table 7.4: List of GUI parameters used by the system.

Example with 30% duty cycle: 300 ns ON time within a 1 μ s period. The black trace shows a TTL representation of the pulses sent to the QCL.

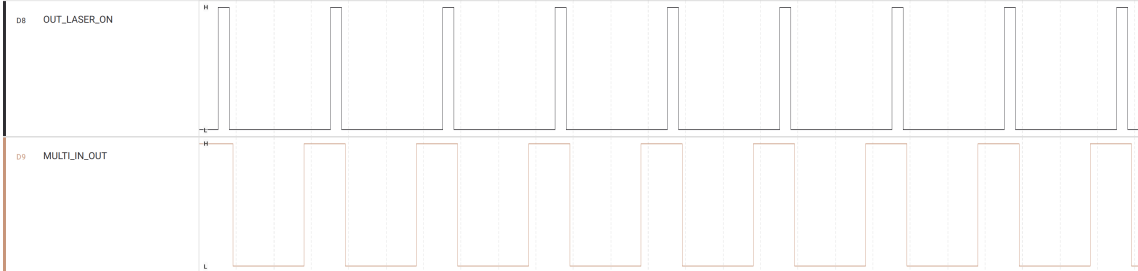


Figure 7.1: Pulsing mode with 3 μs period, 300 ns pulse width and 1 μ sync pulse width.

7.3 External Gating

The internal modulation (typically fast) is modulated by an external signal (typically slower) provided by a 3.3 V CMOS logic (or TTL) signal from an external modulation source using the C-S2M-IN cable's IN_MOD_DIRECT SMA-socket connector. If the external signal pulse width is longer than 50 ms, the output is stopped.

For an external modulation source, pulses are provided via a 3.3 V CMOS logic (or TTL) signal delivered into the C-S2M-IN cable's IN_MOD_DIRECT SMA-socket connector. TTL generators are not supplied by ALPES LASERS.

7.3.1 Connections

Name	Connection	Function	Direction
IN_MOD_DIRECT	Yes	Modulation signal	Input
OUT_LASER_ON	Yes (optional)	3.3 V CMOS logic image of the laser pulses	Output
MULTI_IN_OUT	Yes (optional)	MCU status	Output

Table 7.5: Pin Connections Description.

7.3.2 Parameters Used in the GUI

Only the following GUI parameters are applied in the current firmware revision. Other parameters available in the GUI are not relevant for this configuration.

Parameter	Description	Unit
Output Mode	8: External Gating	N/A
Period	Pulses period	ns
Gating Pulse Width	Pulses length	ns
Gating Voltage	Pulses voltage	V
Peak Current Limit	Pulses current limit	A

Table 7.6: List of GUI parameters used by the system.

Note: The fast internal modulation is not synced with the external modulation. For example the two images on the left both show the external gating signal in green and the S-2m output in yellow for identical parameters. While the pulse length and the repetition rate of the yellow signal are fixed, the time delay between the onset of the external modulation signal and the rise of the first pulse can vary randomly due to variation between internal and external clocks. The S-2m external gating mode does not allow for syncing that would allow this time delay to be fixed.

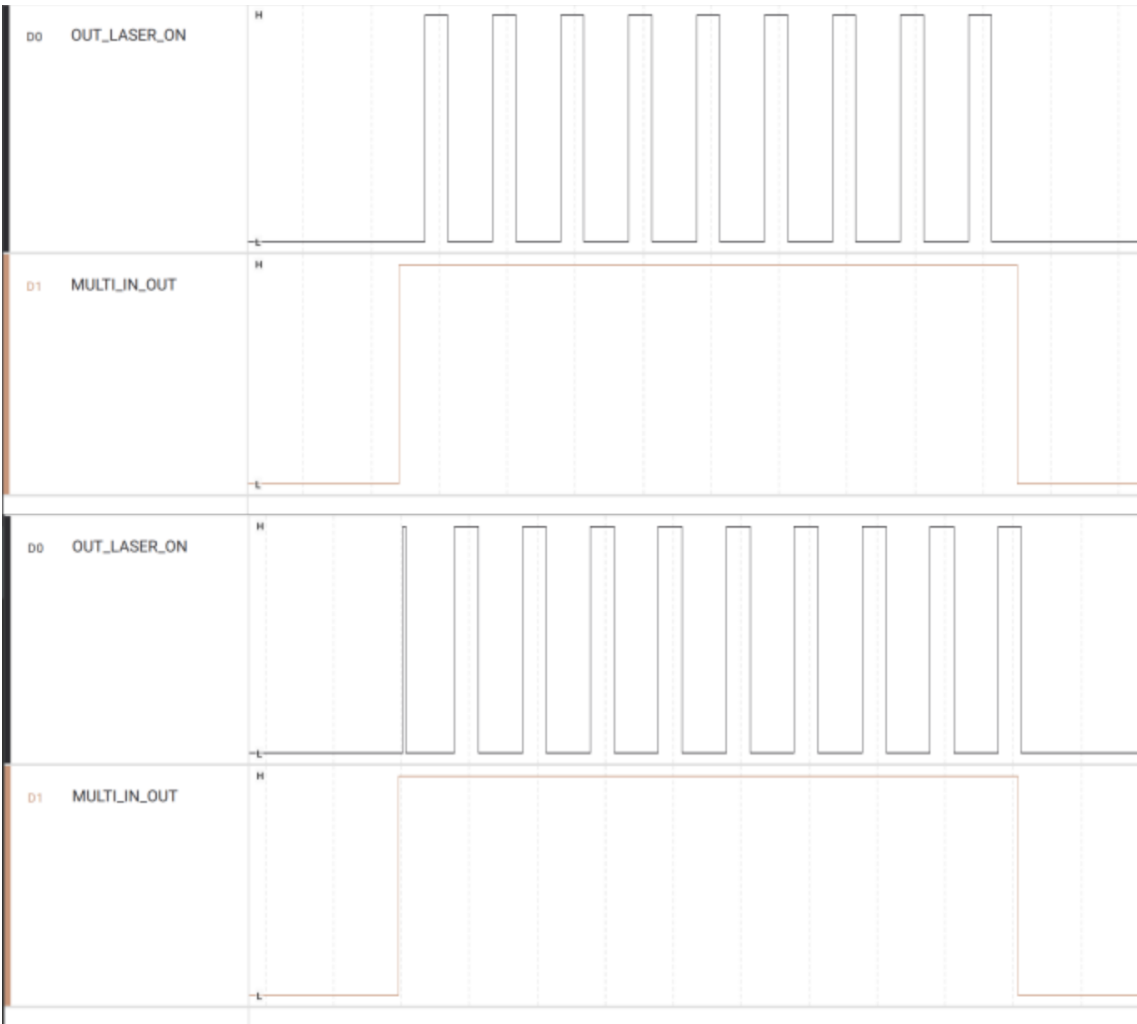


Figure 7.2: Pulsing mode with 1 μ s period and 300 ns pulse width.

7.4 External Trigger

A single pulse is generated 140 ns after rising edge is detected on MULTI_IN_OUT; this pulse is non-retriggerable during one user-defined period. The output current is measured once per pulse, and all protections/monitors (overcurrent, fast overcurrent, overvoltage, overtemperature, out-of-pulse overcurrent) remain active. See figure 7.3

7.4.1 Connections

Name	Connection	Function	Direction
IN_MOD_DIRECT	No	N/A	N/A
OUT_LASER_ON	Yes (optional)	3.3 V CMOS logic image of the laser pulses	Output
MULTI_IN_OUT	Yes	3.3 V CMOS logic or TTL External trigger signal	Input

Table 7.7: Pin Connections Description.

7.4.2 Parameters Used in the GUI

Only the following GUI parameters are applied in the current firmware revision. Other parameters available in the GUI are not relevant for this configuration.

Parameter	Description	Unit
Output Mode	7: External Trigger	N/A
Period	Non-retriggerable period	ns
Pulse Width	Pulses length	ns
Output Voltage	Pulses voltage	V
Peak Current Limit	Pulses current limit	A

Table 7.8: List of GUI parameters used by the system.

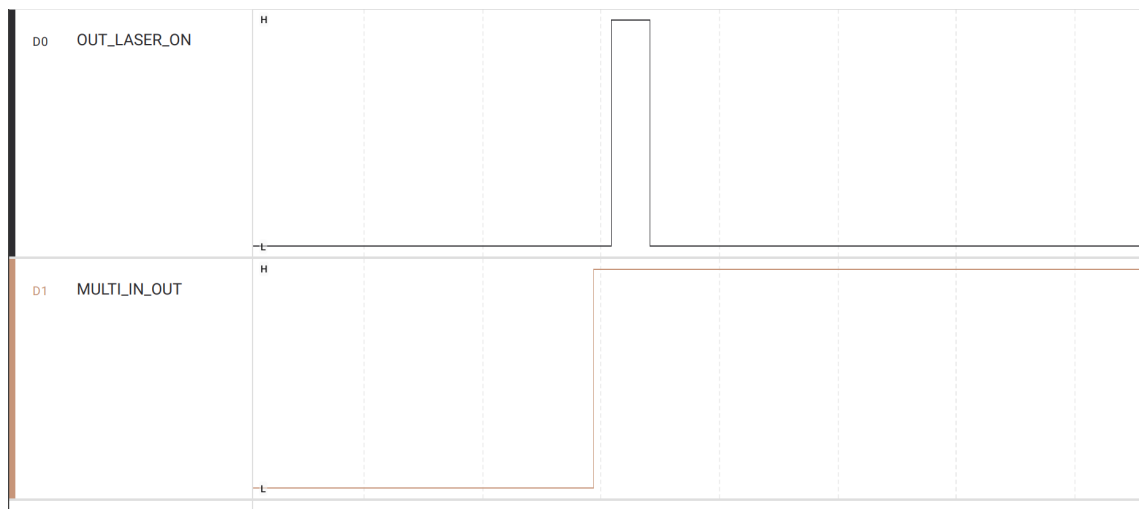


Figure 7.3: A single 500 ns pulse is generated after a fixed delay of 140 ns after the detection of a rising edge on MULTI_IN_OUT. The black trace shows a TTL representation of the pulses sent to the QCL and the brown trace shows the external trigger.

7.5 Burst External Trigger

A user-defined number of pulses are generated when a rising edge is detected on MULTI_IN_OUT, this pulses are non-retriggerable until the end of the burst generation. The output current is measured once per pulse, and all protections/monitors (overcurrent, fast overcurrent, overvoltage, overtemperature, out-of-pulse overcurrent) remain active. See figure 7.4

7.5.1 Connections

Name	Connection	Function	Direction
IN_MOD_DIRECT	No	N/A	N/A
OUT_LASER_ON	Yes (optional)	3.3 V CMOS logic image of the laser pulses	Output
MULTI_IN_OUT	Yes	3.3 V CMOS logic or TTL External trigger signal	Input

Table 7.9: Pin Connections Description.

7.5.2 Parameters Used in the GUI

Only the following GUI parameters are applied in the current firmware revision. Other parameters available in the GUI are not relevant for this configuration.

Parameter	Description	Unit
Output Mode	7: External Trigger	N/A
Period	Pulses period	ns
Pulse Width	Pulses length	ns
Output Voltage	Pulses voltage	V
Peak Current Limit	Pulses current limit	A
Nb. of Pulses	number of repetition	N/A

Table 7.10: List of GUI parameters used by the system.

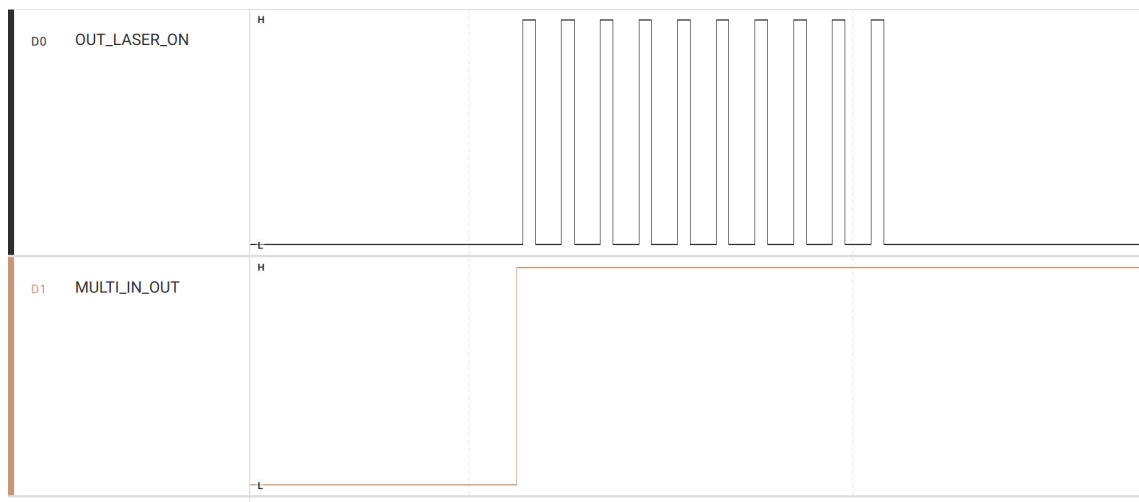


Figure 7.4: A 10 pulses burst of 500 ns pulse is generated after a fixed delay of 140 ns after the detection of a rising edge on MULTI_IN_OUT. The black trace shows a TTL representation of the pulses sent to the QCL and the brown trace shows the external trigger rising edge.

8. Non-volatile Memory

The following information is stored in the S-2m's non-volatile memory. The **NAME** refers to the data packet type where the value occurs. See Ch.10 for further details.

INFO

Name	Type	Description
device_id	uint32_t	Unique ID of the board
sw_version	uint16_t	Board firmware version
hw_version	uint16_t	Board hardware version
input_voltage_measured	float	Measured input (power supply) voltage
output_voltage_measured	float	Measured output (pulse amplitude) voltage
output_current_measured	float	Measured pulse current
MCU_temperature	float	Board controller temperature
laser_temperature	float	Laser temperature (if connected)
output_current_measured_out_of_pulse	float	Measured out-of-pulse current
status	uint16_t	Indicates possible faults from #S2_status
pulse_clock_frequency	uint32_t	Constant indicating pulse timer resolution (100 MHz 10 ns)
API_version	uint32_t	Board API version; equals #S2_API_VERSION if same version
laser_id	char[S2_LASER_ID_LENGTH]	Laser ID

Note: All float values are assumed to be 32-bit IEEE 754 format.

SETTINGS

Name	Type	Description
pulse_period	uint32_t	Pulse period length in 10 ns increments
pulse_width	uint32_t	Output pulse width in 10 ns increments; width \geq period enables CW output
output_voltage_set	float	Output voltage in V, \sim 1 to 25 V
output_current_limit	float	Output current limit in A
pulsing_mode	uint16_t	Output mode (values from #S2_pulsing_mode enum)
external_trigger_mode_nb_of_pulse_repetition	uint16_t	Number of pulses in external burst trigger mode
unused	uint16_t	Output sync pulse width in 10 ns increments
burst_ON	uint32_t	Number of periods with pulsing ON (increments of 10)
burst_OFF	uint32_t	Number of periods with pulsing OFF (increments of 10)
output_voltage_set_A	float	Output voltage in V, \sim 1 to 25 V
output_voltage_set_B	float	Output voltage in V, \sim 1 to 25 V
pulse_width_A	uint32_t	Output pulse width in 10 ns increments; width \geq period enables CW output (mode AUTO)
pulse_width_B	uint32_t	Output pulse width in 10 ns increments; width \geq period enables CW output (mode AUTO)
current_limit_mode	uint16_t	Current limit mode
sync_out_width	uint32_t	Sync pulse width in 10 ns increments

Note: All float values are assumed to be 32-bit IEEE 754 format.

UPTIME

Name	Type	Description
uptime	uint64_t	Time since power-on
total_uptime	uint64_t	Total accumulated uptime
lasing_time	uint64_t	Total lasing time
operation_time	uint64_t	Total operation time

QUERY_BIT

Name	Type	Description
overcurrent_first	uint32_t	Time (total S-2 uptime) at the first occurrence of overcurrent
overcurrent_last	uint32_t	Time (total S-2 uptime) at the last occurrence of overcurrent
overcurrent_count	uint32_t	Count of overcurrent status (1 check/min)
undervoltage_first	uint32_t	Time (total S-2 uptime) at the first occurrence of undervoltage
undervoltage_last	uint32_t	Time (total S-2 uptime) at the last occurrence of undervoltage
undervoltage_count	uint32_t	Count of undervoltage status (1 check/min)
overvoltage_first	uint32_t	Time (total S-2 uptime) at the first occurrence of overvoltage
overvoltage_last	uint32_t	Time (total S-2 uptime) at the last occurrence of overvoltage
overvoltage_count	uint32_t	Count of overvoltage status (1 check/min)
overtemp_first	uint32_t	Time (total S-2 uptime) at the first occurrence of over temperature
overtemp_last	uint32_t	Time (total S-2 uptime) at the last occurrence of over temperature
overtemp_count	uint32_t	Count of over temperature status (1 check/min)

9. Built-in Test

Built-in test (BIT) information of the S-2m can be queried as described in the communication protocol in Sec. 10.2.2. In particular, the BIT provides a log of the time and status fault count for the S-2m card, stored in its non-volatile memory and updated upon triggering of a status error. These are tabulated in Table 9.1.

BIT 1

Error	Unit	Description
overcurrent_first	s	Time (total S-2m uptime) at the first occurrence of overcurrent
overcurrent_last	s	Time (total S-2m uptime) at the last occurrence of overcurrent
overcurrent_count	-	Count of overcurrent status events
undervoltage_first	s	Time (total S-2m uptime) at the first occurrence of undervoltage
undervoltage_last	s	Time (total S-2m uptime) at the last occurrence of undervoltage
undervoltage_count	-	Count of undervoltage status events
overvoltage_first	s	Time (total S-2m uptime) at the first occurrence of overvoltage
overvoltage_last	s	Time (total S-2m uptime) at the last occurrence of overvoltage
overvoltage_count	-	Count of overvoltage status events
overtemp_first	s	Time (total S-2m uptime) at the first occurrence of overtemp
overtemp_last	s	Time (total S-2m uptime) at the last occurrence of overtemp
overtemp_count	-	Count of overtemp status events

Table 9.1: Status errors logged in the S-2m non-volatile memory.

BIT 2

Error	Unit	Description
fast_overcurrent_first	s	Time (total S-2m uptime) at the first occurrence of fast overcurrent
fast_overcurrent_last	s	Time (total S-2m uptime) at the last occurrence of fast overcurrent
fast_overcurrent_count	-	Count of fast overcurrent status events
out_of_pulse_overcurrent_first	s	Time (total S-2m uptime) at the first occurrence of out-of-pulse overcurrent
out_of_pulse_overcurrent_last	s	Time (total S-2m uptime) at the last occurrence of out-of-pulse overcurrent
out_of_pulse_overcurrent_count	-	Count of out-of-pulse overcurrent status events

Table 9.2: Fast and out-of-pulse overcurrent errors logged in the S-2m non-volatile memory.

10. Communication Protocol

The present chapter describes the communication protocol between a host and an S-2m rev. 2005 device, otherwise called simply S-2 in the remainder of this text, with API version 2018102501.

10.1 Communication Overview

10.1.1 Data format

The host computer initiates the communication by sending fixed-size binary data packets to the S-2m. The S-2m then always replies with a fixed-size binary packet to each valid packet it receives. However, the S-2m does not reply to any invalid or corrupted packets it receives.

10.1.2 Data framing

The packets are encapsulated into frames according to the serial line over IP (SLIP) RFC 1055. A delimiting character, called END, decimal 192, is appended to the beginning and the end of the packet. An additional escape character, called ESC, decimal 219, is used to escape any END or ESC byte that occurs in the data itself. The escape sequences of the END and ESC characters are called ESC_END and ESC_ESC given by 219,220 and 219,221 respectively in decimal form.

10.1.3 Data transmission

The frames are exchanged over a serial line with a baudrate of 38400. The serial port settings are 8 data bits, no parity, 1 stop bit, no handshaking.

Because the S-2 ignores corrupted packets, it is a good practice to set a small read timeout of the order of 0.1s on the host. If no response comes within this time, it means that the S-2 will not reply at all. The only exception to this rule is for operations that store settings in the flash memory of the S-2 which can take a few seconds.

On the other hand, the three packet types SET_SETTINGS, SET_PERSISTENT_SETTINGS and RESET_STATUS_FLAG change the S-2m operation.

The SET_SETTINGS packet is the principal packet sent to operate the S-2m. It allows the host to change the pulse settings (pulsing mode, pulse width, pulse period, pulse voltage) and to set the current protection limit. See the table in [10.2.2](#) for a detailed account.

The SET_PERSISTENT_SETTINGS does the same, moreover it also saves the settings to the flash memory, so that the applied settings will persist after a power cycle of the device. Note that this should not be used very frequently because it is rather slow and the flash memory will wear out eventually.

The RESET_STATUS_FLAG is used to reset the S-2m into normal operation after it has triggered a safety protection (e.g. output current over the protection limit).

10.2.2 Payload formats

The payloads consist of a list of fields transmitted in binary, little-endian, format. The tables of this section describe the structure of all the payloads as an ordered list of fields with their associated data types and byte sizes in the payload. Float values are packed according to the IEEE 754 binary32 representation.

Structure of the INFO payload

Name	Type	Size (Bytes)	Description	Units
device_id	UINT32	4	Unique ID of the board	-
sw_version	UINT16	2	Installed firmware version	-
hw_version	UINT16	2	Hardware version	-
input_voltage_measured	FLOAT	4	Measured input (power supply) voltage	V
output_voltage_measured	FLOAT	4	Measured output (pulse amplitude) voltage	V
output_current_measured	FLOAT	4	Measured pulse current	A
MCU_temperature	FLOAT	4	Board controller temperature	°C
laser_temperature	FLOAT	4	Laser temperature (if connected)	°C
output_current_measured_out_of_pulse	FLOAT	4	Measured out-of-pulse current	A
status	UINT16	2	Indicates possible faults from #S2_status	-
pulse_clock_frequency	UINT32	4	Constant indicating pulse timer resolution	Hz
API_version	UINT32	4	Board API version; equals #S2_API_VERSION if same version	-
laser_id	CHAR[8]	8	Laser ID	-
TOTAL USED bytes		50/60		

Table 10.2: S-2m INFO payload

Structure of the SETTINGS payload

Name	Type	Size (Bytes)	Description	Units
pulse_period	UINT32	4	Pulse period length	10 ns increments
pulse_width	UINT32	4	Output pulse width; width \geq period enables CW output	10 ns increments
output_voltage_set	FLOAT	4	Output voltage setpoint	V
output_current_limit	FLOAT	4	Output current limit	A
pulsing_mode	UINT16	2	Output mode (values from #S2_pulsing_mode enum)	-
external_trigger_mode_nb_of_pulse_repetition	UINT16	2	Number of pulses in external burst trigger mode	-
unused	UINT16	2	Output sync pulse width	10 ns increments
burst_ON	UINT32	4	Number of periods with pulsing ON	increments of 10
burst_OFF	UINT32	4	Number of periods with pulsing OFF	increments of 10
output_voltage_set_A	FLOAT	4	Output voltage setpoint A (AUTO mode)	V
output_voltage_set_B	FLOAT	4	Output voltage setpoint B (AUTO mode)	V
pulse_width_A	UINT32	4	Output pulse width A (AUTO mode)	10 ns increments
pulse_width_B	UINT32	4	Output pulse width B (AUTO mode)	10 ns increments
current_limit_mode	UINT16	2	Current limit mode	-
sync_out_width	UINT32	4	Sync pulse width	10 ns increments
TOTAL USED bytes		52		

Table 10.3: S-2m SETTINGS payload

The *pulsing_mode* controls the type output produced by the S-2.

Structure of the STATUS_FLAG payload

STATUS register (S2_status)

Reset value: 0x00 Access: Read-only

10.2.3 STATUS register field description

Note: *S2_STATUS_OK* corresponds to 0x00 (no fault bits set). If *status* is stored in a 16-bit field, bits [15:8] are reserved and read as 0.

Pulsing mode	Value	Description
OFF	0	No pulses are produced, the output is switched off
INTERNAL	1	Internal generator produces pulses continuously according to the pulse settings
BURST_EXTERNAL_TRIGGER	6	Each valid external trigger starts a burst of external_trigger_mode_nb_of_pulse_repetition pulses
EXTERNAL_TRIGGER	7	One pulse is generated per valid external trigger; width/voltage from internal settings
EXTERNAL_GATING	8	The internal modulation, is modulated by an external TTL signal

Table 10.4: S-2m pulsing mode options

Name	Type	Size (Bytes)	Description	Units
status_flag	UINT16	2	Which status flag (see INFO structure field status) to reset	-

Table 10.5: S-2m STATUS_FLAG payload

Field	Bits	Access	Reset	Description
UNDERVOLTAGE	[0]	RW	0	Supply below threshold. Set to 1 when undervoltage fault is detected.
OVERCURRENT	[1]	RW	0	Overcurrent fault detected.
OVERVOLTAGE	[2]	RW	0	Overvoltage fault detected.
OVERTEMP	[3]	RW	0	Over-temperature fault detected.
FAST_OVERCURRENT	[4]	RW	0	Fast overcurrent detected.
OUT_OF_PULSE_OVERCURRENT	[5]	RW	0	Overcurrent detected outside the pulse window.
BOOT_FAIL	[6]	RW	0	Firmware/boot sequence failure.
RESERVED	[7]	—	0	Reserved. Read as 0, write 0.

Table 10.6: STATUS register field description

For instance, if the S-2 is in the OVERCURRENT state, the host can send a RESET_STATUS_FLAG packet with the *status_flag* of the payload set to 1 (corresponds to the OVERCURRENT *status* value of the INFO structure).

Structure of the QUERY_BIT payload

Name	Type	Size (Bytes)	Description	Units
overcurrent_first	UINT32	4	Time (total S-2 uptime) at the first occurrence of overcurrent	s
overcurrent_last	UINT32	4	Time (total S-2 uptime) at the last occurrence of overcurrent	s
overcurrent_count	UINT32	4	Count of overcurrent status events	-
undervoltage_first	UINT32	4	Time (total S-2 uptime) at the first occurrence of undervoltage	s
undervoltage_last	UINT32	4	Time (total S-2 uptime) at the last occurrence of undervoltage	s
undervoltage_count	UINT32	4	Count of undervoltage status events	-
overvoltage_first	UINT32	4	Time (total S-2 uptime) at the first occurrence of overvoltage	s
overvoltage_last	UINT32	4	Time (total S-2 uptime) at the last occurrence of overvoltage	s
overvoltage_count	UINT32	4	Count of overvoltage status events	-
overtemp_first	UINT32	4	Time (total S-2 uptime) at the first occurrence of overtemp	s
overtemp_last	UINT32	4	Time (total S-2 uptime) at the last occurrence of overtemp	s
overtemp_count	UINT32	4	Count of overtemp status events	-

Table 10.7: S-2m QUERY_BIT payload

11. Environmental Specifications

The S-2m has been rigorously tested to the following specifications:

- Non-operating temperature: -20 to +71 °C
- Operating temperature: 0 to 70 °C (non-condensing)
- Vibrations: 1 hour per axis of the vibration profile depicted in Fig. 11.1
- Mechanical shock: 3-Axis total of 18 shocks 85 g, 5 ms half-sine
- Temperature shock: non-operational thermal shock at a rate of 11 °C/min during warm-up from -20 °C to 35 °C or cool-down from 55 °C to 0 °C
- Outgassing: TML less than 1%, CVCM less than 0.1%, as defined in test method ASTM-E-595

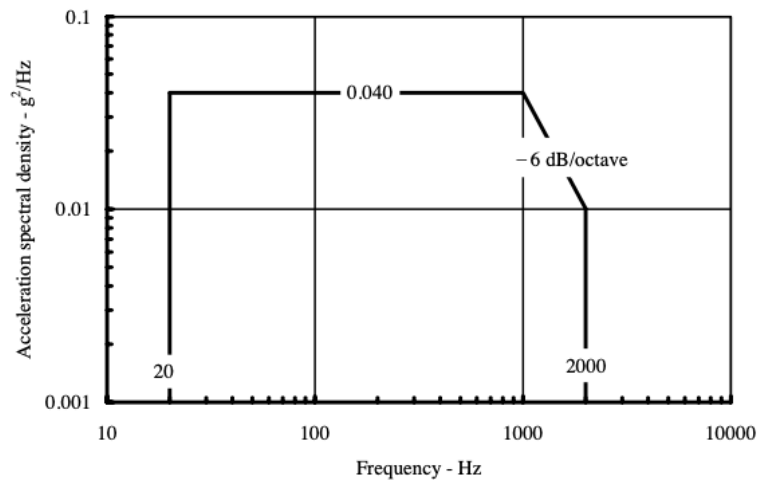


Figure 11.1: General minimum integrity exposure profile for vibration testing, ref. MIL-STD-810F Fig. 514.5C-17

12. Troubleshooting

12.1 Quick checks

1. Power supply (voltage/current, polarity, wiring) correct.
2. I/O connections (MULTI_IN_OUT, IN_MOD_DIRECT, HHL) correct.
3. Pulsing parameters (period, width, mode) consistent.
4. Temperature and protections not tripped; read the STATUS register.
5. Compatible firmware/API versions (host and S-2m).

12.2 Symptoms, causes and remedies

Table 12.1: Troubleshooting guide

Symptom	Likely cause	Diagnostic / Check
All LEDs are off	Power supply fault or boot failure	Verify that the power supply provides the correct voltage, ensure all connections are secure, and try power-cycling the S-2m
Only the red LED is on	An error was detected	Read the STATUS register to identify the fault
Error status is OVERCURRENT/ FAST_OVERCURRENT	The QCL may be degraded or the current limit is set too low	Check QCL integrity and verify the configured current limit
Error status is OUT_OF_PULSE_OVERCURRENT	The S-2m may be degraded or some ripples are detected during the off time of the pulses.	Check QCL integrity and verify the configured current limit
Error status is UNDERVOLTAGE	The power supply may be degraded or its maximum output power has been exceeded	Check the power supply integrity

Symptom	Likely cause	Diagnostic / Check
The green and red LEDs are on but no pulse is generated	<ol style="list-style-type: none"> 1. Electrical connection issue 2. A safety condition is not met 3. IN_MOD_DIRECT input forces the output low 4. QCL failure 	<ol style="list-style-type: none"> 1. Check the S-2m to QCL connection 2. Check if pulses are visible on OUT_LASER_ON 3. Ensure the IN_MOD_DIRECT input is unplugged or not pulled down 4. Check QCL integrity
Voltage too low at load	Cable drop / setpoint too low	Measure at load terminals; compare setpoint vs. measurement

12.3 Reporting issues

To help us identify and resolve problems as quickly as possible, please include the following information when contacting support:

- A short description of the problem (expected vs. observed behavior).
- The status of the LEDs at the time of the issue.
- A simple diagram or description of how the S-2m is connected in your setup.
- The JSON file generated by pressing `Export Device Status` button.
- The content of the `STATUS` register (if accessible).
- Operating mode and settings in use (pulsing parameters, limits, etc.).
- Serial numbers of the S-2m and the connected QCL.
- GUI or API version used.
- The ambient temperature during operation.
- Photos of the setup and oscilloscope screenshots, if available.
- Any other information that may be relevant.

Providing these details will allow us to reproduce the conditions, understand the context of the issue, and offer you a solution more efficiently.

