User's Guide

SMC11 *Puy Mary* Ultra-Low Noise Current Source

C-Series Modules – Laser Diode Controller

SISYPH
Signals & Systems for Physics

www.sisyph.com

1 General Information

1.1 Important Notice

The information given in this guide is subject to change without notice.

1.2 Scope

This manual provides the user with a description of the operation for the Low-Noise Current Source module SMC11-R18A.

1.3 Related Documents

All documents listed below are available online. See the product page.

Document	Release Number
Datasheet	SMC11-SS01-R18A
PCB legend	SMC11-AG01-R18A
Block diagram	SMC11-SG01-R18B
Front panel	SMC11-DD02-R18A
Typical performance curves	SMC11-SS02-R17B

1.4 Certification

Signals and Systems for Physics certifies that this product met its published specifications at the time of shipment.

1.5 Warranty

This Signals and Systems for Physics product is warranted against defects in materials and workmanship for a period of one (1) year from the date of shipment.

1.6 Absolute Maximum Ratings

All SMC-Series modules are designed to be operated in laboratory environment.

Parameter	Rating
Environmental Temperature	$> 15°$ C and $< 30°$ C
Environmental Humidity	$< 60\,\%$

1.7 Specifications

All specifications regarding the product are reported in the datasheet available online. See section 1.3. In what follows, the two output current options are denoted by V210 (210 mA) and V470 (470 mA).

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2 Overview

The SMC-Series modules are the ideal instruments for controlling the current and the temperature of narrow linewidth laser diodes. With an ultra-low noise current sink (SMC11) and sub-mK thermal control stability (SMC20 & SMC31), the SMC-Series is the right choice for the most demanding applications.

Because SMC-Series was first designed for frequency stabilization and OPLL applications, the SMC11 current sink provides in addition two current modulation inputs since ultra-low noise current and fast current modulation are key parameters for achieving the best phase noise performance of your stabilized lasers. Using the SMC-Series laser diode controller with the SMA- or SMB-Series modules, complete turn-key solutions are available for your laser frequency stabilizations or phase-locked lasers.

2.1 Description

Referring to the block diagram of the SMC11 module (see section 1.3), the setpoint of the low-noise current source is controlled using a front panel trimmer. The operating current can be also controlled using a voltage *via* the analog interface bus. For monitoring and current limiting purposes, the operating DC current is measured before the high-speed path, which is organized in two sections according to the frequency range.

Thus, for RF-modulation frequencies, the low-level signal is applied through an AC-coupling capacitor *via* a coaxial connector (SMA) located on the front-panel. Lower frequency modulation signals, such as frequency stabilization commands, are DC-coupled to the operating current through a transconductance stage. The input of this amplifier is either selected from a front-panel coaxial connector (BNC) or from the analog interface.

Safe operation of the diode laser is assured through a series of features, including a current limiter, a status monitoring, a slow turn-on circuit. The current limiter uses the DC current monitoring signal and a current limit value to control the conduction of a bypass transistor. The current limit value is set using a front-panel trimmer. When the current limiter is engaged, the bypass element sinks the exceeding current of the source. This operation is both signaled by a front-panel led and an active-low digital output. The status monitoring circuit is able to shut down the current source when at least one of the following is detected: a fault from the power supply interface, a broken interlock loop, a temperature controller failure. Once the shut down procedure is triggered, the current limiter is forced and a shorting relay is closed to protect the laser diode. Note that a compliance over-voltage can also trigger a laser shut down. In addition, a fast recovery diode is connected to the output to prevent reverse voltage operation.

The laser is connected to the current source output *via* a coaxial connector (SMA) located on the front-panel. An active-low digital input signal initiates the laser turn-on procedure: once a 5-s delay is elapsed, the shorting relay opens and the slow turn-on circuit is engaged, which provides that the laser diode current settles after a ramp transient. A front-panel led and a digital output signal that the laser is running. The current source output is also connected to the analog interface for custom applications purpose.

2.2 Grounding

It is recommended to operate the laser diode floating without connection to ground. Note that many laser packages ground one terminal of the laser to the package case, *e.g.* telecom laser diodes in 14-pin butterfly cases. It is still recommended to use configurations where the package case does not connect to ground. In situations where the laser case must be connected to ground, be careful to understand all potential ground paths in your system to avoid inadvertant ground loops or short circuits. *In such situations, only the laser anode can be grounded.*

2.3 Laser Diode

The **Laser Current SMA Connector** provides the electrical connection to the laser diode itself. For special situations, the diode can be also connected through the **Analog I/O Interface Connector.**

2.4 Interlock

The interlock function requires a low-resistance electrical connection between terminals **Interlock Source Output** and **Interlock Sense Input** for the laser to operate. *Neither of these pins may be allowed to contact ground or any other signal.*

3 Operation

3.1 Front Panel

There are a total of two SMAs, one BNC, two trimmers and three leds on the front panel, they are described in this section. Refer to the section 1.3 for more information on the front-panel. *Only laser with floating terminals or grounded anode can be used with the SMC11 Current Sink.*

3.1.1 Current Setpoint Trimmer

The **Current Setpoint Trimmer** sets the laser diode current from 0 (full counterclockwise) to its maximal value (full clockwise). This trimmer is enabled when the digital /**Setpoint Input** is set high or left open. To adjust the setpoint current:

1. Measure the operating current. For this purpose, connect a digital voltmeter to the **Current Monitor** output.
2. Set the /**Enable Input** high. It can be also left open.
3. Set the /**Setpoint Input** high. It can be also left open.
4. Adjust the operating current to the desired value using the **Current Setpoint Trimmer**.
5. If the limiter triggers, the current limit value should be increased. *Note that the current noise density increases if the current limit and the setpoint values are too close.* To prevent this degradation, the current limit value should be set 20% higher.

3.1.2 Current Limit Trimmer

The **Current Limit Trimmer** sets the laser diode current limit from 0 (full counterclockwise) to its maximal value (full clockwise). To set the current limit value:

1. Measure the operating current. For this purpose, connect a digital voltmeter to the **Current Monitor** output.
2. Set the /**Enable Input** high to disable the current source. Its output is now shorted to ground and the current limiter should engage.
3. If the current limiter is not engaged, increase the operating current using the **Current Setpoint Trimmer** until the limiter triggers.

4. Adjust the current limit to the desired value.
5. Bring the operating current back to the desired value using **Current Setpoint Trimmer**.

Note that the current noise density increases if the current limit and the setpoint values are too close. To prevent this degradation, the current limit value should be set at least 10% higher.

3.1.3 Red Status Led

The **Red Status Led** is lit when the current limiter is engaged. In this case, the DC operating current is adjusted to the current limit value using an internal loop.

3.1.4 Yellow Status Led

The **Yellow Status Led** is lit when the laser is off: the shorting relay is closed and no current flows through the diode laser.

3.1.5 Green Status Led

The **Green Status Led** is lit when the laser is running: the shorting relay is open and the current delivered by the source flows through the laser.

3.1.6 RF Modulation SMA Connector

The **RF Modulation Input** is used for high-frequency modulation of the laser diode current, for example, to create FM sidebands. Connect the 50-Ω output of a function generator to this input using an SMA coaxial cable. Can be left open if not used. Refer to the datasheet for maximum admissible ratings. *Note that excess level on this input could damage the laser diode.*

3.1.7 Laser Current SMA Connector

The output current source is delivered to the laser diode through the **Laser Current SMA Connector** *via* a coaxial cable. The laser diode connections are:

Cable	Laser Diode
Center conductor	Laser cathode
Outer (shield) conductor	Laser anode

3.1.8 Servo Modulation BNC Connector

The **Servo Modulation Input** is intended to laser frequency control, providing a DC coupled current modulation over a large bandwidth. The applied voltage is converted into a laser diode current using a transcondutance stage, which provides a modulation coefficient of +1 mA/V. Because this stage features an automatic bias circuit, the laser diode setpoint is not altered whether the **Servo Modulation Input** is connected, grounded or left open. To enable the input from the front-panel, the **Servo Source Selector Switch** located on the printed circuit board must be set. A signal from the analog interface connector can be also selected as modulation input using the same configuration switch.

3.2 Analog I/O Interface Connector

Like all SMC-Series modules, the SMC11 has two 50-pin stack-through headers acting as Analog I/O and Digital I/O interfaces. In this section each pin allocated to the analog interface is described.

3.2.1 Current Monitor

The **Current Monitor** provides the measurement of the DC operating current. This output can drive light loads or it can be left open if not used. A copy of the **Current Monitor** is also available on the **Digital Voltmeter Connector**. In order to output the **Current Monitor** through a front-panel BNC connector, consider the SMC111 module.

3.2.2 Current Setpoint Input

The **Current Setpoint Input** provides the user with remote control of the operating current using a DC voltage. To enable this input and disables the front-panel trimmer, the digital /**Setpoint Enable Input** is set low. The allowed input range is then $0/+5\,\mathrm{V}$, which corresponds to full range output. Because the **Current Setpoint Input** is received by a differential amplifier, the control voltage is applied between two the terminals labeled **Setpoint Pos** and **Setpoint Neg**.

3.2.3 Servo Modulation Input

The **Servo Modulation Input** allows fast control of the laser current, for example in laser frequency control applications. This input acts like its front-panel counterpart: the applied voltage is converted into an laser diode current using a transcondutance stage, which provides a modulation coefficient of $1\,\mathrm{mA/V}$. Since the **Current Setpoint Input** is received by a differential amplifier, the modulation voltage is applied between two the terminals labeled **Servo Pos** and **Servo Neg**. Because this stage features an automatic bias circuit, the laser diode setpoint is not altered whether the **Servo Modulation Input** is connected, grounded or left open. To enable the input from the front-panel, the **Servo Source Selector Switch** located on the printed circuit board must be set.

3.2.4 Laser Diode Anode Output

The **Laser Diode Anode Output** provides the user for connecting the laser without using the front-panel **Laser Current SMA Connector**, which is left open in this case. *This terminal is internally connected to the reference ground.*

3.2.5 Laser Diode Cathode Output

The **Laser Diode Cathode Output** provides the user for connecting the laser without using the front-panel **Laser Current SMA Connector**, which is left open in this case.

3.2.6 Current Limit Monitor

The **Current Limit Monitor** provides the measurement of the current limit value. This output can drive light loads or it can be left open if not used. In order to output the **Current Limit Monitor** through a front-panel BNC connector, consider the SMC111 module.

3.2.7 Reference Ground Output

The **Reference Ground Output** provides a clean ground connection ($0\,\mathrm{V}$)) for analog differential measurements. *Do not tie this pin to the ground of the measuring circuitry.* Left open if not used.

3.2.8 Shorting Relay Common

The **Shorting Relay Common** is connected to the common of the second switch of the shorting relay. This switch is aimed at user applications requiring to know whether the laser is running or not.

3.2.9 Shorting Relay NC

When the laser is off, the **Shorting Relay NC** and **Shorting Relay Common** terminals are shorted.

3.2.10 Shorting Relay NO

When the laser is running, the **Shorting Relay NO** and **Shorting Relay Common** terminals are shorted.

3.2.11 Analog Power Supply

The analog circuitry of the module operates from +15 V and −15 V power supplies. It is recommended to use the SMZ00 module to connect these sources. The digital ground **DGND** terminal must be tied to the analog ground **AGND**.

3.2.12 Pin Assignments of the Analog Bus Connector

Signal label	Pin assignment	Direction
Servo Modulation Pos.	AIO.37	input
Servo Modulation Neg.	AIO.39	input
Current Setpoint Pos.	AIO.42	input
Current Setpoint Neg.	AIO.44	input
Current Limit Monitor	AIO.35	output
Current Monitor	AIO.40	output
Reference Ground	AIO.46	output
Laser Diode Anode	AIO.7	output
Laser Diode Cathode	AIO.9	output
Shorting Relay Common	AIO.3	input/output
Shorting Relay NC	AIO.1	input/output
Shorting Relay NO	AIO.5	input/output
AGND	AIO.6	power input
−15 V	AIO.45	power input
+15 V	AIO.47	power input
AGND	AIO.49	power input
Chassis	AIO.2	chassis ground input (Earth)

3.3 Digital I/O Interface Connector

Like all SMC-Series modules, the SMC10 has two 50-pin stack-through headers acting as Analog I/O and Digital I/O interfaces. In this section each pin allocated to the digital interface is described.

3.3.1 /Laser Enable Input

To enable the current source output, the /**Laser Enable Input** is driven low. If no faults are detected, the current is delivered to the laser after a delay of 5 s. Whenever the /**Laser Enable Input** goes high or a fault occurs, the laser is immediately shut down. Because the current source features a slow turn-on, it is

not necessary to bring the current back to zero prior enabling the output. In order to control the /**Laser Enable Input** through a front-panel switch, consider the SMC121 module.

3.3.2 /Setpoint Enable Input

The /**Setpoint Enable Input** is driven low to enable the remote control of the operating current *via* the **Current Setpoint Input**. In this case, the front-panel trimmer is disabled and the current is set using a DC voltage. When the /**Setpoint Enable Input** is set high or left open, the current is controlled using the trimmer. In order to control the /**Setpoint Enable Input** through a front-panel switch, consider the SMC121 module.

3.3.3 /Power Fault Input

This active-low input is used to shut the laser down when a power supply fault is detected. The /**Power Fault Input** is driven by the SMZ00 Power Interface module, which is able to provide such a signal. Until the /**Power Fault Input** goes high, the laser remains shorted whatever the level of the /**Laser Enable Input**.

3.3.4 /Temperature Fault Input

An low digital level on the /**Temperature Fault Input** shut the laser down immediately. This input is driven by the SMC20 Temperature Controller module to indicate that a severe fault is detected in the thermal control path. Until the /**Temperature Fault Input** goes high, the laser remains shorted whatever the level of the /**Laser Enable Input**. To enable the temperature monitoring, the **Temperature Fault Sensing Switch** located on the printed circuit board must be set.

3.3.5 Interlock Source Output

A low-resistance switch must be connected between the interlock terminals for the laser to operate. The **Interlock Source Output** is aimed to source +5 V through a current limiting resistor. Connect one of the switch contact to the **Interlock Source Output**. *This terminal is not allowed to contact ground or any other signal.*

3.3.6 Interlock Sense Input

When the Interlock Sense Input is driven low or left open, the laser is shut down immediately. Connect this input to the second terminal of the interlok switch. Until the **Interlock Sense Input** goes high, the laser remains shorted and whatever the level of the /**Laser Enable Input**. The **Interlock Sense Input** terminal is not allowed to contact ground or any other signal. To enable the interlock function, the **Interlock Status Switch** located on the printed circuit board must be set. In order to output the /**Interlock Sense Input** through a front-panel BNC connector, consider the SMC111 module.

3.3.7 /Laser On Output

The digital/**Laser On Output** is driven low when the laser is running.

3.3.8 /Limit Output

The digital/**Limit Output** is driven low to indicate that the current limiter is engaged.

3.3.9 /Source Output

The digital/**Source Output** is driven low to indicate that the current controller is a current source where the laser cathode terminal is grounded. This output can be used for example by the laser mount to prevent bad connections between the current controller and the laser diode.

3.3.10 Digital Power Supply

The digital circuitry of the module operates from a +5 V power supply. It is recommended to use the SMZ00 module to connect this source. The digital ground **DGND** terminal must be tied to the analog ground **AGND**.

3.3.11 Pin Assignments of the Digital Bus Connector

Signal label	Pin assignment	Direction
/Laser Enable	DIO.37	input
/Setpoint	DIO.35	input
Interlock Sense	DIO.40	input
/Temperature Fault	DIO.26	input (from C20 Temperature Controller)
/Power Fault	DIO.45	input (from Z00 Power Interface)
/Laser ON	DIO.36	output
/Limit	DIO.38	output
Interlock Source	DIO.42	output
+5 V	DIO.47	power input
+5 V	DIO.48	power input
DGND	DIO.49	power input
DGND	DIO.50	power input
Chassis	DIO.1	chassis ground input (Earth)

3.4 On-Board Settings and Connectors

There are three switches and one header on the printed circuit board.

3.4.1 Temperature Fault Sensing Switch

To disable the /**Temperature Fault Input**, set the **Temperature Fault Sensing Switch** off. This operation is not recommended because in this case the laser is not protected from a thermal control failure. Set the switch on for normal operation.

SW601.1	Temperature Fault Sensing Status
on	Enabled, normal operation
off	Disabled, not recommended operating mode

3.4.2 Interlock Status Switch

To disable the interlock function, set the **Interlock Status Switch** on. Because this operation is not recommended for safety reasons, the switch should be set in off-position for normal operation.

SW601.2	Interlock Status
on	Disabled, not recommended operating mode
off	Enabled, normal operation

3.4.3 Servo Source Selector Switch

To select which signal from the front-panel or the analog interface is used for the current modulation, the **Servo Source Selector Switch** must be set in proper position:

SW701.1	SW701.2	Servo Modulation Input from
on	off	Analog Interface terminals
off	on	Front-panel BNC

3.4.4 Digital Voltmeter Connector

The four-pin **Digital Voltmeter Connector** is intended to measure the DC operating current using a small digital voltmeter module (DVM). To connect the voltmeter, use the following pin assignments :

J202 pin	Signal	DVM pin
1	Current Monitor	Positive Input (High),
2	+5 V	Positive Power Supply, 100 mA max
3	Analog Ground	Negative Input (Low)
4	Digital Ground	Negative Power Supply (0 V)

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