User's Guide

SMC31 – *Mont-Aigoual* – 1A Linear TEC Driver

C-Series Modules – Laser Diode Controller

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1 General Information

1.1 Important notice

1.2 Scope

This manual provides the user with a description of the operation for the Linear TEC Driver module SMC31-R19A.

1.3 Related documents

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

Document	Release Number
Datasheet	SMC31-SS01-R19A
Block diagram	SMC31-SG01-R17A
Front-panel	SMC31-DD02-R17A
PCB Legend	SMC31-AG02-R19A

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 ??.

Contents

2 Overview

The SMC-Series modules are the ideal instruments for controlling the current and the temperature of diodes laser for AMO physics. With an ultra-low current noise density $\leq 20\,\mathrm{pA}/\sqrt{\mathrm{Hz}}$ (SMC10) and sub-mK thermal control stability (SMC20 & SMC31), the SMC-Series is the right choice for the most demanding applications.

Because the SMC31 TEC Driver was first designed as power stage of the SMC20 temperature controller, it features an efficient power voltage-to-current converter. Using the SMC31, continuous output current up to 1 A can be delivered to the thermoelectric cooler. Since noise is a primary concern, the SMC31 is based on a linear power amplifier stage providing a clean output current.

In addition, the SMC31 offers multiple protection features, including current limitation, over-temperature and short-circuit detection. Thermistor and TEC connections from the laser head to the SMC-Series Controller modules are made by the use of a DSUB-9 connector (male) located on front-panel.

Like all SM-Series modules, the SMC20 is shipped with the schematic diagrams of its electronic circuitry providing all required information for advanced users.

2.1 Description

The SMC31 Linear TEC driver was designed to provide a clean output current to the TEC. For this purpose, an analog power stage is used instead of a switched-mode power amplifier. This choice leads to an output current free of digital spikes that can degrade the performance in term of laser frequency noise. The second benefit of the linear amplifier over its switching counterpart is the absence of limit-cycles when the temperature controller operates in constant temperature mode. This type of oscillations during the closed-loop operation is indeed due to the non-linearity of the actuator and the dead-zone that exists in a switched-mode amplifier is drastically reduced in this linear driver.

Referring to the block diagram (section **??**), the output current is delivered to the TEC by a bridge-amplifier operating in a Voltage-to-Current Converter configuration (VCC). The load is connected between the two outputs of the VCC. A current sense resistor provides measurement of the current flowing through the TEC.

The VCC is driven by the command voltage delivered by the SMC20 Temperature Controller. The polarity of the command signal can be changed to restore the stability of the closed-loop. The current is sourced to the TEC when the temperature controller is engaged.

The power stage is protected against an excessive temperature of the output amplifiers. Such fault can be detected after an output overload resulting from a short circuit. The protection of the TEC includes a current limiting function that prevents the TEC current from operating at current levels exceeding 1 A. Moreover, if the SMC20 Temperature detects a thermistor fault or an out-of-range laser diode temperature, then the VCC power stage is immediately disabled and no current is sourced to the TEC.

A D-SUB9 male connector is provided to connect the laser thermal parts to the TEC driver and temperature controller. Spare terminals of this connector are allowed for custom applications. Because all signals are connected to the analog interface, it is possible to use a different connection scheme than original D-SUB9. The status of the TEC Driver is displayed using three leds on the front-panel. This information is also available through the digital interface. A header is provided on the printed ciruit board in order to measure the TEC's current using a small digital voltmeter. Consider the SMC121 and SMC112 modules to access some of the TEC Driver's signals using BNCs and switches.

2.2 Connections to the temperature controller

The SMC20 Temperature Controller was designed to operate with the SMC31 Linear TEC Driver through the analog and digital interfaces. To allow operation, the modules need to be stacked.

2.3 TEC connections to the driver

The TEC terminals are connected to the driver output using the **Laser Temperature Connector**. Refer to the *Front Panel Specifications* for pin assignments. If this connector can not be used, the **Analog I/O Interface Connector** provides an access to the VCC outputs.

2.4 Thermistor connections to the temperature controller

The thermistor terminals are connected to the **SMC20 Temperature Controller** through the **Laser Temperature Connector**. Refer to the *Front Panel Specifications* for pin assignments. If this connector can not be used, the **Analog I/O Interface Connector** provides an access to the thermistor.

2.5 Spare connections to the laser head

Additional connections to the laser head are allowed using the **Laser Temperature Connector**. They are intended for custom applications like thermalization of the laser diode's case using a second TEC-thermistor pair. Refer to the *Front Panel Specifications* for pin assignments.

3 Operation

3.1 Front-panel

There are three leds and one D-SUB9 connector on the front-panel, they are described in this section. Refer to the section **??** for more information on the front-panel.

3.1.1 Laser Temperature Connector

The male D-SUB9 marked **Laser Temperature Connector** allows the user to connect the thermal parts of the laser head to the TEC driver and SMC20 Temperature Controller module. While four terminals are dedicated to this purpose, the remaining pins of the connector are provided for custom applications. For instance, these terminals can be used to control the case's temperature of the laser diode using a second TEC-thermistor pair. *None of the terminals is allowed to contact ground or any other signal.* To connect the laser head to the **Laser Temperature Connector**, use the assignments:

Pin	Signal	Description
1	$TEC+$	TEC positive terminal
2	$TEC-$	TEC negative terminal
3	$PWR1$	power signal, custom application
4	$PWR2$	power signal, custom application
5	$SIG3$	low-power signal, custom application
6	$RT+$	thermistor terminal
7	$RT-$	thermistor terminal
8	$SIG1$	low-power signal, custom application
9	$SIG2$	low-power signal, custom application
Shield	*Chassis*	Earth ground

3.1.2 Status Leds

These three leds are intended to display the TEC driver status.

Led	Status
Green	TEC driver operating
Red	Fault (over-temperature) detected
Yellow	Current limiter engaged

3.2 Analog I/O interface connector

Like all SMC-Series modules, the SMC31 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 Command Input

The Voltage to Current Converter (VCC) of the SMC31 is drived by the **Command Input** voltage. Up to $\pm 1\,A$ can be sourced to the thermoelectric cooler (TEC) for a $\pm 10\,V$ input. While the **Command Input** signal is normally delivered by the SMC20 Temperature Controller module *via* the Analog interface bus, another temperature controller can be used. In this case, the command signal must be applied to this input.

3.2.2 Current Monitor

The output current flowing through the load can be measured using the **Current Monitor** signal. This output is able to drive light loads such as digital voltmeter. Can be left open if not used. In order to access this signal through a front-panel BNC connector, consider the SMC112 module.

3.2.3 Positive Thermoelectric Cooler Output

The **TEC+ Output** is connected to the positive output of the VCC. This signal is dedicated to specific laser head connections. *This terminal is not allowed to contact ground.* Left open if not used.

3.2.4 Negative Thermoelectric Cooler Output

The **TEC- Output** is connected to the negative output of the VCC. This signal is dedicated to specific laser head connections. *This terminal is not allowed to contact ground.* Left open if not used.

3.2.5 Spare Power Signal

The power signals **PWR1** and **PWR2** are connected to the **Laser Temperature Connector** located on the front-panel. They can be used for specific applications where a connection to the laser head is required, in order to drive another TEC for example. Left open if not used.

3.2.6 Spare Low-Power Signal

The low-power signal **SIG1**, **SIG2** and **SIG3** are connected to the **Laser Temperature Connector** located on the front-panel. They can be used for specific applications where a connection to the laser head is required, in order to use a second thermistor for example. Left open if not used.

3.2.7 Positive Thermistor Input

The **RT+ Input** terminal is used by the SMC20 Temperature Controller to measure the temperature of the laser diode. When the SMC31 is used, this input is available on the **Laser Temperature Connector** located on front-panel. *This terminal is not allowed to contact ground.* Left open if not used.

3.2.8 Negative Thermistor Input

The **RT- Input** is used by the SMC20 Temperature Controller to measure the temperature of the laser diode. When the SMC31 is used, this input is available on the **Laser Temperature Connector** located on front-panel. *This terminal is not allowed to contact ground.* Left open if not used.

3.2.9 Reference Ground Output

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

3.2.10 Analog Power Supply Inputs

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

3.2.11 Pin assignments

Signal label	Pin assignment	Direction
Thermistor RT+	AIO.23	input (to SMC20)
Thermistor RT-	AIO.25	input (to SMC20)
Command	AIO.32	input (from SMC20)
Current Monitor	AIO.22	output
Reference Ground	AIO.20	output
TEC+	AIO.19	output
TEC-	AIO.21	output
PWR1	AIO.15	input/output
PWR2	AIO.17	input/output
SIG1	AIO.16	input/output
SIG2	AIO.18	input/output
SIG3	AIO.14	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	Earth - Chassis ground input

3.3 Digital I/O Interface connector

Like all SMC-Series modules, the SMC31 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 /Controller On Output

The operation of the power stage is controlled by the SMC20 Temperature Controller using its /**Controller On Output**. Thus, the VCC output current is allowed to flow through the TEC when the temperature controller is engaged and if no fault is detected.

3.3.2 /Negative Polarity Input

In order to provide a stable closed-loop when the SMC20 Temperature Controller operates in Constant Temperature mode, the polarity of the VCC path can be changed using the /**Negative Polarity Input**. The sensitivity of the **Command Input** is negative when the /**Negative Polarity Input** is driven low. Positive polarity is obtained when the /**Negative Polarity Input** is high or left open. For proper operation of this input, the **Polarity Selector Switch** located on the printed circuit board must be switched off. In order to control this input through a front-panel switch, consider the SMC121 module.

3.3.3 /Amplifier Fault Output

The /**Amplifier Fault Output** is driven low if a thermal overload of the VCC's power stage is detected. Such fault can result from a short-circuit at VCC's outputs. Left open if not used.

3.3.4 /Amplifier On Output

The /**Amplifier On Output** is driven low when the TEC driver is operating. Can be left open if not used.

3.3.5 /Limiter Output

The VCC features an output current limiter that prevents TEC operation above 1 A. The /**Limiter Output** is driven low when the limiter is engaged. Can be left open if not used.

3.3.6 Digital Power supply

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

3.3.7 Pin Assignments

Signal label	Pin assignment	Direction
/Controller On	DIO.28	output (from SMC20)
/Fault	DIO.21	output
/Limiter	DIO.24	output
/On	DIO.23	output
/Negative Polarity	DIO.22	input
+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	Earth - Chassis ground input

3.4 PCB Settings and Connectors

There are one switch and one header on the printed circuit board.

3.4.1 Polarity Selector Switch

The switch labeled SW301A on the printed circuit board is allowed to select the sign of the sensitivity of the **Command Input**. When the switch is on, the polarity is negative whatever the level of the digital /**Negative Polarity Input**. If the switch is off, the sign is controlled by the digital input.

/Negative Polarity Input	SW301A	Polarity
Low, High or left open	On	Negative
High or left open	Off	Positive
Low	Off	Negative

3.4.2 Digital Voltmeter Connector

The four-pin **Digital Voltmeter Connector** is intended to measure the current through the load using a small digital voltmeter module (DVM). For this purpose the **Current Monitor Output** is connected to this header (J203). To connect the voltmeter, use the following pin assignments :

J203 pin	Signal	DVM pin
1	Current Monitor	Positive Input (High), sensitivity +1 A/V
2	+5 V	Positive Power Supply, 100 mA max
3	Analog Ground	Negative Input (Low)
4	Digital Ground	Negative Power Supply (0 V)

4 Circuitry

4.1 Circuit description

The module is powered by ±15 V from the analog interface connector (J201) and by +5 V from the digital interface connector (J301). These power supply inputs are both protected against reverse voltage and over voltage transients.

The power stage, based on two power operational amplifiers in a bridge (U402A and U401A), is organized to source bidirectional currents to the TEC from the +5 V power supply. For this purpose, U401A acts as a current pump while the other arm of the bridge is powered by U402A. The load is connected to the bridge output through a current sense resistor. The gain of the current pump is both given by this resistance and the resistor ratio RA405A/R403. The same current sense resistor provides TEC current measurement using the instrumentation amplifier U405. The output current limiter is set to ±1.2 A by the resitors R401 and R407. The protection of the output stage against short-circuits and over-temperature operation is done using the thermal flags of the power amplifiers as fault events leading to a power stage shutdown.

The command signal from the temperature controller (J201) is applied to the power stage through a differential amplifier (U407). The conditional inversion of the command signal is done using U407A which polarity is controlled by U403A.

4.2 Printed circuit board legend

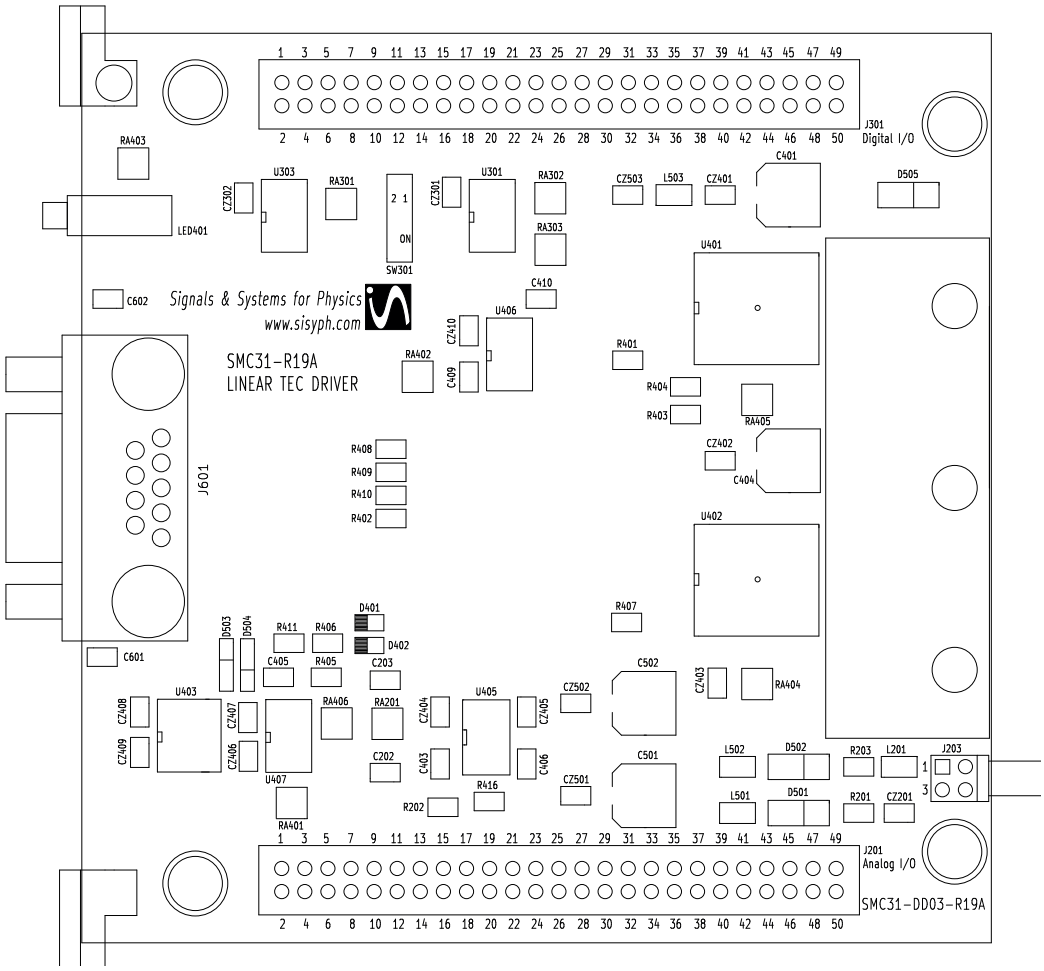

Figure 1: SMC31 Printed Circuit Board legend

Document Revision History

Release	Comments
SMC31-SN01-R19A	Added gender of DSUB connector Updated module identifiifier Updated current noise density of SMC11 Completed name *Mont-Aigoual* Updated PCB legend
SMC31-SN01-R17A	first release