User's Guide

SMA10 – RF Frequency Mixer

A-Series Modules – Laser Frequency Stabilization

SISYPH
Signals & Systems for Physics

phone (+33)781-547-391
www.sisyph.com

Contents

1 Scope

The information given in this guide applies to the SMA10-R15B module and its related documents or hardware

Related document	Release number
Circuit diagram	SMA10-DD02-R15B
Printed circuit board	SMA10-DD02-R15B

2 Overview

The SMA10 module is an electronic board for use in laser frequency stabilizations where the frequency offset $\delta\nu$ between the laser source and the resonance of the reference cavity requires tight and quick control. When used in a Pound-Drever-Hall locking scheme, the SMA10 acts as a frequency discriminator and provides a voltage related to the frequency offset.

In the abundant litterature covering the topic of the laser stabilization, the frequency error voltage is usually approximated as

$$\epsilon\,(V) = \frac{2.71 R P_{\mathrm{i}}}{\Delta\nu}\delta\nu \tag{1}$$

where $\Delta\nu$ is the cavity linewidth in units of Hz, R is the responsivity of the amplified photodetector in V/W and P_{i} is the incident light power in watt. The numeric value 2.71 is calculated assuming a phase modulation index β of 1.1.

The signal ϵ in the equation above is the amplitude of the RF signal delivered by the photodetector and oscillating at the phase modulation frequency. Since the required frequency translation of the error spectrum is obtained by a down-converter mixer, the designer of the control loop must take account of the conversion gain noted χ in units of V/V. The error output voltage e of the SMA10 module is given by

$$e\,(\mathrm{V}) = \frac{2.71 R P_{\mathrm{i}}}{\Delta\nu}\chi\delta\nu \tag{2}$$

This error signal is further processed by a high-speed compensator (SMA20 module) to maintain the frequency offset under control.

3 Operation

3.1 Front panel

There are a total of three SMAs and one BNC on the front panel, they are described in this section.

3.1.1 Photodetector Input

Connect the amplified photodetector output with a 50-ohm coaxial cable. After passing through isolation and coupler stages, the **Photodetector Input** signal is applied to the RF input of the mixer. The power level should be lower than +14 dBm and *DC voltages are not tolerated.*

3.1.2 Oscillator Input

Connect the phase reference signal coming from the RF source with a 50-ohm coaxial cable. The source can be either a SMA40 module or a RF signal generator. The required power input level for proper operation is +17 dBm. After an isolation stage, the **Oscillator Input** signal is applied to the LO input of the mixer. *DC voltages are not tolerated.*

3.1.3 Photodetector Monitor

This output signal is intended for closed-loop spectral analysis of the RF error signal, usually using a spectrum analyzer. It provides a copy (−20 dB) of the **Photodetector Input**. This output should be terminated in a 50-ohm load if not used.

3.1.4 Error Monitor

This BNC provides a tenfold copy of the error output for a DC-analysis using a oscilloscope or a signal analyzer. An AC/DC coupling selector located on the printed circuit board is provided to remove the DC component. Left the **Error Monitor** output open if not used.

3.2 Bus Headers Connections

Like all SMA-Series modules, the SMA10 has two 50-pin stack-through headers acting as Analog I/O and Digital I/O busses. In this section each pin allocated to the SMA10 operation is described.

3.2.1 Error Output

The error signal is transmitted to the bus using the differential pair (**ERR-POS**, **ERR-NEG**). The module using this signal (such as the high-speed compensator SMA20) retrieves the error information with a differential input stage.

3.2.2 Reference Input

The **Reference Input** signal is summed to the error and provides a convenient way to adjust the frequency offset during closed-loop operation. Its ON/OFF operation is controlled by the digital bit /**REF**. Use the differential pair (**REF-POS**, **REF-NEG**) to apply the control voltage. Left open if not used.

3.2.3 External IF Input

This signal is intended to bypass the mixer during tests. Its ON/OFF operation is controlled by the digital bit /**IF**. Use the differential pair (**IF-POS**, **IF-NEG**) to apply the user controlled IF voltage. Left open if not used.

3.2.4 Signal Ground

A clean signal ground **GND** is provided as a reference for measurements purposes. *Do not connect this pin to a ground signal*, use a differential sense circuit. Left open if not used.

3.2.5 Reference Control Input

This active-low input controls the ON/OFF operation of the **Reference Input**. An internal pull-up resistor sets automatically the reference signal OFF when the control input /**REF** is left open.

3.2.6 External IF Control Input

This active-low input controls the ON/OFF operation of the **External IF Input**. An internal pull-up resistor sets automatically the external IF signal OFF when the control input /**IF** is left open.

3.2.7 Power Supply

The module needs analog ±15 V and digital +5 V power supplies. It is recommended to use the SMA00 module to connect these sources.

3.2.8 Pin Assignments

The pin allocations of the **Analog I/O** and **Digital I/O** stack-through headers are given in Tables 1 and 2.

Signal label	Pin assignment	Direction
ERR-POS	AIO.38	output
ERR-NEG	AIO.40	output
REF-POS	AIO.4	input
REF-NEG	AIO.6	input
IF-POS	AIO.8	input
IF-NEG	AIO.10	input
GND	AIO.39	output
−15 V	AIO.45	input
+15 V	AIO.47	input
AGND	AIO.49	input

Table 1: Analog I/O connector pin assignments.

Signal label	Pin assignment	Direction
/REF	DIO.42	input
/IF	DIO.41	input
+5 V	DIO.47 & DIO.48	input
DGND	DIO.49 & DIO.50	input

Table 2: Digital I/O connector pin assignments.

3.3 On-board Settings

3.3.1 AC/DC Coupling Selector

Use this switch located on the printed circuit board to remove the DC component of the **Error Monitor** output. When the switch is on, the monitoring signal is DC-coupled. This setting has no effect on the **Error Output** signal behavior.

4 Circuit Description

The **Photodetector Input** J301 is isolated from the signal ground by the transformer RF301. This avoids ground-loops while maintaining the 50-ohm termination while the capacitor CY301 provides an AC-path to the chassis ground. The output of the transformer is then applied to the coupler RF303 whose the −20 dB coupled output provides the **Photodetector Monitor** signal (J302). The main output of the coupler is fed to the RF mixer (RF304) input. The **Oscillator Input** J303 is also isolated from the local ground using the transformer RF302 whose output is applied to the LO input of the mixer.

The relay K301B is intended to choose the IF signal between the output of the mixer and the **External IF Input** signal. The relay is controlled by the inverters U301A, U301B and U301C whose inputs are connected to the /**IF** pin of the **Digital I/O** connector. Before being used, the differential (**IF-POS**, **IF-NEG**) signal is fed to the difference amplifier U303A providing 50-ohm termination and isolation. The differential input signal is available through the **Analog I/O** connector. When the digital input /**IF** is left open, the IF signal is switched to the mixer output allowing normal closed loop operation.

The IF signal is then applied to the passive network L301 L302 C316 and C315. These components allow the implementation of first and second order low-pass filters or diplexer, the latter ensuring the mixer output a constant termination within a wide frequency range. By default, none of these filters are implemented because they must be tuned precisely to the application to avoid a phase margin degradation.

In order to control the closed-loop error voltage throughout the **Analog I/O** bus, a reference signal is summed to the amplified IF signal (U302A). The differential input signal (**REF-POS**, **REF-NEG**) is fed to the differential amplifier U303C that provides isolation and 50-ohm load termination. The operation is controlled through the **Digital I/O** bus by the digital input /**REF**. This input, which is buffered by the inverters U301E, U301F and U301D, can be left open if it is unused. In this case, the reference signal is off.

The **Error Monitor** output provides a tenfold copy (U305A) of the error voltage. The switch S301 located on the printed circuit board permits the use of DC-block capacitors C318 and C319 to remove the DC component of the error signal. The capacitor C320, which is not installed by default, introduces a pole in the feedback path of the amplifier to reject the high frequency spectrum.

Finally, the error voltage is buffered by a differential stage (U304A and U304C) and fed to the (**ERR-POS**, **ERR-NEG**) pins of the **Analog I/O** connector.

Document Revision History

Release	Comments
SMA10-SN01-R15A	first release

Notice