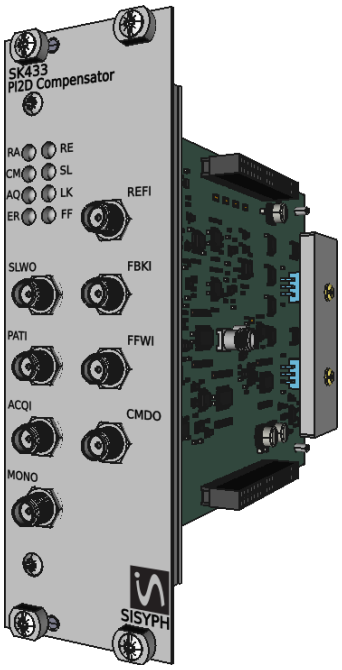
Datasheet

SK433*Velay*
PI2D Compensator

SK-Series Modules

Features

- **Analog high-speed PI2D w/ digital control**
- **Bandwidth ≥ 10 MHz, delay ≤ 30 ns**
- **Input noise ≤ 10 nV/rtHz**
- **De-saturation auxiliary loop**
- **Analog design – Free of digital noise**
- **Remote interface**
- **Platform and stand-alone operation**



Applications

- **Pound-Drever-Hall laser locking**
- **Optical phase-locked laser**
- **Optical frequency combs**
- **Quantum physics and engineering**
- **Time & Frequency instrumentation**

General Description

Overview

The SK433 *PI2D Compensator* was primary designed for use in laser control applications involving high-speed servo loops. Low-noise and wide bandwidth closed-loop performances are achieved through a low-noise front-end differential amplifier followed by a programmable PI²D compensator.
The SK433 also includes an auxiliary integrator which can be used for preventing the saturation of the high-speed primary loop. Indeed, by using this integrator within an secondary servo loop, the PI2D's output signal can be automatically detrended. Like all modular instruments of the SK-Series, the SK433 *PI2D Compensator* can be operated stand-alone or within a platform where several modules can be assembled to configure a specific control or measurement system. For example, the SK433 can be coupled to the SK301 *RF Demodulator* for high-performance, closed-loop laser frequency control.

Functional Block Diagram

Refer to the *Functional Block Diagram* available online for a synthetic presentation of the SK433.

User's Guide

The last version of the SK433 *User's Guide* is available online at the product page.

Programming Guide

The online *Programming Guide* provides a detailed description of the SK433's remote commands.

Remote Interface

SK433's settings are changed through the remote interface. All instrument settings can also be queried *via* the remote interface. The module generates a status signal to report a specific event to the host computer. The SK433 can be operated either inside or outside the dedicated SPK-Series platform.

Front-Panel Display

The front panel of the SK433 provides the user with minimal information about the status of the instrument.

PI²D Compensator

The SK433 features a configurable high-speed compensator operating from an internally generated error signal. This signal is provided by the input differential amplifier, which compares the feedback signal to the reference. Both external feedback and reference signals can be connected to the differential amplifier *via* several interfaces : either front-panel SMA, user terminal blocks or expansion connector can be used. Several options are provided for the reference signal : the related input of the differential amplifier can be either i) routed to the external input, ii) driven by the internal setpoint DAC or, iii) tied to the analog ground voltage. The error voltage is first processed by the high-frequency integrator. Due to its limited output voltage range, this integrator may not be able to provide alone the required drive DC-level. The low-frequency integrator or the offset DAC must be used to extend the locking range. The programmable gain amplifier, designed to preserve the low-noise specifications of the input difference amplifier, is completed with a differentiator stage to form a high-speed PID compensator.

Slow Compensator

The PI²D compensator is able to provide tight and fast control when it is used to drive a fast actuator. Unfortunately, high-speed actuators are usually less powerful than their slower counterparts and a saturation of the command signal may occurs when the PI²D compensator has to compensate large drifts. In order to maintain the loop locked over a wider range, a second loop can be used to automatically remove the large DC-components of the command signal. For this purpose, the SK433 features an auxiliary integrator whose output can be used to drive a much more powerful actuator, forming a secondary slow-loop able to prevent the saturation the main command signal.

Search Pattern Signal

Search pattern signals are specific open-loop command signals used to acquire lock for open-loop systems featuring a narrow sensor range. During the acquisition phase, the search pattern signal is routed to the command output to obtain a relevant sensor signal. Locking is then obtained by switching the command from the pattern signal generator to the compensator's output. Switching from the acquisition phase to lock can be provided by an external out-of-range detector, which continuously analyzes the sensor's output signal. Search pattern signal can be also used to sweep the manipulated variable over the desired locking point for system optimization purposes.

Specifications

PI²D Compensator

Control Law
Digitally configurable, analog PI²D + offset

Inputs (REFI, FBKI)
Interface	SMA, UTB, EXP
Impedance	1 kΩ
Range	±4 V
Bandwidth	≥ 10 MHz

Reference Setpoint DAC
Range	−2500 mV to +2500 mV
Resolution	1 mV
Precision	1 %
1-h Drift	≤ 10 µV

Error Fine Control DAC
Range	−25 000 µV to +25 000 µV
Resolution	10 µV
Precision	1 %
1-h Drift	≤ 10 µV

Internal Error
Range	±4 V
CMRR	≥ 120 dB at $f = 100$ Hz
	≥ 100 dB at $f = 10$ kHz
Initial Offset	≤ 2 mV at ERRC = 0 µV
Noise	≤ 10 nV/$\sqrt{\text{Hz}}$, $f \geq 10$ kHz

Proportional Gain
Gain	−21 dB to +23 dB in 3-dB steps
Precision	±1 dB
Bandwidth	≥ 10 MHz
Delay	≤ 25 ns, from FBKI to CMDO

Low-Frequency Integrator
0-dB Freq.	10 Hz to 100 kHz in 1-2-5 steps
Precision	20 %

High-Frequency Integrator
0-dB Freq.	100 Hz to 1 MHz in 1-2-5 steps
Precision	20 %

High-Frequency Differentiator
0-dB Freq.	500 Hz to 5 MHz in 1-2-5 steps
Precision	20 %
HF-Gain	+12 dB or +20 dB, ±2 dB

Feed-Forward Input (FFWI)
Interface	SMA, UTB, EXP
Impedance	100 kΩ
Input Range	±5 V
Output Range	±2.5 V
Output Atten.	0.5 V/V, fixed
Transm. Gain	variable, from −100 % to +100 %
Bandwidth	≥ 150 kHz
Rise/Fall Time	≤ 5 µs
Turn-On Delay	≤ 5 ms

Output (CMDO)
Interface	SMA, UTB, EXP
Impedance	50-Ω series
Range	±4 V

Output Offset DAC
Range	−2500 mV to +2500 mV
Resolution	1 mV
Precision	1 %
1-h Drift	≤ 1 mV

Slow Compensator

Control Law
Digitally configurable, analog integrator + offset

Output (SLWO)
Interface	SMA, UTB, EXP
Impedance	50-Ω series
Range	±10 V

Output Offset DAC
Range	−5000 mV to +5000 mV
Resolution	2.5 mV
Precision	5 %
1-h Drift	≤ 100 µV

Integrator
0-dB Freq.	0.1 Hz to 1000 Hz in 1-3-10 steps
Precision	20 %

Lock Acquisition

Search Pattern Input (PATI)
Interface	SMA, UTB, EXP
Impedance	100 kΩ
Range	±1 V.

Internal Search Pattern Generator
Waveform	triangle, symmetrical
Period	3 ms to 10 s in 1-3-10 steps
Amplitude	1 V_{pp} to 12 V_{pp} in 3-dB steps

Feed-Forward Input (ACQI)
Interface	SMA, UTB, EXP
Impedance	100 kΩ
Range	0 V to +5 V
Threshold	+1 V to +4 V in 500-mV steps
Delay	≤ 2 ms

Monitoring

Monitoring Output (MONO)
Interface	SMA connector, UTB, EXP
Impedance	100-Ω series
Max. Level	±10 V

General Characteristics

This module is designed to be operated in laboratory environment.

Operating Temperature

Range	+15 °C to +40 °C non-condensing

Host PC Communications

UART format	9600 baud, 8-bit data 1 stop-bit, no flow control
Interface	DIN41612 backplane connector

Connectors

Backplane	DIN41612-C96 male
Expansion/Test	
AIO	40-pin PC/104 header
DIO	40-pin PC/104 header
SLWO	SMA front-panel, left
PATI	SMA front-panel, left
ACQI	SMA front-panel, left
MONO	SMA front-panel, left
REFI	SMA front-panel, right
FBKI	SMA front-panel, right
FFWI	SMA front-panel, right
CMDO	SMA front-panel, right
AGND	SMA, pcb, top side

Front-Panel Indicators

RE, RA	Remote interface error, activity
CML	Saturation, PI²D command
CSL	Saturation, slow-command
ER	Saturation, error signal
FF	Feed-forward enabled
LK	Lock state

Power Supply Inputs

Analog	+15 V × 200 mA
Analog	−15 V × 200 mA
Digital	+5 V × 30 mA

Printed Circuit Board

Form factor	Eurocard.
Dimensions	100 × 160 × 1.6 mm (carrier) 100 × 150 × 1.6 mm (mezzanine)
Technology	4-layer, improved FR-4

Physical Properties

Height	128.4 mm (3U)
Width	Double-wide, 40 mm (8HP)
Depth	174.5 mm
Weight	≈ 300 g
Front-Panel	Anodized aluminium with rear conductive

Warranty

One (1) year parts and labor on defects

Ordering Information

SK433 Module

The SK433 module can be ordered with different options.

Ordering Code	Front-Panel Options
SK433-FP	Shielded 3U-8HP front-panel (standard)
SK433-NP	No front-panel

Accessories

No accessories are related to the SK433 module.

Document Identifier

This document is identified by SK433-SU02-P24A.

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Important Notice

Information in this document is subject to change without notice.

Signals and Systems for Physics
BP90406
16 place saint-Georges
F31000 Toulouse France
Phone (+33) 781 547 391
www.sisyph.com