Operation and Service Manual

Scaling Amplifier

SIM983

Stanford Research Systems

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General Information

The SIM983 Scaling Amplifier, part of Stanford Research Systems' Small Instrumentation Modules family, performs the function

$$V_{\text{out}} = G \times (V_{\text{in}} + V_{\text{ofs}})$$

where V_{in} and V_{out} are voltages (up to ±10 V) at the input and the output of the instrument, respectively, G is a user-specified gain, and V_{ofs} is a user-specified offset voltage. The instrument is accurate within its resolution.

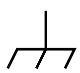
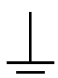
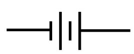
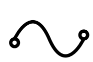
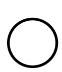
Safety and Preparation for Use

The front-panel input, front-panel output, and the rear-panel output coaxial (BNC) connectors in the SIM983 are referenced to the Earth, and their outer casings are grounded. No dangerous voltages are generated by the module.

Do not exceed ±15 *volts to the Earth at the center terminal of each BNC connector.* Do not install substitute parts or perform unauthorized modifications to this instrument.

The SIM983 is a single-wide module designed to be used inside the SIM900 Mainframe. Do not turn on the power to the mainframe or apply voltage input to the module until the module is completely inserted into the mainframe and locked in place.

Symbols you may Find on SRS Products

Symbol	Description
	Alternating current
	Caution - risk of electric shock
	Frame or chassis terminal
	Caution - refer to accompanying documents
	Earth (ground) terminal
	Battery
	Fuse
	On (supply)
	Off (supply)

Notation

The following notation will be used throughout this manual:

- Front-panel buttons are set as [gain];
  [gain ▲▼] is shorthand for "[gain ▲] & [gain ▼]".
- Front-panel indicators are set as *OVLD*.
- Signal names are set as ¬STATUS.
- Signal levels are set as HIGH.
- Remote command names are set as *IDN?.
- Literal text other than command names is set as `OFF`.
- Special ASCII characters are set as ⟨CR⟩.

Remote command examples will all be set in monospaced font. In these examples, data sent by the host computer to the SIM983 are set as `straight teletype font`, while responses received by the host computer from the SIM983 are set as *`slanted teletype font`*.

Specifications

Performance Characteristics

		Min	Typ	Max	Units
Input	Voltage [1]	−10.0		+10.0	V
	Coupling	DC			
	Resistance	0.99	1.00	1.01	MΩ
	Capacitance		8		pF
	Bias current [2]			40	pA
	Voltage noise [3, 4], 1 kHz		53		$nV/\sqrt{Hz}$
	10 kHz		44		$nV/\sqrt{Hz}$
	Current noise, 10 kHz		10		$fA/\sqrt{Hz}$
	Terminals	Grounded BNC [5]			
Gain	Absolute value	0.01		19.99	
	Polarity	Inverting, non-inverting			
	Resolution	0.01			
	Accuracy [2]	±0.01			
	Stability			±10	ppm/°C
Offset [3]	Voltage	−10.00		+10.00	V
	Resolution, $\lvert V_{ofs}\rvert \leq 1.999$ V	1			mV
	$\lvert V_{ofs}\rvert \geq 2.00$ V	10			mV
	Accuracy [2, 4, 6]	±1 ± 200			mV + ppm
	Stability [4]			±20 ± 20	(μV + ppm)/°C
	Settling time [7]			2	s
AC performance	−3 dB bandwidth, $\lvert G\rvert \leq 1.00$	2.0			MHz
	Gain-bandwidth product, $\lvert G\rvert \geq 1.00$	3.0			MHz
	[8] $\lvert G\rvert \geq 2.40$	5.0			MHz
	$\lvert G\rvert \geq 4.20$	10.0			MHz
	$\lvert G\rvert \geq 9.60$	17.0			MHz
	Slew rate	70			V/μs
	THD, 1 kHz			−80	dB
Output	Voltage [1]	−10.0		+10.0	V
	Maximum current	±100			mA
	Short circuit duration	Indefinite			
	Resistance		50		Ω
	Terminals	Grounded BNC, front [5] and rear [9]			
Operating	Temperature [10]	0		40	°C
	Power	+5, ±15			V DC
	Supply current, +5 V		100		mA
	±15 V		300		mA

Conditions:

[1] An overload will be detected and the instrument is not guaranteed to perform properly if these limits are exceeded, or if $|V_{in} + V_{ofs}|$ exceeds the limits. Continuous application of an input voltage V_{in} in excess of ±15 V will damage the instrument.
[2] At 23 °C.
[3] Referred to input.
[4] For $|G| \geq 1$. For $|G| < 1$, the specification applies to the output-referred noise and offset.
[5] Amphenol 31–10–4052 or similar.
[6] Following an autocalibration at (23 ± 5) °C within 24 hours; following a 2-hour warmup.
[7] To within 0.1% of the final value.
[8] The gain-bandwidth product (GBP) determines the −3 dB bandwidth: For gain G, the bandwidth is GBP/$|G|$.
[9] Tyco 227169–4 or similar.
[10] Non-condensing.

General Characteristics

Interface	Serial (RS–232) through SIM interface
Connectors	BNC (2 front [5], 1 rear [9]); DB–15 (male) SIM interface
Weight	1.5 lbs
Dimensions	1.5″ W × 3.6″ H × 7.0″ D

1 Getting Started

This chapter gives you the necessary information to get started quickly with your SIM983 Scaling Amplifier.

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1.1 Introduction to the Instrument

The SIM983 Scaling Amplifier provides fine adjustable gain and offset control of an analog signal. The gain ($0.01 \leq |G| \leq 19.99$), its polarity (inverting or non-inverting), and the offset voltage ($-10.00\,\mathrm{V} \leq V_{\mathrm{ofs}} \leq +10.00\,\mathrm{V}$) can be set from either the front panel or remotely. A remote computer can access the module through the SIM900 Mainframe, using RS–232 or GPIB.

remote interface

The digital control circuitry in the SIM983 is designed with a special clock-stopping architecture. The microcontroller is turned on only when the polarity, gain, or offset are being changed, during remote communications, or when an overload condition occurs. This guarantees that no digital noise contaminates low-level analog signals. A user-commanded autocalibration procedure allows one to control the input-referred offset to within ±1 mV of the desired value.

DC accuracy

The amplifier's high slew rate allows it to output a ±10 V peak-peak sine wave at a frequency of 1 MHz. The gain stage of the amplifier is compensated in a flexible fashion to provide a sensible pulse response, so the bandwidth of the instrument is adjusted according to its gain[1]. The ample output current in the SIM983 permits one to drive a 50 Ω load.

AC performance

If the maximum input voltage is exceeded, or the gain or offset cause the output voltage to exceed its maximum, the appropriate overload LED turns on. If armed, the module also generates a status signal to alert the user of the overload condition. The SIM983 can be operated outside the SIM900 Mainframe by powering it with its required DC voltages.

A block diagram of the amplifier is shown below in Figure 1.1.

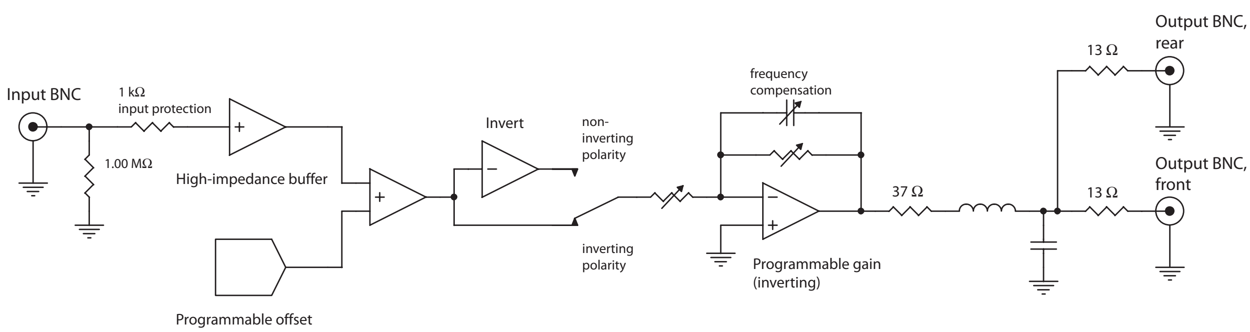

Figure 1.1: The SIM983 block diagram.

[1] The gain-bandwidth product changes with the gain.

1.1.1 Front and rear panels

Figure 1.2: The SIM983 front and rear panels.

1.2 Front-Panel Operation

1.2.1 Polarity

The polarity is the sign of the gain. It is indicated on the upper display of the front panel. To change the polarity, press the [polarity] button once. Holding this button has no effect.

Pressing the [polarity] button has no effect on the input-referred offset. However, a simultaneous press of [polarity] and one of [gain ▲▼] has a special meaning. This press initiates autocalibration (Section 2.2).

1.2.2 Gain

The gain G can be set to an absolute value between 0.01 and 19.99. To raise or lower the absolute value of the gain, press the button [gain ▲] or the button [gain ▼]. The decimal point position of the gain displayed on the front panel is fixed, so the resolution of the gain is 0.01. If the button [gain ▲] is pressed when the gain $G = \pm 19.99$, the press has no effect. If the button [gain ▼] is pressed when $G = \pm 0.01$, the press has no effect. Pressing the [gain ▲▼] buttons does not change the polarity.

If a [gain ▲▼] button is pressed and held, the gain is continuously adjusted. The rate of the adjustment increases as the button is held. If the absolute value of the gain is being lowered, the rate of the adjustment changes as $|G|$ crosses 1.00, and possibly again as $|G|$ crosses 0.10.

resetting gain

If *both* [gain ▲] and [gain ▼] buttons are pressed at the same time, the absolute value of the gain is reset to 1.00. This action does not change the polarity.

Pressing one of [gain ▲▼] and [polarity] at the same time has a special meaning. This press initiates autocalibration (Section 2.2).

1.2.3 Offset

The input-referred voltage offset V_{ofs} can be set to a value between −10.00 V and +10.00 V. Its value, in volts, is shown on the second line of displays on the front panel of the amplifier.

To increase or decrease the offset, press the button [offset ▲] or the button [offset ▼]. Unlike the gain, the "up" and "down" buttons adjust the offset, not its absolute value. Thus, for example, pressing the button [offset ▲] when $V_{ofs} = -5.49$ V makes $V_{ofs} = -5.48$ V. If the button [offset ▲] is pressed when $V_{ofs} = +10.00$ V, the press has no effect. If the button [offset ▼] is pressed when $V_{ofs} = -10.00$ V, the press has no effect.

Between the values $-2.00\,\text{V} < V_{ofs} < +2.00\,\text{V}$, the offset is selected with 0.001 V resolution; the position of the decimal point on the front-panel displays is shifted to the left. Although the resolution is 0.01 V for $|V_{ofs}| \geq 2.00$ V, the accuracy of the offset is still ±1 mV ± 0.02%. Thus, for example, setting $V_{ofs} = -5.48$ V produces V_{ofs} = (−5.480 ± 0.001 ± 0.001) = (−5.480 ± 0.002) V.

If an [offset ▲▼] button is pressed and held, the offset is continuously adjusted. The rate of the adjustment increases as the button is held. If the value crosses the threshold $V_{ofs} = \pm 2.00$ V, the rate changes appropriately.

resetting offset

If *both* [offset ▲] and [offset ▼] buttons are pressed at the same time, the offset is reset to 0.000 V.

1.2.4 Overload

There are two overload indicators, one *OVLD* LED in the INPUT block and one *OVLD* LED in the OUTPUT block of the front panel. The overload signal can also be asserted on the STATUS pin. See Section 3.5.

1.2.4.1 Input overload

overload limits

An overload condition is recognized and the input *OVLD* LED is activated if the absolute value of the voltage applied to the input exceeds certain limits. These limits are typically ±10.0 V, and are between

$$-10.4\,\text{V} \le V_{\text{min}} \le -9.9\,\text{V}, \quad 9.9\,\text{V} \le V_{\text{max}} \le 10.4\,\text{V}.$$

The overloaded state is also recognized, and the input overload LED activated, if the sum of the input voltage and the commanded offset, $|V_{\text{in}} + V_{\text{ofs}}|$, exceeds these limits. To distinguish between the two input overload possibilities, use the command OVLD? . The overload LED stays on for a minimum of 50 ms; after this time it turns off if the overload condition has ceased.

1.2.4.2 Output overload

An overload condition is recognized and the output *OVLD* LED is activated if the absolute value $|G \times (V_{\text{in}} + V_{\text{ofs}})|$ exceeds the limits in Section 1.2.4.1. The overload LED stays on for a minimum of 50 ms; after this time it turns off if the overload condition has ceased.

1.3 Connections

For a discussion of the front and rear BNC connections, see Section 2.1. The SIM interface connector is discussed in Section 1.6.1.

1.4 Power-On

The instrument retains the values of the gain and the offset in non-volatile memory. Upon power-on, those settings are restored to their values before the power was turned off.

The power-on configuration of the remote interface is detailed in Section 3.3.1.

1.5 Restoring the Default Configuration

The default configuration of the SIM983 is $G = +1.00$, $V_{ofs} = 0.000\,\mathrm{V}$, and bandwidth `0` (see Section 2.3.1). This configuration is reached from the remote interface by issuing the *RST command. To reset only the gain or the offset to their default values, use button combinations described in Sections 1.2.2 or 1.2.3.

1.6 SIM Interface

The primary connection to the SIM983 Scaling Amplifier is the rear-panel DB–15 SIM interface connector. Typically, the SIM983 is mated to a SIM900 Mainframe via this connection, either through one of the internal mainframe slots or the remote cable interface.

It is also possible to operate the SIM983 directly, without using the SIM900 Mainframe. This section provides details on the interface.

1.6.1 SIM interface connector

The DB–15 SIM interface connector carries all the power and communication lines to the instrument. The connector signals are specified in Table 1.1.

Pin	Signal	Direction Src ⇒ Dest	Description
1	SIGNAL_GND	MF ⇒ SIM	Ground Reference 1
2	¬STATUS	SIM ⇒ MF	Status/service request (GND = asserted, +5 V= idle)
3	RTS	MF ⇒ SIM	HW handshake (+5 V= talk; GND = stop)
4	CTS	SIM ⇒ MF	HW handshake (+5 V= talk; GND = stop)
5	¬REF_10MHZ	MF ⇒ SIM	10 MHz reference (No connection in SIM983)
6	−5V	MF ⇒ SIM	Power supply (No connection in SIM983)
7	−15V	MF ⇒ SIM	Power supply
8	PS_RTN	MF ⇒ SIM	Ground Reference 2
9	CHASSIS_GND		Chassis ground
10	TXD	MF ⇒ SIM	Async data (start bit = "0"= +5 V; "1" = GND)
11	RXD	SIM ⇒ MF	Async data (start bit = "0"= +5 V; "1" = GND)
12	+REF_10MHZ	MF ⇒ SIM	10 MHz reference (No connection in SIM983)
13	+5V	MF ⇒ SIM	Power supply
14	+15V	MF ⇒ SIM	Power supply
15	+24V	MF ⇒ SIM	Power supply (No connection in SIM983)

Table 1.1: SIM interface connector pin assignments, DB–15.

1.6.2 Direct interfacing

The SIM983 is intended for operation in the SIM900 Mainframe, but users may wish to directly interface the module to their own systems without the use of additional hardware.

The mating connector needed is a standard DB–15 receptacle, such as Tyco part number 747909–2 (or equivalent). Clean, well-regulated supply voltages of ±15.0 V DC, +5.0 V DC must be provided, following the pinout specified in Table 1.1 and the minimum currents in the table on Page vi. Ground must be provided on Pins 1 and 8, with chassis ground on Pin 9. The ¬STATUS signal may be monitored on Pin 2 for a low-going TTL-compatible output indicating a status message. See Section 3.5 for the description of status messages.

The SIM983 has no internal protection against reverse polarity or overvoltage on the +5 V and the ±15 V power-supply pins. Supply voltages above 5.5 V on Pin 13, above +16 V on Pin 14, or below −16 V on Pin 7 are likely to damage the instrument.

1.6.2.1 Direct interface cabling

If the user intends to directly wire the SIM983 independent of the SIM900 Mainframe, communication is usually possible by directly connecting the appropriate interface lines from the SIM983 DB–15 plug to the RS–232 serial port of a personal computer.[2] Connect RXD from the SIM983 directly to RD on the PC, TXD directly to TD, and similarly RTS→RTS and CTS→CTS. In other words, a null-modem-style cable is *not* needed.

To interface directly to the DB–9 male (DTE) RS–232 port typically found on contemporary personal computers, a cable must be made with a female DB–15 socket to mate with the SIM983, and a female DB–9 socket to mate with the PC's serial port. Separate leads from the DB–15 need to go to the power supply, making what is sometimes know as a "hydra" cable. The pin connections are given in Table 1.2.

DB–15/F to SIM983			Name
		DB–9/F	
3	⟷	7	RTS
4	⟷	8	CTS
10	⟷	3	TxD
11	⟷	2	RxD
		5	Computer Ground
		to Power Supply	
7	⟷	−15 V DC	
13	⟷	+5 V DC	
14	⟷	+15 V DC	
1	⟷	Ground 1 (separate wire to Ground)	
8	⟷	Ground 2 (separate wire to Ground)	
9	⟷	Chassis Ground (separate wire to Ground)	

Table 1.2: SIM983 direct interface cable pin assignments.

note about grounds

The distinct Ground References 1 and 2, and the chassis ground, are

[2] Although the serial interface lines on the DB–15 do not satisfy the minimum voltage levels of the RS–232 standard, these lines are typically compatible with desktop personal computers.

not directly connected within the SIM983. Ground 1 carries the return currents of digital control signals and the power supplies, whereas the input voltage and the output voltage reference to Ground 2 (Section 2.1.2). When operating in the SIM900, the three grounds are tied together in the SIM900 Mainframe. Grounds 1 and 2 are connected through back-to-back Schottky diodes, so they cannot be more than ∼ ±0.35 V apart. The three ground lines should be separately wired to a single, low-impedance ground source at the power supply.

1.6.2.2 Serial settings

The initial serial port settings at power-on are: baud rate 9600, 8 bits, no parity, 1 stop bit, and RTS flow control. The baud rate of the SIM983 cannot be changed. The flow control and the parity may be changed with the FLOW and PARI commands.

2 Description of Operation

This chapter provides a number of additional details of the operation of the SIM983.

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2.1 Signal Connections and Grounding

2.1.1 Output drive

The output impedance of the SIM983 Scaling Amplifier is 50 Ω. The amplifier can drive load impedances from ∞ to 50 Ω for the full ±10 V range of output voltage. When driving a 50 Ω load, the gain will be half of that displayed on the front panel.

The rear-panel output connector is wired in parallel with the front-panel output, and shares some of the output impedance (Figure 1.1). The output stage is not designed to drive two 50 Ω loads simultaneously.

2.1.2 Grounds

Both the input and the output of the SIM983 are referenced to ground. To maintain the DC accuracy of the instrument, there are two separate ground references. Ground 1 (Pin 1 of the SIM interface connector) provides a return path for digital control signals and the power supply currents, while Ground 2 (Pin 8 of the interface connector) serves as the reference point for analog voltages. The outer casings of the input and the output front-panel BNC connectors are tied to Ground 2. The output current of the amplifier returns to the power supply through Ground 2.

The outer casing of the rear-panel output BNC is connected to chassis ground, Pin 9 of the DB–15 SIM interface connector. The separate power, analog, and chassis grounds are *not* directly connected within the amplifier. When operating in the SIM900 Mainframe, the three grounds are tied together inside the mainframe, and through the mainframe to the Earth. Grounds 1 and 2 are connected inside the SIM983 through back-to-back Schottky diodes, so they cannot be more than ∼ ±0.35 V apart.

2.2 Autocalibration

To ensure DC offset accuracy, the amplifier must be self-calibrated within the 24 hours preceding a measurement. A valid autocalibration must take place at (23 ± 5) °C with the module warmed up for at least 2 hours at (23 ± 5) °C. If the module is being used inside the SIM900 Mainframe, the autocalibration must also be inside the mainframe. Otherwise, perform the autocalibration with the same connection to an independent supply as you use for the operation. The autocalibration is only accurate if the output has stabilized within ±15 mV of zero for at least 2 minutes immediately preceding the calibration. However, the gain and the offset need not be at their default values; after the calibration completes, these values are restored.

Disconnect all inputs and outputs to the SIM983 while performing the autocalibration. To calibrate, issue the command ACAL, or press the button [polarity] and one of [gain ▲▼] at the same time. The calibration completes and the instrument is ready for operation within 2 seconds. If autocalibration is unsuccessful, for example because an external voltage (which cannot be nulled) is applied to the input, the calibration parameters revert to their original values and the command LDDE? will return Code 1.

Autocalibration does not affect gain accuracy.

2.3 AC Characteristics

2.3.1 Bandwidth

The gain-bandwidth product (GBP) of the SIM983 is a measure of its small-signal behavior, and depends on $|G|$. Four gain ranges correspond to four values of gain-bandwidth product, as specified in the table on Page vi. For $|G| \geq 1$, the $-3\,\mathrm{dB}$ small-signal bandwidth of the amplifier is $f_{-3\,\mathrm{dB}} = \mathrm{GBP}/|G|$. For $|G| < 1$, $f_{-3\,\mathrm{dB}}(G) \gtrsim f_{-3\,\mathrm{dB}}(G = 1.00)$.

The gain-bandwidth product is determined by a compensation capacitor in the feedback path of the gain-stage amplifier. It is possible to override the value of this capacitor, giving the instrument more bandwidth. To do this, use the command BWTH. If the bandwidth is altered in this way, the next front-panel button press will return the bandwidth to the value appropriate for the current gain. Cycling the power will also return the bandwidth to its default value for the gain.

If the bandwidth is set to a value other than its default, the amplifier may exhibit slow settling, excessive ringing, or oscillations.

The small-signal settling time of the amplifier is a complex function of its gain and its bandwidth.

2.3.2 Slew rate

The slew rate of an amplifier is a measure of its large-signal behavior. It is the maximum rate of change of the output voltage, measured in V/s. The slew rate (SR) determines the maximum undistorted AC signal that can be output; for a sine-wave output at a frequency f, the maximum peak-peak voltage is $|V_{\max} - V_{\min}| = \mathrm{SR}/(\pi f)$. The SIM983 is designed to be able to output a full-range sine wave at 1 MHz.

If the output or an intermediate stage of the amplifier is driven beyond the limits in the table on Page vi, large-signal behavior is not guaranteed.

2.4 Clock Stopping

The microprocessor clock of the SIM983 stops if the module is idle, "freezing" the digital circuitry. The following actions "wake up" the clock:

1. A power-on.
2. A press of a front-panel button.
3. Activity (send or receive) at the remote interface.
4. An overload.

The clock runs for as long as is necessary to complete a gain or offset adjustment, or to communicate the output of a query through the remote interface. However, the clock will remain active for as long as the overload condition exists.

This default behavior can be modified with the remote command AWAK. Setting AWAK `ON` will prevent the clock from stopping. The module returns to AWAK `OFF` upon power-on.

3 Remote Operation

This chapter describes operating the SIM983 over the serial interface.

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3.1 Index of Common Commands

Symbol	Definition
f	Floating-point value
i	Bit number (0–7)
j	Unsigned integer (0–255)
m	Unsigned integer (0–3)
z	Literal token
(?)	Required for queries; illegal for set commands
var	Parameter always required
{*var*}	Required parameter for set commands; illegal for queries
[*var*]	Optional parameter for both set and query forms

General

HELP(?)	3 – 9	Instrument Help
AWAK(?) {*z*}	3 – 10	Keep Clock Awake

Configuration

GAIN(?) {*f*}	3 – 10	Gain
OFST(?) {*f*}	3 – 10	Offset
BWTH(?) [*m*]	3 – 11	Bandwidth

Calibration

ACAL	3 – 11	Autocalibration

Status

*CLS	3 – 11	Clear Status
*STB? [*i*]	3 – 12	Status Byte
*SRE(?) [*i*,] {*j*}	3 – 12	Service Request Enable
*ESR? [*i*]	3 – 12	Standard Event Status
*ESE(?) [*i*,] {*j*}	3 – 12	Standard Event Status Enable
CESR? [*i*]	3 – 12	Communication Error Status
CESE(?) [*i*,] {*j*}	3 – 13	Communication Error Status Enable
OLSR? [*i*]	3 – 13	Overload Status
OLSE(?) [*i*,] {*j*}	3 – 13	Overload Status Enable
PSTA(?) {*z*}	3 – 13	Pulse ¬STATUS Mode
LBTN?	3 – 13	Last Button
OVLD?	3 – 14	Overload

Interface

*RST	3 – 14	Reset
*IDN?	3 – 15	Identify
*TST?	3 – 15	Self Test

*OPC(?)	3 – 15	Operation Complete
CONS(?) {*z*}	3 – 15	Console Mode
LEXE?	3 – 16	Execution Error
LCME?	3 – 16	Command Error
LDDE?	3 – 17	Device Error
TOKN(?) {*z*}	3 – 17	Token Mode
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Serial Communications

FLOW(?) {*z*}	3 – 18	Flow Control
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3.2 Alphabetic List of Commands

★

*CLS	3 – 11	Clear Status
*ESE(?) [*i*,] {*j*}	3 – 12	Standard Event Status Enable
*ESR? [*i*]	3 – 12	Standard Event Status
*IDN?	3 – 15	Identify
*OPC(?)	3 – 15	Operation Complete
*RST	3 – 14	Reset
*SRE(?) [*i*,] {*j*}	3 – 12	Service Request Enable
*STB? [*i*]	3 – 12	Status Byte
*TST?	3 – 15	Self Test

A

ACAL	3 – 11	Autocalibration
AWAK(?) {*z*}	3 – 10	Keep Clock Awake

B

BWTH(?) [*m*]	3 – 11	Bandwidth

C

CESE(?) [*i*,] {*j*}	3 – 13	Communication Error Status Enable
CESR? [*i*]	3 – 12	Communication Error Status
CONS(?) {*z*}	3 – 15	Console Mode

F

FLOW(?) {*z*}	3 – 18	Flow Control

G

GAIN(?) {*f*}	3 – 10	Gain

H

HELP(?)	3 – 9	Instrument Help

L

LBTN?	3 – 13	Last Button
LCME?	3 – 16	Command Error
LDDE?	3 – 17	Device Error
LEXE?	3 – 16	Execution Error

O

OFST(?) {*f*}	3 – 10	Offset
OLSE(?) [*i*,] {*j*}	3 – 13	Overload Status Enable

OLSR? [*i*]	3 – 13	Overload Status
OVLD?	3 – 14	Overload

P

PARI(?) {*z*}	3 – 18	Parity
PSTA(?) {*z*}	3 – 13	Pulse ¬STATUS Mode

T

TERM(?) {*z*}	3 – 17	Response Termination
TOKN(?) {*z*}	3 – 17	Token Mode

3.3 Introduction

Remote operation of the SIM983 is through a simple command language documented in this chapter. Both set and query forms of most commands are supported, allowing the user complete control of the amplifier from a remote computer, either through the SIM900 Mainframe or directly via RS–232 (see Section 1.6.2.1).

See Table 1.1 for the specification of the DB–15 SIM Interface Connector.

3.3.1 Power-on configuration

The initial settings for the remote interface are 9600 baud with no parity and flow control RTS, and with local echo disabled (CONS OFF).

The values of the gain and the offset are retained in non-volatile memory. Upon power-on, those settings are restored to their values before the power was turned off. The bandwidth is set to the value appropriate for the stored gain.

Where appropriate, the reset (default) value for parameters is listed in **boldface** in the command descriptions.

3.3.2 Buffers

The SIM983 stores incoming bytes from the host interface in a 64-byte input buffer. Characters accumulate in the input buffer until a command terminator (either ⟨CR⟩ or ⟨LF⟩) is received, at which point the message is parsed and executed. Query responses from the SIM983 are buffered in a 64-byte output queue.

If the input buffer overflows, then all data in *both* the input buffer and the output queue are discarded, and an error is recorded in the CESR and ESR status registers.

3.3.3 Device Clear

The SIM983 host interface can be asynchronously reset to its power-on configuration by sending an RS–232-style ⟨break⟩ signal. From the SIM900 Mainframe, this is accomplished with the SRST command; if directly interfacing via RS–232, then use a serial break signal. After receiving the Device Clear, the CONS mode is turned OFF. Note that this *only* resets the communication interface; the basic function of the SIM983 is left unchanged; to reset the amplifier, use *RST.

The Device Clear signal will also terminate the output of the HELP? command from the SIM983.

3.4 Commands

This section provides syntax and operational descriptions for remote commands.

3.4.1 Command syntax

The four letter mnemonic (shown in CAPS) in each command sequence specifies the command. The rest of the sequence consists of parameters.

Commands may take either *set* or *query* form, depending on whether the "?" character follows the mnemonic. *Set only* commands are listed without the "?", *query only* commands show the "?" after the mnemonic, and *optionally query* commands are marked with a "(?)".

Parameters shown in { } and [ ] are not always required. Parameters in { } are required to set a value, and should be omitted for queries. Parameters in [ ] are optional in both set and query commands. Parameters listed without surrounding characters are always required.

Do *not* send ( ) or { } or [ ] as part of the command.

Multiple parameters are separated by commas. Multiple commands may be sent on one command line by separating them with semicolons (;) so long as the input buffer does not overflow. Commands are terminated by either ⟨CR⟩ or ⟨LF⟩ characters. Null commands and whitespaces are ignored. Execution of the command does not begin until the command terminator is received.

tokens *Token* parameters (generically shown as *z* in the command descriptions) can be specified either as a keyword or as an integer value. Command descriptions list the valid keyword options, with each keyword followed by its corresponding integer value. For example, to set the response termination sequence to ⟨CR⟩+⟨LF⟩, the following two commands are equivalent:

TERM CRLF —or— TERM 3

For queries that return token values, the return format (keyword or integer) is specified with the TOKN command.

3.4.2 Notation

The following table summarizes the notation used in the command descriptions:

Symbol	Definition
f	Floating-point value
i	Bit number (0–7)
j	Unsigned integer (0–255)
m	Unsigned integer (0–3)
z	Literal token
(?)	Required for queries; illegal for set commands
var	Parameter always required
{*var*}	Required parameter for set commands; illegal for queries
[*var*]	Optional parameter for both set and query forms

3.4.3 Examples

Each command is provided with a simple example illustrating its usage. In these examples, all data sent by the host computer to the SIM983 are set as `straight teletype font`, while responses received by the host computer from the SIM983 are set as *`slanted teletype font`*.

The usage examples vary with respect to set/query, optional parameters, and token formats. These examples are not exhaustive, and are intended to provide a convenient starting point for user programming.

3.4.4 General commands

HELP(?)

Instrument Help

Outputs a condensed version of Section 3.4 to the remote interface.

HELP may be used with or without the query sign, with the same effects.

Example:

```
HELP?
Notation:
f is a floating-point number;
i is bit number (0..7);
j is an 8-bit unsigned integer (0..255);
m is a 2-bit unsigned integer (0..3);
z is a token
(?) question required for queries, illegal for set commands;
[] = parameter is optional for both set and query forms;
{} = parameter is required to set, illegal for queries;
parameter without brackets is always required;
the brackets themselves should not be sent.

General commands:
HELP?             - Send this text.
AWAK(?) {z}       - Keep the module clock awake.

Configuration commands:
GAIN(?) {f}       - Set/query gain.
OFST(?) {f}       - Set/query offset.
BWTH(?) [m]       - Output bandwidth.

Calibration commands:
ACAL              - One-time autocalibration.

Status commands:
*CLS              - Clear Status.
*STB?   [i]       - Query the Status Byte.
*SRE(?) [i,] {j}  - Service Request Enable.
*ESR?   [i]       - Query Standard Event Status register.
*ESE(?) [i,] {j}  - Standard Event Status Enable.
CESR?   [i]       - Query the Communications Error Status.
CESE(?) [i,] {j}  - Communications Error Status Enable.
OLSR?   [i]       - Query Overload Status register.
OLSE(?) [i,] {j}  - Overload Status Enable.
PSTA(?) {z}       - Pulse Status or change its level.
LBTN?             - Which button last pressed?
OVLD?             - Input or output currently overloaded?
```

```
Interface commands:
*RST            - Reset to known state.
*IDN?           - Identify.
*TST?           - Does nothing.
*OPC(?)         - Operation complete.
CONS(?) {z}     - Console OFF/ON.
LEXE?           - Last Execution Error.
LCME?           - Last Communications Error.
LDDE?           - Last Device-Dependent Error.
TOKN(?) {z}     - Turn token mode OFF/ON.
TERM(?) {z}     - Cmd line end (NONE, CR, LF, CRLF, LFCR).

Serial interface commands (baud rate is always 9600):
FLOW(?) {z}     - Flow control (NONE, RTS, XON).
PARI(?) {z}     - Parity (NONE, EVEN, ODD, MARK, SPACE).
```

AWAK(?) {*z*}

Keep Clock Awake

Set (query) the SIM983 keep-awake mode {to z = (**OFF 0,** ON 1)}.

Ordinarily, the clock oscillator for the SIM983 microcontroller is held in a stopped state, and only enabled during processing of events (Section 2.4). Setting AWAK ON forces the clock to stay running, and is useful only for diagnostic purposes.

Example: `AWAK ON`

3.4.5 Configuration commands

GAIN(?) {*f*}

Gain

Set (query) the amplifier gain {to f}. The module accepts signed floating-point values in the range $-19.99 \le f \le 19.99$. The reset value is f = **+1.00.**

After a GAIN set command, the bandwidth is set to the value appropriate for the new gain. Gain queries do not alter the bandwidth.

Example:
```
GAIN 1.4232E1; GAIN?
+14.23
```

OFST(?) {*f*}

Offset

Set (query) the offset of the amplifier {to f volts}. The module accepts signed floating-point values in the range $-10.000 \le f \le 10.000$. The reset value is f = **0.000.**

Setting or querying the offset does not change the bandwidth.

Example: `OFST -7.032; OFST?`
-07.030

BWTH(?) [*m*]

Bandwidth

Set (query) the gain-bandwidth product of the amplifier [to *m*]. Valid values of the optional parameter are `0` through `3`, with a larger value corresponding to a greater gain-bandwidth product in the specification table on Page vi. When the gain is set from the front panel or from the remote interface, the bandwidth automatically reverts to the following:

Range	Bandwidth *m*
$0.01 \le \|G\| \le 2.39$	0
$2.40 \le \|G\| \le 4.19$	1
$4.20 \le \|G\| \le 9.59$	2
$9.60 \le \|G\| \le 19.99$	3

The bandwidth is also automatically selected from this table if the optional parameter is omitted.

Example: `GAIN 17; BWTH 1; BWTH?`
1
`GAIN 17; BWTH?`
3

3.4.6 Calibration commands

ACAL

Autocalibration

Perform a self-calibration (Section 2.2). *Make sure to disconnect all inputs and outputs to the SIM983, and to set the output to zero.* Remote commands are not processed until ACAL is complete.

Example: `ACAL`
`LDDE?`
0
checks for success of an autocalibration.

3.4.7 Status commands

The Status commands query and configure registers associated with status reporting of the SIM983. See Section 3.5 for the status model.

---

*CLS

Clear Status

*CLS immediately clears the ESR, CESR, and OLSR status registers.

Example: `*CLS`

*STB? [*i*]

Status Byte

Query the Status Byte register [Bit *i*].

Execution of the *STB? query (without the optional Bit *i*) always causes the ¬STATUS signal to be deasserted. Note that *STB? *i* will *not* clear ¬STATUS, even if Bit *i* is the only bit presently causing the ¬STATUS signal.

Example:
```
*STB?
16
```

*SRE(?) [*i*,] {*j*}

Service Request Enable

Set (query) the Service Request Enable register [Bit *i*] {to *j*}.

Example:
```
*SRE 0,1
```

*ESR? [*i*]

Standard Event Status

Query the Standard Event Status Register [Bit *i*].

Upon execution of *ESR? , the returned bit(s) of the ESR register are cleared.

Example:
```
*ESR?
64
```

*ESE(?) [*i*,] {*j*}

Standard Event Status Enable

Set (query) the Standard Event Status Enable register [Bit *i*] {to *j*}.

Example:
```
*ESE 6,1
ESE?
64
```

CESR? [*i*]

Communication Error Status

Query the Communication Error Status Register [Bit *i*].

Upon executing a CESR? query, the returned bit(s) of the CESR register are cleared.

Example:
```
CESR?
0
```

CESE(?) [*i*,] {*j*}

Communication Error Status Enable

Set (query) the Communication Error Status Enable register [Bit *i*] {to *j*}.

Example: `CESE?`
2

OLSR? [*i*]

Overload Status

Query the Overload Status Register [Bit *i*].

Upon executing an OLSR? query, the returned bit(s) of the OLSR register are cleared.

Example: `OLSR?`
3

OLSE(?) [*i*,] {*j*}

Overload Status Enable

Set (query) the Overload Status Enable register [Bit *i*] {to *j*}.

Example: `OLSE 4`

PSTA(?) {*z*}

Pulse ¬STATUS Mode

Set (query) the Pulse ¬STATUS mode {to *z* = (**OFF 0**, ON 1)}.

When PSTA ON is set, all new service requests will only *pulse* the ¬STATUS signal LOW (for a minimum of 1 μs). The default behavior is to latch ¬STATUS LOW until a *STB? query is received.

A reset does not alter PSTA. The value in boldface above is the power-on value.

Example: `PSTA?`
OFF

LBTN?

Last Button

Query the number of the last button pressed. The response is

LBTN?	Last button
1	[polarity]
2	[gain ▲]
3	[gain ▼]
4	[offset ▲]
5	[offset ▼]
6	Both [gain ▲] and [gain ▼] (reset gain)
7	Both [offset ▲] and [offset ▼] (reset offset)
8	One of [gain ▲▼] and [polarity] (autocalibrate)

The value `0` is returned if no button was pressed since the last LBTN?.

A query of LBTN? always clears the button code, so a subsequent LBTN? will return `0`.

Example: `LBTN?`
5

OVLD? Overload

Query the current overload state. The response is

OVLD?	Overloaded
1	Input
2	Input + offset
4	Output

Combination overloads are reported by summing the values of the individual overload flags. This command complements the OLSR status register described in Section 3.5.7, and the three overload flags correspond one-to-one with bits in OLSR. However, once cleared by OLSR? or *CLS, the overload status bits will stay cleared even though the overload condition may persist and remain reported by OVLD?.

Example: `OVLD?`
6
implies that the input is *not* overloaded; the intermediate stage ($V_{in} + V_{ofs}$) *is* overloaded; and the output *is* overloaded.

3.4.8 Interface commands

The Interface commands provide control over the interface between the SIM983 and the host computer.

---

*RST Reset

Reset the SIM983 to its default configuration.

*RST sets the following:

- Clock oscillator to stop during idle time (AWAK `OFF`).
- Gain to +1.00.
- Offset to 0.000 V.
- Bandwidth to `0`.
- The token mode to `OFF`.

*RST does *not* affect PSTA, CONS, TERM, and all service-enable registers (*SRE, *ESE, CESE, or OLSE).

Example: `*RST`
`CONS?`
1

***IDN?**

Identify

Query the device identification string.

The identification string is formatted as:

`Stanford_Research_Systems,SIM983,s/n******,ver#.###`

where `SIM983` is the model number, `******` is a 6-digit serial number, and `#.###` is the firmware revision level.

Example: `*IDN?`
`Stanford_Research_Systems,SIM983,s/n004900,ver2.0`

***TST?**

Self Test

There is no internal self-test in the SIM983 after the power-on, so this query always returns `0`.

Example: `*TST?`
`0`

***OPC(?)**

Operation Complete

Sets the OPC flag in the ESR register.

The query form *OPC? writes a `1` into the output queue when complete, but does not affect the ESR register.

Example: `*OPC?`
1

CONS(?) {*z*}

Console Mode

Set (query) the console mode {to *z* = (**OFF 0**, ON 1)}.

CONS causes each character received at the input buffer to be copied to the output queue.

A reset does not alter CONS. The value in boldface above is the power-on value. CONS is set to `OFF` upon Device Clear.

Example: `CONS ON`

LEXE?

Execution Error

Query the Last Execution Error code. A query of LEXE? always clears the error code, so a subsequent LEXE? will return `0`. Valid codes are:

Value	Definition
0	No execution error since last LEXE?
1	Illegal value
2	Wrong token
3	Invalid bit

Example:
```
*STB? 12; LEXE?; LEXE?
3
0
```
The error (3, "Invalid bit") is because *STB? only allows bit-specific queries of 0–7. The second read of LEXE? returns 0.

LCME?

Command Error

Query the Last Command Error code. A query of LCME? always clears the error code, so a subsequent LCME? will return `0`. Valid codes are:

Value	Definition
0	No command error since last LCME?
1	Illegal command
2	Undefined command
3	Illegal query
4	Illegal set
5	Missing parameter(s)
6	Extra parameter(s)
7	Null parameter(s)
8	Parameter buffer overflow
9	Bad floating point
10	Bad integer
11	Bad integer token
12	Bad token value
14	Unknown token

Example:
```
*IDN
LCME?
4
```
The error (4, "Illegal set") is due to the missing "?".

LDDE? — Device Error

Query the Last Device-Dependent Error code. A query of LDDE? always clears the error code, so a subsequent LDDE? will return `0`. Valid codes are:

Value	Definition
0	No execution error since last LEXE?
1	Unable to autocalibrate

Example:

```
ACAL
LDDE?
0
```

indicates a successful autocalibration.

TOKN(?) {*z*} — Token Mode

Set (query) the token query mode {to *z* = (**OFF 0**, ON 1)}.

If TOKN ON is set, then queries to the SIM983 that return tokens will return a text keyword; otherwise they return a decimal integer value. Thus, the only possible responses to the TOKN? query are ON and 0.

Example: `TOKN OFF`

TERM(?) {*z*} — Response Termination

Set (query) the ⟨term⟩ sequence {to *z* = (NONE 0, CR 1, LF 2, **CRLF 3**, or LFCR 4)}.

The ⟨term⟩ sequence is appended to all query responses sent by the module, and is constructed of ASCII character(s) 13 (carriage return) and 10 (line feed). The token mnemonic gives the sequence of characters.

A reset does not alter TERM. The value in boldface above is the power-on value.

Example:

```
TOKN ON; TERM?
CRLF
```

3.4.9 Serial communication commands

Note that the SIM983 can only support a single baud rate of 9600. A reset does not change the serial interface settings; use Device Clear.

FLOW(?) {*z*}

Flow Control

Set (query) flow control {to *z* = (`NONE 0`, **`RTS 1`**, `XON 2`)}. The value in boldface is the power-on value.

Example: `FLOW 0`

PARI(?) {*z*}

Parity

Set (query) the parity {to *z* = (**`NONE 0`**, `ODD 1`, `EVEN 2`, `MARK 3`, `SPACE 4`)}. The value in boldface is the power-on value.

Example:
```
TOKN ON; PARI?
EVEN
```

3.5 Status Model

status registers The SIM983 status registers follow the hierarchical IEEE–488.2 format. A block diagram of the status register array is given in Figure 3.1.

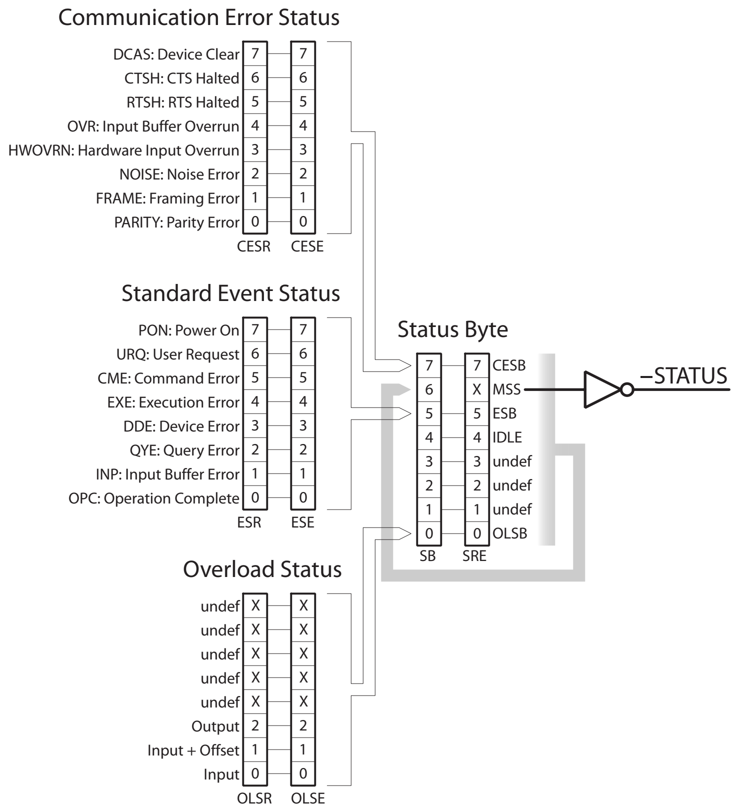

Figure 3.1: Status register model for the SIM983 Scaling Amplifier.

There are two categories of registers in the SIM983 status model:

Event Registers : These read-only registers record the occurrence of defined events. If the event occurs, the corresponding bit is set to 1. Upon querying an event register, all set bits within it are cleared. These are sometimes known as "sticky bits," since once set, a bit can only be cleared by reading its value. Event register names end with SR.

Enable Registers : These read/write registers define a bitwise mask for their corresponding event register. If a bit position is set in an event register while the same bit position is also set in the enable register, then the corresponding summary bit message is set. Enable register names end with SE.

At power-on, all status registers are cleared.

3.5.1 Status Byte (SB)

The Status Byte is the top-level summary of the SIM983 status model. When masked by the Service Request Enable register, a bit set in the Status Byte causes the ¬STATUS signal to be asserted on the rear-panel SIM interface connector.

Weight	Bit	Flag
1	0	OLSB
2	1	undef (0)
4	2	undef (0)
8	3	undef (0)
16	4	IDLE
32	5	ESB
64	6	MSS
128	7	CESB

OLSB : Overload Summary Bit. Indicates whether one or more of the enabled flags in the Overload Status Register has become true.

IDLE : Indicates that the input buffer is empty and the command parser is idle. Can be used to help synchronize SIM983 query responses.

ESB : Event Status Bit. Indicates whether one or more of the enabled events in the Standard Event Status Register is true.

MSS : Master Summary Status. Indicates whether one or more of the enabled status messages in the Status Byte register is true.

CESB : Communication Error Summary Bit. Indicates whether one or more of the enabled flags in the Communication Error Status Register has become true.

3.5.2 Service Request Enable (SRE)

Each bit in the SRE corresponds one-to-one with a bit in the SB register, and acts as a bitwise AND of the SB flags to generate MSS. Bit 6 of the SRE is undefined—setting it has no effect, and reading it always returns 0. This register is set and queried with the *SRE(?) command.

At power-on, this register is cleared.

3.5.3 Standard Event Status (ESR)

The Standard Event Status Register consists of 8 event flags. These event flags are all "sticky bits" that are set by the corresponding events, and cleared only by reading or with the *CLS command. Reading a single bit (with the *ESR? *i* query) clears only Bit *i*.

Weight	Bit	Flag
1	0	OPC
2	1	INP
4	2	QYE
8	3	DDE
16	4	EXE
32	5	CME
64	6	URQ
128	7	PON

OPC : Operation Complete. Set by the *OPC command.

INP : Input buffer error. Indicates data has been discarded from the input buffer.

QYE : Query Error. Indicates data in the output queue has been lost.

DDE : Device-Dependent Error. Unused in the SIM983.

DDE : Device-Dependent Error. Indicates a failed autocalibration.

EXE : Execution Error. Indicates the error in a command that was successfully parsed. Out-of-range parameters are an example.

CME : Command Error. Indicates a command parser-detected error.

URQ : User Request. Indicates that a front-panel button was pressed.

PON : Power On. Indicates that an off-to-on transition has occurred.

3.5.4 Standard Event Status Enable (ESE)

The ESE acts as a bitwise AND with the ESR register to produce the single-bit ESB message in the Status Byte Register (SB). The register can be set and queried with the *ESE(?) command.

At power-on, this register is cleared.

3.5.5 Communication Error Status (CESR)

The Communication Error Status Register consists of 8 event flags; each of the flags is set by the corresponding event, and cleared only by reading the register or with the *CLS command. Reading a single bit (with the CESR? *i* query) clears only Bit *i*.

Weight	Bit	Flag
1	0	PARITY
2	1	FRAME
4	2	NOISE
8	3	HWOVRN
16	4	OVR
32	5	RTSH
64	6	CTSH
128	7	DCAS

PARITY : Parity error. Set by serial parity mismatch on the incoming data byte.

FRAME : Framing error. Set when an incoming serial data byte is missing the STOP bit.

NOISE : Noise error. Set when an incoming serial data byte does not present a steady logic level during each asynchronous bit-period window.

HWOVRN : Hardware Overrun. Set when an incoming serial data byte is lost due to internal processor latency. Causes the input buffer to be flushed, and resets the command parser.

OVR : Input buffer Overrun. Set when the input buffer is overrun by the incoming data. Causes the input buffer to be flushed, and resets the command parser.

RTSH : RTS Holdoff Event. Set when the SIM983 receives an RTS hold-off signal from the SIM900 Mainframe, requesting the SIM983 cease transmitting data to the SIM900.

CTSH : CTS Holdoff Event. Set when the SIM983 generates a CTS hold-off signal to the SIM900 Mainframe, requesting the SIM900 cease transmitting data to the SIM983.

DCAS : Device Clear. Indicates that the SIM983 received the Device Clear signal (an RS–232 ⟨break⟩). Clears the input buffer and the output queue, and resets the command parser.

3.5.6 Communication Error Status Enable (CESE)

The CESE acts as a bitwise AND with the CESR register to produce the single-bit CESB message in the Status Byte Register (SB). The register can be set and queried with the CESE(?) command.

At power-on, this register is cleared.

3.5.7 Overload Status (OLSR)

The Overload Status Register consists of 3 event flags; each of the flags is set by the corresponding overload, and cleared only by reading the register or with the *CLS command. Reading a single bit (with the OLSR? *i* query) clears only Bit *i*.

Weight	Bit	Flag
1	0	Input
2	1	Input + Offset
4	2	Output
8	3	undef (0)
16	4	undef (0)
32	5	undef (0)
64	6	undef (0)
128	7	undef (0)

Input : Input overload. Indicates that $|V_{in}| > 10.0\,V$ (see also Section 1.2.4.1).

Input + Offset : Intermediate stage overload. Indicates that $|V_{in} + V_{ofs}| > 10.0\,V$.

Output : Output overload. Indicates that $|V_{out}| > 10.0\,V$.

Reading this register (with the OLSR? query) clears all overload bits that are set. If the overload condition persists, the bits will remain cleared until the overload condition ceases and reoccurs. Use OVLD? to query the current state of the overload.

3.5.8 Overload Status Enable (OLSE)

The OLSE acts as a bitwise AND with the OLSR register to produce the single-bit OLSB message in the Status Byte Register (SB). The register can be set and queried with the OLSE(?) command.

At power-on, this register is cleared.

4 Performance Verification

This chapter describes the tests necessary to verify the SIM983is operating correctly and within specified calibration. interface.

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4.1 Verifying the DC Accuracy

The gain and the offset of the SIM983 Scaling Amplifier are calibrated at the factory. Besides self-calibration, there are no user-adjustable calibration settings.

4.1.1 Getting ready

To verify the DC performance of the SIM983, one needs a DC signal source (able to output either polarity) and, as a minimum, a voltmeter accurate to ±500 μV or better. Two voltmeters with matched calibration are most convenient, such as two channels of the Stanford Research Systems' SIM970 Quad DVM. The SIM928 Isolated Voltage Source is recommended as the calibrator; however, the wiper of a potentiometer connected to a power supply can be a simpler if less convenient solution. The DC source must be quiet. If the verification is done with only one voltmeter, cables have to be connected and disconnected between measurements, so the voltage source must be stable within the voltmeter's accuracy. No such stability is required if two voltmeters are used.

1. Warm up the SIM983 for at least 2 hours.
2. If the voltmeter requires a warmup of a certain duration prior to establishing its accuracy specifications, or an autocalibration, be certain to complete these.
3. Perform an autocalibration of the SIM983 as specified in Section 2.2.

In order to perform the measurements, connect the output of the voltage source to the input of the amplifier and to Voltmeter 1. Connect the output of the SIM983 to Voltmeter 2. If using only one voltmeter, use it to alternately measure the DC source voltage and the output voltage of the SIM983.

4.1.2 Interpreting the accuracy specifications

Gain and offset errors specified in the table on Page vi contribute to the overall output error. The error in $V_{out} = G \times (V_{in} + V_{ofs})$ is

$$\delta V_{out} = \delta G \times (V_{in} + V_{ofs}) + G \times \delta V_{ofs}.$$

The gain error δG and the offset error δV_{ofs} both have temperature-dependent contributions, mentioned in the specification table under "Stability".

4.1.2.1 Error budget

Consider, for example, a measurement with $G = +15.00$, $V_{in} = 6.192\,V$, and $V_{ofs} = -5.480\,V$, performed at a laboratory temperature of +28 °C. [1] The following are the worst-case contributions of the factors specified in the table on Page vi to the output error:

Specification	Contribution to Overall Error, V
Gain accuracy, ±0.01	$\pm 0.01 \times (6.192 - 5.480) = \pm 0.0071$
Gain stability, $(28\,°C - 23\,°C) \times (\pm 10\,ppm/°C) = \pm 50 \times 10^{-6}$	$\pm 50 \times 10^{-6} \times (6.192 - 5.480) = \pm 0.0000$
Offset accuracy, ±1 mV ± 200 ppm	$15.00 \times (\pm 0.001 \pm 200 \times 10^{-6} \times (-5.480)) = \pm 0.0314$
Offset stability, $(28\,°C - 23\,°C) \times (\pm 20\,\mu V/°C \pm 20\,ppm/°C) = \pm 100\,\mu V \pm 100 \times 10^{-6}$	$15.00 \times (\pm 0.0001 \pm 100 \times 10^{-6} \times (-5.480)) = \pm 0.0097$
Total	$= \pm 0.0482$

The output of the instrument is therefore

$$V_{out} = 15.00 \times (6.192\,V - 5.480\,V) \pm 0.0482\,V = (10.68 \pm 0.05)\,V$$

if the amplifier is performing within its specifications.

Consider another example, with $G = -0.19$, $V_{in} = -3.954\,V$, and $V_{ofs} = -5.480\,V$, performed at a laboratory temperature of +23 °C. For $|G| < 1$, the specified offset error term is referenced to the output, according to Note 4 on Page vii. The worst-case error budget is

Specification	Contribution to Overall Error, V
Gain accuracy, ±0.01	$\pm 0.01 \times (-3.954 - 5.480) = \pm 0.0943$
Offset accuracy, ±1 mV ± 200 ppm	$\pm 0.001 \pm 200 \times 10^{-6} \times (-0.19) \times (-3.954 - 5.480) = \pm 0.0014$
Total	$= \pm 0.0957$

The stability terms are zero because the test is taken at the calibration temperature. The output of the SIM983 is therefore

$$V_{out} = -0.19 \times (-3.954\,V - 5.480\,V) \pm 0.0957\,V = (1.79 \pm 0.10)\,V$$

if the unit is working according to the specifications.

When interpreting the results of a DC performance test of the SIM983, always account for the voltmeter accuracy specifications.

4.1.2.2 Recalibration

If the module fails its DC accuracy specifications, return it to Stanford Research Systems for a new calibration.

[1] Note that the input voltage by itself, or the output voltage by itself, overloads the amplifier at the chosen gain, but their combination does not.

4.2 Performance Test Record

4.2.1 DC Test

Serial number

Lab temperature (°C) =

G	V_{in} (V)	V_{ofs} (V)	V_{out} (V)	$G \times (V_{in} + V_{ofs})$ (V)	Error (V)	Gain accuracy error (V)	Gain stability error (V)	Offset accuracy error (V)	Offset stability error (V)	Cal within spec?

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