

Operation and Service Manual

# Isolated Voltage Source

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**SIM928**



Stanford Research Systems

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## Certification

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*SIM928 Isolated Voltage Source*

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## General Information

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The SIM928 Isolated Voltage Source, part of Stanford Research Systems' Small Instrumentation Modules family, is a low-noise programmable voltage source intended for sensor biasing and other demanding, low-power applications. Dual, auto-switching internal nickel-metal-hydride batteries provide continuous uninterrupted operation at the isolated output, which can deliver up to  $\pm 20$  V bias at up to  $\pm 10$  mA current load.

## Safety and Preparation for Use

The front-panel binding post outputs (+ and -) are isolated from the Earth, the power-line-outlet ground, and the metal chassis of the module. No dangerous voltages are generated by the SIM928. However, if a dangerous voltage is externally applied to the module, it may be present on (either) binding post connector, the chassis, or the SIM interface connector, and may cause injury or death.

*Do not exceed  $\pm 40$  V to the Earth at either binding post terminal.*

The SIM928 ships from the factory with the internal battery pack installed and ready for operation. Do not install substitute parts or perform any unauthorized modifications to this instrument.

The SIM928 is a single-wide module designed to be used inside the SIM900 Mainframe. Do not turn on the power 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 [Button];  
[Adjust ▲▼] is shorthand for “[Adjust ▲] & [Adjust ▼]”.
- Front-panel indicators are set as *Overload*.
- Remote command names are set as \*IDN?.
- Literal text other than command names is set as OFF.

## Specifications

### Performance Characteristics

	Min	Typ	Max	Units	
Output	Output range	-20		+20	V
	Floating output	-40		+40	V (common mode to ground)
	Noise		10		$\mu\text{V}_{\text{rms}}$ , 1 kHz BW
	Settable resolution		1		mV
	Display resolution		1		mV, $ V  < 1.999$ V
			10		mV, $ V  < 19.99$ V
	Max. output current	-10		+10	mA (before dropout)
	Short circuit current		$\pm 15$		mA
	Short circuit duration	indefinite			
	Batteries	Number of batteries	2		1 operating, 1 charging/standby
Chemistry		Nickel metal hydride			
Charge time			5		h
Discharge time			12		h (10 mA load)
Lifetime			1000		charge cycles, 2 yr shelf life
Battery switching		Automatic, when active battery is fully discharged			
Switchover glitch		<1 mV for <1 ms			
Battery charge override		Allows manual switching of batteries. Triggered when [Battery Override] is held for 5 s or more. Only armed when standby battery is in ready state			
Operating	Temperature	0		40	$^{\circ}\text{C}$
	Power	-15, +5, +24			V DC
	Supply current		250		mA (+5 V)
			40		mA (-15, +24 V)

### General Characteristics

Interface	Serial (RS-232) through SIM interface
Connectors	Banana binding posts (+, -, and chassis ground)
	DB-15 (male) SIM interface
Weight	3 lbs
Dimensions	1.5" W $\times$ 3.6" H $\times$ 7.0" D



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# 1 Getting Started

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This chapter gives you the necessary information to get started quickly with the SIM928 Isolated Voltage Source.

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## 1.1 Introduction to the Instrument

The SIM928 Isolated Voltage Source is ideally suited for applications demanding flexibility and low-noise from a programmable voltage source.

### 1.1.1 Overview

The basic function of the SIM928 is to generate a user-specified voltage, between  $-20\text{ V}$  and  $+20\text{ V}$ , between the  $\oplus$  and  $\ominus$  front-panel terminals. The architecture of the SIM928 uses an internal battery to power the output stage. This provides an ideal voltage source, free of power-supply ripple. Two independent batteries are used; while one is powering the output circuitry, the second is either being recharged or held in standby. When the output battery nears its fully-discharged state, the standby battery is seamlessly switched into the output circuit, and the depleted battery switched to the internal charger. With this arrangement, essentially continuous isolated bias voltage is available to the user.

Note that, although the output stage is energized by internal storage batteries, the control circuitry is powered externally (typically, by the SIM900 Mainframe). Absent any external power, the SIM928 will be off.

### 1.1.2 Power-on State

The SIM928 stores its operation state (programmed voltage and on/off configuration) in non-volatile memory. At power-on, the SIM928 will return to its previous configuration after a brief system check and initialization.

*first use after extended storage*

The power-on system check includes a brief test of both internal batteries. If either battery appears fully discharged, it will be switched onto the internal charger circuit; if both batteries appear discharged (as can occur after an extended storage period), the SIM928 will not be able to turn on the output stage. In this case, you should allow about 5–6 hours of powered operation to bring the first battery up to full charge, at which time it will switch to the *On* state and begin charging the second battery. This period can be shortened by power-cycling the SIM900 Mainframe, which will cause the SIM928 to re-initiate its power-on checks. Note that at least 1–2 hours should be allowed to provide a sufficient partial charge for reasonable operation.

## 1.2 Front-Panel Operation

The front panel of the SIM928(see Figure 1.1) provides a simple operator interface.



Figure 1.1: The SIM928 front and rear panels.

## 1.2.1 Adjust

Routine operation of the SIM928 is through the front panel “ADJUST” block.

### 1.2.1.1 On/Off toggle

The output circuit of the SIM928 is toggled between enabled and disabled with [On/Off]. In the event of an overvoltage Trip (see section 1.2.3.2), press [On/Off] to clear the *Trip* indicator.

### 1.2.1.2 Changing the programmed voltage

The remaining 6 adjust keys allow changing the programmed voltage from the front panel. Brief taps on [100 mV ▲▼] increment or decrement the setting by 100 mV; similarly, the [10 mV ▲▼] and [1 mV ▲▼] step the setting by 10 mV and 1 mV, respectively. Holding any of these keys for 1 second begins an (accelerating) auto-repeat for faster voltage changes. Note that the auto-repeat function will *not* scroll across 0 V; when decreasing a positive setting, or increasing a negative setting, the auto-repeat will stop at 0 V. To reverse the polarity, the key must be released and then re-pressed to resume auto-repeat.

Note that the programmed voltage can be modified independent of the on/off state of the SIM928. Adjusting the voltage while in the On

state causes the output voltage to change in real time.

When the programmed voltage  $|V| < 1.999\text{ V}$ , the display shows the full settable resolution of the SIM928. At greater voltages ( $|V| > 1.999\text{ V}$ ) the least significant digit shown corresponds to 10 mV. It is still possible to make discrete 1 mV steps using [1 mV▲▼]; by counting key taps, the user can determine the sub-display voltage setting. When  $|V| \geq 2.00\text{ V}$ , the display always corresponds to the *truncated* value of the programmed voltage. For instance, if  $V = +2.120\text{ V}$  through  $+2.129\text{ V}$ , the display will show  $+2.12$ ; similarly, if  $V = -12.730\text{ V}$  through  $-12.739\text{ V}$ , the display will show  $-12.73$ .

## 1.2.2 Battery

The “BATTERY” block of the front panel shows the present state of the SIM928’s internal battery system. The two batteries, labeled “A” and “B”, correspond to the two shaded rows, while the available battery states *On*, *Charge*, and *Ready* correspond to the three columns. A battery is *On* when it is switched to power the output stage; *Ready* corresponds to a battery in the (nominally) fully-charged state that is ready for operation when the *On* battery is depleted. The *Charge* state indicates that the battery is connected to the charger circuit.

### 1.2.2.1 Battery cycle

Under typical operation, a fully charged battery should run for 12–18 hours before being depleted. When the *On* battery is nearly discharged, an internal threshold circuit signals the SIM928 controller to begin a battery switch-over. The stand-by battery (which at this point is typically in the *Ready* state) is switched onto the output circuit, after which the discharged battery is switched to the charger circuit. A “diode-or” circuit effectively prevents the discharged battery from loading down the fresh battery, and the output driver operates without interruption.<sup>1</sup>

When the discharged battery is first connected to the charger circuit, a resistive load is briefly applied to complete the discharge of the cell to a known starting voltage. From that point, the charger applies a fixed charging current for ~ 5 hours to completely charge the battery.

If power is interrupted while the battery is charging, the charge cycle will *not* resume; rather, the power-on system check will select the most depleted battery for initial operation and place the other battery in the *Ready* state (assuming neither battery appears fully discharged). This algorithm ensures that a battery cannot be over-charged by an unfortunate series of power-cycles.

<sup>1</sup> A small glitch may appear at the output when the fresh battery switches in

### 1.2.2.2 Battery charge override

For some applications, it may be important to insure that the SIM928 will not begin a battery switch-over during a particularly sensitive experiment. The [Battery Override] can be used to force the *Ready* battery to be switched to *On* immediately, ensuring a 12+ hour period of un-switched operation.

The [Battery Override] is only armed when one of the batteries is in the *Ready* state; while a battery is in the *Charge* state, this key is temporarily disabled. To initiate a forced switch-over, press and hold [Battery Override] for at least 5 seconds. Over the next few seconds, the standby battery will be switched in, and the previously *On* battery will be switched to the standby (*Ready*) state—not to the charger—where it will remain.

### 1.2.2.3 Service batteries

The nickel-metal-hydride battery packs used in the SIM928 have a finite lifetime. After around 1000 charge/discharge cycles, the remaining battery capacity is significantly reduced; to restore the instrument to full performance, the battery pack must be replaced. The yellow *service batteries* indicator turns on when the battery pack has reached this limit. The SIM928 will continue to operate properly with reduced-capacity batteries; the only effect will be the battery switch-over will occur more frequently.

It is also possible, if a SIM928 is left in storage for several years without operation, that the batteries will have lost a significant fraction of their capacity due to aging. In this case, the yellow *service batteries* indicator will *not* turn on, but the user may notice a shorter period between battery charge cycles. The manufacture date of the battery pack can be determined with the remote `BIDN?` query.

Replacement battery packs can be ordered from Stanford Research Systems.

## 1.2.3 Output

The SIM928 output voltage is available at the front-panel between the red  $+$  and black  $-$  banana jack/binding posts. These connectors accept standard 0.175" in Banana plugs. The binding post accommodates wire leads up to #12 AWG, as well as open spade lugs for #8 studs (0.165" minimum opening).

The lower, green terminal is tied to the SIM928 chassis, and is available for user grounding. Either output terminal may be tied to chassis ground, if desired.

### 1.2.3.1 Output Overload

The SIM928 is specified to maintain its programmed voltage difference between the output terminals for load currents smaller than  $\pm 10$  mA. If an low-impedance load causes the output current to reach around  $\pm 15$  mA, the output will go into current-limit mode, and the red *OVL*D indicator will turn on. The SIM928 can remain in overload indefinitely, and will return to its programmed output voltage as soon as the load current is reduced.

### 1.2.3.2 Overvoltage / TRIP

In addition to its current-limiting circuitry, the SIM928 has an overvoltage sensing circuit that detects excessive voltage across the output terminals. If the voltage across the outputs exceeds  $\sim \pm 30$  V, this protection circuitry disconnects the output driver from the output terminals, and the red *Tri*p indicator will turn on. Typically, an overvoltage TRIP is generated by some external voltage applied to the SIM928 across its output terminals.

To clear an overvoltage TRIP, press [On/Off]. This will return the SIM928 to the *Off* state; a second press of [On/Off] will attempt to switch the instrument back on. If the overvoltage condition still exists, the output will again trip off.

## 1.3 SIM Interface

The primary connection to the SIM928 Isolated Voltage Source is the rear-panel DB-15 SIM interface connector. Typically, the SIM928 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 SIM928 directly, without using the SIM900 Mainframe. This section provides details on the interface.

### 1.3.1 SIM interface connector

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

### 1.3.2 Direct interfacing

The SIM928 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.

Pin	Signal	Direction Src ⇒ Dest	Description
1	SIGNAL_GND	MF ⇒ SIM	Ground reference for signal
2	-STATUS	SIM ⇒ MF	Status/service request (GND=asserted, +5V=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 (optional connection)
6	-5 V	MF ⇒ SIM	Power supply (No connection in SIM928)
7	-15 V	MF ⇒ SIM	Power supply (Battery charger)
8	PS_RTN	MF ⇒ SIM	Power supply return
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 (optional connection)
13	+5 V	MF ⇒ SIM	Power supply (digital circuitry)
14	+15 V	MF ⇒ SIM	Power supply (No connection in SIM928)
15	+24 V	MF ⇒ SIM	Power supply (Battery charger)

Table 1.1: SIM Interface Connector Pin Assignments, DB-15

The mating connector needed is a standard DB-15 receptacle, such as Amp part # 747909-2 (or equivalent). Clean, well-regulated supply voltages of -15,+5,+24 VDC must be provided, following the pin-out specified in Table 1.1. 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.

*The SIM928 has no internal protection against reverse polarity, missing supply, or overvoltage on the power supply pins.*

### 1.3.2.1 Direct interface cabling

If the user intends to directly wire the SIM928 independent of the SIM900 Mainframe, communication is usually possible by directly connecting the appropriate interface lines from the SIM928 DB-15 plug to the RS-232 serial port of a personal computer.<sup>2</sup> Connect RXD from the SIM928 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

<sup>2</sup> Although the serial interface lines on the DB-15 do not satisfy the minimum voltage levels of the RS-232 standard, they are typically compatible with desktop personal computers

with a female DB-15 socket to mate with the SIM928, 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 SIM928	Name
	DB-9/F
3 ↔ 7	RTS
4 ↔ 8	CTS
10 ↔ 3	TxD
11 ↔ 2	RxD
5	Computer Ground
	to P/S
7 ↔	-15 VDC
13 ↔	+5 VDC
15 ↔	+24 VDC
8,9 ↔	Ground (P/S return current)
1 ↔	Signal Ground (separate wire to Ground)

Table 1.2: SIM928 Direct Interface Cable Pin Assignments

### 1.3.2.2 Serial settings

The initial serial port settings at power-on are: 9600 Baud, 8-bits, no parity, 1 stop bit, and RTS/CTS flow control. These may be changed with the **BAUD**, **FLOW**, or **PARI** commands.

The maximum *standard* baud rate that the SIM928 supports is 38400. The minimum baud rate is 110. Above 38400, the SIM928 can be set to the following (non-RS-232-standard) baud rates: 62500, 78125, 104167, 156250. Note that these rates are typically not accessible on a standard PC RS-232 port, but can be used between the SIM928 and the SIM900 Mainframe.



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## 2 Remote Operation

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This chapter describes operating the SIM928 over the serial interface.

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## 2.1 Index of Common Commands

symbol	definition
<i>i,j</i>	Integers
<i>f</i>	Floating-point values
<i>z</i>	Literal token
(?)	Required for queries; illegal for set commands
<i>var</i>	Parameter always required
{ <i>var</i> }	Required parameter for set commands; illegal for queries
[ <i>var</i> ]	Optional parameter for both set and query forms

---

### Output

VOLT(?) { <i>f</i> }	2 – 9	Voltage
OPON	2 – 9	Output On
OPOF	2 – 9	Output Off
EXON(?) { <i>z</i> }	2 – 9	Excitation On/Off

---

### Battery

BCOR	2 – 9	Battery charger override
BATS?	2 – 10	Battery State
BIDN? <i>z</i>	2 – 10	Battery Identification

---

### Serial Communications

BAUD(?) { <i>i</i> }	2 – 10	Baud Rate
FLOW(?) { <i>z</i> }	2 – 11	Flow Control
PARI(?) { <i>z</i> }	2 – 11	Parity

---

### Status

*CLS	2 – 11	Clear Status
*STB? [ <i>i</i> ]	2 – 11	Status Byte
*SRE(?) [ <i>i</i> ,] { <i>j</i> }	2 – 11	Service Request Enable
*ESR? [ <i>i</i> ]	2 – 11	Standard Event Status
*ESE(?) [ <i>i</i> ,] { <i>j</i> }	2 – 11	Standard Event Status Enable
CESR? [ <i>i</i> ]	2 – 11	Communication Error Status
CESE(?) [ <i>i</i> ,] { <i>j</i> }	2 – 12	Communication Error Status Enable
OVCR? [ <i>i</i> ]	2 – 12	Overload Condition
OVSr? [ <i>i</i> ]	2 – 12	Overload Status
OVSE(?) [ <i>i</i> ,] { <i>j</i> }	2 – 12	Overload Status Enable
PSTA(?) { <i>z</i> }	2 – 12	Pulse –STATUS Mode

---

### Interface

*RST	2 – 12	Reset
CONS(?) { <i>z</i> }	2 – 12	Console Mode
*IDN?	2 – 13	Identify

---

*OPC(?)	2-13 Operation Complete
LEXE?	2-13 Execution Error
LCME?	2-13 Device Error
LBTN?	2-14 Button
TOKN(?) {z}	2-14 Token Mode
TERM(?) {z}	2-14 Response Termination

## 2.2 Alphabetic List of Commands

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### ★

*CLS	2 – 11	Clear Status
*ESE(?) [i,] {j}	2 – 11	Standard Event Status Enable
*ESR? [i]	2 – 11	Standard Event Status
*IDN?	2 – 13	Identify
*OPC(?)	2 – 13	Operation Complete
*RST	2 – 12	Reset
*SRE(?) [i,] {j}	2 – 11	Service Request Enable
*STB? [i]	2 – 11	Status Byte

---

### B

BATS?	2 – 10	Battery State
BAUD(?) {i}	2 – 10	Baud Rate
BCOR	2 – 9	Battery charger override
BIDN? z	2 – 10	Battery Identification

---

### C

CESE(?) [i,]{j}	2 – 12	Communication Error Status Enable
CESR? [i]	2 – 11	Communication Error Status
CONS(?) {z}	2 – 12	Console Mode

---

### E

EXON(?) {z}	2 – 9	Excitation On/Off
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### F

FLOW(?) {z}	2 – 11	Flow Control
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### L

LBTN?	2 – 14	Button
LCME?	2 – 13	Device Error
LEXE?	2 – 13	Execution Error

---

### O

OPOF	2 – 9	Output Off
OPON	2 – 9	Output On
OVCR? [i]	2 – 12	Overload Condition
OVSE(?) [i,]{j}	2 – 12	Overload Status Enable
OVSr? [i]	2 – 12	Overload Status

---

### P

PARI(?) {z}	2 – 11	Parity
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PSTA(?) {z}      2-12 Pulse -STATUS Mode

---

**T**

TERM(?) {z}      2-14 Response Termination

TOKN(?) {z}      2-14 Token Mode

---

**V**

VOLT(?) {f}      2-9 Voltage

## 2.3 Introduction

Remote operation of the SIM928 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 voltage source from a remote computer, either through the SIM900 Mainframe or directly via RS-232 (see Section 1.3.2.1).

See Table 1.1 for specification of the DB-15 SIM interface connector.

### 2.3.1 Power-on configuration

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

Most of the SIM928 instrument settings are stored in non-volatile memory, and at power-on the instrument returns to the state it was last in when power was removed. Exceptions are noted in the command descriptions.

Reset values of parameters are shown in **boldface**.

### 2.3.2 Buffers

Incoming data from the host interface is stored in a 32-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 SIM928 are buffered in a 128-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.

### 2.3.3 Device Clear

The SIM928 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 interface is reset to 9600 baud and CONS mode is turned OFF. Note that this *only* resets the communication interface; the basic function of the SIM928 is left unchanged; to reset the instrument, see \*RST.

## 2.4 Commands

This section provides syntax and operational descriptions for remote commands.

### 2.4.1 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 are omitted for queries. Parameters in [ ] are optional in both set and query commands. Parameters listed without any 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 whitespace are ignored. Execution of command(s) 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 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.

### 2.4.2 Notation

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

symbol	definition
<i>i,j</i>	Integers
<i>f</i>	Floating-point values
<i>z</i>	Literal token
(?)	Required for queries; illegal for set commands
<i>var</i>	Parameter always required
{ <i>var</i> }	Required parameter for set commands; illegal for queries
[ <i>var</i> ]	Optional parameter for both set and query forms



### 2.4.3 Output commands

These commands directly query and control the output state of the SIM928.

---

VOLT(?) {f}	Voltage Set (query) the programmed voltage {to f}.
OPON	Output On Turn the output on. The output state can be queried with the EXON(?) command, below.
OPOF	Output Off Turn the output off. The output state can be queried with the EXON(?) command, below.
EXON(?) {z}	Excitation On/Off Set (query) the output {to z=(OFF 0, ON 1)}. The output can also be turned on with the OPON command, and turned off with the OPOF command.

---

### 2.4.4 Battery commands

These commands directly query and control the battery system of the SIM928.

---

BCOR	Battery charger override Forces the SIM928 to switch the active output battery.  BCOR follows the same rules as the front-panel [Battery Override] button (see section 1.2.2.2). In particular, the command will only be operative if one of the batteries is in the “ready” state (see BATS?, below). Furthermore, the SIM928 may delay initiating BCOR by up to 1 s for internal synchronization.  To verify that BCOR has actually initiated a battery switch, the user program should: <ol style="list-style-type: none"> <li>1. Query OVSR? to clear the “Battery Switch” flag;</li> <li>2. Issue the BCOR command;</li> <li>3. Wait at least one second;</li> <li>4. Query OVSR? again to check for the “Battery Switch” flag.</li> </ol>
------	--

---

---

**BATS?** Battery State

Query the battery status of the SIM928.

The response is return in the format:  
 <a> , <b> , <x>  
 where <a> and <b> correspond to batteries “A” and “B”, and are equal to 1 for in use, 2 for charging, and 3 for ready/standby.

The third parameter, <x>, is normally 0; it is set to 1 if the *service batteries* indicator is lit.

---

**BIDN? z** Battery Identification

Query the battery identification parameter z.

Valid parameters to query are:

Value	Definition
PNUM 0	Battery pack part number
SERIAL 1	Battery pack serial number
MAXCY 2	Design life (# of charge cycles)
CYCLES 3	# charge cycles used
PDATE 4	Battery pack production date (YYYY-MM-DD)

The MAXCY parameter returns the estimated maximum number of charge-discharge cycles that *each* battery in the pack can sustain before suffering a significant reduction in charge capacity. The CYCLES parameter reports the actual number of cycles used by the “most used” battery in the pack. Typically, both batteries in the pack will have the same number of cycles (within  $\pm 1$ ), but it is possible, through power-cycling at odd times, to have one battery see more overall use than the other.

#### 2.4.5 Serial communication commands

---

**BAUD(?) {i}** Baud Rate

Set (query) the baud rate {to i}.

At power-on, the baud rate defaults to 9600.

Actual baud rate settings depend on implementation details of the SIM928, based on modulo prescalars of the 10 MHz system clock. As a result, queries of BAUD? will in general be slightly different from the set values. For example, after setting BAUD 9600, the query BAUD? will respond 9470. The functional requirement for successful asynchronous serial communication is no greater than  $\sim 5\%$  mismatch in baud rates.

---

---

FLOW(?) {z}	Flow Control Set (query) flow control {to z=(NONE 0, RTS 1, XON 2)}. At power-on, the SIM928 defaults to FLOW RTS flow control.
PARI(?) {z}	Parity Set (query) parity {to z = (NONE 0, ODD 1, EVEN 2, MARK 3, SPACE 4)}. At power-on, the SIM928 defaults to PARI NONE.

---

### 2.4.6 Status commands

The Status commands query and configure registers associated with status reporting of the SIM928. See Section 2.5 for more details.

---

*CLS	Clear Status *CLS immediately clears the ESR, CESR, and the OVSR.
*STB? [i]	Status Byte Reads the Status Byte register [bit <i>i</i> ]. Execution of the *STB? query (without the optional bit <i>i</i> ) always causes the –STATUS signal to be deasserted. Note that *STB? <i>i</i> will <i>not</i> clear –STATUS, even if bit <i>i</i> is the only bit presently causing the –STATUS signal.
*SRE(?) [i,] {j}	Service Request Enable Set (query) the Service Request Enable register [bit <i>i</i> ] {to <i>j</i> }.
*ESR? [i]	Standard Event Status Reads the Standard Event Status Register [bit <i>i</i> ]. Upon executing *ESR?, the returned bit(s) of the ESR register are cleared.
*ESE(?) [i,] {j}	Standard Event Status Enable Set (query) the Standard Event Status Enable Register [bit <i>i</i> ] {to <i>j</i> }.
CESR? [i]	Communication Error Status Query Communication Error Status Register [for bit <i>i</i> ]. Upon executing a CESR? query, the returned bit(s) of the CESR register are cleared.

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---

CESE(?) [i,j]	<p>Communication Error Status Enable</p> <p>Set (query) Communication Error Status Enable Register [bit i] {to j}.</p>
OVCR? [i]	<p>Overload Condition</p> <p>Query Overload Condition Register [for bit i].</p>
OVSR? [i]	<p>Overload Status</p> <p>Query Overload Status Register [for bit i].</p> <p>Upon executing a OVSR? query, the returned bit(s) of the OVSR register are cleared.</p>
OVSE(?) [i,j]	<p>Overload Status Enable</p> <p>Set (query) Overload Status Enable Register [bit i] {to j}.</p>
PSTA(?) {z}	<p>Pulse –STATUS Mode</p> <p>Set (query) the Pulse –STATUS Mode {to z=(OFF 0, ON 1)}.</p> <p>When PSTA ON is set, any new service request will only <i>pulse</i> the –STATUS signal low (for a minimum of 1 <math>\mu</math>s). The default behavior is to latch –STATUS low until a *STB? query is received.</p> <p>At power-on, PSTA is set to OFF.</p>

---

### 2.4.7 Interface commands

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*RST	<p>Reset</p> <p>Reset the SIM928 to default configuration.</p> <p>The following commands are internally executed upon *RST:</p> <ul style="list-style-type: none"> <li>• VOLT 0</li> <li>• EXON OFF</li> </ul>
CONS(?) {z}	<p>Console Mode</p> <p>Set (query) the Console mode {to z=(OFF 0, ON 1)}.</p> <p>CONS causes each character received at the Input Buffer to be copied to the Output Queue.</p> <p>At power-on and Device-Clear, CONS is set to OFF.</p>

---

---

**\*IDN?** Identify

Read the device identification string.

The identification string is formatted as:  
 Stanford\_Research\_Systems,SIM928,s/n\*\*\*\*\*,ver#.#  
 where \*\*\*\*\* is the 6-digit serial number, and #.# is the firmware revision level.

---

**\*OPC(?)** Operation Complete

Operation Complete. Sets the OPC flag in the ESR register.

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

---

**LEXE?** Execution Error

Query the last execution error code. Valid codes are:

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

---

**LCME?** Device Error

Query the last command error code. 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
13	Bad hex block
14	Unknown token

---

LBTN?

Button

Query the last button-press code. Valid codes are:

Value	Definition
0	no button pressed since last LBTN?
1	[On/Off]
2	[100 mV ▲]
3	[100 mV ▼]
4	[10 mV ▲]
5	[10 mV ▼]
6	[1 mV ▲]
7	[1 mV ▼]
8	[Battery Override]

TOKEN(?) {z}

Token Mode

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

If TOKEN ON is set, then queries to the SIM928 that return tokens will return the text keyword; otherwise they return the decimal integer value.

Thus, the only possible responses to the TOKEN? query are ON and 0.

At power-on, TOKEN OFF is set.

TERM(?) {z}

Response Termination

Set (query) the <term> sequence {to z=(NONE 0, CR 1, LF 2, CRLF 3, 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/or 10 (line feed).

At power-on, TERM CRLF is set.

## 2.5 Status Model

The SIM928 status registers follow the hierarchical IEEE–488.2 format. A block diagram of the status register array is given in Figure 2.1.

There are three categories of registers in the SIM928 status model:

- Condition Registers : These read-only registers correspond to the real-time condition of some underlying physical property being monitored. Queries return the latest value of the property, and have no other effect. Condition register names end with CR.
- Event Registers : These read-only registers record the occurrence of defined events. When the event occurs, the corresponding bit is set to 1. Upon querying an event register, any 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 any 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.

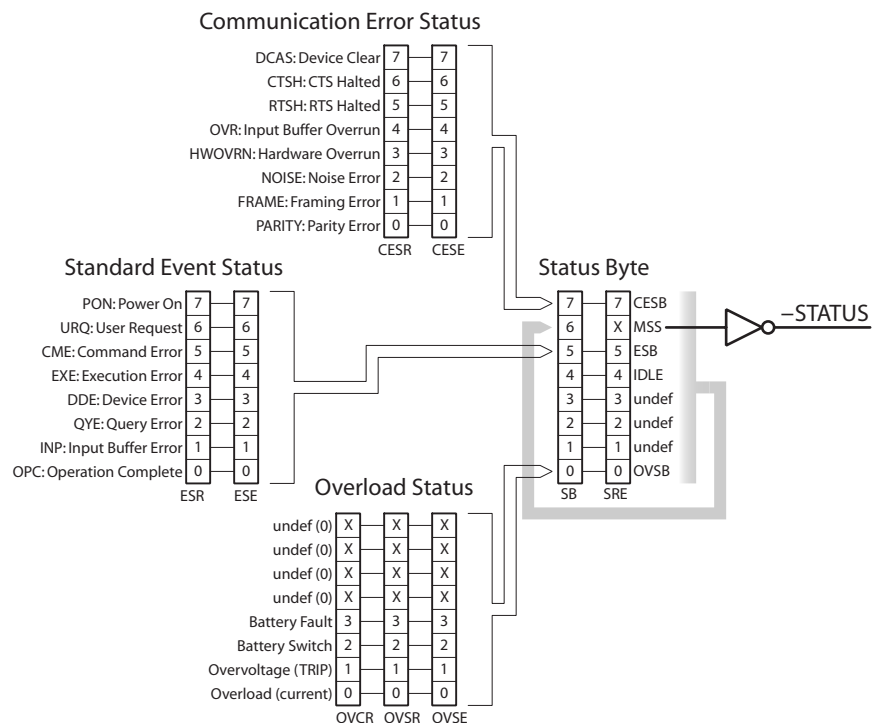


Figure 2.1: Status Register Model for the SIM928.

### 2.5.1 Status Byte (SB)

The Status Byte is the top-level summary of the SIM928 status model. When masked by the Service Request Enable register, a bit set in the Status Byte causes the  $\text{-STATUS}$  signal to be asserted on the rear-panel SIM interface connector.

Typically,  $\text{-STATUS}$  remains asserted (low) until a  $\text{*STB?}$  query is received, at which time  $\text{-STATUS}$  is deasserted (raised)<sup>1</sup>. After clearing the  $\text{-STATUS}$  signal, it will only be re-asserted in response to a *new* status-generating condition.

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

**OVSB :** Overload Status 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 SIM928 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. Note that while  $\text{-STATUS}$  is released by the  $\text{*STB?}$  query, MSS is only cleared when the underlying enabled bit message(s) are cleared.

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

Bits in the Status Byte are *not* cleared by the  $\text{*STB?}$  query. These bits are only cleared by reading the underlying event registers, or by clearing the corresponding enable registers.

<sup>1</sup> but see the PSTA command



### 2.5.2 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 the MSS bit in the SB and the  $\text{-STATUS}$  signal. 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.

This register is cleared at power-on.

### 2.5.3 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 event, 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. Indicates a SIM928 had a delayed execution error, due to an illegal mode state. The error code can be queried with `LDDE?`.

EXE : Execution Error. Indicates an error in a command that was successfully parsed. Out-of-range parameters are an example. The error code can be queried with `LEXE?`.

CME : Command Error. Indicates a parser-detected error. The error code can be queried with `LCME?`.

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

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

### 2.5.4 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). It can be set and queried with the \*ESE(?) command.

This register is cleared at power-on.

### 2.5.5 Communication Error Status (CESR)

The Communication Error Status register consists of 8 event flags; each of which is set by the corresponding event, and cleared only by reading 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 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 incoming data. Causes the Input Buffer to be flushed, and resets the command parser.

RTSH : Undefined for the SIM928. Command Error. Indicates a parser-detected error.

CTSH : Undefined for the SIM928.

DCAS : Device Clear. Indicates the SIM928 received the Device Clear signal (an RS-232 <break>). Clears the Input Buffer and Output Queue, and resets the command parser.

### 2.5.6 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). It can be set and queried with the CESE(?) command.

This register is cleared at power-on.

### 2.5.7 Overload Status (OVCR)

The Overload Condition Register consists of 3 single-bit monitors of conditions within the SIM928. Bits in the OVCR reflect the real-time values of their corresponding signals. Reading the entire register, or individual bits within it, does not affect the OVCR.

Weight	Bit	Flag
1	0	Overload
2	1	Overvoltage / TRIP
4	2	Battery Switch
8	3	Battery Fault
16	4	undef (0)
32	5	undef (0)
64	6	undef (0)
128	7	undef (0)

Overload : The output driver reached its current limit ( $\sim \pm 15$  mA).

Overvoltage / TRIP : The protection circuitry tripped off. This happens if the voltage across the outputs exceeds  $\pm 25$  V, and typically can only occur if an external voltage is applied to the instrument.

Battery Switch : Indicates a battery switch-over event has occurred, either due to the *On* battery being depleted, or a user-initiated [Battery Override] event.

Battery Fault : Indicates a gross battery failure (such as no battery installed). Detected at power-on only.

### 2.5.8 Overload Status (OVSR)

The Overload Status Register consists of (latching) event flags that correspond one-to-one with the bits of the OVCR (see above). Upon the transition  $0 \rightarrow 1$  of any bit within the OVCR, the corresponding bit in the OVSR becomes set.

Bits in the OVSR are unaffected by the  $1 \rightarrow 0$  transitions in the OVCR, and are cleared only by reading or with the \*CLS command. Reading a single bit (with the OVSR? *i* query) clears only bit *i*.

### 2.5.9 Overload Status Enable (OVSE)

The OVSE acts as a bitwise AND with the OVSR register to produce the single bit OVSB message in the Status Byte Register (SB). It can be set and queried with the OVSE(?) command.

This register is cleared at power-on.