

Operation and Service Manual

# Voltage Controlled Current Source

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**CS580**



Stanford Research Systems

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## Certification

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CS580 Voltage Controlled Current Source

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# Contents

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<b>General Information</b>	<b>iii</b>
Safety and Preparation for Use . . . . .	iii
Symbols . . . . .	iv
Notation . . . . .	v
Specifications . . . . .	vi
<b>1 Getting Started</b>	<b>1 – 1</b>
1.1 How to use this manual . . . . .	1–2
1.2 Preliminaries . . . . .	1–2
1.2.1 Equipment needed . . . . .	1–2
1.2.2 Preparations before use . . . . .	1–2
1.3 DC current and monitor output . . . . .	1–3
1.3.1 Procedure . . . . .	1–3
1.3.2 Discussion . . . . .	1–4
1.4 AC modulation . . . . .	1–5
1.4.1 Procedure . . . . .	1–6
1.4.2 Discussion . . . . .	1–7
1.5 Compliance limit and high impedance monitoring . . . . .	1–7
1.5.1 Procedure . . . . .	1–7
1.5.2 Discussion . . . . .	1–8
<b>2 Operation</b>	<b>2 – 1</b>
2.1 Navigating the front panel . . . . .	2–2
2.1.1 Gain . . . . .	2–2
2.1.2 Settings . . . . .	2–3
2.1.3 Adjust . . . . .	2–3
2.1.4 Configuration . . . . .	2–3
2.1.5 Input . . . . .	2–3
2.1.6 Speed . . . . .	2–3
2.1.7 Shield . . . . .	2–4
2.1.8 Isolation . . . . .	2–4
2.1.9 Monitor . . . . .	2–4
2.1.10 Output . . . . .	2–4
2.2 Power-on keys . . . . .	2–4
2.2.1 Power-on reset . . . . .	2–4
2.2.2 Power-on identify . . . . .	2–4

2.3	Introduction to the instrument . . . . .	2-5
2.3.1	Clock stopping architecture . . . . .	2-5
2.4	Instrument overview . . . . .	2-5
2.4.1	Input section . . . . .	2-5
2.4.2	DC current . . . . .	2-6
2.4.3	Compliance voltage . . . . .	2-7
2.4.4	Current source . . . . .	2-7
2.4.5	Speed setting . . . . .	2-8
2.4.6	Guard buffer . . . . .	2-8
2.4.7	Isolation . . . . .	2-9
2.4.8	Output . . . . .	2-9
2.5	Configurations and grounding . . . . .	2-9
2.5.1	Floating configurations . . . . .	2-9
2.5.2	Grounded configurations . . . . .	2-11
2.6	Error messages . . . . .	2-12
<b>3</b>	<b>Remote Operation</b> . . . . .	<b>3-1</b>
3.1	Index of commands . . . . .	3-2
3.2	Alphabetic list of commands . . . . .	3-3
3.3	Introduction . . . . .	3-5
3.3.1	Interface configuration . . . . .	3-5
3.3.2	Buffers . . . . .	3-5
3.4	Commands . . . . .	3-6
3.4.1	Command syntax . . . . .	3-6
3.4.2	Notation . . . . .	3-7
3.4.3	Examples . . . . .	3-7
3.4.4	Configuration commands . . . . .	3-8
3.4.5	Setting commands . . . . .	3-11
3.4.6	Setup commands . . . . .	3-11
3.4.7	Interface commands . . . . .	3-11
3.4.8	Status commands . . . . .	3-12
3.5	Status model . . . . .	3-16
3.5.1	Status byte (SB) . . . . .	3-16
3.5.2	Service request enable (SRE) . . . . .	3-17
3.5.3	Standard event status (ESR) . . . . .	3-17
<b>A</b>	<b>Fuse and ac Line</b> . . . . .	<b>A-1</b>
A.1	Power Entry module . . . . .	A-1
A.2	ac voltage selector . . . . .	A-1
A.3	Fuse installation . . . . .	A-2

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## General Information

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### Safety and Preparation for Use



#### WARNING

**Dangerous voltages, capable of causing injury or death, are present in this instrument. Do not remove the product covers or panels. Do not apply power or operate the product without all covers and panels in place.**

#### AC line voltage

The CS580 Voltage Controlled Current Source operates from a 100 V, 120 V, 220 V–230 V, or 240 V nominal ac power source having a line frequency of 50 Hz or 60 Hz. Before connecting the power cord to a power source, verify that the LINE VOLTAGE SELECTOR, located in the rear panel power-entry module, is set so that the correct ac line voltage value is visible. For operation with 220 V ac power, the LINE VOLTAGE SELECTOR should be set to 230 V.



#### CAUTION

The CS580 Voltage Controlled Current Source will be damaged if operated with the LINE VOLTAGE SELECTOR set for the wrong ac line voltage, or if the wrong fuses are installed. Verify that the correct line fuses are installed before connecting the line cord. For 100 V/120 V, use 1 A fuses; for 220 V–230 V/240 V, use 0.5 A fuses. See appendix A for detailed instructions.

#### Line cord






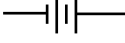



The CS580 Voltage Controlled Current Source has a detachable, three-wire power cord for connection to the power source and to a protective ground. The chassis of the instrument is connected to the outlet ground to protect against electrical shock. Always use an outlet which has a properly connected protective ground.

#### Service

The CS580 Voltage Controlled Current Source does not have any user serviceable parts inside. Refer service to a qualified technician.

Do not install substitute parts or perform any unauthorized modifications to this instrument. Contact the factory for instructions on how to return the instrument for authorized service and adjustment.

### 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.



### WARNING

A warning means that injury or death is possible if the instructions are not obeyed.



### CAUTION

A caution means that damage to the instrument or other equipment is possible.

Typesetting conventions used in this manual are:

- Front-panel buttons are set as [Button]
- Front-panel knobs are set as Knob
- Front-panel indicators are set as *Overload*
- Remote command names are set as \*IDN?
- Literal text other than command names is set as OFF

Remote command examples will all be set in monospaced font. In these examples, data sent by the host computer to the CS580 are set as `straight teletype font`, while responses received by the host computer from the CS580 are set as *slanted teletype font*.

## Specifications

All performance specifications after 1 hour warm-up at 23 °C ±2 °C ambient.

### Current Output

Parameter	Specification
Output current	0 to ±110 mA, in 9 ranges
Compliance voltage	0 to 50 V (bipolar)
Compliance voltage error	0.5 % + 50 mV (max. overshoot 1.5 V)
DC output resistance	10 <sup>12</sup> Ω (1 nA/V gain)
Output capacitance	< 12 pF (filter off); < 500 pF (filter on)
Guard output	−50 V to +50 V, 5 kΩ internal resistance
Output power	5 V·A (four quadrant sourcing / sinking)
Total harmonic distortion	0.05 % (typ.)
Output connectors	3-lug Triax for current output. Banana jacks for voltage monitoring
Common mode voltage	250 V <sub>rms</sub> max. (DC to 60 Hz)
Common mode isolation	> 1 GΩ; < 1 nF

### Monitor Output

Parameter	Specification
Source impedance	5 kΩ
Output bandwidth	20 kHz (typ., into high impedance)

### Input

Parameter	Specification
Input range	−2 V to +2 V
Input impedance	100 kΩ
Input connector	BNC



**Analog input performance**

Gain	Max output	-3 dB Bandwidth (0 $\Omega$ load, typ.)	DC Gain accuracy
1 nA/V	2.2 nA	5 kHz	1.2 %
10 nA/V	22 nA	10 kHz	1.2 %
100 nA/V	220 nA	20 kHz	1.2 %
1 $\mu$ A/V	2.2 $\mu$ A	75 kHz	0.5 %
10 $\mu$ A/V	22 $\mu$ A	150 kHz	0.5 %
100 $\mu$ A/V	220 $\mu$ A	150 kHz	0.5 %
1 mA/V	2.2 mA	150 kHz	0.5 %
10 mA/V	22 mA	200 kHz	0.5 %
50 mA/V	110 mA	150 kHz	1 %

Parameter	Specification
Gain drift	200 ppm/ $^{\circ}$ C
Offset	3 mV (referred to input)
Offset drift	1 mV/ $^{\circ}$ C (referred to input)

**DC current performance**

Specifications are for the internal dc current source, with external analog input off.

Gain	Max output	DC accuracy	Resolution	Drift (typ.)
1 nA/V	2 nA	0.5 % + 10 pA	100 fA	100 ppm/ $^{\circ}$ C + 100 fA/ $^{\circ}$ C
10 nA/V	20 nA	0.5 % + 10 pA	1 pA	100 ppm/ $^{\circ}$ C + 200 fA/ $^{\circ}$ C
100 nA/V	200 nA	0.5 % + 100 pA	10 pA	100 ppm/ $^{\circ}$ C + 2 pA/ $^{\circ}$ C
1 $\mu$ A/V	2 $\mu$ A	0.1 % + 1 nA	100 pA	50 ppm/ $^{\circ}$ C + 20 pA/ $^{\circ}$ C
10 $\mu$ A/V	20 $\mu$ A	0.1 % + 10 nA	1 nA	50 ppm/ $^{\circ}$ C + 200 pA/ $^{\circ}$ C
100 $\mu$ A/V	200 $\mu$ A	0.1 % + 100 nA	10 nA	50 ppm/ $^{\circ}$ C + 2 nA/ $^{\circ}$ C
1 mA/V	2 mA	0.1 % + 1 $\mu$ A	100 nA	50 ppm/ $^{\circ}$ C + 20 nA/ $^{\circ}$ C
10 mA/V	20 mA	0.1 % + 10 $\mu$ A	1 $\mu$ A	50 ppm/ $^{\circ}$ C + 200 nA/ $^{\circ}$ C
50 mA/V	100 mA	0.1 % + 50 $\mu$ A	10 $\mu$ A	50 ppm/ $^{\circ}$ C + 1 $\mu$ A/ $^{\circ}$ C

**Noise**

Gain	Noise density		RMS noise, inp. off	
	Input off	Input on	0.1 to 10 Hz	>10 Hz
1 nA/V	10 fA/ $\sqrt{\text{Hz}}$	10 fA/ $\sqrt{\text{Hz}}$	20 fA	50 pA
10 nA/V	20 fA/ $\sqrt{\text{Hz}}$	20 fA/ $\sqrt{\text{Hz}}$	80 fA	50 pA
100 nA/V	60 fA/ $\sqrt{\text{Hz}}$	60 fA/ $\sqrt{\text{Hz}}$	400 fA	300 pA
1 $\mu\text{A}/\text{V}$	300 fA/ $\sqrt{\text{Hz}}$	400 fA/ $\sqrt{\text{Hz}}$	4 pA	1 nA
10 $\mu\text{A}/\text{V}$	3 pA/ $\sqrt{\text{Hz}}$	4 pA/ $\sqrt{\text{Hz}}$	40 pA	5 nA
100 $\mu\text{A}/\text{V}$	30 pA/ $\sqrt{\text{Hz}}$	40 pA/ $\sqrt{\text{Hz}}$	400 pA	40 nA
1 mA/V	300 pA/ $\sqrt{\text{Hz}}$	400 pA/ $\sqrt{\text{Hz}}$	4 nA	400 nA
10 mA/V	3 nA/ $\sqrt{\text{Hz}}$	4 nA/ $\sqrt{\text{Hz}}$	40 nA	4 $\mu\text{A}$
50 mA/V	15 nA/ $\sqrt{\text{Hz}}$	20 nA/ $\sqrt{\text{Hz}}$	200 nA	20 $\mu\text{A}$

**Remote Interfaces**

RS-232	DB-9 connector, 9600 baud
Optical fiber	Connection to SX199 Optical Interface Controller. Provides isolated connectivity to GPIB, RS-232, and Ethernet.

**General**

Parameter	Specification
Temperature	0 °C to 40 °C, non-condensing
Power	< 30 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	8.3" W $\times$ 3.5" H $\times$ 13" D
Weight	10 lbs
Fuse	one (1) AG size 0.25" $\times$ 1.25", or two (2) metric size 5 $\times$ 20 mm, "slow blow"

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# 1 Getting Started

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This chapter provides step-by-step instruction to get started quickly with the CS580 Voltage Controlled Current Source. Refer to chapter 2 for a more complete introduction to the CS580.

## In This Chapter

<b>1.1</b>	<b>How to use this manual</b>	<b>1-2</b>
<b>1.2</b>	<b>Preliminaries</b>	<b>1-2</b>
1.2.1	Equipment needed	1-2
1.2.2	Preparations before use	1-2
<b>1.3</b>	<b>DC current and monitor output</b>	<b>1-3</b>
1.3.1	Procedure	1-3
1.3.2	Discussion	1-4
<b>1.4</b>	<b>AC modulation</b>	<b>1-5</b>
1.4.1	Procedure	1-6
1.4.2	Discussion	1-7
<b>1.5</b>	<b>Compliance limit and high impedance monitoring</b>	<b>1-7</b>
1.5.1	Procedure	1-7
1.5.2	Discussion	1-8

## 1.1 How to use this manual

Two possible starting points are available to new users of the CS580. Those who want to begin with an overview to the functional layout of the instrument should turn to Chapter 2.

Users who prefer to jump in and begin using the CS580 first should continue with this Chapter, where a series of step-by-step procedures are given to verify the basic performance of the instrument. This will also provide a quick introduction to the CS580 and how it is operated.

Chapter 3 discusses remote operation of the CS580, over the optical fiber or RS-232 interface.

## 1.2 Preliminaries

This chapter provides step-by-step instructions for verifying the basic operation of the CS580. In addition to confirming proper operation, it provides a good introduction to operating the current source.

### 1.2.1 Equipment needed

To perform all the steps described in this chapter, you will need:

1. a collection of several BNC cables and tees.
2. the CS580 triax-to-alligator cable,
3. a dual banana-to-BNC (female) adapter,
4. a collection of leaded resistors: 10  $\Omega$ , 1 k $\Omega$ , 100 k $\Omega$ , 10 M $\Omega$ , and (optionally) 1 G $\Omega$ ,
5. a function generator,
6. two multimeters (either hand-held type or benchtop),
7. a general purpose 2-channel oscilloscope with a 10 M $\Omega$ , 10 $\times$  passive probe with ground clip.

### 1.2.2 Preparations before use



#### CAUTION

1. Before using the instrument, verify the rear-panel power entry module is properly configured for the power line voltage in your region. Applying power with improper setting of the line voltage selector will result in significant damage to the CS580.
2. Turn the rear-panel Power switch to off.
3. Plug in the AC line cord to the rear-panel power entry module, and into a grounded wall outlet.

4. Connect a BNC cable from function generator output to the CS580 front-panel INPUT BNC. Tee the connection to also go to Channel 1 of the oscilloscope.
5. Plug the triax-to-alligator cable into the front-panel OUTPUT triax connector.
6. Switch on the AC power while holding the INPUT [Enable] button depressed. Once the CS580 indicators all light, you may release [Enable]. This will perform the power-on reset. After several seconds, the display will show “DEf Cfg”, and then “0.0000”.
7. Connect the triax red alligator clip to one end of the 1 k $\Omega$  resistor. Connect the triax black alligator clip to the other end of the 1 k $\Omega$  resistor. Place the resistor on a non-conductive surface, and ensure that the triax green alligator clip is not touching any conductor.
8. Connect the banana-to-BNC adaptor into the MONITOR jack on the front panel. Ensure the “ground” side of the adaptor is plugged into the black receptacle.
9. Allow the unit to warm up for 1 hour for full specified performance. Warm up is not needed to test basic functionality.

### 1.3 DC current and monitor output

This first test demonstrates the basic connections of the CS580, and will exercise the internal DC current generator.

#### 1.3.1 Procedure

1. Press the INPUT [Enable] button to turn off the INPUT On indicator.
2. Connect one multimeter to the MONITOR output, and set the multimeter to read volts. Label this voltmeter “Monitor”.
3. Connect the second voltmeter using test leads to measure the voltage across the 1 k $\Omega$  resistor, and set the multimeter to read volts. Label this voltmeter “Resistor”.
4. Ensure the *DC current* indicator is illuminated in the SETTINGS block. If not, briefly press in the **ADJUST** knob.
5. Turn the **ADJUST** knob to set DC current to 0.250 mA. Verify that both voltmeters still displays approximately 0 V.

6. Press the OUTPUT [Enable] button to turn on the output. The *On* indicator should light, and both voltmeters should display approximately 250 mV.
7. Turn the **ADJUST** knob to set the DC current to 1.000 mA. The voltmeters should now display 1 V.
8. Press the OUTPUT [Enable] button to turn off the output, and then press the [Shield] button to select *Guard*. Press the key-Ground button to select *Ground*.
9. Press the OUTPUT [Enable] button to turn on the output again. The *Compliance limit* indicator should light, indicating the output reached the limit voltage (presently 10 V). The “Monitor” meter should read near 10 V, while the “Resistor” meter should read near 0 V.
10. Carefully disconnect the triax black alligator lead from the resistor, and then connect the triax green alligator lead to the resistor at the point where the black lead was just removed. Both meters should now display 1 V.
11. Press the OUTPUT [Enable] button to turn off the output.

### 1.3.2 Discussion

For the preceding example, the CS580 was used as a DC current source, and the default settings for gain and compliance voltage were left unchanged.

The 3 terminals of the triax connection, referred to as center, inner shield, and outer shield, are accessed from the red, black, and green alligator clips respectively. The center conductor (red clip) is always the current output of the instrument, and is the high impedance node where current is sourced/sunk by the CS580 to the user’s load. The outer shield (green clip) is always tied to chassis ground.

The inner shield (black clip) is configured by the SHIELD and ISOLATION sections of the front panel. When SHIELD is configured as *Return*, the inner shield is electrically connected to the return node of the current source; when so configured, this node may be used to complete the current source circuit. When SHIELD is configured as *Guard*, the inner shield is driven by the voltage buffer to track the voltage of the center conductor. In this mode, the inner shield acts as a “driven guard” to reduce leakage and potentially increase AC bandwidth, but it cannot be used to carry the return current of the source.

When ISOLATION is configured as *Float*, the entire current source circuit is disconnected from chassis ground. In this configuration,

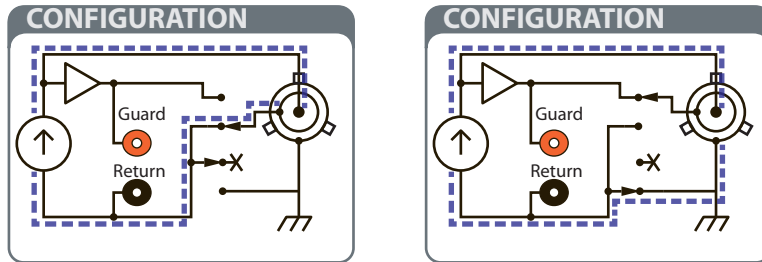


Figure 1.1: Two typical CS580 configurations. On the left, the inner shield is connected to the current return, and the source is floating. On the right, the inner shield is connected to the driven guard, and the source is grounded.

return current must be wired back to the instrument through the “Return” node. This can either be via the inner shield (if SHIELD is configured for *Return*), or else by the MONITOR Return terminal (the black banana receptacle). When ISOLATION is configured as *Ground*, the Return node of the current source is electrically tied to chassis ground. In this configuration, return current may flow back to the source via any path to chassis ground (although in practice, the outer shield is typically used).

In the preceding example, we first operated with the CS580 in *Float* mode, with SHIELD set to *Return* (see Figure 1.1, left-hand side). The current source’s circuit flowed from the center conductor (red clip), through the 1 k $\Omega$  resistor, then to the inner shield (black clip) back to the source. The “Monitor” voltage showed the voltage across the resistor as measured by the internal voltage buffer, while the “Resistor” voltmeter measured the same voltage directly.

When the configuration was changed to SHIELD *Guard*, and ISOLATION *Ground* (see Figure 1.1, right-hand side), initially there was no return path for current and the CS580 source went into compliance voltage limiting. The “Monitor” voltage showed the center conductor reached the limit voltage (at it’s default value of 10 V), but no current was flowing as could be seen by the “Resistor” voltmeter reading 0 V.

When the black clip was removed from the 1 k $\Omega$  resistor and replace with the green clip, a return path was again established for the current. Now the instrument came back out of compliance limiting, and again both voltmeters reported the voltage across the resistor.

## 1.4 AC modulation

This exercise demonstrates using the analog voltage input to generate ac current outputs with the CS580.

### 1.4.1 Procedure

1. If not already done, follow the initial preparations described in section 1.2.2.
2. Set the function generator to output a sine wave, 1.0 V peak to peak, at 1 kHz.
3. Using the 10 M $\Omega$  10 $\times$  probe, connect the probe to the same side of the 1 k $\Omega$  resistor as the red alligator clip. Connect the probe ground clip to the opposite side of the 1 k $\Omega$  resistor (adjacent to the black alligator clip from the CS580.)
4. Using the **GAIN** knob, select 1 mA/V.
5. Trigger the oscilloscope on Channel 1 (the function generator signal), and verify that Channel 2 (the scope probe) shows now signal.
6. Press the OUTPUT [Enable] button to turn on the current output. Verify that Channel 2 on the oscilloscope shows a similar signal.
7. If available on the function generator, vary the waveform from sine to square, triangle, and sawtooth. Verify that similar waveforms appear on Channel 2. Return the function generator to sine wave output.
8. Try turning the **GAIN** knob to select 10 mA/V, and verify the CS580 does not allow the gain to change with the output on and analog input enabled.
9. Press the OUTPUT [Enable] button to disable the current output, and then turn the **GAIN** knob to select 10 mA/V. Press the OUTPUT [Enable] button again to re-enable the current output, and verify that Channel 2 on the oscilloscope now shows a 10 V pp.
10. If necessary, press the **ADJUST** knob to select *DC current*, and then turn **ADJUST** to select  $-1.0$  mA. Verify that Channel 2 on the oscilloscope is now offset by  $-1$  V.
11. Press the INPUT [Enable] button to disable the analog input, and verify that Channel 2 on the oscilloscope now shows a flat  $-1$  V dc. Turn the **GAIN** knob back to 1 mA/V, and press INPUT [Enable] again. Verify that Channel 2 now shows a 1 V pp ac signal, still offset by  $-1$  V.



### 1.4.2 Discussion

In this example, the analog input was used to create arbitrary ac currents. When configured for 1 mA/V, the CS580 was outputting 1.0 mA pp in response to the 1.0 V pp analog input. Note that gain changes could only be performed with the output disabled, or the input disabled. Additional dc current, set from the front panel, is added to the analog input signal.

## 1.5 Compliance limit and high impedance monitoring

This exercise generates low-level currents into a relatively high impedance load, and will demonstrate the compliance limit function as well as using the monitor output to measure a high impedance load.

### 1.5.1 Procedure

1. If not already done, follow the initial preparations described in section 1.2.2, but connect the 1 G $\Omega$  resistor rather than the 1 k $\Omega$  resistor to the triax cable. Be careful not to touch the resistor body with your fingers, as skin oils will effectively short out the high impedance of the resistor. If no G $\Omega$  resistor is available, use a 10 M $\Omega$  instead.
2. (Optionally) Arrange the resistor inside a small metal box with the alligator leads coming out, supported on plastic or ceramic so that neither end of the resistor can touch the metal box. Clip the green alligator lead to the metal box to ground it. If skipping this step, leave the green clip unattached. Note that significant line frequency interference (50 Hz or 60 Hz) is expected if no grounded enclosure is used.
3. Connect the MONITOR output to Channel 2 of the oscilloscope using a BNC cable.
4. Using the **GAIN** knob, select 10 nA/V (if using a 10 M $\Omega$  resistor, select 1  $\mu$ A/V).
5. Set the function generator to output a sine wave, 1.0 V pp, at 10 Hz.
6. Press the OUTPUT [Enable] button to turn on the current output. Verify that Channel 2 on the oscilloscope shows a 10 V pp signal, corresponding to 10 nA pp (1.0  $\mu$ A pp for 10 M $\Omega$ ).
7. Press the **ADJUST** knob to select *Compliance voltage*, and then turn **ADJUST** to select 2.0 V. Verify that Channel 2 on the oscilloscope is now showing clipping at  $\pm 2$  V.

### 1.5.2 Discussion

When connected to a high impedance load, attaching additional test leads (such as a 10 M $\Omega$  scope probe) is not practical—if operating with a 1 G $\Omega$  load, such a probe would shunt away 99% of the output current, leaving the intended load starved of current.

This is the essential purpose of the MONITOR output. Internal to the CS580, an electrometer-grade voltage buffer provides a unity gain copy of the voltage across the external load. Note that the monitor output has 5 k $\Omega$  output source impedance, which can limit the monitor bandwidth when driving significant cable lengths. This monitor output can then be used for external measurements (such as with an oscilloscope) without affecting the current flowing through the load.

Do note, however, that the black banana terminal of the MONITOR output is electrically tied to the return node of the current source. When using the CS580 in floating mode, making a grounded connection to the MONITOR output (such as through an oscilloscope) will effectively ground the current source as well.

Finally, adjusting the compliance voltage limit showed the active voltage limiting of the CS580.

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## 2 Operation

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This chapter provides a basic overview of the CS580 Voltage Controlled Current Source.

### In This Chapter

<b>2.1</b>	<b>Navigating the front panel</b>	<b>2-2</b>
2.1.1	Gain	2-2
2.1.2	Settings	2-3
2.1.3	Adjust	2-3
2.1.4	Configuration	2-3
2.1.5	Input	2-3
2.1.6	Speed	2-3
2.1.7	Shield	2-4
2.1.8	Isolation	2-4
2.1.9	Monitor	2-4
2.1.10	Output	2-4
<b>2.2</b>	<b>Power-on keys</b>	<b>2-4</b>
2.2.1	Power-on reset	2-4
2.2.2	Power-on identify	2-4
<b>2.3</b>	<b>Introduction to the instrument</b>	<b>2-5</b>
2.3.1	Clock stopping architecture	2-5
<b>2.4</b>	<b>Instrument overview</b>	<b>2-5</b>
2.4.1	Input section	2-5
2.4.2	DC current	2-6
2.4.3	Compliance voltage	2-7
2.4.4	Current source	2-7
2.4.5	Speed setting	2-8
2.4.6	Guard buffer	2-8
2.4.7	Isolation	2-9
2.4.8	Output	2-9
<b>2.5</b>	<b>Configurations and grounding</b>	<b>2-9</b>
2.5.1	Floating configurations	2-9
2.5.2	Grounded configurations	2-11
<b>2.6</b>	<b>Error messages</b>	<b>2-12</b>

## 2.1 Navigating the front panel

The front panel of the CS580 is organized into distinct functional sections. A picture of the entire front panel is in Figure 2.1, below.



Figure 2.1: The CS580 front panel.

### 2.1.1 Gain

Use the **Gain** knob to select the voltage-to-current gain of the CS580, from 1 nA/V to 50 mA/V. This also sets the range for the dc current setting to  $\pm 2$  V times the gain. For instance, when set to 10  $\mu$ A/V gain, the range of dc current is  $\pm 20$   $\mu$ A.

Note that **Gain** cannot be changed when the output is on *and* the analog input is also on.

## 2.1.2 Settings

This block displays either the dc current setting, or the compliance voltage setting. Pressing the **Adjust** knob toggles between the two displays, which are indicated below the numeric display.

## 2.1.3 Adjust

The **Adjust** knob is used to both toggle between dc current and compliance voltage, and adjusting either of those two settings. The current “focus” of the knob is indicated by the two small indicator LEDs just below the numeric display—briefly press and release the **Adjust** knob to toggle between *DC current* and *Compliance voltage*.

Turning the knob modifies the displayed value. To quickly set the parameter to zero, press *and hold* the knob inwards for several seconds, until the display shows zero.

## 2.1.4 Configuration

This section of the front panel indicates the present configuration of the instrument. The upper pair of LED indicators within the diagram show the state of the SHIELD mode, as either *Guard* or *Return*. The lower pair of LED indicators show the ISOLATION mode, as either *Float* (the upper, yellow indicator) or *Ground* (the lower, green indicator).

The *CPU* indicator shows when the internal digital circuitry of the CS580 is active in response to a user command.

## 2.1.5 Input

The user analog input voltage is applied to the BNC in the INPUT section. Note that the analog input voltage is only applied when the *On* indicator is lit. Pressing the [Enable] button toggles the *On* state.

The *Overload* indicator reflects both the maximum input range of the analog input ( $\pm 2$  V) as well as any dc current being added by the CS580.

## 2.1.6 Speed

Pressing the [Speed] button toggles between *Fast* and *Slow* mode. When *Slow* is selected, a 470 pF capacitor is added to the output node.

### 2.1.7 Shield

Pressing the [Shield] button toggles between *Guard* and *Return* modes. This controls the inner shield of the triax connector, selecting between the driven guard and the current source return.

The [Shield] setting cannot be changed when the output is *On*.

### 2.1.8 Isolation

Pressing the [Ground] button toggles between *Float* and *Ground*, and effectively isolates the current source circuit from chassis ground.

The [Ground] setting cannot be changed when the output is *On*.

### 2.1.9 Monitor

The banana jacks of the MONITOR block provide a convenient way to monitor the operating voltage of the current source output. Note that the black Return jack may be needed to complete the current circuit when operating in *Float + Guard* mode. Also note that the red Guard jack has a 5 k $\Omega$  output impedance, which can limit the bandwidth when monitoring an ac signal through long cables.

### 2.1.10 Output

The triaxial connector of the OUTPUT block is the main connection to the current source. The source output is toggled *On* and off by pressing the OUTPUT [Enable] button. If the operating voltage reaches the compliance voltage limit, the *Compliance limit* indicator lights.

## 2.2 Power-on keys

There are two special button operations available to users while turning on power to the CS580.

### 2.2.1 Power-on reset

Pressing and holding the Input [Enable] button while turning on power will restore the default configuration of the CS580. This is equivalent to the remote \*RST command.

### 2.2.2 Power-on identify

Pressing and holding the [Speed] button while turning on power will cause the instrument's serial number and firmware revision number to be shown on the numeric display.

## 2.3 Introduction to the instrument

The CS580 Voltage Controlled Current Source is a benchtop instrument for sourcing and sinking low-noise currents from femtoamps to milliamps. The key feature of the CS580 is the analog voltage input, which lets researchers use their existing ac instruments, such as lock-in amplifiers, to control the output current. The output triaxial connector can be configured for either return current or driven guard operation, and the entire current source may be floated or grounded by user command.

Configuration of the instrument is controlled either from the front panel buttons, or from your computer using one of the remote interfaces. Commands are processed by an internal microcontroller that halts its internal clock when idle, preventing unwanted digital noise.

### 2.3.1 Clock stopping architecture

This “clock-stopping” architecture, first introduced by SRS in the SR560 Voltage Preamplifier, eliminates the inconvenience and reliability issues associated with mechanical panel controls, and makes full remote operation of the CS580 possible. Whenever the microcontroller becomes active, the *CPU* activity indicator illuminates, clearly showing when the digital clock is running. This occurs in response to front-panel button presses or remote computer commands.

The numeric display on the CS580 is exclusively for setting either the dc output current, or the compliance voltage limit. No “live” readings are made by the CS580, and the numeric display is statically driven to eliminate any possible switching noise.

## 2.4 Instrument overview

A functional overview of the CS580 with its main sections is given below. A block diagram of the CS580 is shown in Figure 2.2.

A key feature of the CS580 is its floating power design. The entire output circuit is powered by an isolated power supply, allowing the user to establish the ground reference anywhere within their setup.

### 2.4.1 Input section

The analog input section of the CS580 consists of a 100 k $\Omega$  input impedance, unity-gain isolation amplifier. Isolation is required to bring the user’s voltage input from the front-panel BNC, referenced to chassis ground, to the floating circuitry of the current source. This signal path can be enabled or disabled by remote command or by pressing the INPUT [Enable] button.

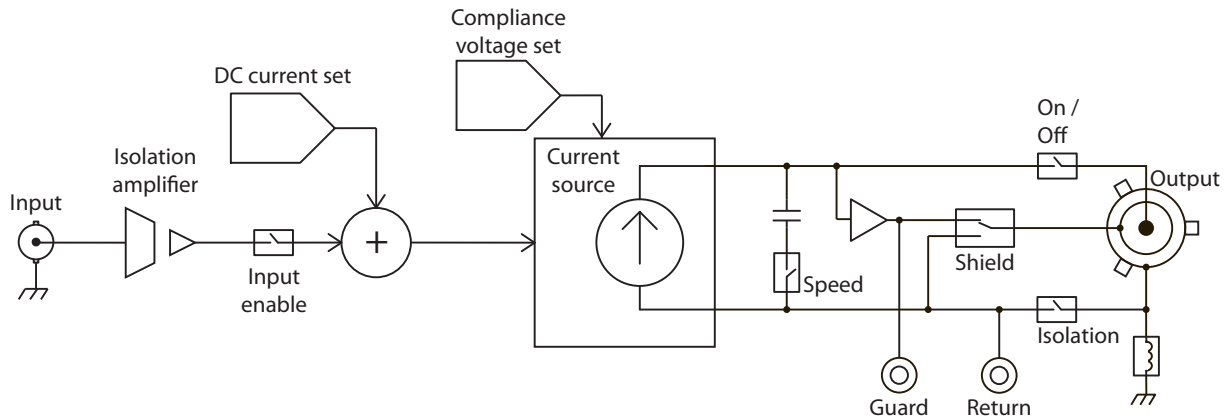


Figure 2.2: The CS580 block diagram.

This analog programming voltage is converted to current by the selected gain setting, which can be set from 1 nA/V up to 50 mA/V in nine (9) ranges. The analog input is dc coupled, meaning that any combination of ac and dc inputs, within the input range of  $\pm 2$  V, may be used.

Note that the **GAIN** setting cannot be modified when the analog input is enabled *and* the current output is enabled. Also note that the *Overload* indicator reflects the combination of both input voltage *and* the internally-generated dc current (see below).

## 2.4.2 DC current

In addition to the analog programming voltage, the CS580 has an internal dc current generator. This setting is controlled either from the front panel or remotely, and is always active when the current output is enabled, even if the analog input section is disabled. Briefly pressing the **ADJUST** knob toggles the adjustment focus between *DC current* and *Compliance voltage*. While *DC current* is selected, the current can be set to zero by pressing and holding the knob in for several seconds.

The range of dc current setting is controlled by the gain selection. See the specification table in section on page vii for details. Note that when increasing gain settings, the dc current value remains unchanged. But when decreasing gain, if the previous setting becomes out of range, the value is forced to the maximum. For example, if the dc current is set to 8.45  $\mu$ A while on the 10  $\mu$ A/V gain, and then **GAIN** is turned down to the 1  $\mu$ A/V setting, the dc current is forced to 2  $\mu$ A (the maximum value for the new gain setting).



### 2.4.3 Compliance voltage

The Compliance voltage setting limits the voltage that can be produced on the current output node of the CS580. The compliance can be set between 0 and 50 V, either from the front panel or remotely. For situations where there is a maximum safe operating voltage for the external load, the user should adjust the compliance voltage to a value smaller than the safe maximum. The user should also estimate the voltage needed for the desired current being sent to the load. The compliance voltage should be adjusted to a value greater than this to avoid limiting the output due to compliance voltage.

For example, if an experiment needs to source  $2\ \mu\text{A}$  into a  $10\ \text{M}\Omega$  load, the minimum compliance voltage setting needed to not clip the current is  $V = I \times R = 2\ \mu\text{A} \times 10\ \text{M}\Omega = 20\ \text{V}$ . If the maximum safe voltage for the load is 30 V, then a reasonable setting for the compliance voltage limit might be 25 V. Note that if the compliance voltage limit is set below 20 V, clipping will occur. For instance, if the compliance voltage is set to 10 V, then the output current will limit to  $\pm 1\ \mu\text{A}$ .

#### 2.4.3.1 Compliance voltage accuracy and overshoot

Users should understand the accuracy limits of the compliance voltage circuitry. For dc or slowly-varying signals, the compliance voltage error can be up to  $50\ \text{mV} + 0.5\%$  of the compliance setting. In the previous example where the compliance voltage was set to 25 V, the actual limiting voltage would be  $25\ \text{V} \pm 175\ \text{mV}$ .

The situation is different for rapidly changing signals, such as large amplitude square waves. In such cases, it is possible for the actual output voltage to overshoot the compliance voltage limit by up to 1.5 V. Users should adjust the compliance voltage setting accordingly, especially in situations where the operating voltage is near the maximum allowable value for the load.

#### 2.4.3.2 Active loads

When sinking current from any *active* load, care must be taken to ensure that the active load voltage is within the compliance voltage setting of the CS580.

### 2.4.4 Current source

The current source circuitry forms the heart of the CS580. A voltage-controlled current source, with 9 separate gain resistors, provide the output current through the triaxial connector.

### 2.4.5 Speed setting

The front panel SPEED section allows the user to switch between *Fast* and *Slow* configurations, by pressing the [Speed] button. When set to *Slow*, a 470 pF capacitor is switched in across the current source output, effectively limiting its bandwidth. Note that the actual response time from this filter depends on the load impedance, with an effective time constant given roughly by the product of the load resistance with the total output capacitance (470 pF plus cable capacitance plus load capacitance).

### 2.4.6 Guard buffer

The output node of the current source is monitored with an electrometer-grade unity-gain voltage buffer. This element serves two purposes: driving the guarded inner shield (when configured for *Shield Guard* mode), and also to support voltage measurements without loading the external circuit.

#### 2.4.6.1 Triax inner shield

When the CS580 is configured for *SHIELD Guard*, the inner shield conductor of the triax is connected to the buffer output. This configuration “bootstraps” the inner shield to track the center conductor potential, minimizing the effect of leakage current through the cable as well as charging currents for cable capacitance. Operating in *SHIELD Guard* mode can provide a significant improvement in settling time, effective bandwidth, and dc leakage current losses, but in cases with very long cables or excessive capacitance, instability or even oscillation of the buffer amplifier is possible.

When the CS580 is configured for *SHIELD Return*, the inner shield conductor of the triax is connected to the current source return node. For some experiments, this provides a convenient return path for current from the external load back to the instrument. Also, in cases where the *Guard* configuration showed instability or oscillation, operating in *SHIELD Return* avoids these difficulties.

#### 2.4.6.2 Banana jack

Regardless of the *SHIELD* configuration, the electrometer-grade unity gain voltage buffer is always connected to the red banana jack in the *MONITOR* section. This terminal is intended to provide the user a convenient point to measure the operating voltage without loading the external circuit.

### 2.4.7 Isolation

The entire current source section of the CS580 can be isolated to float the source relative to chassis ground. Control of this feature is through the [Ground] button, which toggles the ISOLATION setting between *Float* and *Ground*. When set to *Ground*, the return node of the current source is connected to chassis ground (through a low-resistance inductor to help minimize noise). When set to *Float*, there is no dc connection internal to the CS580 between the current source circuit and ground.

### 2.4.8 Output

The current output of the CS580 is produced on a three-lug triaxial connector located on the front panel. The outer shield of this connector is always connected to chassis ground, through a low-resistance inductor. The inner shield terminal of the triax is controlled by the SHIELD block, described previously in section 2.4.6.1. The center conductor is the current source output. When OUTPUT is set to *On*, the current source circuit is active and the center conductor is connected to the output of the source. When not on, the center conductor is disconnected from the internal source circuitry and the source is disabled.

## 2.5 Configurations and grounding

There are four distinct configurations of the current source, based on the user settings for ISOLATION and SHIELD.

### 2.5.1 Floating configurations

The first two configurations shown have the current source fully disconnected from chassis ground.

#### WARNING

**To prevent electric shock and/or damage to the CS580, do not exceed 250 V between any of the floating nodes of the current source and chassis ground.**

Isolation is provided for maximum flexibility for situations where either ground is established at some fixed point in the circuit other than the CS580 (as a means to avoid ground loops), or for cases where the current is connected to an external low-voltage source.

#### 2.5.1.1 General comments on floating operation

Unless the CS580 is being used to inject current into an external circuit operating at some non-zero voltage, the best noise performance will be obtained by ensuring there is one (and ideally only one) ground

connection in the current path. Operating in a fully-floating mode can leave an experiment susceptible to common-mode pickup, which can lead to unwanted ac currents flowing through capacitive paths to ground.

A common experimental situation involves isolated circuits going to low temperature stages within a cryostat. Typically these lines will pass through RF “ $\pi$ -filters” which present a capacitive path to earth on each line. In this configuration, operating the CS580 in a Floating configuration, but grounding the current path at the cryostat feed-through entrance, can provide the best overall performance. Note that it is important to ground the black lead (current return), as this lead already has lower ac impedance to ground within the instrument. See Figure 2.3 for an example.

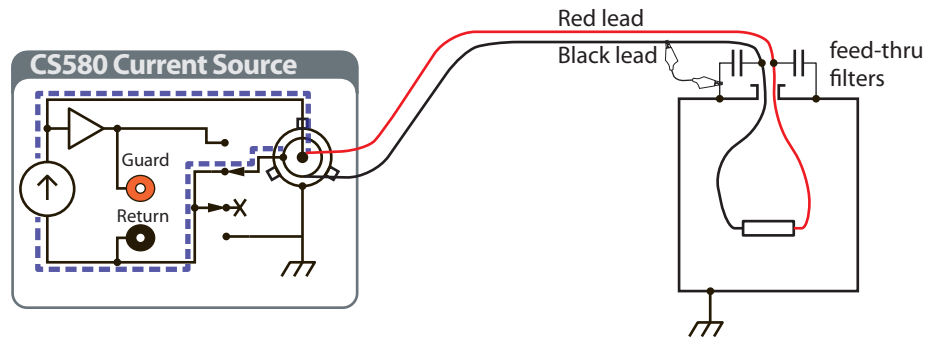


Figure 2.3: Floating source, grounded at the load. Note the remote ground connection is made on the black lead (current return) side of the current path.

### 2.5.1.2 Floating source, return current through inner shield

This configuration is selected when ISOLATION is set to *Float*, and SHIELD is set to *Return*. Schematically, the configuration is shown in Figure 2.4.

Return current can flow back from the external load through the inner shield of the triax connector. The voltage on the load may be monitored between the red and black banana jacks in the MONITOR block, but remember that these terminals are also floating with the current source.

### 2.5.1.3 Floating source, inner shield as guard

This configuration is selected when ISOLATION is set to *Float*, and SHIELD is set to *Guard*. Schematically, the configuration is shown

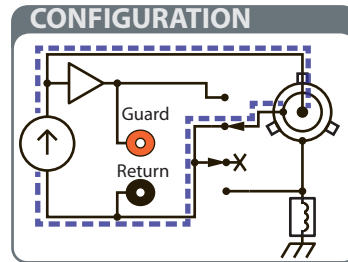


Figure 2.4: Floating source, return shield. The inner shield is connected to the current return, and the source is floating.

in Figure 2.5.

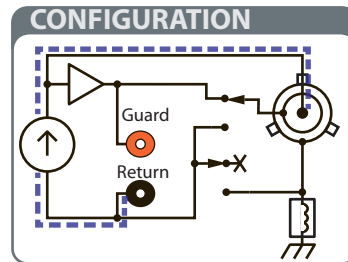


Figure 2.5: Floating source, guard shield. The inner shield is connected to the driven guard buffer, and the source is floating.

Return current in this configuration must flow back to the CS580 through the black banana jack in the MONITOR block, as this is the only connection available for return current.

## 2.5.2 Grounded configurations

These next two configurations shown have the current source return connected to the outer shield of the triax, and also to chassis ground (through a low-resistance inductor).

### 2.5.2.1 Grounded source, inner shield as current return

This configuration is selected when ISOLATION is set to *Ground*, and SHIELD is set to *Return*. Schematically, the configuration is shown in Figure 2.6.

Return current can flow back from the external load through the inner or outer shield of the triax connector. The voltage on the load may be monitored between the red and black banana jacks in the MONITOR block.

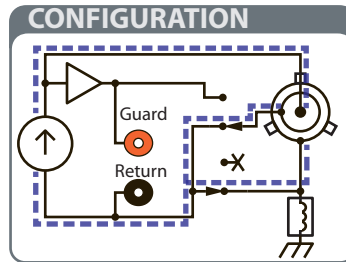


Figure 2.6: Grounded source, return shield. The inner shield is connected to the current return, and the source is grounded.

### 2.5.2.2 Grounded source, inner shield as guard

This configuration is selected when ISOLATION is set to *Ground*, and SHIELD is set to *Guard*. Schematically, the configuration is shown in Figure 2.7.

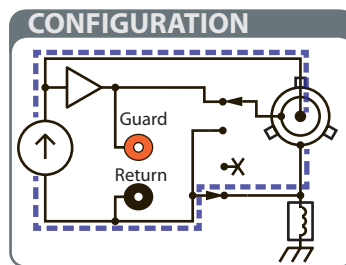


Figure 2.7: Grounded source, guard shield. The inner shield is connected to the driven guard buffer, and the source is grounded.

Return current in this configuration may flow back to the CS580 through the outer shield of the triax connector, while the inner shield serves as a driven guard for the experiment.

## 2.6 Error messages

When the CS580 first turns on, it performs a number of internal self-checks before beginning operation. If one of these fails, the following error messages may appear on the numeric display.

### 2.6.0.3 Firmware corruption

If the non-volatile program memory becomes corrupted, the CS580 may display the message “Err FL” indicating the flash memory is invalid. This failure is unlikely, but the instrument will not operate in this mode and must be returned to the factory for service.

#### 2.6.0.4 Configuration lost

If the memory recording the last configuration of the CS580 is determined to be corrupted upon power-up, the message “Err CF” is displayed. This message may be cleared by pressing any button, after which the instrument will begin operating from the default configuration (as though \*RTS had run).

#### 2.6.0.5 Calibration lost

If the memory recording the factory calibration values becomes corrupted, the CS580 the message “Err CL” will be displayed. This message can be cleared by pressing any button, after which the nominal calibration values will be reloaded. In this case, the instrument will operate but will not perform to specification. Return the instrument to the factory for recalibration.





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## 3 Remote Operation

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This chapter describes operating the CS580 over the remote interfaces.

### In This Chapter

<b>3.1</b>	<b>Index of commands</b>	<b>3-2</b>
<b>3.2</b>	<b>Alphabetic list of commands</b>	<b>3-3</b>
<b>3.3</b>	<b>Introduction</b>	<b>3-5</b>
3.3.1	Interface configuration	3-5
3.3.2	Buffers	3-5
<b>3.4</b>	<b>Commands</b>	<b>3-6</b>
3.4.1	Command syntax	3-6
3.4.2	Notation	3-7
3.4.3	Examples	3-7
3.4.4	Configuration commands	3-8
3.4.5	Setting commands	3-11
3.4.6	Setup commands	3-11
3.4.7	Interface commands	3-11
3.4.8	Status commands	3-12
<b>3.5</b>	<b>Status model</b>	<b>3-16</b>
3.5.1	Status byte (SB)	3-16
3.5.2	Service request enable (SRE)	3-17
3.5.3	Standard event status (ESR)	3-17

### 3.1 Index of commands

Symbol	Definition
<i>f, g</i>	Floating-point value
<i>i, j</i>	Unsigned integer
<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

---

#### Configuration

GAIN(?) { <i>z</i> }	3-8	Gain
INPT(?) { <i>z</i> }	3-8	Analog input
RESP(?) { <i>z</i> }	3-8	Speed
SHLD(?) { <i>z</i> }	3-9	Inner shield
ISOL(?) { <i>z</i> }	3-9	Isolation
SOUT(?) { <i>z</i> }	3-9	Output

---

#### Settings

CURR(?) { <i>f</i> }	3-11	DC current
VOLT(?) { <i>g</i> }	3-11	Compliance voltage

---

#### Setup

ALRM(?) { <i>z</i> }	3-11	Audible alarms
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---

#### Interface

*IDN?	3-11	Identify
TOKN(?) { <i>z</i> }	3-12	Token Mode
*OPC(?)	3-12	Operation complete
*RST	3-12	Reset

---

#### Status

OVLDT?	3-13	Overload
*STB? [ <i>i</i> ]	3-13	Status byte
*SRE(?) [ <i>i</i> ,] [ <i>j</i> ]	3-13	Service request enable
*ESR? [ <i>i</i> ]	3-13	Standard event status
*ESE(?) [ <i>i</i> ,] [ <i>j</i> ]	3-14	Standard event status enable
*CLS	3-14	Clear status
LEXE?	3-14	Last execution error
LCME?	3-15	Last command error

**3.2 Alphabetic list of commands****★**


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*CLS	3-14	Clear status
*ESE(?) [i,] {j}	3-14	Standard event status enable
*ESR? [i]	3-13	Standard event status
*IDN?	3-11	Identify
*OPC(?)	3-12	Operation complete
*RST	3-12	Reset
*SRE(?) [i,] {j}	3-13	Service request enable
*STB? [i]	3-13	Status byte

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**A**

ALRM(?) {z}	3-11	Audible alarms
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---

**C**

CURR(?) {f}	3-11	DC current
-------------	------	------------

---

**G**

GAIN(?) {z}	3-8	Gain
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---

**I**

INPT(?) {z}	3-8	Analog input
ISOL(?) {z}	3-9	Isolation

---

**L**

LCME?	3-15	Last command error
LEXE?	3-14	Last execution error

---

**O**

OVLDT?	3-13	Overload
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---

**R**

RESP(?) {z}	3-8	Speed
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---

**S**

SHLD(?) {z}	3-9	Inner shield
SOUT(?) {z}	3-9	Output

---

**T**

TOKN(?) {z}	3-12	Token Mode
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---

**V**

VOLT(?) {g}

3-11 Compliance voltage

### 3.3 Introduction

Remote operation of the CS580 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 current source from a remote computer through RS-232, or through the optical fiber and the SX199 interface to GPIB, RS-232, or ethernet interfaces.

Where applicable, the corresponding front-panel interface to each command is also indicated. Most instrument settings are retained in non-volatile memory. Upon power-on, these settings are restored to their values before the power was turned off. Where appropriate, the default value for parameters is listed in **boldface** in the command descriptions.

#### 3.3.1 Interface configuration

Both RS-232 and optical fiber interfaces are fixed configuration, 9600 baud, 8-bit, with no parity or flow control.

#### 3.3.2 Buffers

The CS580 stores incoming bytes from the remote interfaces in separate 128-byte input buffers. Characters accumulate in the input buffer until a command terminator (<CR> or <LF>) is received, at which point the message is parsed and enqueued for execution. Query responses from the CS580 are buffered in interface-specific 256-byte output queues. Queries are returned to the interface from which they were received (RS-232 or optical).

If an input buffer overflows, then all data in the input buffer are discarded, and an error is recorded in the ESR status register.

## 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 reference mode to internal, the following two commands are equivalent:

RESP SLOW      —or—      RESP 1

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
<i>f, g</i>	Floating-point value
<i>i, j</i>	Unsigned integer
<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

### 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 CS580 are set as *straight teletype font*, while responses received by the host computer from the CS580 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 Configuration commands

GAIN(?) {z}

Gain

Set (query) the voltage-to-current gain setting {to z}. Allowable values for z are:

z Value	Gain	z Value	Gain
G1nA 0	1 nA/V	G100uA 5	100 $\mu$ A/V
G10nA 1	10 nA/V	G1mA 6	1 mA/V
G100nA 2	100 nA/V	G10mA 7	10 mA/V
G1uA 3	1 $\mu$ A/V	G50mA 8	50 mA/V
G10uA 4	10 $\mu$ A/V		

The GAIN command is equivalent to turning the **GAIN** knob. Note that the DC current range is always  $\pm 2$  V times the gain; for example, when GAIN G10uA, the DC current range is  $\pm 20$   $\mu$ A.

Note that the GAIN command may not be set while the analog input *and* the output are both enabled.

*Example:* GAIN?  
G10UA

INPT(?) {z}

Analog input

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

The analog input BNC is controlled through the INPT command, or equivalently by pressing the INPUT [Enable] button. Note that the analog input is controlled independently of the current source output (SOUT).

*Example:* INPT ON

RESP(?) {z}

Speed

Set (query) the current source filter response speed {to z=(FAST 0, SLOW 1)}.

When switched to RESP SLOW, a 470 pf capacitor is connected from the current source output to the current return, limiting the output bandwidth in a load-impedance dependent way. The RESP command is equivalent to pressing the [Speed] button.

*Example:* RESP 0



---

**SHLD(?) {z}** Inner shield

Set (query) the inner-shield connection mode {to z=(**GUARD 0**, **RETURN 1**)}.  
 When switched to **SHLD GUARD**, the triax inner shield is connected to the voltage buffer output, providing a driven guard function. When switched to **SHLD RETURN**, the inner shield is tied to the current source return node. The **SHLD** command is equivalent to pressing the [Shield] button.

Note that the **SHLD** command may not be set while the output is enabled.

*Example:* **SHLD GUARD**

---

**ISOL(?) {z}** Isolation

Set (query) the current source isolation mode {to z=(**GROUND 0**, **FLOAT 1**)}.  
 When switched to **ISOL FLOAT**, the current source is electrically isolated from chassis ground; to complete the circuit, current must be returned to the CS580 through the “Return” node, either at the black banana receptacle or (when configured as **SHLD RETURN**) on the inner shield.

When set to **ISOL GROUND**, the current source return node is electrically connected to chassis ground; in this configuration, return current may also be carried on the triax outer shield.

Note that the **ISOL** command may not be set while the output is enabled.

The **ISOL** command is equivalent to pressing the [Ground] button.

*Example:* **ISOL FLOAT**

---

**SOUT(?) {z}** Output

labelcmd:SOUT

Set (query) the current source output mode {to z=(**OFF 0**, **ON 1**)}.  
 The current source output is enabled or disabled using the **SOUT** command. When set to **SOUT OFF**, the triax center conductor is disconnected from the current source. When set to **SOUT ON**, the center conductor is electrically connected to the CS580 current source output node. Note that the current source output is controlled independently of the analog input (INPT).

The SOUT command is equivalent to pressing the OUTPUT [Enable] button.

*Example:* SOUT ON

### 3.4.5 Setting commands

---

**CURR(?) {f}** DC current

Set (query) the internally-generated DC current {to *f*}, in amperes. The default value is **CURR 0.0**.

Note that the allowable range for **CURR** depends on the **GAIN** setting; the DC current range is always  $\pm 2V$  times the gain; for example, when **GAIN G10uA**, the allowed range for **CURR** is  $-20E-6$  to  $+20E-6$ .

The **CURR** command is equivalent to the front panel “DC current” setting, which can be modified with the **ADJUST** knob.

*Example:* CURR 1.25e-9

---

**VOLT(?) {g}** Compliance voltage

Set (query) the compliance voltage limit {to *g*}, in volts. The default value is **VOLT 10.0**.

The allowable range for **VOLT** is always 0 to 50.

The **VOLT** command is equivalent to the front panel “Compliance voltage” setting, which can be modified with the **ADJUST** knob.

*Example:* VOLT 35

### 3.4.6 Setup commands

---

**ALRM(?) {z}** Audible alarms

Set (query) audible alarms {to  $z=(\text{OFF } 0, \text{ON } 1)$ }.

Note that all sounds that are not “key clicks” are considered “alarms” for the purpose of the **ALRM** command. There is no corresponding front-panel method to access this command; it is exclusive to the remote interface.

### 3.4.7 Interface commands

---

**\*IDN?** Identify

Query the CS580 identification string.

The response is formatted as:  
 Stanford\_Research\_Systems,CS580,s/n\*\*\*\*\*,ver#.##  
 where \*\*\*\*\* is the 6-digit serial number, and #.## is the firmware revision level.

*Example:* \*IDN?

---

*Stanford\_Research\_Systems, CS580, s/n098023, ver1.00*

---

TKN(?) {z}	<p>Token Mode</p> <p>Set (query) the token response mode {to z=(<b>OFF 0</b>, <b>ON 1</b>)}.</p> <p>Token response mode controls the formatting of response messages generated by the CS580 to remote queries of token-type values. When <b>TOKN OFF</b>, the CS580 responds with the numeric version of the token quantity. When <b>TOKN ON</b>, the text version is returned.</p> <p><i>Example:</i> TKN? ON</p>
*OPC(?)	<p>Operation complete</p> <p>The set form, *OPC, will set the OPC bit in the Standard Event Status register; the query form, *OPC?, will return the value 1.</p> <p>*OPC is useful for pacing streams of remote commands; the *OPC command will not be processed by the command execution of the CS580 until all preceding commands have been executed.</p> <p><i>Example:</i> *OPC? 1</p>
*RST	<p>Reset</p> <p>Reset the CS580 to its default configuration.</p> <p>The following commands are internally executed upon receipt of the *RST command:</p> <ul style="list-style-type: none"> <li>• GAIN G1MA</li> <li>• INPT ON</li> <li>• RESP FAST</li> <li>• SHLD RETURN</li> <li>• ISOL FLOAT</li> <li>• SOUT OFF</li> <li>• VOLT 10.0</li> <li>• CURR 0.0</li> <li>• ALRM ON</li> </ul> <p>The same reset to default configuration can also be performed by holding the INPUT [Enable] button depressed while switching on power.</p>

### 3.4.8 Status commands

---

OVLD?	<p>Overload</p> <p>Reads the current value of the signal overload status. Returns an integer between 1 and 3 if an overload is detected, or 0 if there is no overload.</p> <p>The response integer is binary-weighted based on the two (2) separate signal stages that can generate an overload detect:</p> <table border="1" style="margin-left: 20px;"> <thead> <tr> <th style="border-right: 1px solid black;">Value</th> <th>Definition</th> </tr> </thead> <tbody> <tr> <td style="border-right: 1px solid black; text-align: center;">1</td> <td>Compliance limit reached</td> </tr> <tr> <td style="border-right: 1px solid black; text-align: center;">2</td> <td>Analog input overload</td> </tr> </tbody> </table> <p>If <i>Compliance limit</i> is lit, then OVLD? returns 1. If the <i>INPUT Overload</i> indicator is lit, then OVLD? returns 2. If both <i>Overload</i> and <i>Compliance limit</i> are simultaneously lit, then OVLD? returns 3. If neither are lit, then OVLD? returns 0.</p> <p>If TOKN ON mode is set, then the OVLD? query responds either NONE (0), OUTPUT (1), INPUT (2), or INP&amp;OUT (3).</p> <p><i>Example:</i> OVLD? 0</p>	Value	Definition	1	Compliance limit reached	2	Analog input overload
Value	Definition						
1	Compliance limit reached						
2	Analog input overload						

---

*STB? [i]	<p>Status byte</p> <p>Reads the Status Byte register [bit <i>i</i>].</p> <p><i>Example:</i> *STB? 0</p>
-----------	---

---

*SRE(?) [i,] {j}	<p>Service request enable</p> <p>Set (query) the Service Request Enable register [bit <i>i</i>] {to <i>j</i>}.</p> <p><i>Example:</i> *SRE 0, 1</p>
------------------	---

---

*ESR? [i]	<p>Standard event status</p> <p>Reads the Standard Event Status Register [bit <i>i</i>].</p> <p>Upon executing *ESR?, the returned bit(s) of the ESR register are cleared.</p> <p><i>Example:</i> *ESR? 64</p>
-----------	--

---

---

\*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

---

\*CLS                                      Clear status  
 \*CLS immediately clears the ESR register.

*Example:* \*CLS

---

LEXE?                                    Last 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
4	Queue full
5	Not compatible

*Example:* CURR 12.0; LEXE?; LEXE?  
 1;0

The error (1, "Illegal value,") is because the parameter value (12.0) is too large for CURR. The second read of LEXE? returns 0.

## LCME?

Last 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 execution 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

*Example:* \*IDN

LCME?

4

The error (4, "Illegal set") is due to the missing "?".

### 3.5 Status model

status registers The CS580 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 Model for the CS580 Voltage Controlled Current Source

There are three categories of registers in the status model of the current source:

**Event Registers :** These read-only registers record the occurrence of defined events within the current source. If 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** or **EV**.

**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 in the Status Byte. Enable register names end with **SE** or **EN**.

**Status Byte :** This read-only register represents the top of the status model, and is populated with summary bit messages and interface condition bits. Enabled bits within the Status Byte generate the remote Request Service event.

At power-on, all status registers are cleared.

#### 3.5.1 Status byte (SB)

The Status Byte is the top-level summary of the CS580 status model. When enabled by the Service Request Enable register, a bit set in the Status Byte causes the MSS (Master Summary Status) bit to be set.

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



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.

This register is read with the \*STB? query.

### 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	undef (0)
4	2	QYE
8	3	DDE
16	4	EXE
32	5	CME
64	6	undef (0)
128	7	undef (0)

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

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

DDE : Device-Dependent Error. Indicates an internal command queue overflow.

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.

#### 3.5.3.1 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.

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## Appendix A Fuse Installation and ac Line Select

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The CS580 operates from 100 V, 120 V, 220 V, 230 V, or 240 V nominal ac power having a line frequency of 50 Hz or 60 Hz, and accommodates both North American single-fuse or metric dual-fuse operation. This appendix provides detailed instructions for modifying the input voltage selection and replacing the line fuse.

### A.1 Power Entry module

The line cord receptacle, power switch, fuse holder, and line voltage selector are all part of the “power entry module” located on the rear panel of the CS580. Detailed instructions for changing the line voltage selection and fuse replacement follow.

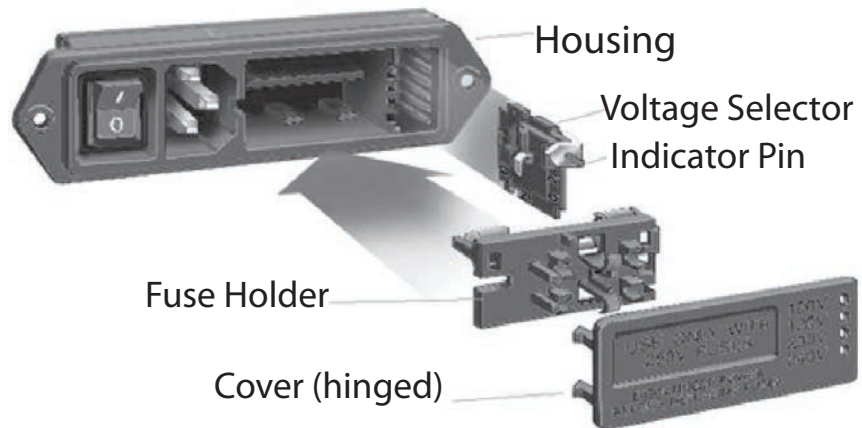


Figure A.1: The CS580 Power Entry assembly.

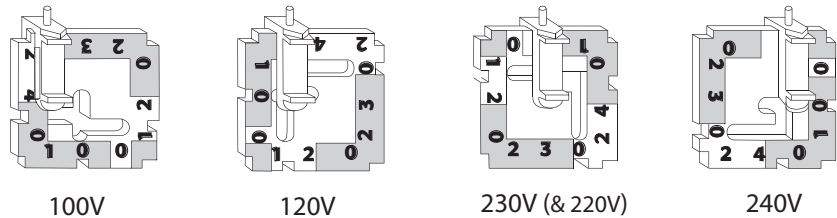
### A.2 ac voltage selector

The CS580 line voltage selection is indicated by the white pin visible at the right hand edge of the power entry module. In the image below, the line voltage selection is showing 120 V. Note that the 230 V position is appropriate for both 220 V and 230 V nominal ac line voltages.



The following steps describe how to change the line voltage selection:

1. Disconnect and remove the power cord.
2. Open the fuse cover (see instructions, below, for fuse installation for detailed illustrations).
3. Pull the voltage selector card straight out of the housing, using small needle-nose pliers to grip the plastic indicator pin body.
4. Orient the selector card so that the desired line voltage is readable at the bottom.



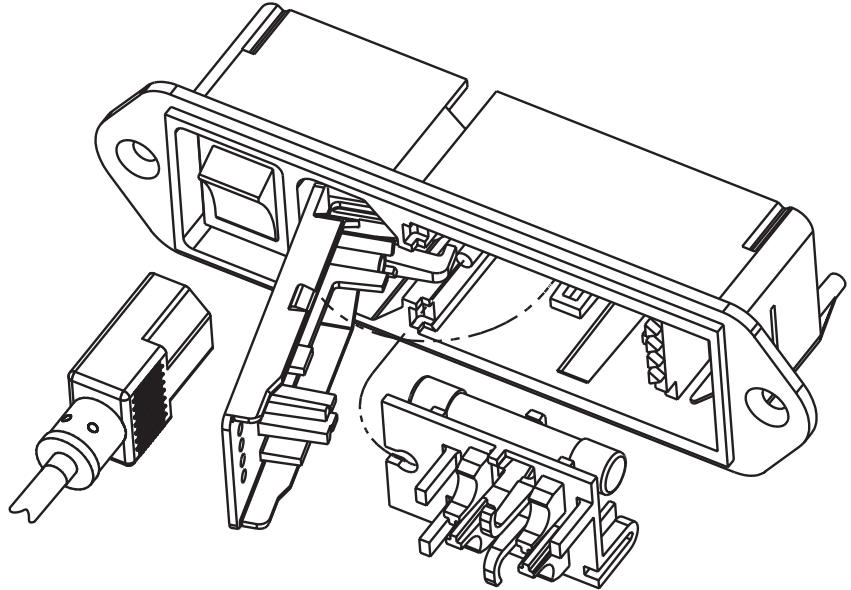
5. Orient indicator pin to point up when desired line voltage is readable at the bottom (note that when indicator pin is fixed, successive voltages are selected by rotating the card 90° clockwise).
6. Insert the voltage selector card into the housing, with the printed side of the card facing the fuse and IEC connector. Orient the card so the text showing the desired voltage is inserted first.
7. Replace the fuse cover and snap into position, verifying the indicator pin is showing at the desired line voltage.
8. If necessary, replace the fuse for the appropriate rating based on line voltage.

### A.3 Fuse installation

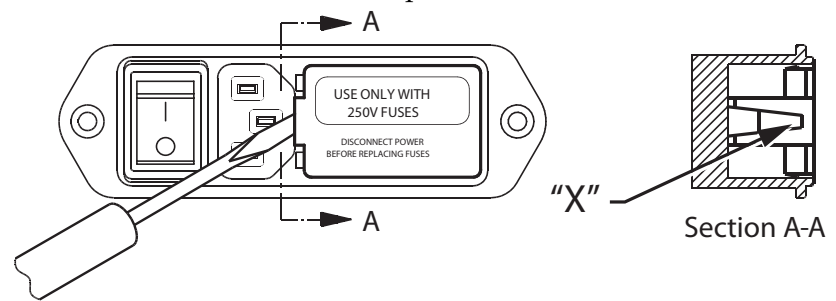
Two options are available for fusing the CS580—North American style single fuse, and metric dual fuse installation. The fuse holder is reversible to accommodate both styles.

The following steps describe how to install or replace the fuse(s):

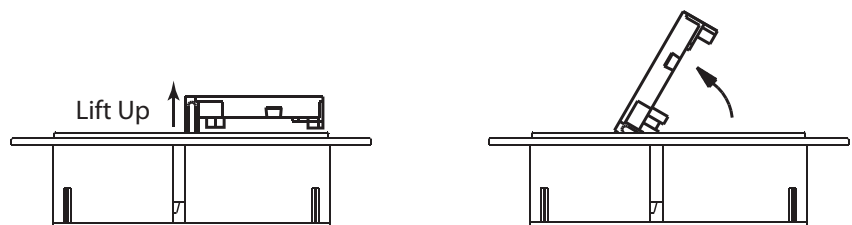
1. Disconnect and remove the power cord.



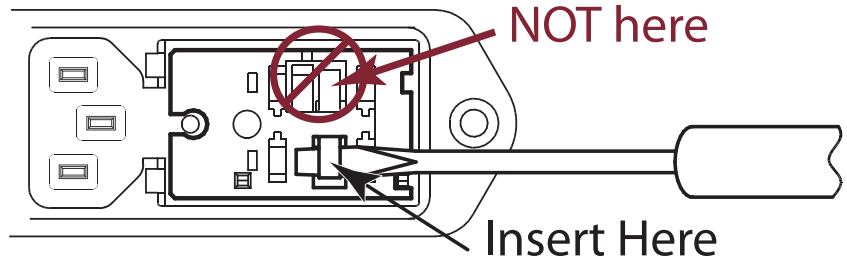
2. Insert a small screwdriver at the point "X" as shown.



3. Gently lift the entire door back, away from the rear panel of the CS580. Lift away approximately 0.25" (6 mm). Once lifted, the door will pivot on its hinge to expose the fuse holder.

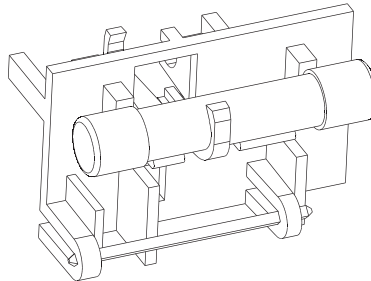


4. When the fuse holder is installed in the single fuse (North American) position, apply a screwdriver or small needle nose pliers as shown and gently lift out. Use a tool as shown, do not use fingers.

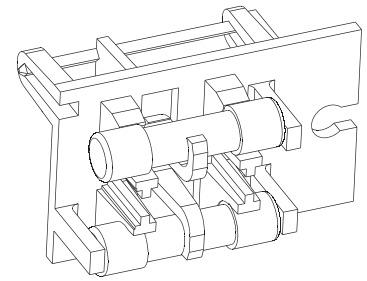


When the fuse holder is installed in the dual (metric) position, it will normally release as soon as the door is opened.

5. Install one (1) AG size 0.25" × 1.25" fuse or two (2) metric size 5 × 20 mm fuses as shown. *Install fuses on one side only—do not install both AG and metric together at the same time.*



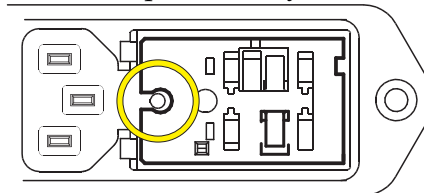
North American  
single fuse installation



Metric  
dual fuse installation

Also note that, when installing the North American AG fuse, the fuse is not *centered* on the plastic retaining hook, but rather shifted towards the right-hand side (see image, above left). If the fuse is not properly aligned, the fuse holder will not seat properly and line voltage will not be provided to the instrument.

6. Replace the fuse holder into housing, fuse first. Be sure to align the circular opening on the fuse holder with the orienting pin within the power entry module.



7. Swing and push to snap the door back in place.