DC215 DC Voltage/Current Source

User Manual

Stanford Research Systems

Certification

Stanford Research Systems certifies that this product met its published specification at the time of shipment.

Warranty

This Stanford Research Systems product is warranted against defects in materials and workmanship for a period of one (1) year from the date of shipment.

Service

For warranty service or repair, this product must be returned to a Stanford Research Systems authorized service facility. Contact Stanford Research Systems or an authorized representative for a RMA (Return Material Authorization) Number before returning this product for repair. These are available at *www.thinksrs.com* under Support, Repair/Calibration.

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Safety Procedures and Precautions

Observe the following general safety precautions during all phases of operation of this instrument. Failure to comply with these precautions or with other specific warnings elsewhere in this manual violates the safety standards of intended use of this instrument and may impair the protection provided by the equipment. Stanford Research Systems, Inc. assumes no liability for the customer's failure to comply with these requirements.

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 DC215 DC Voltage/Current Source operates from a 100V, 120V, 220-230V or 240V nominal AC power source with a line frequence of 50 or 60 Hz. Before connecting a power cord to a power source, verify that the LINE VOLTAGE SELECTOR, located on the rear panel power entry module, is set to the correct AC line voltage. See *Fuse Installation and Line Select* (page 171) for detailed instructions.

Caution

The DC215 Voltage/Current Source will be damaged if operating with the LINE VOLTAGE SELECTOR set to 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. Use two (2) metric size 5 x 20 mm fuses. For 100V/120V, use 1 A fuses; for 220V/230V/240V use 0.5 A fuses. See *Fuse Installation and Line Select* (page 171) for detailed instructions.

LINE CORD

The DC215 Voltage/Current Source uses 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.

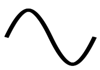
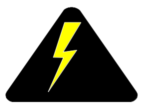
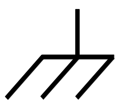
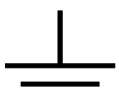
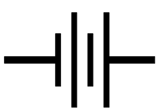
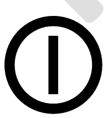
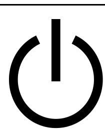
SERVICE

The DC215 Voltage/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 Stanford Research Systems or an authorized representative for service and repair to ensure all safety features are maintained.

Output Trip

If the DC215 detects an overvoltage or over current event or oscillations, the output is turned off and disconnected from the internal circuitry and a TRIP message is displayed. If this happens, disconnect the load, press [CLR] to clear the trip and turn the output on again. If the TRIP message appears again, the DC215 may be malfunctioning. Contact Stanford Research Systems or an authorized representative for service and repair to ensure all safety features are maintained.

Symbols You May Find on SRS Products

Symbol	Description
	**Alternating Current**
	**Caution – risk of electrical shock**
	**Frame or Chassis terminal**
	**Caution – refer to accompanying document**
	**Earth (ground) terminal**
	**Battery**
	**Fuse**
	**Power On**
	**Power Off**
	**Power Standby**

Specifications

ALLOW PROPER WARM UP TIME

Performance specifications apply after 1 hr. warmup at 23 ±1 °C, ≤85% RH, non-condensing, unless otherwise stated. The unit may not meet all specifications unless sufficient time is allowed for the unit to stabilize at the designed operating temperature.

Voltage Source

±[ppm of setting + µV]

Range	Source Range	Resolution	24 Hour Stability	24 Hour Accuracy	90 Day Accuracy	1 Year Accuracy
10mV	±12.0000mV	100 nV	20 + 0.5	50 + 1	60 + 4	*tbd*
100mV	±120.000mV	1 µV	30 + 1	50 + 2	60 + 5	*tbd*
1V	±1.20000V	10 µV	10 + 2	15 +6	35 + 12	*tbd*
10V	±12.0000V	100 µV	10 + 6	15 + 40	35 + 50	*tbd*
32V	±32.000V	1 mV	10 + 20	20+ 150	50 + 250	*tbd*

Range	Max Current	Output Resistance	Noise 0.3 Hz to 10 Hz	Noise 0.3 Hz to 10 kHz	CMRR (50/60 Hz)	Temp Coeff ±(ppm setting + µV)/°C
10mV	---	~ 2Ω	1.0 µVpp	12 µVpp	110 dB	16 + 0.2
100mV	---	~ 2Ω	1.5 µVpp	15 µVpp	110 dB	16 + 0.4
1V	240 mA	≤3 mΩ	7 µVpp	50 µVpp	120 dB	5 + 1
10V	240 mA	≤3 mΩ	20 µVpp	75 µVpp	120 dB	5 + 3
32V	240 mA	≤3 mΩ	50 µVpp	150 µVpp	120 dB	5 + 10

Current Source

±[ppm of setting + µA]

Range	Source Range	Resolution	24 Hour Stability	24 Hour Accuracy	90 Day Accuracy	1 Year Accuracy
1mA	±1.20000mA	10 nA	10 + 1	30 + 0.02	50 + 0.025	*tbd*
10mA	±12.0000mA	100 nA	10 + 10	30 + 0.20	50 + 0.25	*tbd*
100mA	±120.000mA	1 µA	20 + 100	55 + 1.5	70 + 2.0	*tbd*
200mA	±240.00mA	10 µA	20 + 200	155 +15.0	175 + 25.0	*tbd*

Range	Max Voltage	Output Resistance	Noise 0.03 Hz to 10 Hz	Noise 0.03 Hz to 10 kHz	CMRR (50/60 Hz)	Temp Coeff ±(ppm setting + µA)/°C
1mA	±32V	≥ 100 MΩ	5 nApp	50 nApp	100 nA/V	9 + 0.001
10mA	±32V	≥ 100 MΩ	70 nApp	200 nApp	100 nA/V	9 + 0.01
100mA	±32V	≥ 10 MΩ	600 nApp	2.5 µApp	100 nA/V	12 + 0.10
200mA	±32V	≥ 10 MΩ	1 µApp	10 µApp	100 nA/V	12 + 0.20

Rise and Settling Times

Typical time constant and settling times for a 0 to full scale step, into the specified load, for a fixed range. Values excludes any processing time, range change, ramping, any limiter function or reactive loads.

Time Constant is the time from 0 to 63% of the final value (typ)
Settling Time is from 0 to 99.9% of the final value (typ)

Voltage

Range	Load	Time Constant (HiBW)	Time Constant (LoBW)	Settling Time (HiBW)	Settling Time (LoBW)
10 mV	1 MΩ	0.2 ms	1.0 ms	1 ms	7 ms
100 mV	1 MΩ	0.2 ms	1.0 ms	1 ms	7 ms
1 V	1 MΩ	0.2 ms	1.0 ms	1 ms	7 ms
10 V	1 MΩ	0.2 ms	1.5 ms	1 ms	11 ms
30 V	1 MΩ	0.2 ms	2.0 ms	1 ms	14 ms

Current

Range	Load	Time Constant (HiBW)	Time Constant (LoBW)	Settling Time (HiBW)	Settling Time (LoBW)
1 mA	30 kΩ	0.2 ms	2 ms	1.2 ms	12 ms
10 mA	3 kΩ	0.2 ms	2 ms	1.2 ms	12 ms
100 mA	300 Ω	0.2 ms	2 ms	1.2 ms	12 ms
200 mA	150 Ω	0.2 ms	2 ms	1.2 ms	12 ms

Response Time

Response Time is measured from an output setting event* until the output settles to within to 0.1% of final value. No ramping, no limiting; purely resistive load as described for Rise and Settling Times.

Response time for 0 to full scale step

- Step within a range
- Step to a different range
- Output ON
- Source Type change

Conditions	HiBW	LoBW
Output Change within a range	<1 ms	<10 ms
Output Change within 1, 10 or 30 V ranges	<4 ms	<10 ms
Output Change within all ranges	<10 ms	15 ms
Changing Output Type	*tbd*	*tbd*
Output Off	~6 ms	~6 ms
Output On	~6 ms	~12 ms

* An output setting event is after a front panel value has been entered, a remote interface command has been received, a sequence step occurs or a DIO signal has been received.

Ramping

The output can be set to ramp between output settings
Ramp Time: 0 - 3600.0 s with 0.1 s resolution

Reactive Loads

Reactive (not purely resistive) loads may increase the rise, settling and response times due to an over or under damped response. Large reactive loads may slow these times significantly due to the limiter behavior.

Maximum reactive loads

Output	HiBW	LoBW
Capacitive Load (Voltage Out, Voltage Limit)	*tbd*	≥100 µF
Inductive Load (Current Out, Current Limit)	*tbd*	≥1 mH

Limiting

Independent positive and negative limits. Limits are not active to 10 & 100 mV ranges.

Limit	Limit Magnitude	Limit Resolution
Current Limit (Active for 1, 10 & 30 V ranges	1 mA to 240 mA	1 mA
Voltage Limit (Active for 1, 10, 100, 200 mA ranges	0.1 V to 32 V	0.1 V

Output Sequences

A variable length output sequence can be created from the front panel, downloaded over the remote interfaces or loaded from a USB drive. Sequences are for a single output type (voltage or current) and use the selected ramp time.

Number of steps	2 – 10000
Step Trigger Source	Manual, Timed (0.1 - 3600.0 s with 0.1 s resolution), Command, External Step Trigger or Measurement End

Voltage monitor

±[ppm of setting + µV]

Range	Source Range	Max Resolution	24 Hour Stability	90 Day Accuracy	1 Year Accuracy	Temp Coeff ±(ppm reading + µV)/°C
Current Out All ranges	±32.000V	10 µV	50 +100	xx + y	*tbd*	*tbd*
Voltage Out						
10mV	±12.0000mV	10 nV	20 +2	xx + y	*tbd*	*tbd*
100mV	±120.000mV	10 nV	20 + 3	xx + y	*tbd*	*tbd*
1V	±1.20000V	1 µV	10 + 5	xx + y	*tbd*	*tbd*
10V	±12.0000V	1 µV	10 + 10	xx + y	*tbd*	*tbd*
32V	±32.000V	1 µV	10 + 30	xx + y	*tbd*	*tbd*

Note: Maximum resolution is always available over the remote interfaces but is limited to ≤5.5 digits on the front panel.

Current Monitor

±[ppm of setting + µA]

Range	Source Range	Max Resolution	24 Hour Stability	90 Day Accuracy	1 Year Accuracy	Temp Coeff ±(ppm reading + µA)/°C
Voltage Out All ranges	±240.00mA	100 nA	50 + 3.0	xx + y	*tbd*	*tbd*
Current Out						
1mA	±1.20000mA	10 nA	10 + 0.01	xx + y	*tbd*	*tbd*
10mA	±12.0000mA	10 nA	10 + 0.10	xx + y	*tbd*	*tbd*
100mA	±120.000mA	10 nA	20 + 0.80	xx + y	*tbd*	*tbd*
200mA	±240.00mA	10 nA	20 + 1.4	xx + y	*tbd*	*tbd*

Note: Maximum resolution is always available over the remote interfaces but is limited to ≤5.5 digits on the front panel.

Measurement Settings

Voltage and current measurements are made simultaneously. Only one measurement can be viewed at a time on the front panel. Both are simultaneously available when logging or over the remote interface.

Measurement Trigger	Auto, Timed (period of 0.1 – 3600.0 s with 0.1 s resolution), Command, Ready (including Ready Delay)
Integration Time	Slow (588 ms), Medium (294 ms), Fast (147 ms), Very Fast (74 ms)
Noise Rejection	87 dB at 50/60 Hz
Ready Delay	0.002 – 100.000 s
Voltage Sense	2 wire or 4 wire sensing

REL

Both voltage and current measurements can be offset from a stored value (VREL & IREL). The stored REL values can be set simultaneously by a front panel keypress, entered explicitly from the Measure menu or set over any of the remote interfaces.

Logging

Measurements can be logged to a USB drive or over any of the remote interfaces

Number of logged points	1 – 199999 or continuous logging

Digital IO

There is a single male DB-9 connector with most of the I/O signals plus configurable input and output BNC connectors. All levels are TTL.

DB-9

Outputs	Output ON (output), Trigger Out, Ready
Inputs	Output ON (input), Trigger In

BNC Output

One of the following can be selected	Output ON (output), Trigger Out, Ready, Measurement Active, Step Active

BNC Input

One of the following can be selected	None, Output ON (input), Trigger In

Remote Interfaces

RS-232

Connector	DB-9 female
Format	No parity, 8 bits, 1 stop bit, CTS/RTS
Baud rates	4800, 9600, 19200, 38400, 57800 and 115200

GPIB

Format	IEEE 488.2
Address	0 - 30

LAN

10/100 Base-T

TCP/IP & DHCP

USB Storage

For USB memory devices (typically flash drives)

Connector	USB A-Type socket
Supports	USB 2.0, USB 1.1 and USB 1.0 drives
File System	FAT32, single level
Disk Size	≤32GB

General Specifications

Operating Temperature	0 to 40 °C, ≤85% RH, non-condensing
Storage Temperature	-20 to +50 °C, ≤85% RH, non-condensing
Altitude	≤ 4000 m
Pollution Degree	Category 2: (EN61010-1; only non-conductive pollution)
Power	<40 W, 100/120/220/240 VAC, 50/60 Hz
Fuses	two (2) 5x20 mm fuses
Dimensions	8.3” x 3.55” x 16””
Weight	14 lbs.

Maximum Allowable Input Voltages

Output Hi to Output Lo or Sense Hi to Sense Lo	±32 Vpk
Output Hi/Sense Hi or Output Lo/Sense Lo to Guard	±50 Vpk
Output Hi to Sense Hi or Output Lo to Sense Lo	±0.5 Vpk
Output Hi/Lo, Sense Hi/Lo or Guard to Chassis	±250 Vpk

Manual Convention

The following conventions are used in the manual to describe different functions of the interface.

[KEY]

This refers to a front panel key.

<CMD>

This refers to a remote interface command.

{DigIO}

This refers to a Digital IO signal

[CLR]

The Clear key cancels the entry currently being made.

[V/A], [mV/mA], [Enter]

These keys cause the current entry to be executed. Either [V/A] or [mV/mA] act as a generic entry key for non voltage or current values.

[SHIFT]

This key activates the alternate functions of keys, indicated by the functions in small letters above the keys.

[←] [→] [↑] [↓]

These keys are used to navigate menus and increment or decrement values.

Menus can be between one and three levels deep and are accessed by shifted keys. [↑] [↓] are used to cycle thru the different choices on the present menu level. [→] or [Enter] drops you down a menu level. [←] takes you up a level.

Throughout the manual, text in *Italics* refers to another section of the manual.

Source

The DC215 uses the following conventions:

- Source Type refers to the output type, either voltage (V, mV) or current (A, mA)
- Source Range refers to the output range
- Source Value refers to the output value

Messages

There are three different types of messages that appear on the DC215's front panel:

- Brief: These messages are briefly displayed after a user action on the front panel. They typically indicate the success or failure of a front panel action.
- Semi-Sticky: These messages that something occurred that may not be directly related to user action. These are typically for long term functions (like logging) that can be halted due to outside actions. These messages persist until the user presses any key.
- Hard-Sticky: These messages denote that something wrong has occurred with the DC215 or load (like a trip) and user intervention is required. These messages turn the DC215's output off and disconnect it from the load. They are cleared by pressing [CLR]. See *Troubleshooting* (page xx) for information on dealing with Trips.

All messages are Brief unless otherwise noted.

How this Manual is Organized

This manual provides instructions on how to install and operate a BGA244 Binary Gas Analyzer.

Before operating the DC215, carefully read and familiarize yourself with all precautionary notes in the Safety and Installation sections at the beginning of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter 1: *Quick Start*
Describes making initial measurements to familiarize the user with the DC215.

Chapter 2: *Basics*
Describes the front and rear panels and the user interface.

Chapter 3: *Operation Guide*
Describes how to configure and operate the instrument and explains all of its functionality in detail.

Chapter 4: *Applications Guide*
Describes how to optimize the DC215 for the best performance in your application.

Chapter 5: *Remote Programming*
Describes how to control the DC215 using the computer interfaces.

Chapter 6: *Service*
Troubleshooting, Maintenance and Calibration of the DC215.

Chapter 1: Quick Start

Unpacking

Inspect all components of the SRS DC215 upon unpacking. Report any damage to Stanford Research Systems immediately. Compare the contents of the shipping container to the list below and report any discrepancies.

See www.thinksrs.com/downloads/PDFs/Manuals/DC215m.pdf for the complete DC215 User's Manual.

What is included with the DC215

1. One DC215
2. One Power cord
3. One Quick Start Guide

Quick Start Guide

What's Needed

Equipment required to briefly evaluate the DC215.

- Precision DMM with at least 5 digits resolution
- 2 banana plug test leads
- 2 banana to clip leads
- 1 kΩ resistor

Refer to Chapter 2 (page 9) for a detailed description of the DC215 front panel controls and rear panel.

Note: [Enter] refers to either the [V/A] or [mV/mA] keys.

Example 1: Turning on the Instrument

This section describes the initial steps for first operating the DC215. Pay special attention to the AC line selector setting.

Power Entry Module

Verify that the rear panel power entry module is properly configured for the line voltage in your region. Applying power with the incorrect line voltage setting may result in significant damage to the DC215. See *Fuse Installation and Line Select* (page 171) for details.

1) Plug the AC line cord into the rear panel power entry module and then into a grounded wall outlet.

2) Press the Power Button (lower right side of the front panel) while holding the [CLR] key down to reset the instrument to its factory default state.

3) Power cycle the DC215 (off-on).

4) Observe the sign on messages and Self Test.

    a. The model (dc215) and firmware version (x.xx) are displayed

    b. Next the serial number is displayed

    c. Finally the Self Test message is shown, followed by either "test PASS" or "test FAIL". See *Self Tests* (page 169) in case the Self Tests fail.

5) At this point the unit is in the default configuration, with the output off. Allow the unit to warm up for a hour for full specified performance. Warm up is not necessary to test basic functionality.

Example 2: Setting the Output

This section describes how to connect the unit to the DMM and set the source voltage using the DC215s user interface.

Voltage Output

1) Connect the DC215 Output terminals (Hi and Lo) to the DMM voltage input terminals (Hi and Lo) with banana cables. Turn on the DMM, set it to DC voltage and autorange.

2) Press [ON/OFF] to turn on the Output. Observe the voltage on the DMM (~0.0 mV). The DC215 current monitor should read ~0.0 mA since there is no load.

3) Type [1] [0] [V/A] to set the source voltage to +10.0000 V. The DMM should read very close to +10.0000 V. The DC215 current monitor may read up to ~0.001 mA depending on the input impedance of the DMM.

4) Press the [←] cursor key. Notice that the least significant digit begins to flash. Press the [↑] cursor key four times to change the source voltage to +10.0004 V. The DMM should read very close to +10.0004 V.

5) Press the [↓] RANGE key to change the source range to 1V which is indicated by the “rAnGE 1V” message. Observe that the source voltage was coerced to 0.00000 V, since the previous 10 V setting is outside of the 1V range.

6) Type [±] [1] [V/A] to set the source voltage to -1.00000 V. The DMM should read very close to -1.00000 V.

Current Output

7) Press [ON/OFF] to turn the output off. Press [V/I] to change to current output.

8) Connect the DC215 Output terminals (Hi and Lo) to the DMM current input terminals (Hi and Lo) with banana cables. Set the DMM to DC current and autorange.

9) Press [ON/OFF] to turn the Output. Observe the voltage on the DMM (~0.0 mA). The DC215 voltage monitor should read ~0.0 mV since there is no load.

10) Type [1] [0] [mV/mA] to set the source current to 10.0000 mA. The DMM should read very close to +10.0000 mA. The DC215 voltage monitor may read up to ~100 mV depending on the burden resistance of the DMM.

11) Press the [↑] RANGE key to change the source range to 100mA indicated by the “rAnGE 100m” message. Observe that the source current is still set to 10.000 mA, since the previous 10 mA setting is within the 100mA range. The DMM and DC215 voltage monitor should read the same as on the previous step.

12) Press [ON/OFF] to turn the output off.

Example 3: Setting Current and Voltage Limits

This section describes how to set the current and voltage limits.

1) Press [Shift] [7] to enter the recall menu. Press [0] [Enter] to recall the default setup.

Current Limits

2) Connect the DC215 Output terminals (Hi and Lo) to the 1 kΩ load resistor using the banana to clip leads.

3) Turn the DC215 output on and set the source voltage to 10 V. The DC215 current monitor should read about +10.0 mA.

4) Press the [↓] SETTING key two times until +Lim is displayed. Type [5] [mV/mA] to set the +Limit to +5 mA.

5) The +Lim indicator (top right side of front panel) should light and the DC215 current monitor should read about 5.00 mA.

Voltage Limits

6) Turn the DC215 output off. Change the source type to current.

7) Press the [↑] SETTING key twice until Source is displayed.

8) Turn the DC215 output on and set the source current to -10 mA. The DC215 voltage monitor should read about -10.0 V.

9) Press the [↓] SETTING key three times until -Lim is displayed. Type [-] [5] [V/A] to set the -limit to -5 V.

10) The -Lim indicator (top right side of front panel) should light and the DC215 voltage monitor should read about -5.00 V.

11) Turn the output off.

Example 4: Measurements

This section describes how to configure measurements and ramping.

1) Press [Recall] [0] to recall the default setup.

2) Connect the DC215 Output terminals (Hi and Lo) to the DMM voltage input terminals (Hi and Lo) with banana cables. Set the DMM to DC voltage and autorange.

3) Turn the DC215 output on and set the source voltage to +0.10 V. The DMM should read about +100.00 mV.

Configure Measurement

4) Press [SHIFT] [2] to toggle the monitor display to voltage. It should read about +100.00 mV.

5) Press [SHIFT] [4] to enter the Measure menu and [→] to enter the trigger submenu. Press [↓] to display "timE", then [Enter] to set.

6) Press the [↓] cursor key to display the measure time menu, then [→] to enter it. Type [.] [2] [Enter] to set the measurement time to 0.2 s. (Note that the Mrate indicator is flashing).

7) Press the [↓] cursor key to display the integration time menu, then [→] to enter it. Press the [↓] cursor key twice to display "FASt", then [Enter] to set. (Note that the Mrate indicator has stopped flashing).

8) Press the [←] cursor key to exit the measurement menu.

Examine Voltage Monitor

9) Note that the monitor measurements are updating more rapidly.

10) Turn the output off.

Example 5: Ramping

This section describes how to configure and control ramps.

Note: The DC215 and DMM should set to the configuration at the end of Example 4.

1) Turn the output on.
2) Press the [↓] SETTING key four times until T_{ramp} is displayed. Type [2] [0] [Enter] to set the ramp time to 20 s.
3) Press the [↑] SETTING key four times until Source is displayed.
4) Set the output to +10.0 V.
5) Press the [↓] SETTING key to display RealTime. Watch as the RealTime, voltage monitor and DMM all ramp up to 10 V.
6) Press the [↑] SETTING key to display Source.
7) Set the output to 0 V.
8) Press [SHIFT] [PAUSE] to pause the ramp. Change the SETTING display to RealTime. Note that the Pause Indicator is blinking and RealTime, voltage monitor and DMM are all the same voltage.
9) Press [SHIFT] [PAUSE] again to resume the ramp. Note that the Pause Indicator has stopped blinking and RealTime, voltage monitor and DMM are all ramping again.
10) Press [SHIFT] [PAUSE] a third time to again pause the ramp. Note the values for RealTime, VMon and the DMM.
11) Press [SHIFT] [Enter]. This terminates the ramp and sets the output to the ramp value when [SHIFT] [Enter] was pressed. Confirm the values for RealTime, VMon and the DMM.
12) Press the [↑] SETTING key to display Source. Set the output to 0 V.
13) After a few seconds, press [SHIFT] [STEP]. This immediately terminates the ramp at the final set value. Confirm the values for RealTime, voltage monitor and the DMM.
14) Set the output to 10V.
15) After a few seconds, press [SHIFT] [CLR]. This immediately terminates the ramp to the previous set value. Confirm the values for RealTime, VMon and the DMM.
16) Turn the output off.

Example 6: Sequence

1) If a sequence has been previously saved in the DC215, perform a power-on [CLR] to erase the sequencer memory. Otherwise just do [RCL] [0] to load the default setup.

2) Connect the DC215 Output terminals (Hi and Lo) to the DMM voltage input terminals (Hi and Lo) with banana cables. Set the DMM to DC voltage and autorange.

Create Sequence

3) Press [PROG] to enter Program mode.

4) Press the following keys to enter a six point sequence:
   [0] [V/A]
   [1] [V/A]
   [2] [V/A]
   [3] [V/A]
   [4] [V/A]
   [5] [V/A]

5) Press [PROG] to exit the Program mode.

Configure Sequence Parameters

6) Press [SHIFT] [.] to enter Sequence menu. Press the [↓] cursor key to display the time submenu, then [→] to enter it. Type [6] [Enter] to set the step time to 6 s.

7) Press the [↓] cursor key to display the repeat submenu, then [→] to enter it. Press [↓] to toggle the repeat mode to “On’, then [Enter] to set.

8) Press the [↓] cursor key twice to the display submenu, then [→] to enter it. Press [↓] to toggle to “MEAS’, then [Enter] to set.

9) Press the [←] cursor key to exit the sequence menu.

Configure Measurement

10) Press [SHIFT] [4] to enter the Measure menu. Press the [→] cursor key to enter the trigger submenu. Press [↓] to display “timE”, then [Enter] to set.

11) Press the [↓] cursor key to display the measure time menu, then [→] to enter it. Type [.] [5] [Enter] to set the measurement time to 0.5 s.

12) Press the [↓] cursor key to display the integration time menu, then [→] to enter it. Press [↑] to display “mEd”, then [Enter] to set.

13) Press the [←] cursor key to exit the measurement menu.

14) Press [SHIFT] [2] to toggle the monitor display to voltage.

Examine Sequence

15) Turn the output on, and press [RUN] to start the sequence.

16) Observe the source voltage, monitor and DMM reading as the sequence advanced through its steps.

Set Ramping

17) Press [RUN] to stop the sequence.

18) Press the [↓] SETTING key four times until T_{ramp} is displayed. Set the ramp time to 3 s.

19) Press the [↑] SETTING key three times until RealTime is displayed.

Examine Sequence with Ramping

20) Press [RUN] to start the sequence.

21) Observe the ramping sequence on RealTime, voltage monitor and the DMM as the sequence ramps through its steps.

22) Turn the output off.

Chapter 2: Basics

This chapter describes the front and rear panels of the DC215, plus elements of the user interface.

Front Panel

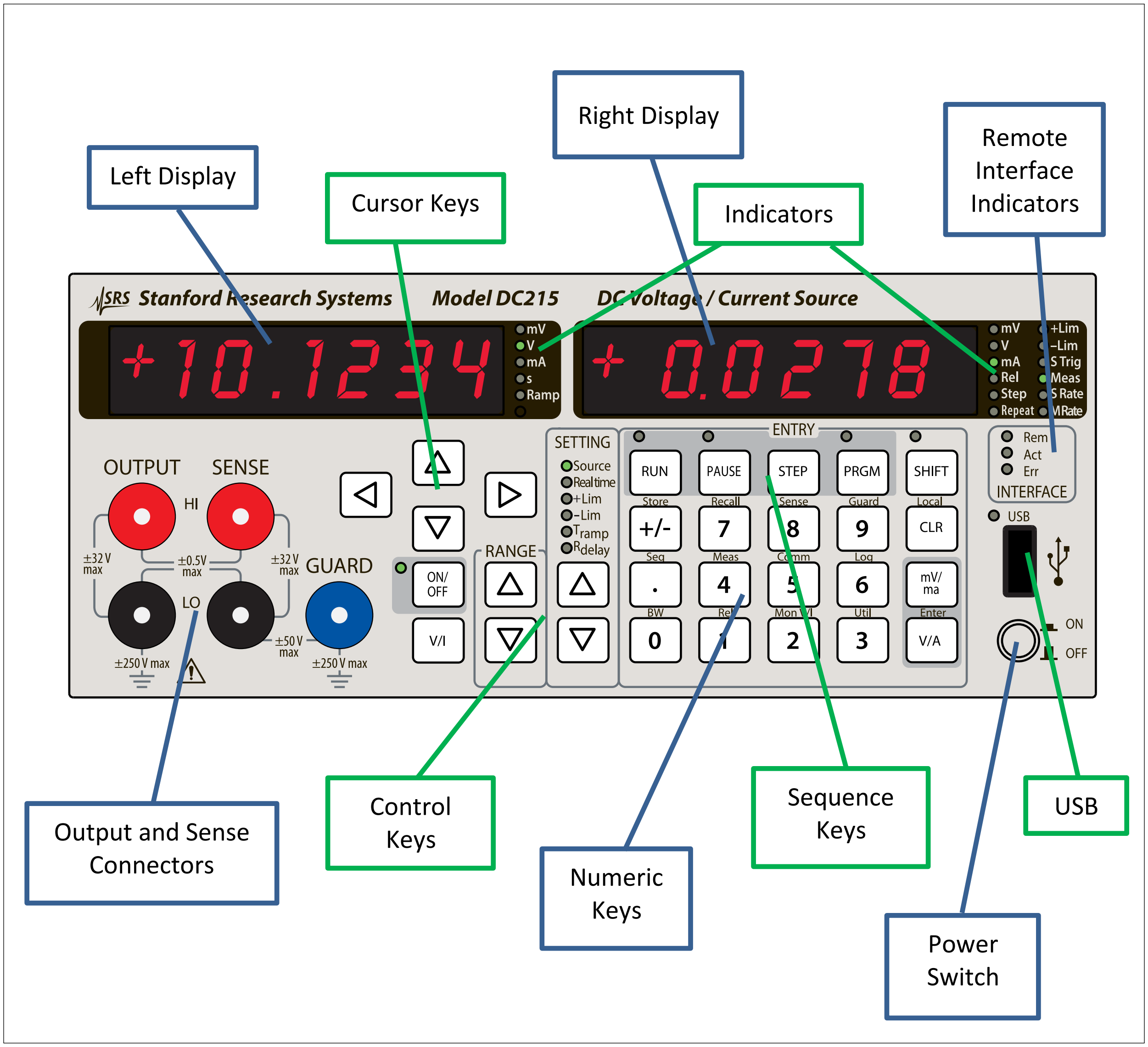


FIGURE 1: FRONT PANEL

The front panel consists of several different sections:

- Power Switch: Switches AC power to the DC215 on and off
- Display: Displays the set and measured values
- Keypad Area: Used to configure and set the output
- Output Connectors: Connects the voltage and current source to external devices
- Remote Status Indicators: Shows the status of the remote interface
- USB 2.0 Type A connector: For connection to a USB storage device

Power Switch

This connects the DC215 to AC line voltage. Press the button to turn the power on or off.

Note that powering on the DC215 does not automatically turn the output on. After AC power is switched on, use [ON/OFF], <OUTP> or {DIO} to toggle the output on or off.

Display Area

The display area makes up the upper third of the front panel. It includes the left and right displays, as well as the indicators associated with the displays.

Left Display

The left side display usually shows the source value (voltage or current), indicated by the units indicators immediately to the right of the display. Besides the source value, it can display limits, ramp and delay times, menu items and other messages.

Right Display

The right side display usually shows measured values (voltage or current), indicated by the units indicators immediately to the right of the display. Besides measured values, it can display sequence information, menu items and other messages.

Indicators

There are two groups of indicators associated with the displays, one for the left side display and one for the right side display. These indicate units for the different items displayed, as well as status information. No units are displayed while messages are being shown.

- V, mV, mA, s: These indicate the units (voltage, current or time) of the associated display.
- Ramp: Indicates that an output ramp is occurring.
- Rel: Indicates that measurement Rel is active.
- Step: Indicates the step number of a sequence when steps are displayed.
- +Lim/-Lim: Indicates that the + or - output limiter is active.

- S Trig: Indicates that a step trigger has occurred.
- Meas: Indicates that a measurement is active
- S Rate: A warning that indicates a step trigger has occurred while the on-going step is still in process.
- M Rate: A warning that indicates a measurement trigger has occurred while an on-going measurement is still in process.

Keypad Area

The keypad area contains cursor keys, numeric keys, control keys and indicators.

Cursor Keys

The cursor keys are used to adjust setting values or to navigate within the menu system.

See *Display and Entry Behavior* (page 14) for details on using the cursor keys.

Numeric Keys

The numeric keys include 0 – 9, ±, decimal point and [CLR] (clear). There are two Enter keys: [mV/mA] and [V/A] that are used for both united and non-united entry.

See *Display and Entry Behavior* (page 14) for details on using the numeric keys.

The numeric keys in conjunction with [SHIFT] are used to access secondary functions and the menuing system.

Control Keys

The control keys perform various actions as well as bringing different parameters to the entry screen for modification. There are indicators associated with some of the control keys.

[ON/OFF]

The [ON/OFF] key is one of the controls that can switch the output On or Off. See *ON/OFF Behavior* (page 22) for more details. The On indicator is lit when the output is on regardless of the method used to turn it on.

Note: [ON/OFF] can be overridden by the Output Enable. See *Output Control* (page 23) for details.

[V/I]

This toggles between the voltage and current source type (voltage or current).

When changed, a source type message is briefly displayed in the left display, the units indicators and decimal point are updated and the output is turned off.

Note: After toggling between voltage and current, the output range is set to the last source value and range for that source type, indicated by the units and decimal point.

Source Range [↑] or [↓]
This increases or decreases the output range. When changed, a range message is briefly displayed in the left display and the units and decimal point are adjusted.

Setting List [↑] or [↓]
This selects which parameter from the Setting list is shown in the left side display. The active setting is indicated by the adjacent indicator. There are six different parameters, most of which can be displayed and edited:

- Source (Source Value): The set value when the Output is on. See *Source* (page 24 for details.
- Real time (Real time value): This shows the instantaneous set value. It is the same as the Source Value, except during ramps or if the output is off. Note that this is a Read Only value and cannot be set. See *Real Time Display* (page 28) for details.
- +Lim (Plus Limit): The positive limit value. Limits are the inactive source type (current limit for voltage out and voltage limit for current out) and cannot be set for the 10 mV and 100 mV ranges. See *Limits* (page 29) for details.
- -Lim (Minus Limit): The negative limit value. Limits are the inactive source type (current limit for voltage out and voltage limit for current out) and cannot be set for the 10 mV and 100 mV ranges. See *Limits* (page 29) for details.
- T_{ramp} (Ramp Time): The amount of time (in seconds) for an output ramp. Note that this is active for both sequence and non-sequence operations. See *Ramping* (page 25) for details.
- R_{delay} (Ready Delay): The amount of time (in seconds) from Source Change Complete until the Ready signal goes active. See *Ready/R_{delay}* (page 30) for details.

Sequence Keys
These keys are controls for the Sequencer. See *Sequencer Controls* (page 47) for details.

- [RUN] (Run Sequence): Begins a sequence. The Run indicator is illuminated when a sequence is running.
- [PAUSE] (Pause sequence or ramp): This pauses a sequence or ramp at the point when it was pressed. The Pause indicator flashes while a sequence or ramp is paused. See *Ramping* (page 25) for details on behavior.
- [STEP] (Step Trigger): This is one of several step triggers. If active, pressing it advances the sequence by one step. It also has an effect on ramps. See *Ramping* (page 25) for details on this behavior.
- [PRGM] (program): This enters the Sequencer Program mode where sequence steps can be entered. The Program indicator is illuminated in this mode.

Shifted Key Functions

The numeric keys have secondary functions that are either menus or direct actions. These are accessed by first pressing [SHIFT] to enter the shift mode and then pressing the desired key. The shift indicator is illuminated when in the shift mode. See the topics listed for details.

- [SHIFT] [±] (Store): Store instrument settings 1 – 9. See *Store* (page 58) for details.
- [SHIFT] [7] (Recall): Recall instrument settings 1 – 9, or the default setting 0. See *Recall* (page 58) for details.
- [SHIFT] [8] (Sense): Set voltage sense to 2 or 4 wire. See *Sense* (page 32) for details.
- [SHIFT] [9] (Guard): Set the Guard on or off. See *Guard* (page 32) for details.
- [SHIFT] [CLR] (Local): Set the remote interface to local. See *Remote Programming* (page 111) for details.
- [SHIFT] [.] (Seq): Enter the Sequencer menu. See *Sequencer* (page 37) for details.
- [SHIFT] [4] (Meas): Enter the Measurements menu. See *Measurements* (page 33) for details.
- [SHIFT] [5] (Comm): Enter the Communication menu. See *Communication* (page 73) for details.
- [SHIFT] [6] (Log): Enter the Logging menu. See *Logging* (page 52) for details.
- [SHIFT] [0] (BW): Set the Bandwidth to Hi or Lo. See *Bandwidth* (page 31) for details.
- [SHIFT] [1] (Rel): Toggle the voltage and current monitor Rel setting. See *Rel* (page 34) for details.
- [SHIFT] [2] (Mon V/I): Toggle the displayed Monitor value. See *Measurements* (page 33) for details.
- [SHIFT] [3] (Util): Enter the Utility menu. See *Utilities* (page 63) for details.
- [SHIFT] [PAUSE]: Pauses/resumes a ramp. See *Ramping* (page 25) for details.
- [SHIFT] [STEP]: Jumps to the final point of a ramp. See *Ramping* (page 25) for details.
- [SHIFT] [CLR]: Cancels a ramp and reverts to the previous source value. See *Ramping* (page 25) for details.
- [SHIFT] [Enter]: Loads the Real Time value to the source value & ends a ramp. See *Ramping* (page 25) for details.

Display and Entry Behavior

Focus

Digits entries or menu choices on either display that can be modified by the cursor keys are said to be in “focus” and will intensity modulate (blink) at about 1 Hz. “Focus” can refer to a single digit, a sequence number or a menu choice.

Modifying Settings with the Cursor Keys

Pressing any of the cursor keys will bring the most recently modified digit into focus when adjusting settings. Press [←] or [→] to select the desired digit, then press [↑] or [↓] to increment/decrement that digit. The setting is immediately incremented/decremented upon pressing the [↑] or [↓], so it is unnecessary to press one of the enter keys to load the new value.

Modifying Values with Numeric Entry

Values are entered by typing the value, followed by pressing one of the enter keys. Select the unit keys (V/A, mV/mA) for current and voltage entries. For all other entries these keys directly enter the displayed value regardless of units. Pressing [CLR] while editing a value will revert to the previous value.

Navigating Menu and Selections with the Cursor Keys

Menus can be between one and three levels deep and are accessed by shifted keys as described in *Shifted Key Function* (page 13). [↑] [↓] are used to cycle thru the different choices on the present menu level. [→] or [Enter] drops you down a menu level. [←] takes you up a level.

Single level menus:

- Use [↑] [↓] to display the desired choice.
- Press [Enter] to select the displayed choice.
- If the entered value is accepted, an “Update” message is displayed and the the display returns to the main level. If not an error message is displayed and the display remains on the current level.

Two/three level menus

- Use [↑] [↓] to display the desired submenu.
- Press [Enter] or [→] to enter the displayed submenu.
- Use [↑] [↓] to display the desired choice within the sub menu.
  (These steps can be repeated for three level menus)
- When you selected the appropriate choice, press [Enter] to select the displayed value.
- If the entered value is accepted, an “Update” message is displayed and the front panel goes up a level in the menu. If not an error message is displayed and the display remains on the current level.
- From here you can either
    - Press [←] to return to go up a level or return to the main menu.
    - Select other menu choices you wish to enter.

Remote Interface Indicators

These indicate activity and status for the remote interface. See *Remote Programming* (page 111) for details.

- Rem (Remote): Indicates that the DC215 is in Remote Mode.
- Act (Activity): Flashes while there is activity on one of the remote interfaces.
- Err (Error): Indicates that an error occurred on one of the remote interfaces.

USB Socket

The USB A-Type socket is used to connect an external USB drive (usually a memory stick) to the DC215 to load or store sequences or to store logging files. It supports USB2.0: high speed mass storage (MSC) class.

When communicating with the USB device, the USB indicator is illuminated. See *USB Memory Device Interface* (page 67) for details.

Output and Sense Connections

The Source Output and Sense connectors on the front panel contain the output terminals for the voltage and current source.

The red and black terminals on the left side under the OUTPUT label are the HI and LO output terminals for both the voltage and current source types. See *Output Connections* (page 22) for details.

The red and black terminals on the right side under the SENSE label are the HI and LO voltage sense terminals when the 4-wire sense mode is selected. Note that in 4-wire mode, the Sense terminals are connected to the corresponding Output terminals through 1 MΩ resistors. The Sense terminals are not connected for the 2-wire sense mode. See *Remote Sensing* (page 80) for details.

The Blue terminal to the right of the sense terminals is the GUARD connection, which can connect to the internal guard shield. See *Guarding* (page 82) for details.

Rear Panel

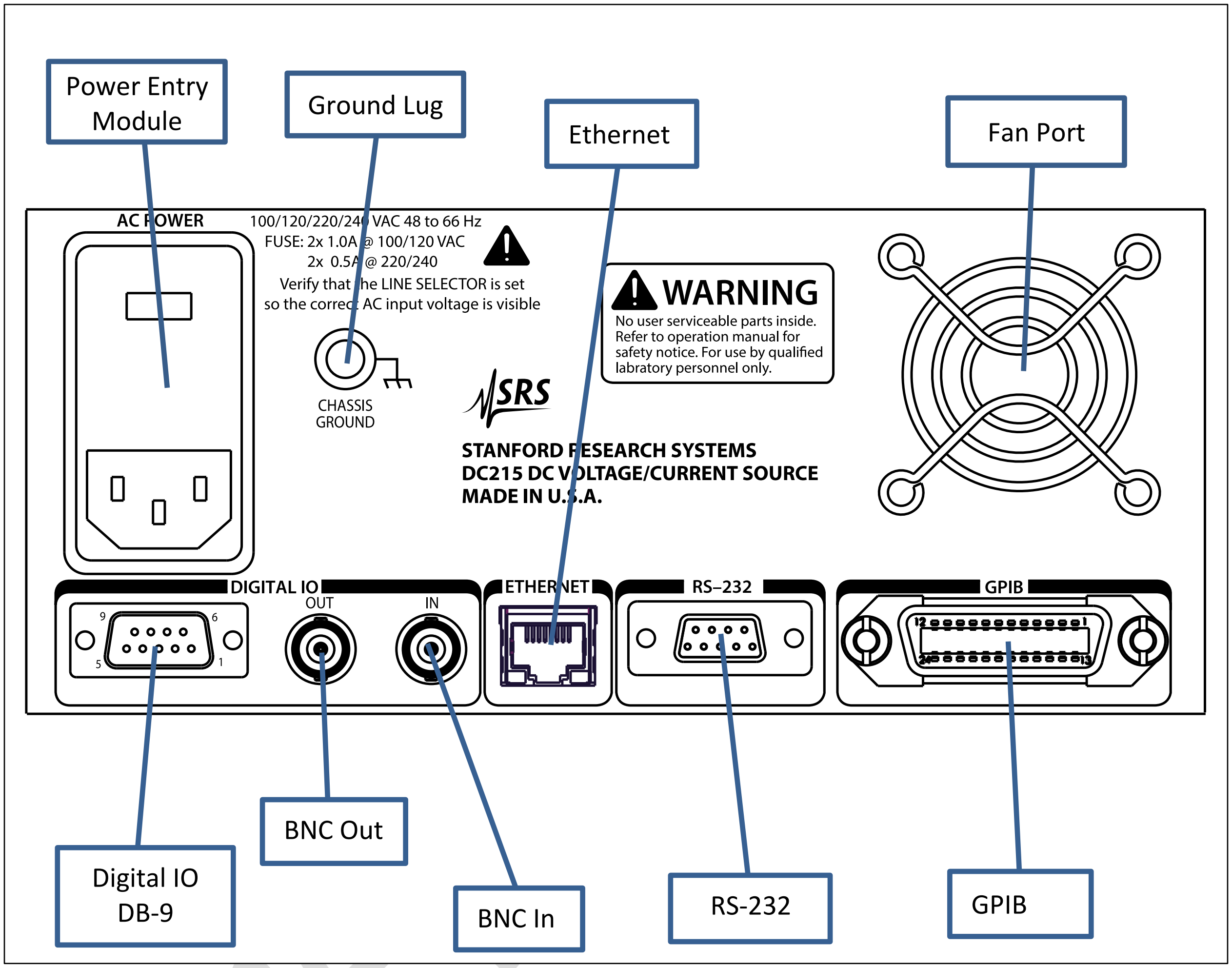


FIGURE 2: REAR PANEL

Power Entry Module

The power entry module provides an IEC 60320-1 AC input connection, fusing and line voltage selection. See *Fuse Installation and Line Select* (page 171) for details on setting the line voltage selection and fuses.

Ground Lug

This is connected to chassis ground and can be used to minimize ground potentials between instruments.

Fan Port

A ventilation fan is used to cool the DC215. Be certain to not block the fan port and ensure no foreign debris gets caught in the fan. See *Environment* (page 109) for installation requirements.

Computer Interfaces

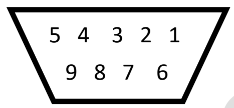
See *Remote Programming* (page 111) for details on interfacing the DC215 to a remote computer.

GPIB

The DC215 has a GPIB (IEEE-488) communications port for communications over a GPIB bus. The instruments support the IEEE-488.1 (1978) interface standard and supports the required common commands of the IEEE-488.2 (1987) standard.

RS-232

The RS-232 port uses a standard 9 pin, female, subminiature-D connector. It is configured as a DCE and supports baud rates from 4.8 kb/s to 115 kb/s. The remaining communication parameters are fixed at 8 Data bits, 1 Stop bit, No Parity, with RTS/CTS configured to support Hardware Flow Control.



RS-232 Pinout

Ethernet

The Ethernet uses a standard RJ-45 connector to connect to a local area network (LAN) using standard Category-5 or Category-6 cable. It supports both 10 and 100 Base-T Ethernet connection and a variety of TCP/IP configuration methods.

Digital IO

There are three connectors used for Digital I/O: BNC input, BNC output and DB-9 input/output. See *Using Digital IO* (page 92) for information on using these signals. See *Digital IO* (page 63) for details on configuring the digital inputs and outputs.

Chapter 3: Operation Guide

This chapter describes the configuration and behavior of the DC215. See *Basics* (page 9) for details on the User Interface and the *Applications Guide* (page 79) for details on applications.

Introduction

The DC215 uses a precision DAC to produce voltages and currents with high accuracy, linearity, and precision. The outputs are low noise and are stable both over long and short duration.

Nearly all instrument functions can be controlled from either the front panel or any of the remote interfaces.

Features

- Produces voltages to ±32 volts and and currents to ±240 mA
- Four Quadrant operation, acting as both a current source and sink
- Measurements for output voltage and current for both source type with 5 ½ digit resolution
- Data logging to external USB drive or remote interface
- Output sequences of up to 10000 points that set both the output range and value can be stored
- Settable ramping for both normal and sequence operations
- Digital IO to synchronize to multiple DC215's or other equipment
- Nine complete instrument non-volatile stored settings
- GPIP, RS-232 & Ethernet interfaces to control all instrument functions
- USB interface to external memory devices for logging or saving/loading sequence programs

Connections

- Output off disconnects the voltage or current source to avoid damaging the DC215 or DUT
- 2 Wire or 4 Wire connections
- Internal/External Guard

Four Quadrant Operation

The DC215 operates in all four quadrants, both sourcing and sinking current. The maximum outputs are ±32 volts, or ±240 mA.

This means the DC215 can be used as both a precision voltage or current source as well as a precision load.

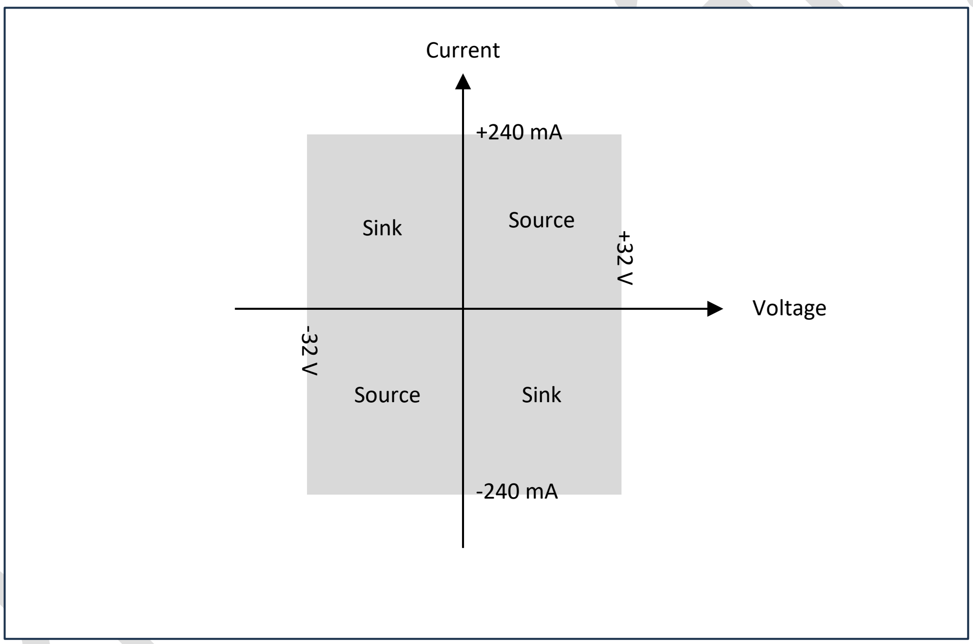


FIGURE 3: VOLTAGE-CURRENT MAP

Connection Examples

The DC215 can operate with both passive loads (resistors, capacitors, inductors) and active loads (batteries, voltage and current sources).

Connecting two voltage sources or two current sources can be problematic unless there are load resistors that allow both sources to output the correct values and the limits are carefully managed. See the diagram below for the appropriate series or parallel resistor to be used depending on the source types.

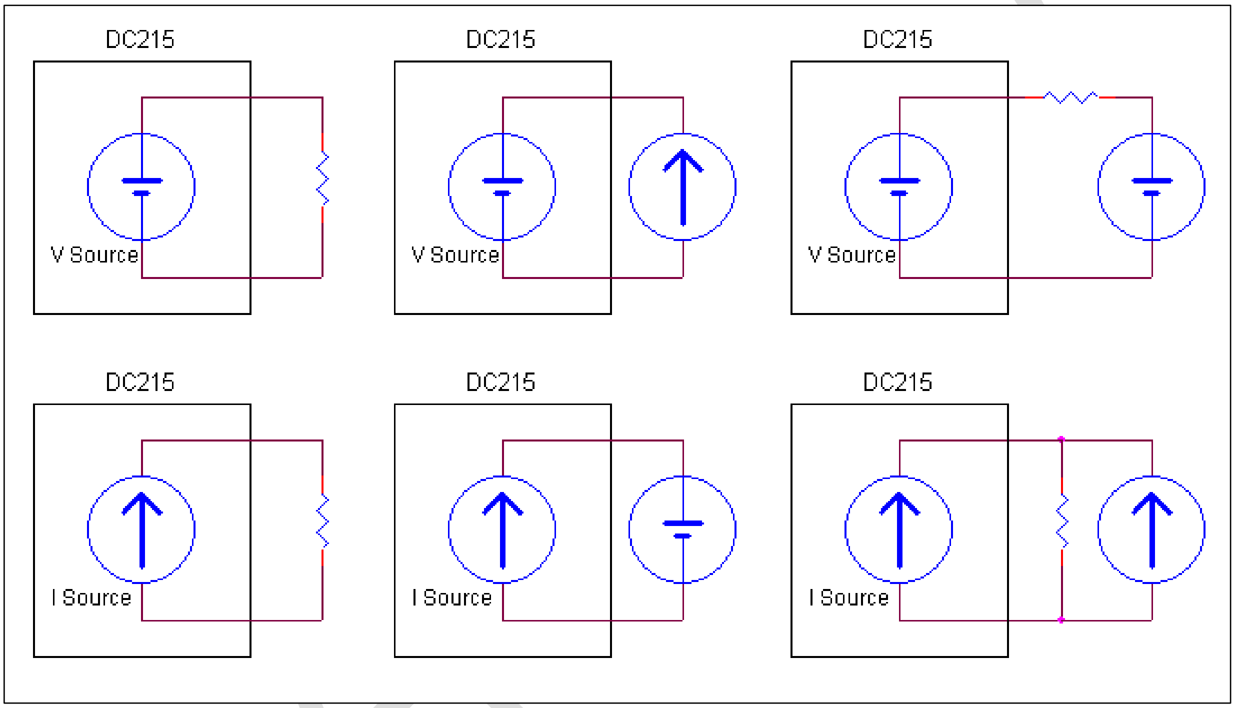


FIGURE 4: CONNECTION EXAMPLES

Operation

The basic functions of the DC215 are described here, including ON/OFF, Source Type, Range and Value, Ramping, Limits and functions.

Output Connections

Output HI (red) and Output LO (black) are the output terminals for both voltage and current out. Sense HI (red) and Sense LO (black) are voltage sense terminals used in 4-wire sense mode. See *Sense* (page 32).

The Guard (blue) terminal is used for external guard mode. See *Guard* (page 32).

Power ON

Upon power on, the unit display the model number, firmware version and the unit serial number. Next it will run Self Test, report the results and load the most recent settings from nonvolatile memory.

The instrument continuously monitors front panel key presses and saves the current instrument settings to nonvolatile memory after about 10 seconds of inactivity. To prevent memory wear out, the unit does not automatically save setting from remote interface commands. These settings can be saved and recalled explicitly to memory by the <*SAV> and <*RCL> commands if desired.

The DC215 can be forced to revert to its factory default settings. Turn the power on while holding down [CLR]. All instrument settings besides the remote interface configuration will be set to their default values. See Default Instrument Setup for a list of all instrument settings.

Output ON/OFF Behavior

The Output ON/OFF function can be controlled by several different means. ON/OFF functions work in parallel; any method can turn the output on or off. The output state is indicated by the ON LED. See Output Timing (page 85) for the response time.

- [ON/OFF] toggles the output on and off.
- Remote command <OUTP> sets the output on (1) or off (0).
- If configured, {ON/OFF Control} sets the output based on its transition edge (on for falling edge, off for rising edge). See *Output Control* (page 23) for details.

If {Output Enable} is selected and de-asserted, it will turn off the output or hold off any of the ON functions. See *Output Control* (page 23) for details.

If ramping is active, turning the output on initiates a ramp starting from 0 to the set value. When the output is turned off, the output immediately goes to 0.

When the output is off, Measurement Triggers are held off, and all active measurements are cancelled. Data Logging is disabled and T_{ramp} (ramp timer), T_{Meas} (measurement timer) and R_{delay} (ready delay timer) are reset.

The Sequencer will operate when the output is off for testing. While no signals will be output, it will step through the sequence, displaying the output values and updating the step trigger lines.

Output Control (Digital IO)

The Output Control (Digital IO) can be configured to either act as an output enable or as an ON/OFF control signal. This function is selected in *Digital IO* (page 63).

Output Enable (OE)

When set to Output Enable (OE) mode, {Output Control} overrides [ON], <OUTP> or any other "Output On" function. Use the following behavior for the output enable signal. Note that setting Output Enable low, does not automatically turn the output back on; one of the "Output On" functions must occur after OE is turned on.

Output Control low (Output Enabled)

The output can be turned on or off by any of the "Output On" functions.

Output Control high (Output Disabled)

The output is held off regardless of any "Output On" functions. If the output is on, it is turned off and held off upon Output Control going hi. The Output Disabled bit (#3) of OMSR/OMER is set when the output is disabled.

A "disabled" message (diSAb) appears on the front panel if Output Disable turns the output off or holds off the output from being turned on.

Note: If Output Control is selected and not pulled low, the output **will** be disabled and remain off regardless of any "Output On" events.

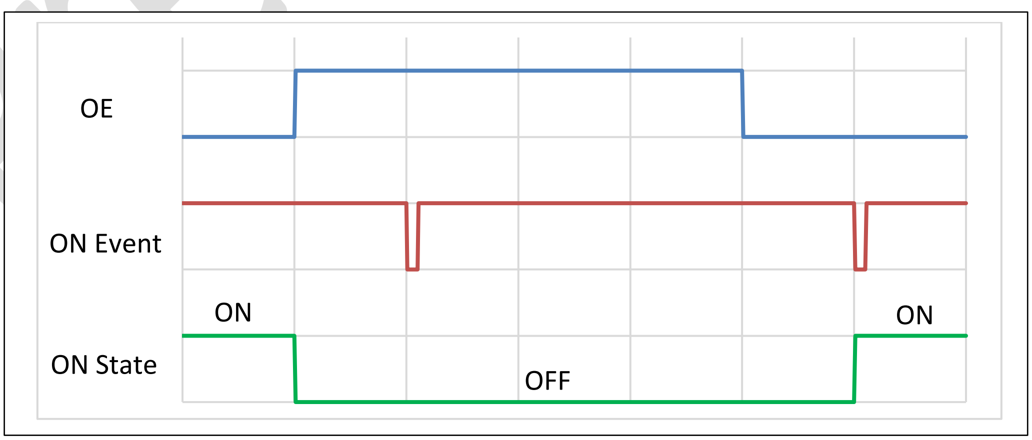


FIGURE 5: OUTPUT ENABLE BEHAVIOR

ON/OFF Control

When ON/OFF Control is selected, the output can be turned on or off based on rising or falling edges:

- The output is turned on for a falling edge of ON/OFF Control
- The output is turned off for a rising edge of ON/OFF Control

Note that ON/OFF control is only one of several "Output ON" functions, all of which are simultaneously active.

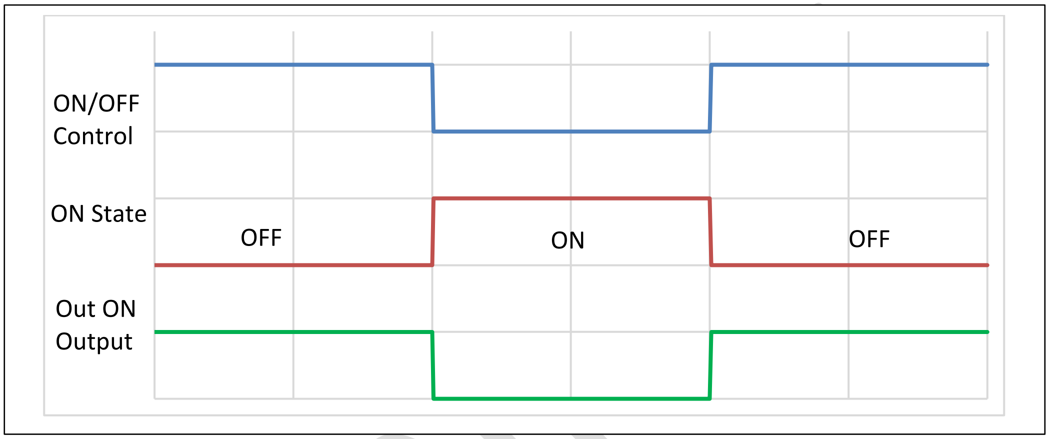


FIGURE 6: ON/OFF CONTROL

Source

The Source can be set to voltage or current output, over a number of different ranges and output values.

V/I

- [V|I] toggles between voltage and current output.
- <VORI> sets the source type to voltage (0) or current (1).

The Source type is indicated by the display units LEDs. When the source type is changed, a "V Out" or "I Out" message is briefly displayed and the DC215 is set to the last range used for that Source type.

Changing the source type leaves the output in the OFF state. This includes all behavior listed under the ON|OFF function.

Range

- The Source range is changed by the RANGE [↑] and [↓] keys.
- <Range i> sets the range based on "i".

The range is indicated by the decimal point location on the Source display, which is fixed for a given output range. Changing the range moves the decimal point on the Source display. A "range xxx" message is briefly displayed while changing ranges.

If the present value is within the limits of the new range, the output is set to that value. If the present value is not valid for the new range, the output is set to 0, and the output remains on.

Changing ranges terminates any existing ramp, jumping to the final value of the ramp, resetting the ramp timer terminating any R_{delay} and pulsing Ready.

TABLE 1: VOLTAGE RANGES

Range	Source Range	Resolution	Max Current
1 V	±1.20000 V	10 µV	±240 mA
10 V	±12.0000 V	100 µV	±240 mA
30 V	±32.000 V	1 mV	±240 mA

TABLE 2: MV RANGES

Range	Source Range	Resolution	Max Current
10 mV	±12.0000 mV	100 nV	~±66.7 mA
100 mV	±120.000 mV	1 µV	~±6.06 mA

* A voltage divider is used for the 10 & 100 mV ranges, with an output impedance of ~2.0 Ω. When used into low resistance loads, the output voltage may decrease.

TABLE 3: CURRENT RANGES

Range	Source Range	Resolution	Max Current
1 mA	±1.20000 mA	10 nA	±32 V
10 mA	±12.0000 mA	100 nA	±32 V
100 mA	±120.000 mA	1 µA	±32 V
200 mA	±240.000 mA	10 µA	±32 V

Value

The Source Value display is in the Settings list, accessed by the Setting [↑] and [↓] keys.

Source value can be set anywhere within the selected range using:

- Numeric keys
- Cursor keys
- <SORC> command

Values outside of the selected range will be rejected and an error message will be displayed.

Ramping

The DC215 can be set to linearly ramp between output values.

If the Ramp Time (T_{ramp}) is set to zero, the output immediately jumps to the next source value. If the Ramp Time is set to a non-zero value, the output will ramp from the Previous Source Value to the New Source Value in T_{ramp} seconds.

The slope of the ramp is:

$$\frac{New\ Source\ Value - Previous\ Source\ Value}{Ramp\ Time}$$

Ramps behave slightly differently for the Sequence mode. See *Ramps and Sequences* (page 45) for details on ramping behavior in the Sequence mode.

Ramp Time (T_{ramp})

T_{ramp} (ramp time) is in the Setting list, accessed by the Setting [↑] and [↓] keys.

T_{ramp} can be set between 0.0 and 3600.0 s in 0.1 s increments, using the following:

- Numeric keys
- Cursor keys
- <RTIM> command

Values outside of 0.0 and 3600.0 s will be rejected and an error message will be displayed.

Behavior during ramping

- The Real Time Display (in the Setting list) shows the instantaneous value being output during a ramp. See *Real Time Display* (page 28) for details on its behavior.
- If the output is turned ON with ramping active, the output ramps from "0" to the set value using the ramp timing.
- If the output is turned off with ramping active, the output turns off immediately (no ramp).
- If the Source Type is changed during a ramp, the output turns off immediately (no ramp) and normal Source Type change behavior applies.
- If the range or BW is changed during a ramp, the output immediately jumps to final value of the ramp, and normal range change behavior applies.
- If the Source Value or Ramp Time are changed during a ramp, the previous ramp is considered to have ended and a new ramp is calculated from that point and started. This ramp starts from the present output value & ends at the (new) Source Value, using the (new) Ramp Time.
- Most functions act as usual, with a few special cases listed below.

When a ramp is active

- The output ramps at the calculated rate.
- The Source Display shows the final value.
- The Real Time display shows the present output value.
- The RAMP LED is lit.

- The following special functions exist only for ramping. Besides [SHIFT] [PAUSE], these all end the existing ramp.
  - [SHIFT] [PAUSE] pauses the output and ramp timer at their present value. [SHIFT] [PAUSE] a second time resumes the ramp.
  - [SHIFT] [STEP] jumps to the last point of the ramp and ends the ramp.
  - [SHIFT] [Enter] (either V/I or mV/mA) loads the present value to the set value and ends the ramp.
  - [SHIFT] [CLEAR] reverts to the previous source value and ends the ramp.

While a ramp is paused

- The output setting is fixed at the present (paused) point in the ramp and the ramp timer is frozen at its present value.
- The Source Display shows the final value.
- The Real Time display shows the present value.
- The PAUSE LED flashes at 1 Hz. (RAMP LED is static ON).
- The special functions are still available from the paused value.
  - [SHIFT][PAUSE] Resumes the ramp from the current amplitude and ramp timer values.
  - [SHIFT][STEP] jumps to the last point of the ramp and ends the ramp.
  - [SHIFT][Enter] (either V/I or mV/mA) loads the present source value to the set value and ends the ramp.
  - [SHIFT][CLEAR] cancels the ramp, reverts to the previous source value and ends the ramp.

When a ramp is resumed (pressing [SHIFT][PAUSE] from the paused state):

- The ramp continues from the paused value with the present Source & Ramp time values.
- The PAUSE LED is turned off.
- The RAMP LED remains on until the ramp has completed.

When a ramp is complete

- The output setting is at its final value, with the ramp timer reset for the next ramp.
- The Source and Real Time displays both show the final value.
- The ramp LED is off.
- All keys are active & any parameters can be changed.

Figure 7 shows behavior of the different special ramp functions traces. For all traces, a ramp begins at *t = 1*, then one of the following special functions at *t = 2*. For the top trace (Pause), [SHIFT] [PAUSE] is pressed a second time at *t = 6*. For the others only a single action occurs. Although not shown here, the other special functions can be invoked when the ramp is paused.

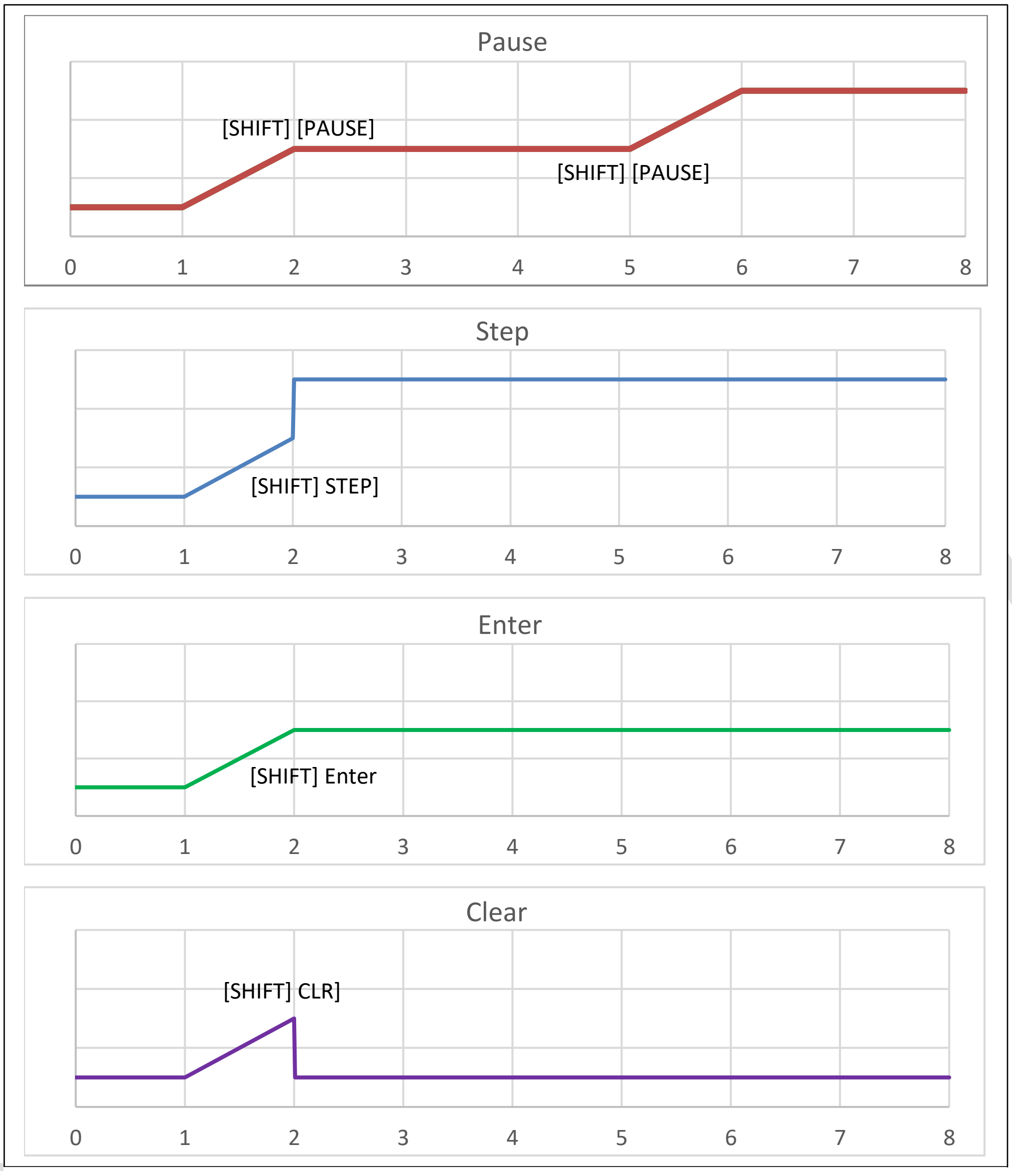


FIGURE 7: BEHAVIOR WHILE RAMPING

Real Time Display

The RealTime display shows the instantaneous output value. It is in the Settings list, accessed by the Setting [↑] and [↓] keys.

The Real Time value can be read from the Real Time display in the setting list or with the <REAL?> command.

Unless a ramp is active, Real Time displays the same value as the Source display or "0" if the output is off. During ramping, it displays the value being output in real time.

Note: The RealTime Display is read only. The SETTING selection must be changed to Source in order to change the output. If the user attempts to change the setting from the Real Time display, an error is generated (real time). Other functions can be accessed as normal. See *Ramping* (page 25) for detailed behavior.

Limits

The voltage and current limits protect output loads by limiting the peak voltage or current output from the DC215.

The adjustable Current Limits are active for the 30 V, 10 V and 1 V ranges. There is a pair of limits (±) that act on these ranges. The current limits are not active on the 10 mV and 100 mV ranges.

The adjustable Voltage Limits (or compliance voltage) are active for current out. There is a pair of limits (±) that act on all current ranges.

In addition, there are fast, fixed current limit set to ±350 mA that are active for all source types and ranges.

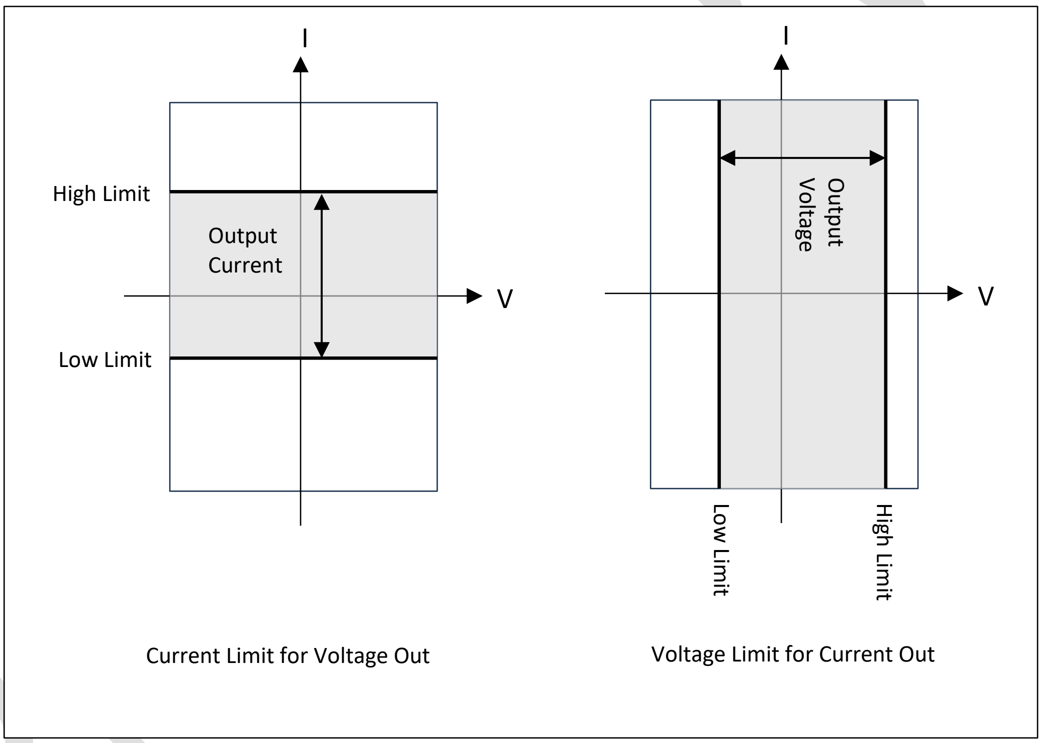


FIGURE 8: CURRENT AND VOLTAGE LIMITS

+Limit, -Limit

The ±Limits displays are in the Settings list, accessed by the Setting [↑] and [↓] keys.

Limit value can be set anywhere within the selected range using:

- Numeric keys
- Cursor keys
- <LIMI> command

Note that the limits are signed values and must be set as such. Values outside of the selected range will be rejected and an error message will be displayed.

TABLE 4: LIMIT RANGE & RESOLUTION

	Step Size	+LIMIT	-LIMIT
Current Limit	1 mA	+1 mA to +240 mA	-240 mA to -1 mA
Voltage Limit	0.1 V	+0.1 V to 32.0 V	-32.0 V to -0.1 V

Trips

The DC215 hardware will turn off the output (output trip) and disconnect the load if an external device is in danger of damaging the DC215,

If this occurs, a Trip message (Out Trip) is displayed on the display. This must be explicitly cleared before any changes can be made to the instrument, including turning the output back on. Press [CLR] to clear the trip and re-enable the output.

Voltage Trip and Current Trip are active for 1 V, 10 V, 30 V and all mA ranges. mV Trip is only active for the 10 mV and 100 mV ranges.

TABLE 5: TRIP THRESHOLDS

	Trip
Current Trip	> ±135% of range
Voltage Trip (30 V)	> ±34 V
Voltage Trip (1, 10 V)	> ±13.7 V
mV Trip	> ±170 mV

Note that a Trip is an uncommon event that should not occur during normal operation. When it does occur, it means something is wrong that must be corrected by the user to avoid damaging the DC215. If the trip cannot be cleared or reoccurs after turning the output on, see *Troubleshooting* (page **Error! Bookmark not defined.**).

Ready/Rdelay

The Ready signal is active Rdelay seconds after a source change is complete (SCC). The Ready signal is available as both an internal and Digital IO signal. It is typically used to synchronize internal or external measurements.

Source Change Complete (SCC)

For Normal (non Sequence) Operations

- The last set point of a ramp, or the set value if no ramp.
- In addition, changes to a ramp defining parameter during a ramp, forces a SCC (end the previous ramp and begin a new ramp. This includes the value, range, BW, T_{RAMP}, [SHIFT] [CLEAR], [SHIFT] [STEP] or [SHIFT] [ENTER].

For Sequence operation

- The last set point of a ramp, or the set value if no ramp.
- A step trigger occurring during a ramp, a ramp end, a step trigger occurring at the same time as a ramp end, or a value set when a sequence is ended.
- Note that for range/amplitude changes during a step, only a single SCC occurs.

Ready Delay (R_{delay})

Ready Delay (R_{delay}) is in the Setting list, accessed by the Setting [↑] and [↓] keys.

R_{delay} can be set between 0.002 and 100.000s in 0.001 s increments, using the following:

- Numeric keys
- Cursor keys
- <RDLY> command

Values outside of this will be rejected and an error message (bad value) will be displayed.

Behavior

Source Change Complete starts the Rdelay Timer. At the conclusion of the Rdelay Timer, the Ready Signal (both internal and Digital IO) goes active. Note that this behavior is valid for both sequencer and non-sequencer operation. See *Timing Diagrams* (page 85) for more details.

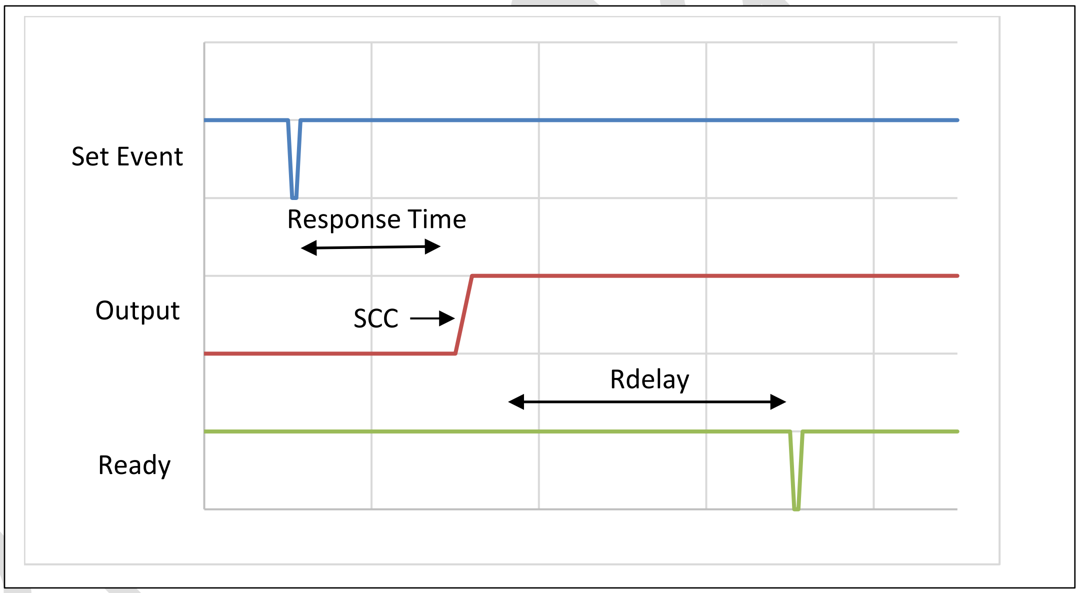


FIGURE 9: READY BEHAVIOR

Bandwidth

Bandwidth has effects on several DC215 parameters.

- Settling Time: Low BW settling time is approximately 10x longer than Hi BW settling time.
- Noise: Low BW noise is about 3 dB lower than HiBW noise.
- Reactive loads: The DC215 output is stable for 10x larger reactive loads for Low BW than for High BW.

See *Output Timing* (page 85) for details on settling time, noise and reactive loads.

BW Menu

Bandwidth (BW) is accessed from the BW menu ([SHIFT] [0]). There are two settings: Hi (high) and Lo (low). These are selected by either:

- [↑] and [↓] cursor keys, followed by [Enter]
- <BAND> command

Sense

The Sense setting selects either 2-wire or 4-wire (remote sensing) for the source circuitry. 4-wire sensing is normally used when there are significant voltage drops on the wires connecting the DC215 and the load. See *Remote Sensing* (page 80) for more information.

When selected, 4-wire sensing is active for the 1, 10 and 30 V ranges. It is inactive for the 10 and 100 mV ranges. On the current ranges, 4-wire sensing is only active for the voltage monitor. This parameter can be set regardless of range.

Sense Menu

2-Wire & 4-Wire Sense is accessed from the Sense menu ([SHIFT] [8]). There are two settings: 2-Wire Sense (Sen 2) and 4-Wire Sense (Sen 4). These are selected by either:

- [↑] and [↓] cursor keys, followed by [Enter]
- <SENS> command

Guard

The Guard setting selects how the DC215 Guard terminal is connected to its internal shield or to an external circuit node. See *Guarding* (page 82) for more details.

Guard Menu

The Guard setting is accessed from the Guard menu ([SHIFT] [9]). There are two settings: Internal (Int) and External (EXt). These are selected by either:

- [↑] and [↓] cursor keys, followed by [Enter]
- <GARD> command

Measurements

The DC215 simultaneously measures both the voltage and current outputs, regardless of the Source Type (V or I). While only one measurement can be displayed on the front panel at a time, both signals are always measured. Ordinarily, the non set parameter is displayed (current for voltage out and voltage for current out).

Measurements can be made over several different periods (integration time) and can be triggered by several different sources. The front panel measurement resolution is limited to 5½ digits. However full resolution is available over the computer interfaces or when logging.

The REL function allows measurements to be displayed relative to pre saved value. Measurements can be disabled to minimize noise on the output. If logging is enabled, the measured values can be logged to a USB memory stick or to the remote interface.

Measurement functions can be accessed from the MEAS menu or the associated remote commands.

See *Measurements and Logging* (page 105) for details on optimizing measurements.

Measurement Ranges

TABLE 6: VOLTAGE MONITOR

Type	Source Range	Measurement Range	Max Resolution
Current Out	all ranges	±32.000 V	1.0 µV
Voltage Out	30 V	±32.000 V	1.0 µV
Voltage Out	10 V	±12.0000 V	1.0 µV
Voltage Out	1.0 V	±1.20000 V	1.0 µV
Voltage Out	100 mV	±120.000 mV	10 nV
Voltage Out	10 mV	±12.0000 mV	10 nV

TABLE 7: CURRENT MONITOR

Type	Source Range	Measurement Range	Max Resolution
Voltage Out	30 V, 10 V, 1V	±240.0000 mA	10 nA
Voltage Out	100 mV	±70.0000 mA	100 nA #
Voltage Out	10 mV	±6.5000 mA	10 nA
Current Out	200 mA	±240.0000 mA	10 nA
Current Out	100 mA	±120.0000 mA	10 nA
Current Out	10 mA	±12.00000 mA	10 nA *
Current Out	1 mA	±1.20000 mA	10 nA *

* 1 nA resolution is available over the remote interface.
\# 10 nA resolution available over the remote interface.

Measurement Display

Normally the value of the most recent measurement is shown on the right side display with the appropriate units displayed by the indicator LEDs. If measurements are disabled, the display will show the inactive pattern (“.....”).

Displaying V or I

After a Source Type change, the measure display defaults to the non set parameter. To toggle to the other parameter, press [SHIFT] [2] (Mon V/I) or use the <DISP> command.

Indicators and Flags

There are several indicators associated with Measurements on the right side of the right hand display.

- mV, V, mA: Indicates the measured quantity.
- Rel: Indicates the REL Mode is active.
- Meas: Measurement Active, which is active during the measurement time.
- MRate: Measurement Trigger Rate Warning. This indicates a measurement trigger has occurred before the previous measurement is completed.

  MRate is not an error, per se. It simply indicates that the user may want to reduce the integration time or increase the time between measurements to resolve it. Measurement triggers that occur while Measurement Active are ignored.

  Note: Depending on the trigger rate, it is possible to generate MRate warnings for any of the integration times.
- Measure Active Flag: The Measure Active Flag (MAct) is active while a measurement is being made. It is set Hi on Measure Trigger and is cleared when the measurement is complete. See *Table xx Integration Time* (page xx) for measurement times.

Rel Mode

The Rel Mode displays deviations from reference values stored in memory. Rel Mode is indicated by the Rel indicator.

Rel V and Rel I are reference values used in the REL display mode. If both Rel V and Rel I are set to zero, the unit is not in the REL mode. If either value is non-zero, the unit is in REL mode. In REL mode, the displayed values is calculated using the following formula:

Displayed Value = Present Measurement – Rel (V/I) Value

Rel V and Rel I can be modified directly by the user from the Measure menu (reference) or by pressing [SHIFT] [1] (Rel), which loads the present measured values into Rel V and Rel I. If the unit is in Rel Mode, pressing [Rel] zeros both Rel V and Rel I, taking the unit out of Rel Mode.

Rel V and Rel I have the following limits, regardless of the output range.

- V Rel: ±33.5 V
- I Rel: ±250 mA

Care should be taken to use appropriate Rel values so as to not artificially limit the display resolution.

Measure Menu

The Measure menu is a multi-level menu that controls the configuration of the measurement functions. It is selected by [SHIFT] [4] (Meas). There are 6 top level selections: Measurement Trigger Source (**trig**), Measure Timer (**tImE**), Integration Time (**integ**), Display V Rel (**rEL V**) and Display I REL (**rEL I**), Enable (**EnAbl**). These are accessed using the cursor keys and [Enter] or [→]. The individual functions can also be set by their dedicated remote commands.

Trigger Source

There are four Measurement Trigger sources: Auto (**Auto**), Timer (**timE**), Ready (**rEAdY**), Measure Trigger Command (**cmd**).

- Auto Trigger: Begins a measurement upon completion of the previous measurement.
- Timer: Begins a measurement at a rate set by the Measurement Timer.
- Ready: Begins a measurement upon the Ready Signal going active. See *Ready/Rdelay* (page 30) for details on ready signal behavior.
- Command: Begins a measurement upon a remote interface trigger command <*TRG> or an IEEE-488 Group Execute Trigger.

The Trigger Source is selected from the Trigger Source sub-menu using the cursor keys plus [Enter] or by using <MTSO>.

Measure Timer

The Measure Timer (T_{MEAS}) controls the measurement rate when the Measure Trigger Source is set for Timed measurements. It can be set from 0.2 and 3600 seconds in 0.1 second increments. When selected, measurements are triggered every T_{MEAS} seconds.

The Measure Timer is set from the Measure Timer sub-menu using the numeric keys plus [Enter] or by the <MTIM> command.

Integration Time

The integration time sets the period of time measurements are integrated over. The values are very fast (**vFASt)**, fast (**FASt)**, medium (**mEd)**, and slow (**Slow),** referring to the measurement speed.

The Integration Time is set from the Integration Time sub-menu using the cursor keys plus [Enter] or by the <INTG> command.

TABLE 8: INTEGRATION TIME

Setting	Integration Time
Very Fast	74 ms
Fast	147 ms
Medium	294 ms
Slow	588 ms

Rel V

Rel V is the reference value used for voltage on the Rel display mode (reference). See Rel Mode for details on setting and viewing this parameter.

Rel V can be set using the following:

- Numeric keypad
- Pressing [SHIFT] [1] (Rel) from the Measure display
- <MREL> command.

Rel I

Rel I is the reference value used for current on the Rel display mode (reference). See Rel Mode for details on setting and viewing this parameter.

Rel I can be set using the following:

- Numeric keypad
- Pressing [SHIFT] [1] (Rel) from the Measure display
- <MREL> command.

Enable

Enables (on) or disables (off) measurements. If measurements are disabled, the display will show the inactive pattern (“.....”).

Measurement Enable is set from the Measurement Enable sub-menu using the cursor keys plus [Enter] or by the <MEAS> command.

Sequencer

The Sequencer plays out a series of output values from a list stored in memory (Sequence Program), stepped through by a “Step Trigger”. For each Step Trigger, a new Source Range and Source Level is set from the sequence file for a fixed source type. Sequences can be set to repeat, allowing them to run continuously until halted.

Sequence Programs are between 2 and 10000 points long and can be entered from the DC215 front panel, over the remote interfaces or downloaded from a USB drive. Each Sequence program includes:

- Source type (V/I) (first entry only)
- Source range (each entry)
- Source level (each entry)

Step Triggers include the internal step timer, the front panel [STEP] key, <QSTP> (remote interface step trigger), external DIO step trigger input or the end of measurement flag. The internal step timer can vary from 0.1 to 3600 seconds per point. External DIO step triggers can be as fast as 1 ms per point. See *External Step Triggers* (page 103) for details on high speed operation.

The sequence length can be limited using the Number of Points function. Ramping can be used to create trapezoid or triangle waveforms. Finally either the sequence step number or the measured value can be displayed at each step.

The Sequencer will operate when the output is off. While no signals will be output, it will respond to controls and step triggers.

Sequence Programs

A Sequence program must be created or loaded before it can be run on the DC215. Sequence programs consist of a single source type and a series of step values made up of range and level values. There are several ways to load Sequence program into the DC215:

- The Program Mode can be used to manually create or edit a Sequence program from the DC215 front panel. See *Program Mode* (page 40) for details.
- Sequencer programs can be loaded from a USB drive. See Saving and Loading Sequence Programs to USB (page 51) for information on saving or loading Sequence programs to/from an external USB memory device. See “*Sequence Programs*” (page 68) for details on the required file format for USB sequence files.

Operation

Step Triggers

A Step trigger advances the sequence through the steps of the Sequence file.

The Step Trigger Mode selects between Normal trigger sources and Measurement End. See Figure 10: Step Trigger Block Diagram for more details.

- Normal mode (Norm): Triggers on any of the Normal Trigger Sources.
- Measurement End mode (MEnd): Triggers only at the conclusion of a Measurement.

Normal Step Triggers

There are four normal step triggers. These triggers are all simultaneously active. To use a single trigger source, don't trigger any of the other sources. Note that the Step Timer is inactivated by setting it to 0.

Note: any step trigger occurs while Step Active is high will be ignored.

- Timer (Step Timer)
- Step key [STEP]
- Step command <QSTP>
- External Step Trigger {DIO}

Step Timer (T_{STEP})

This sets the time between time step triggers.

The internal Step Timer can be set from 0.1 to 3600 s in 0.1 s increments, or set to 0 to disable timed step triggers. See *Step Timer* (page 50) for details.

External Triggers

The Digital IO has both input and output step triggers. Input step trigger is one of the normal trigger sources. Output step trigger pulses for every step trigger regardless of its source. See *Digital IO Signals* (page 57) for details.

[STEP] Key

The front panel STEP key. See *Sequence Keys* (page 47) for details.

<QSTP> Command

This command can be invoked over any of the remote interfaces. See <QSTP> (page 150) for details.

Measurement End

Normal step triggers are inactive when the Measurement End is selected. This trigger source is a software flag that indicates a measurement is complete (Measurement Active Flag de-asserted). See *Indicators and Flags* (page 34) for details on the flag. See *Sequences and Measurements* (page 102) for timing information.

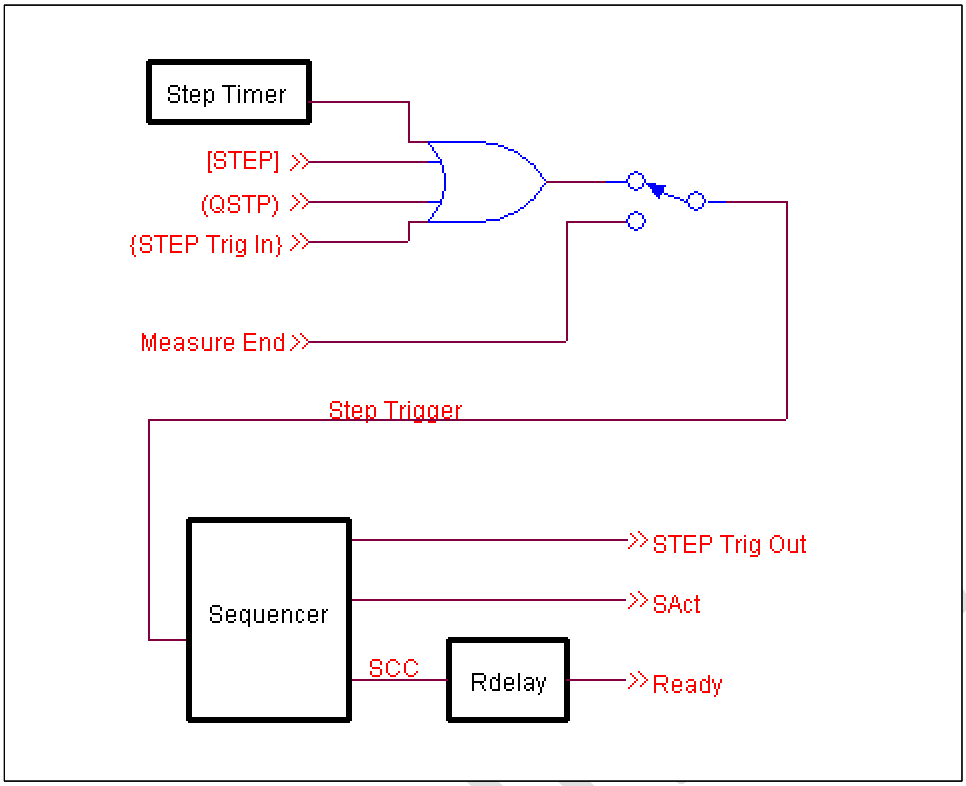


FIGURE 10: STEP TRIGGER BLOCK DIAGRAM

Sequencer Operating Modes

The Sequencer has several operating modes, including Normal (no sequence), Program (create a sequence on the front panel), Run (run a sequence), Pause (pause a running sequence) and Step Adjust (adjust the step number of a paused sequence).

Front Panel Operation

For front panel operation these modes are controlled by four keys: [RUN], [PAUSE] and [PRGM] (Program). The different modes can be accessed per the following table:

TABLE 9: SEQUENCER MODES

Current State	[RUN]	[PAUSE]	[PROGRAM]
Normal	Go to Run *	nothing #	Go to Program
Program	Go to Run *	nothing	Go to Normal
Run	Go to Normal	Go to Pause	Error/Ignore
Pause	Go to Normal	Go to Run	Go to Step Adjust
Step Adjust	Go to Normal	Go to Run	Go to Pause

* Assuming a Sequence Program is loaded, otherwise display an error.
# [SHIFT] [PAUSE] is active for non-sequence ramps

Normal Mode

This is the normal operating mode (i. e. sequences aren't running or being created).

All parameters besides the actual sequence program can be configured in the Normal mode.

The Normal mode is entered from the Run, Pause or Step Adjust modes by pressing [RUN] or by setting <QMOD 0>. This causes the following to occur:

- The Sequence is halted and reset. All timers are reset. Active ramps are terminated, jumping to the final value of the ramp, resetting the ramp timer, terminating R_{delay} and pulsing Ready.
- The output is set to the last step value.
- The indicators, status and DIO signals are updated as needed.

The Normal mode is entered from the Program mode by pressing [PROG] or by setting <QMOD 0>. This causes the following to occur:

- The unit reverts to the previously displayed settings

  Note: The Program mode only makes changes to the Sequence Program, not the instrument settings.

Program Mode

Sequence programs can be created when in the Program Mode. This can be done manually from the front panel or over the remote interface.

In Program mode, all changes are made to the Sequence program rather than to the output. Only the source range or source value can be changed once the sequence has been created. No other menus or settings can be accessed.

Display

In Program mode, the left side display shows the Source Value for the Step Count shown in right side display.

When creating or editing Sequence programs either the left side display (Source Value) or right side display (Step Count) has focus at a given time; never both. Focus is indicated by flashing the active digits of the display. Use the left and right cursor keys [<] [>] to toggle between displays. Only data from the focus display can be directly modified.

The Unset (--.----) source value is displayed for sequence steps where no value has been assigned. The decimal point and units indicators show the range.

The Source Type & Source Range are indicated by the units and decimal point in the left side display. Source Values follow normal Source value rules. They must be within the selected Source Range or an error message is displayed. If a range change sets the displayed Source Value out of range, that value is zeroed. Pressing [CLR] while entering a Source Value will revert to the previous value.

Entering Program Mode

The Program Mode is entered by pressing [PRGM] or by setting <QMOD 1> from the Normal Mode. This causes the following to occur:

- Any active ramps are terminated, jumping to the final value of the ramp, resetting the ramp timer, terminating any R_{delay} and pulsing Ready.
- All timers are reset.
- The indicators, status and DIO signals are updated as needed.

A new Sequence is created if no Sequence program is in memory. Existing Sequence programs are edited.

- The Program source type is inherited from the instruments V/I setting when the program is first created. To change the source type, the sequence must first be deleted and a new program created.
- The Program source type is assigned the Normal mode source type upon the creation. To change the source type the sequence must first be deleted and re-initialized from the normal mode.
- The step count is set to 1 on the right side display.
- The Source Range is set to the value from the Normal Mode prior to entering the Program Mode. This can be changed using the range [↑] [↓] keys.
- The Source value display (left side) has focus. It defaults to the "unset" value (-.----).
- Set the Source value using the keypad following the normal source setting rules.
- Press [ENTER] to load the displayed data into the Step 1 Value. The Step number is auto-incremented.

For each subsequent step:

- The Step Count is displayed for the new step.
- The Source Range defaults to the range from the previous step. The Source Range can be changed if desired.
- The Source Value is initially the "unset value" with the appropriate decimal point and units.
- Set the Source Value using the keypad following the normal source setting rules.
- Press [ENTER] to load the displayed data into that step. The Step number is auto-incremented.

Press [PRGM] or enter <QMOD0> to exit the Program Mode after the last point has been entered.

Editing an existing Sequence

Upon entering the Program Mode with an existing sequence, the source type temporarily changes to the sequence program source type.

- The Source Value display (left) has focus and is set to the previously stored Step 1 values. The Step Count is set to "1".
- Change focus to the Step Count using the cursor keys. Navigate to the desired Step Count using the cursor or numeric keys.
- To add a step to the end of the sequence, either increment past the last Step Value with the cursor keys or enter a Step Value larger than the last value. The Step Count will go to the "last Step Count +1" and display the "unset" Source Value.
- To delete the last step of the program, go to that step and press [CLR]. That step will be un-set and the step counter decremented by 1 to show the new last step.
- Change focus back to the Source Value and edit the Source Range and Source Value as desired.
- Press [ENTER] to load the displayed data into that step. The Step number is auto-incremented.

Press [PRGM] or set <QMOD 0> to exit the Program Mode to the Normal mode after the last point has been entered. Press [RUN] to enter the Run Mode.

Programming or editing a Sequence over the Remote Interface

Any legal sequence step can be programmed from the remote interface using the <QDAT> command. Legal sequence steps include any previously programmed steps or the "last step + 1".

Run Mode

This mode plays out the Sequence program stored in memory using the configured parameters (step trigger, repeat, ramping). Most sequencer related parameters cannot be modified in Run mode. But many non sequencer related parameters can be configured.

Note: There must be a sequence program in memory or an error will appear when attempting to enter Run mode. The source type must match the Sequence program source type or an Output Type error will appear when attempting to enter Run mode.

See *Ramps and Sequences* (page 45) for details on ramping behavior with sequences.

Display

The right side display shows either the Step Count or the V/I monitor values in Run mode. This is as configured by the Display setting. See *Display* (page 50) for details.

Starting from step 1

The Run mode is entered by pressing [RUN] or by setting <QMOD 2> from the Normal or Program modes. This causes the sequence to begin at step 1 as indicated:

- The first step Range and Source Value are set. (Note there is no ramping for the 1st point)
- The Run, Pause and Program indicators are updated as needed.
- The DIO and status signals are updated.
- The Step Trigger indicator is flashed.
- The display is updated.

For each subsequent Step Trigger

- The Range and Source Value are set, including ramping if appropriate.
- The DIO and status signals are updated.
- The Step Trigger indicator is flashed.
- The display is updated.
- For the last step of the sequence program or if the step count equals Point Lim (whichever is less), the DC215 will do the following based on Repeat.
  - If REPEAT is set, the next step trigger causes the Sequencer to restart the sequence.
  - If REPEAT is not set, the Program halts at the final Source Value and turns off the RUN LED.

The Run mode is exited by pressing [RUN].

Resuming from Pause

The Run mode is entered by pressing [PAUSE] or by setting <QMOD 2> from the Pause or Step Adjust modes. This causes the sequence to resume at the step displayed in the Pause mode.

- The last point continues to be output (from when paused)
- All timers are resumed unless they were updated during Pause. (See Pause mode for details if T_{ramp} or T_{STEP} were modified).
- Step Triggers are re-enable.
- The Run, Pause and Program LEDs are updated as needed.
- The DIO and status signals are updated.
- The display is updated.
- Go to "For each subsequent Step Trigger".

Pause Mode

This pauses a running sequence at the present range and source value. Timers are paused, including the R_{delay} timer, if active. Step triggers ignored. Most parameters besides the actual sequence program can be modified in the Pause mode.

Display

In Pause mode the right side display shows either the present Step Count or the V/I monitor value as configured by the Display setting. See *Display* (page 50) for details.

The Pause Mode can be entered by pressing [PAUSE] or setting <QMOD 3> from the Run Mode or by pressing [PRGM] or setting <QMOD 3> from the Step Adjust mode. This causes the following to occur:

- All timers and ramps are paused (or continue to be paused) at their present values.
- All Step Triggers are Held Off.
- The Pause indicator flashes at ~2 Hz.

The Pause mode exits to the Run mode by pressing [PAUSE] or by setting <QMOD 2>. The Pause mode exits to the Normal mode by pressing [RUN] or by setting <QMOD 0>.

Changing certain parameters while in the Pause mode may effect the output upon returning to the Run mode.

- If T_{ramp} is changed while Paused, any **active** ramp is terminated (this only applies if a ramp is active while paused). Terminating the active ramp involves jumping to the final value of the ramp, resetting the ramp timer, terminating R_{delay} and pulsing Ready.
- If T_{STEP} is changed while Paused, a Step trigger is generated upon returning to the Run mode with the same behavior as any other step trigger. Note that if the output is ramping while paused, the ramp should be terminated as described above.

Step Adjust Mode

The Step Adjust Mode allows the step number to be incremented or decremented without generating any step trigger outputs or status signals. This can be helpful to align sequences on multiple units. It is only accessed from the Pause mode. The only parameter that can be modified is the Step count. See *Step Adjust Mode* (page 99) for details.

Display

In Step Adjust mode, the left side display shows the Source Value for the Step Count shown in right side display.

The Step Adjust Mode is entered by pressing [PRGM] or setting <QMOD 4> from the Pause Mode. The only change to the Pause mode configuration is:

- The source value and step number are displayed on the left and right side displays, with the step number in focus.
- The Step Number can be incremented or decremented with the [↑] [↓] cursor keys. All other keys do nothing.

- Upon each increment/decrement, the output is immediately set to that step value, with no ramping, step trigger output or Step Active signals issued.

The Step Adjust mode exits to the Pause mode by pressing [PRGM] or setting <QMOD3>. The Step Adjust mode exits to the Run mode by pressing [PAUSE]] or setting <QMOD 2>. The Step Adjust mode exits to the Normal mode by pressing [RUN] or setting <QMOD 0>.

When the sequence is un-paused, it resumes from the adjusted step number. The following step trigger will advance to the next step as normal.

Ramps and Sequences

The sequencer can operate with ramping on or off. Ramp time (T_{ramp}) can be set independently from Step time (T_{STEP}) or any of the Step Triggers. See *Ramping* (page xx) for details on setting ramps. There are several sequencer behaviors related that depend on T_{ramp}, Tstep and changes in the Source Range.

- Ramping Off Tramp = 0): The output immediately jumps to the next step upon receiving a step trigger.
- Ramping On: A ramp begins upon receiving a step trigger, with the following constraints.
    - Source Range Change: Ramping is suspended for range changes. The output immediately jumps to the new source value without ramping.
    - $T_{ramp} < T_{step}$: If the previous ramp already ended, the next Step Trigger starts a new ramp.
    - $T_{ramp} = T_{step}$: If a Step Trigger occurs at the same time the ramp ends, the output begins a new ramp starting at the final value of the old ramp. This allows the DC215 to generate triangle waves.
    - $T_{ramp} > T_{step}$: If the step trigger occurs during the ramp, the present ramp is terminated (jumps to the final value of the ramp, resets the ramp timer, terminates R_{delay} and pulses Ready) and a new ramp begins toward the next step source value.

Figure 11 shows several sequences with fixed step times and different ramp times. All sequences start at the initial tic mark and step triggers occur every 3 tic marks.

- (a) is for Tramp = 0.
- (b) is for Tramp = Tstep, meaning the ramp ends at the same instant the step timer times out. This can be used to generate triangle like waveforms.
- (c) is for Tramp < Tstep, meaning the ramp completes before the next step.
- (d) is for Tramp > Tstep. When the step times out, the ramp is terminated, with the output jumping to the final value and resetting the ramp timer. At this point the next ramp starts. The dashed line shows where the first ramp would have terminated if the step time was long enough for it to complete.

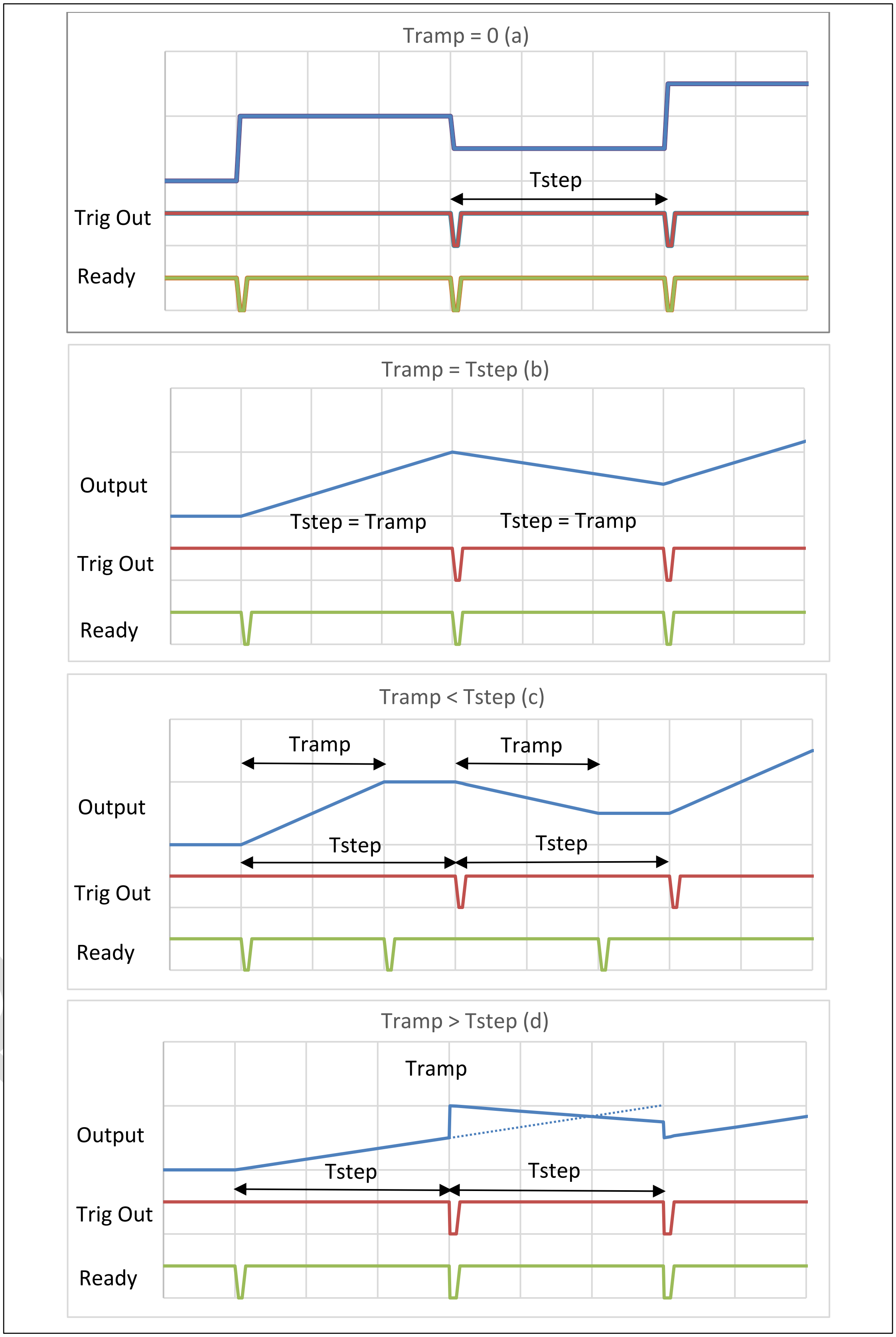


FIGURE 11: RAMPS AND SEQUENCES

Range Changes, Ramping and Sequences

Range changes terminate ramps as described in Ramping (page 25). So any sequence steps that includes a range change will not ramp.

For Tramp = 0.5 and Tstep = 1, the sequence program listed will produce the following waveform.

Step	Source Range	Source Value
1	10V	-5
2	10V	-3
3	10V	-2
4	1V	-1
5	1V	0
6	10V	1
7	10V	2

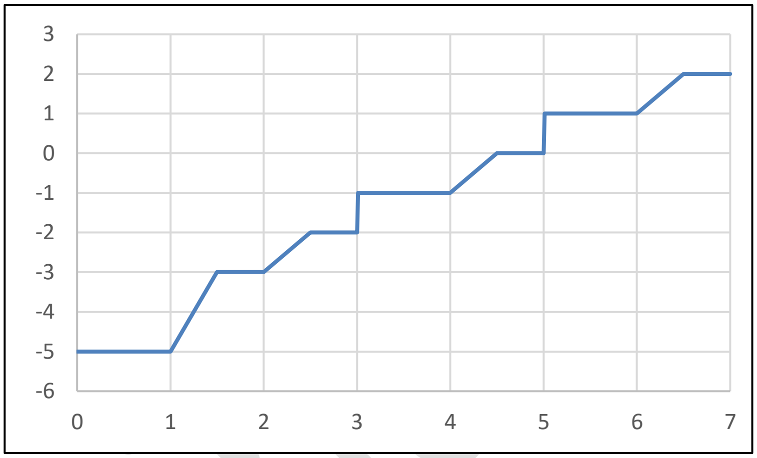


FIGURE 12: RANGE CHANGE, RAMPING AND SEQUENCES

Sequencer Controls

Keys

There are four keys associated with the Sequencer: [RUN], [STEP], [PAUSE] and [PRGM]. Their functions are duplicated by remote commands. See *Sequencer Operating Modes* (page 39) for details. Note these these the function of these keys is largely duplicated by the <QMOD> command.

[RUN]

Starts and stops sequences. If [RUN] is pressed when no sequence program is present, a “nO ProG” error is generated.

- [RUN] or the puts to the unit in the Run Mode from the Normal or Program Modes,
- [RUN] puts the unit in the Normal Mode from the Run, Pause or Step Adjust modes.

[STEP]

This is one of the Step Trigger Sources.

- [STEP] advances a sequence program by one step when in the Run Mode.

[PAUSE]

Pauses sequences.

- [PAUSE] puts the unit in the Pause Mode from the Run Mode.
- [PAUSE] puts the unit in the Run Mode from the Pause or Step Adjust Modes.

[PRGM]

Enters and Exits the Program Mode.

- [PRGM] puts the unit in the Program Mode from the Normal Mode.
- [PRGM] puts the unit in the Normal Mode from the Program Mode.
- [PRGM] puts the unit in the Step Adjust Mode from the Pause Mode.
- [PRGM] puts the unit in the Pause Mode from the Step Adjust Mode.

Indicators and Flags

There are several indicators associated with the sequencer.

- **RUN:** The RUN indicator is lit for the Run, Pause or Step Adjust modes.
- **PAUSE**: The PAUSE indicator blinks at ~2 Hz for the Pause or Step Adjust modes.
- **PRGM:** (Program) The PRGM indicator is lit for the Program or Step Adjust modes.
- **STEP:** The Step units indicator is lit when the step number is displayed in the right side display.
- **S Trig** (Step Trigger): The S Trig indicator flashes for each accepted step trigger.
- **S Rate** (Step Trigger Rate Warning): The S Rate indicator flashes if a step trigger occurs while the Step Active Flag is set. This is the same as bit 6 of LSER.

  S Rate is not an error, per se. It indicates that the user may want to decrease the external step trigger rate. Step triggers that occur during Step Active are ignored.
- **RAMP:** The Ramp indicator is lit while the output is ramping.
- **REPEAT**: The Repeat indicator is lit when the sequencer is in repeat mode.
- **Step Active Flag:** The Step Active Flag is active while a sequence step is being executed. It is set high on a valid Step Trigger and is cleared when the output value or the initial value of a ramp is set. If a step trigger occurs while Step Active is hi, it is ignored. See Figure 13: Trigger and Flag Timing.

Trig/Sync

There are several DIO signals associated with Sequencer operation. These are used to synchronize operations within the DC215 as well as with other instruments. See *Digital IO Signals* (page 56) for details on these signals.

- **Trigger In** (Step Trigger Input): This is a falling edge triggered signal. It is one of 4 normal step triggers.
- **Trigger Out**: This signal is primarily used to synchronize other DC215s during combined sequence programs. See Figure 13: Trigger and Flag Timing.
- **Ready:** This signal pulses low, R_{DELAY} ms after the output level has finished changing (Source Change Complete). Ready is active for both sequences and normal operation.

- **M End** (Measurement End): This trigger source is a software flag that indicates a measurement is complete. See *Measurement Active Flag* (page 34) for details.

Trigger and Flag Timing

The relationship of step trigger, Step Trigger Out and the Step Active flag is shown in the Figure 13.

- Step Trigger (STrig) can be any of the step triggers.
- Step Trigger Out (STrig Out) outputs a 1 µs pulse upon receipt of a valid step trigger.
- Step Active (SAct) is high while a step is being executed. It will vary in duration depending on any range changes.

FIGURE 13: TRIGGER AND FLAG TIMING

If a step trigger occurs while Step Active is high that trigger is ignored and a SRate warning is set (SRate front panel indicator and bit 6 of LSER). For the Figure 14, the second STrig would be ignored and generate a SRate warning.

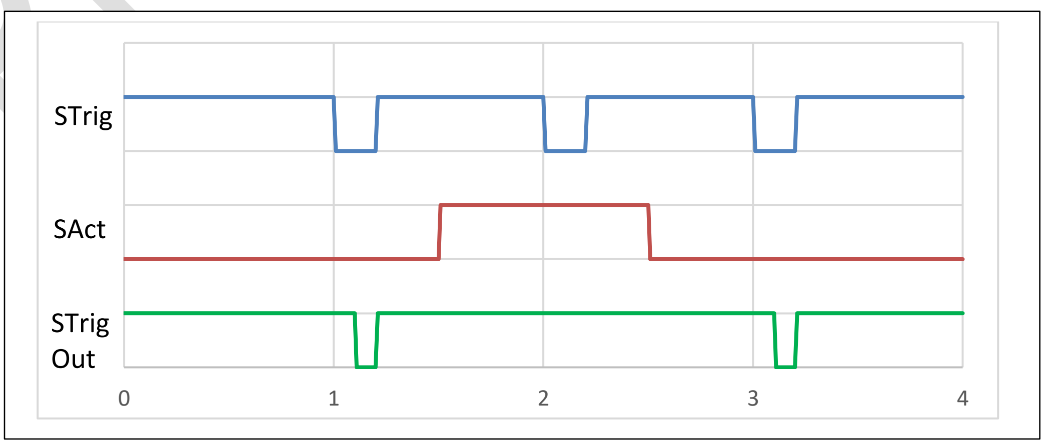


FIGURE 14: OVER TRIGGER

Sequence Menu

The Sequence menu is a multi-level menu for the configuration of the Sequencer functions. It is selected by [SHIFT] [.] (Seq). There are 8 top level selections: Step Trigger Mode (**trig**), Step Timer (**timE**), Repeat mode (**rPt**), Display Mode (**dISP**), Point Limit (**PtLm**), Clear Sequence Program (**CLr**), Load Sequence Program from USB (**L USB**) and Save Sequence Program to USB (**S USB**). These are accessed using the cursor keys and [Enter] or [→]. The individual functions can also be set by their dedicated remote commands.

Step Trigger Mode (trig)

The trigger mode selects which of the step trigger sources are active. See *Step Triggers* (page 38) for details. It is selected using the cursor keys and [Enter] or by <QTRG>.

- Normal mode (**Norm**): Triggers on any of the Normal Trigger Sources.
- Measurement End mode (**MEnd**): Triggers only on the Measurement Active Flag de-asserting.

Normal mode allows any of the following trigger sources: [STEP], <QSTP>, internal step timer (T_S) & {DIO Step Trigger input}. A trigger on any of these trigger sources will trigger a step. Note: To disable timed steps, set the internal step timer to 0.

Step Timer (time)

The Step timer (T_{STEP}) sets the time for internal timed step triggers.

The internal Step Timer is set from 0.1 to 3600 s in 0.1 s increments using the numeric keypad plus [ENTER] or by the <QTIM> command. The step timer can be set to 0 to disable timed step triggers.

Repeat (rPt)

Repeat determines if the sequence will restart after it outputs its final point or if it will halt and go to the Normal mode.

Select **OFF** or **On** using the cursor and [ENTER] keys or the <QREP> command. When on, the Repeat indicator is lit.

Display (diSP)

This selects what is shown on the right side display shows for Run and Pause modes: the step number (**StEP**) or measurement (**MEaS**). It is selected using the cursor and [ENTER] keys or by the with <DISP> command.

Point Limit (PtLm)

By default, the number of steps output by the sequencer before halting or repeating is the number of entries in the sequence program. This can be limited by setting Point Limit less than the number of entries.

Point Limit can be set between 1 and 9999 using the numeric keypad plus [ENTER] or by the <QNPT> command. Setting the point limit to 0 enables all points in the sequence program.

Clear Program (ClEar)

This erases the internal sequence program from memory. It displays **No** or **YES**. Pressing [ENTER] with **YES** selected erases the program in the sequencer memory. Memory can also be cleared using the <QCLR> command.

Note: Clearing the sequence program permanently deletes it.

Saving & Loading Sequence Programs to USB

Sequencer program files can be saved or loaded to a USB flash drive using the **L USB** and **S USB** menu choices. See *USB Memory Device Interface* (page 67) for details on file format, loading & saving files and error behavior.

The file name on the USB memory device for Sequence Program Files is “PRGM*i*.CSV”, where *i* is an integer between 0000 - 9999. Program Files will be addressed on the DC215 using just the integer (0000 – 9999).

Use **L USB** to load a sequencer file from the USB memory device to the DC215. The file index number will appear on the right display. This number can be changed by using the cursor keys or the numeric keys followed by [ENTER] or by the <QSUL> command.

Use **S USB** to save a sequencer file from the DC215 to the USB memory device. The file number will appear on the right display. This number can be changed by using the cursor keys or the numeric keys followed by [ENTER] or by the <QSUS> command.

Save/ Load Abort for Sequence Files

Saving or recalling long sequences can take over a minute in some cases. The user can abort the save or load process by pressing [CLR]. This does the following:

- L USB: This terminates the load function and displays the “aborted” message. No sequence program is saved in the DC215’s sequence buffer.
- S USB: This terminates the save function and displays the “aborted” message. This leaves the partial sequence program on the USB drive.

Note that Abort is a front panel only function.

Testing Sequences

Sequences can be tested with the output off. All step triggers, besides Measurement End, operate the same as when the output is on. This can be useful to test and adjust multiple DC215s synchronized using Digital IO.

Logging

The DC215 can log output settings and measurements to an external USB Memory device or over any of the remote interfaces. Anywhere from 1 to 199999 points can be logged, or logging can be set to run continuously without limit. Each logged entry consists of 6 different values:

- Time Stamp: Time since trace logging began (in 0.1 s increments)
- Source Type: V or I
- Source Range Text values (10V, 1mA...)
- Source Value: Output value as a real number (1.0, 1E-6…)
- Voltage Measurement: Measurement value as a real number (1.0, 1E-3…)
- Current Measurement: Measurement value as a real number (0.10, 1E-5…)

Each logging entry represents a new measurement. Once enabled, logging continues until the set number of values has been logged, logging is disabled or logging is halted due to an error.

The log rate is determined by the measurement rate. See *Measurements* (page 33) for details on all measurement configuration parameters, including VREL and IREL. Logging can operate together with sequences. See *Sequencer* (page 37) for details on sequences configuration. Note that the measurement and sequence parameters should be configured prior to enabling logging.

Logging parameters must be set prior to enabling logging, as they cannot be changed while logging is active. This includes the following:

- Enable
- Number of points (1 – 199999 or 0 for continuous logging)
- File Name (for USB)
- Destination (USB or Comm)
- Error behavior (Halt or Continue on Logging Error)
- REL

Note that logging can only operate when the output is on and measurements are enabled. If the output or measurements are turned off, logging is disabled.

Behavior

The destination, file name (for USB logging), number of points and error behavior must be set prior to logging being enabled. These cannot be changed during Logging. Any attempts to change these during logging will result in a “Log Act” (logging active) error message or an error over the remote interface.

Once enabled, logging continues writing to either the USB device or the remote interface until one of the following occurs:

- If the set number of points has been logged, or logging has been disabled or measurements disabled, a “Log Done” message is displayed and enable is set to off.
- If the Output is turned off, an “Output Error” is displayed.
- If the USB drive cannot be accessed (USB disabled, drive removed or other fault) a “USB Error” is displayed.
- If the internal buffer cannot be written before it overflows a “Log Error” message is displayed.
- If Logging is halted due to some other error a “Log Error” message is displayed.

When logging, data is written to a logging buffer in the DC215 which is periodically written to either the USB device or remote interface. The USB memory device or remote interface computer is responsible for processing data from the logging buffer in a timely manner or it will be lost, and a time out error will be generated.

Numeric Precision

Log files use 4 byte floating point values for data storage. These have slightly less precision than the 8 byte fixed point representation used for calculations in the DC215. Accordingly there may be small differences in values stored during logging for very small values. These differences are well below the instruments accuracy. If this is of concern, use the remote interface to set and query parameters directly without using logging. This supports the full precision of the DC215.

Logging to a USB Device

Log data is saved to the USB device formatted in CSV format (comma separated values). If the named log file does not exist on the USB device, the DC215 creates it and writes the header lines when logging is enabled. If the file already exists, it is overwritten with just the header lines. If logging is disabled and re-enabled, the log counter and time are reset prior to restarting.

Each time logging ends, the Log File index will auto incremented for the *next* time logging is enabled. This value can be edited by the user if a specific file number is desired.

See *USB Memory Device Interface* (page 67) for details on the USB files and errors.

Header

The first few lines of a log file consist of a header which includes the time, date, temperature, VREL & IREL, and headings for the 6 logged values. These are written as soon as logging is enabled.

Each Logged Point

Upon each measurement, data is stored in the logging buffer. Periodically the log file is opened on the USB memory device, the logging buffer data is written, and the file is closed.

Logging will fail if the USB device cannot keep up. Typically, this can be resolved by using a faster USB device or a device with fewer files on it. See *USB Drive Messages* (page 71) for details.

Logging over Remote Interface

There is no header information over the remote interface.

Upon each measurement, data is stored in the logging buffer. This buffer must to be read using the <RLOG> command before it is overwritten by new entries and the data is lost. See Logging Commands (page 143) for details on reading logged values.

There are two methods to determine if a new log value is available. <RLOG?> will return the latest log value if present, or report "!" if a new log entry is not available. Bit #3 in the LSSR/LSER register can be queried to see if a new log point is available.

When logging over the remote interface, RLOG or LSSR/LSER shouldn't be queried more often than about once every 25 ms to avoid overloading the instrument with unnecessary queries.

Logging will fail if the remote computer cannot keep up. Resolving this will require better real time behavior from the remote computer.

Logging Menu

The Log menu is a multi-level menu that controls the configuration of the logging functions. It is selected by [SHIFT] [6] (Meas). There are 5 top level selections: Logging Enable (**Enabl**), Number of points logged (**nPntS**), File Name (**FilE**), Destination (**dESt**), and Error Behavior (**Err**). These are accessed using the cursor keys and [Enter] or directly from the remote interface commands.

Enable (Off|On)

This enables (on) or disables (off) the logging function. When logging is disabled, all logging operations are halted, the logging counter is reset and all internal buffers are cleared.

Note that logging cannot be enabled if the Output is off, Measurements are disabled or the USB is disabled (if selected). This is indicated by "Output Off", "Meas Off" or "USB Disabled" error messages.

Logging is automatically disabled when the number of points has been logged, the output is turned off, measurements are disabled or a Logging Error occurs.

Logging Enable is set from the Logging Enable sub menu using the cursor keys plus [Enter] or by the <ELOG> command.

Number of Points

The number of log points applies to both USB and remote interface logging. The number of points can be set from 1 and 199,999, or set to 0 for continuous logging until halted. When set to continuous logging, the user should disable logging when the desired number of points has been logged.

The Number of Points is set from the Number of Points sub menu using the numeric keypad plus [Enter] or by the <NMPT> command.

File Name

This sets the name of the USB memory device file to be written to. The name for Log Buffer Files on the USB memory device is “LOG*i*.CSV” where *i* is an integer between 0 - 9999. File Names in this menu are indicated by the integer *i*. If errors with the USB memory device occur, an error is generated. See *USB Drive Messages* (page 71) for details.

The File Name Index is set from the File Name sub menu using the numeric keypad plus [Enter] or by the <ULFN> command.

Destination

Data can be logged to a USB memory device (**USB**) or over any of the remote interfaces (**Comm**).

When logging, data is written to a logging buffer in the DC215 which is periodically written to either the USB device or remote interface. The USB memory device or remote interface computer is responsible for processing data from the logging buffer in a timely manner or it will be lost, and a Log error will be generated.

The Destination is set from the File Name sub menu using the cursor keys plus [Enter] or by the <ELOG> command.

Error Behavior

The user can select if the Sequencer should halt (**hAlt**) or continue (**cont**) if a logging error occurs. In both cases, a logging error will appear after the error.

Halt on Error

For Halt on Error, both sequences and logging will stop if a logging error occurs.

Continue on Error

For Continue on Error, sequences will continue to operate if a logging error occurs even though logging has stopped.

Error Behavior is set from the Err sub menu using the cursor keys plus [Enter] or by the <LHOE> command.

Digital IO Signals

The DC215 uses several TTL signals for synchronization with other instruments or between multiple DC215s. Most of these input and output signals are available on a multi-pin DB-9 male connector on the rear panel. There is also a single input BNC connector that can be set to any of the different inputs and a single output BNC connector that can be set to any of the different outputs. See *Digital IO* (page 63) for information on configuring the Digital IO (DIO) signals. See the *Using Digital IO* (page 92) for information on using the Digital IO signals. These are accessed using the cursor keys and [Enter] or directly from the remote interface commands.

Signals

Outputs

There are 3 different output and Flag signals. They are available on the DB-9 connector. Any of them can be selected for the Output BNC in the Utilities menu or by the <BOSO> command. A signal selected for the output BNC is also active on the DB-9 connector.

Output ON Out

Output On Out can be used to control multiple DC215s.

OUTPUT_ON is active low when the output is ON and high when the output is off.

Step Trigger Out

Trigger Out is used to synchronize sequence programs across multiple DC215s.

Trigger Out is high when sequences are not running and pulses low for ~1 µs at each Step Trigger.

Ready Out

Ready is used to synchronize a DC215 with external devices like DMMs. See the *Triggering an External DMM* (page 95) for an example.

Ready is normally high and pulses low for ~1 µs, R_{DELAY} seconds after the output level has finished changing (Source Change Complete). See *Ready/Rdelay* (page 30) for a description of Source Change Complete behavior.

Output Flags

There are 2 different Flag signals which are primarily used for the internal signaling on the instruments firmware. They can be selected for the Output BNC in the Utilities menu or by the <BOSO> command, but are not present on the DB-9 connector.

Note that the flags have ~1 ms resolution and may not accurately report the internal status of the DC215 beyond this.

Measurement Active Flag

The Measurement Active Flag signal can be selected on the Output BNC. It is not available on the DB-9 DIO connector. See *Indicators and Flags* (page 34) for details on the Measurement Active Flag.

Step Active Flag

The Step Active Flag signal can be selected on the Output BNC. It is not available on the DB-9 DIO connector.

The Step Active Flag is only active when sequences are running. It is set high on Step Trigger and cleared after any range change and the DAC value being set, ignoring any ramping. See *Output Timing* (page 85) for more details.

Inputs

There are 2 different input signals. Both are available on the DB-9 connector and can be selected in the Utilities menu for the Input BNC in the Utilities menu or by the <BISO> command.

Note: If a signal is selected for the Input BNC, it is inactive on the DB-9 connector to avoid conflicts. The input signals can be set to inactive to avoid spurious pickup.

Input signals have a selectable debounce function that when active ignores changes for 10 ms after the initial transition. This is selected from the *Digital IO menu* (page 63) or by the <DEBO> commend.

Output Control Input

The Output Control Input can be configured as either an Output Enable (OE) or as an ON/OFF Control. See *Output Control* (page 24) for details on behavior for the Output Control Input and ON/OFF functions.

- **Output Enable** (OE) must be low for the output to be on or be turned on. If OE is high, the output will be turned off and not able to be turned on by any “Output On” function (either [ON] or <OUTP>).

  Note: If selected and not pulled low, the output **will** be disabled and remain off regardless of any “Output On” events.

- **ON/OFF Control** A falling edge turns the Output ON; a rising edge turns the Output OFF.
- **None** If selected, neither of the Output Control Input options are active.

Step Trigger In

Step Trigger In is one of 4 possible step triggers. Step Trigger In is active on the falling edge. See *Step Triggers* (page 38) for details.

System Settings

All the DC215 parameters can be saved & recalled to/from non-volatile memory. These include all the output settings, measurement & logging settings, sequence program and remote interface settings. There are several types of settings that are stored in different locations. This actions can be performed from the front panel or over the remote interface.

- Working Settings: Saved to location 10 about 10 s after last keypress or when explicitly saved over the remote interface. Recalled during power cycle.
- Stored Instrument Settings: Instrument settings saved to locations 1-9.
- Instrument Default Settings: Recall location 0.
- Sequence Program: Created, saved and cleared as described in *Program Mode* (page 40).
- Interface Settings: Saved about 10 s after last setting change or when explicitly saved over the remote interface. Recalled during power cycle.

Store and Recall Settings

Instrument settings can be stored and recalled to/from non-volatile memory. Up to nine different instrument settings (1-9) can be stored and recalled. These settings include all DC215 parameters besides the sequence program and remote interface settings.

Press [SHIFT] [±] (Store) followed by the desired location number (1-9) to store the instrument settings to that location.

The *Default Settings* can be recalled from location 0.

The working settings are saved to location 10 and are recalled upon power on.

Press [SHIFT] [7] (Recall) followed by the desired location number (0-9) to recall the instrument settings from that location. If you select a setup that has not previously been stored, an “Recall Fail” error message will appear.

⚠ If a stored setup is overwritten, the previous value cannot be retrieved.

Note: Setups are stored into Flash memory with a life time of about 100,000 erase cycles. Don’t continuously store settings, especially over the computer interfaces, to avoid wearing out the memory.

Reset

There are several actions that recall different instrument settings:

Power Cycle

- Resets the firmware and hardware
- Clears any Trip conditions
- Erases all volatile parameters
- Loads the working settings (location 10) from when last saved

Recall 0, <*RCL0>

- Resets the hardware
- Cancels any pending operations
- Clears any Trip conditions
- Erases most volatile parameters
- Loads the Default Instrument Setup
- Saves settings to location 10.

<*RST>

- Performs the actions of Recall 0
- Resets firmware
- Resets the message terminator
- Preserves the states of the IEEE-488 interface and Output Queue
- All status and enable registers are preserved
- Arguments and return values are cleared

Recall 1-9

- Resets hardware
- Cancels any pending operations
- Clears any Trip conditions
- Erases most volatile parameters
- Loads the selected Instrument Setup
- Saves settings to location 10.

Power-on [CLR] (Recall Factory Setup)

Selected by applying power while the [CLR] key is held down. This resets all the stored settings to their factory default setting, besides the remote interface.

- Performs the actions of <*RST>
- Resets all remote interfaces
- Clears all queues
- Resets all status & enable registers
- Deletes all stored settings
- Deletes any Sequence Program
- Clears all unused areas in memory
- Saves settings to location 10.

Power-on [5] (Recall Remote Interface Factory Setup)

Selected by applying power while the [PRGM] key is held down. This resets all remote interface settings to the factory default setting.

- Resets all Remote interfaces.
- Sets all Remote interfaces to their default value
- Resets all status registers
- Clears all queues and pending operations
- Saves the remote interface settings to memory

Restore All Factory Settings

To clear all user settings and restore the DC215 to its Factory Configuration, do the following:

- Power-on [CLR] Clears all user settings
- Power-on [5] Clears all remote interface settings

This erases all non-volatile user settings & returns the unit to the condition it shipped for SRS.

Volatility Statement for SRS DC215 (DC Voltage/Current Source

The DC215 contains two types of non-volatile memory:

- 256 kB of flash memory located inside the microcontroller which is used for firmware storage code storage and execution.
- 8 Mbit serial EEPROM which is used for instrument and remote interface settings.

When resetting the unit back to factory settings, the EEPROM is overwritten on a byte for byte basis with the factory settings and all unused memory is erased. The flash for code is left unchanged. “Restore All Factory Settings” is the most thorough wiping procedure available.

Default Instrument Setup

TABLE 10: DEFAULT SETUP

Parameter	Value
Output	Off
Source Type	Voltage
Voltage Range	10 V
Current Range	10 mA
Source Voltage	0 V
Source Current	0 mA
+ Current Limit	240 mA
- Current Limit	-240 mA
+ Voltage Limit	32 V
- Voltage Limit	-32 V
T_{ramp}	0 s
R_{delay}	0.020 s
Sense	2 wire
Guard	Off
BW	Hi
Mon V/I	I
Sequence Prgm (Recall 0 or *RST)	Not effected
Sequence Prgm (Power-on [CLR])	No sequence loaded
Seq/Trig	Norm
Seq/Time	1.0 s
Seq/Repeat	Off
Seq/Point Length	0
Seq/Display	Step
Seq/L USB	0
Seq/S USB	0
Meas/Trigger	Auto
Meas/Time	1.0
Meas/Integration	Slow
Meas/REL V	0
Meas/REL I	0
Meas/Enable	On
Log/Enable	Off
Log/# of Points	100
Log/File	0
Log/Destination	USB

Parameter	Value
Log/Error	Continue
Util/DigIO/OCtrl	None
Util/DigIO/BNC In	None
Util/DigIO/BNC Out	Output On
Util/DigIO/Debounce	Off
Util/Beep	On
Util/Front Panel	On
Util/Name	‘DC215’
Util/RTC/Enable	On
Util/RTC/Year	???
Util/RTC/Month	???
Util/RTC/Day	???
Util/RTC/Hour	???
Util/RTC/Min	???

Default Remote Interface Setup

TABLE 11: DEFAULT REMOTE INTERFACE SETTINGS

Parameter	Value
Comm/GPIB/Enable	On
Comm/GPIB/Address	27
Comm/RS-232 Enable	On
Comm/Baud Rate	9600
Comm/Net/Addr/Ip 1|2|3|4	0|0|0|0
Comm/Net/Subnet/Ip 1|2|3|4	0|0|0|0
Comm/Net/Gate/Ip 1|2|3|4	0|0|0|0
Comm/Net/Linc	100t
Comm/Net/TCPIP	On
Comm/Net/DHCP	Off
Comm/Net/Static	On
Comm/Net/Auto	Off
Comm/Net/Bare	On
Comm/Net/Telnet	On
Comm/Net/Inst	On
Comm/USB/Enable	On

Utilities Menu

There are a number of functions grouped together in the Utility menu. These include configuring the Digital IO, measuring temperature, running self tests and RTC (Real Time Clock), plus other functions.

The Utility menu is a multi-level menu that accesses the different functions, selected by [SHIFT] [3] (Utils). There are 5 top level selections: Digital IO (**digIO**), Internal Temperature (**tEmP**), Keyclick function (**BEEP**), Front Panel (**FtPnl**), Self Test (**StSt**), Self Test Errors (**StErr**), Remote Interface name (**NAmE)** and Time-Date (**t-d**). These are accessed using the cursor keys and [Enter] or directly from the remote interface commands.

Digital IO (digIO)

There are four sub menus under Digital IO: Output Control (**OCtrl**), BNC Input (**BNC In**), BNC Output (**BNC Ou**) and Debounce (**debou**). See *Digital IO Signals* (page 56) for instructions on the behavior of these signals.

Output Control (OCtrl)

There are three options for the Output Control Input: None (**NonE**), Output Enable (**EnAb**) and On/Off Control (**Ctrl**).

- None: Disables the Output Control Input function
- Output Enable: Sets Output Control Input function to Output Enable
- On/Off Control: Output Control Input function to ON/OFF Control

Output Control is selected by the cursor keys plus [Enter] or by the <OCTL> command.

BNC Input (BNCIn)

There are three options for options for the BNC Input: None (**NonE**), Output Control (**OCtrl**) and Step Trigger In (**trig**).

- None: Disables the BNC Input
- Output Control: Sets the BNC Input to Output Control. Output Control behavior is described above. Disables DB-9 Output control signal.
- Step Trigger Input: Sets the BNC Input to Step Trigger In. Disables the DB-9 Step Trigger In signal.

BNC In is selected by the cursor keys plus [Enter] or by the <BISO> command.

BNC Output (BNCOu)

There are five options for options for the BNC Output: Output ON (**OutOn**), Step Trigger Out (**trig**), Ready (**rEAdY**), Measurement Active (**MAct**) and Step Active (**SAct**).

- OutOn: Sets the BNC to Output On.
- TrigOut: Sets the BNC Output to Step Trigger out
- Ready: Sets the BNC Output to Ready
- MAct: Sets the BNC Output to Measurement Active
- SAct: Sets the BNC Output to Step Active

BNC Out is selected by the cursor keys plus [Enter] or by the <BOSO> command.

Debounce (dEbou)

Debounce (**dEbou**) allows you to enable (**On**) or disable (**Off**) the 10 ms digital input debounce function. See *Debounce* (page 64) for details.

Note: If selected, Debounce is active for all input signals.

Debounce is selected by the cursor keys plus [Enter] or by the <DEBO> command.

Temperature (tEmP)

Temperature (**tEmP**) initiates a temperature measurement. It can also be initiated by the <TEMP?> command.

The result is displayed in °C with 0.1 °C resolution.

Note that temperature measurements cannot be made when sequences or logging are active.

Key Click (BEEP)

Key Click (**BEEP)** allows you to enable (**On**) or disable (**Off**) the key click and other acoustic alarms and indicators.

Key Click is selected by the cursor keys plus [Enter] or by the <BEEP> command.

Self Tests

Self Test (StSt) allows the user to run the Self Tests. This can also be initiated by <*TST>. Self Test defaults to off (**Off**). Once turned on (**On**), they run to completion and report pass (“tESt Pass”) or fail (“tESt FaiL”) and exit the menu system. If Self Test fails, the error messages can be read from the Self Test Error Queue or over the remote interface with the <LERR?> command. See *Self Tests* (page 169) for an explanation of the error codes.

Self Test Error Queue (StErr)

The Self Test Error Queue (**StErr**) displays error codes for any self test failures. Errors can also be read using the <LERR?> command.

- If no errors occurred during Self Test, “tESt PASS” is displayed.
- Otherwise errors are displayed in order, with the first error to occur to be displayed first. Errors are displayed as “Err xxx”, with xxx being the error code. Errors are cleared using [CLR] or by reading them over the remote interface using <LERR?>. After the last error is cleared, a “No Error” message is displayed.

See *Self Test Error Codes* (page 169) for an explanation of the error codes. Note that there is a single error queue which can be viewed and cleared from from **StErr** or any of the remote interfaces.

Front Panel Update (FtPnl)

Front Panel Update (**FtPnl**) selects between updating the front panel (**On**) or freezing the front panel to a static value (**FrEEZ**).

Freezing the front panel can be useful when operating sequences at high speed, as updating the display can cause time uncertainty in the DAC update rate. See *External Step Triggers* (page 103) for details on using this function.

Freezing the front panel is selected by the cursor keys plus [Enter] or by the <DISP3,0> command. To exit the frozen state, press [CLR] or send the <DISP3,1> command.

Remote Interface Name (NamE)

The Remote Interface Name (**NAmE**) displays the instrument name as configured over the remote interface. This is set and can be read over the remote interface by the <NAME> command. This feature is useful to identify a particular DC215 within a system with multiple units. See the <NAME> command for details.

Time – Date (t-d)

Time & Date (**t-d**) are maintained with a battery backed up Real Time Clock for use with the USB file system. See *USB Memory Device Interface* (page 67) for details. These are accessed using the cursor keys and [Enter] or directly from the remote interface commands.

There are six sub menus under Time-Date: Enable (**EnAb**), Year (**YeAr**), Month (**Mon**), Day (**dAY**), Hour (**Hour**) and Minute (**Min**).

Enable (On|Off)
Enable (**EnAb**) enables (**On**) or disables (**Off**) the Real Time Clock system.

Note: This is a front panel only function and cannot be set over the remote interface.

Time and Date can be set when the Real Time Clock is enabled, but not when it is disabled.

Enable is selected by the cursor keys plus [Enter].

Year (2000 - 2079)
Selects the year for the Real Time Clock using the numeric entry keys plus [Enter] or the <TDAT> command.

Month (jan – dec)
Selects the month for the Real Time Clock using the cursor keys plus [Enter] or the <TDAT> command.

Day (1 - 31)
Selects the day for the Real Time Clock using the numeric entry keys plus [Enter] or the remote interface with the <TDAT> command.

Hour (0 – 23)
Selects the hour for the Real Time Clock using the numeric entry keys plus [Enter] or the <TDAT> command.

Minute (0 – 59)
Selects the minute for the Real Time Clock using the numeric entry keys plus [Enter] or the <TDAT> command.

USB Memory Device Interface

Sequence and Log files can be saved or recalled from a USB Memory Device connected to the front panel USB port. File types are limited to CSV format. Only specific file names are allowed which are identified on the DC215 by a numeric suffix.

USB Type A-Type Socket

The USB A-Type socket is used to connect USB memory devices (typically flash drives) to store sequence programs or logged measurement results. The USB drive should be formatted as a FAT32 drive. USB 2.0, USB 1.0 & USB 1.1 drives are supported.

Control

Indicators

The USB activity LED is located adjacent the USB connector.

Enable

The USB interface is enabled from the Comm/USB menu or with the <EUSB> command.

Abort

Long sequences can take over a minute to save or load. This process can be aborted by pressing [CLR]. See *Save/Load Abort* (page 51) for specific details.

Note that Abort is a front panel only function and cannot be invoked over the remote interface.

Eject

It is good practice to eject the drive prior to disconnecting a USB memory device from the DC215. This is set in the Comm/USB menu and cannot be invoked over the remote interface.

Note: Failing to eject a USB memory device prior to physically disconnecting can damage the file system, making it impossible to recover data from the device.

File Format and Naming

Date/Time

The files system uses the DC215 real time clock for the date and time of stored CSV files. If the power backup to the RTC runs down, a Self Test error may be reported. To resolve this, allow the RTC power backup to recharge for a couple of hours and set the time and date from as described in *Utilities* (page 65) or with the <TDAT> remote command.

File Description and Naming Conventions

Files can be saved or recalled to/from a USB flash drive in a CSV file format and consist of the following:

- Header lines
- Multiple data lines (separated by line feeds)
- EOF

Each data line represent a single step in a sequence program or a single entry in a log file.

File names for Sequence programs are: "PRGM*i*.CSV", where *i* is an integer between 0 - 9999 used to identify the file to be saved or loaded using LSeq and SSeq, as described in *Saving & Loading Sequencer Programs* (page 51).

File names for Log files are: "LOG*i*.CSV" where *i* is an integer between 0 – 9999, used to identify the file as described in *File Name* (page 55).

Automatic File Number Update

Log File

Each time a log file save operation is completed, the file index will auto incremented for the *next* time a file is saved. This value can be edited by the user if a specific file number is desired.

Sequence File

There is no automatic file index update for sequence files. The file number must be explicitly set by the user.

Sequence Programs

Sequence programs consist of a header, followed by a series of lines of data and is terminated by an <eof> character. When viewed from a text editor, they appear like the following

```
Header line
V,1,1.090000
V,10,1.230000   Optional comments placed at end of lines
V,10,2.340000
…
<eof>
```

Header

The first line of a sequence program is a header that is ignored when loaded from USB to the DC215's internal memory. When a sequence file is stored from the DC215 to a USB drive the header format is:

```
V/I,Range,Source,SRS DC215 Sequencer File
```

Note that if there is no header line, the first data line will be ignored & not added to the DC215 internal sequence memory when downloaded to the DC215.

Data Line

Each data line contains three items, besides optional comments at the end of the line.

- Source Type:
  - Step 1: V or I
  - Other Steps "*" or the same value as on Step 1
- Source Range: Output Range in real numbers (1E-1, 12...)
- Source Level: Output value in real number (1, 1E-6…)

EOF

<eof> is a "Control-D", which is the ASCII 10 (decimal) or 0A (hexadecimal) character.

Comments

Sequence files can have comments appended by adding to the end of each line after the source value. This can be used to include instrument settings or descriptions of the file. Any characters after source value and before the line feed or EOF will be ignored when the file is loaded into the DC215 internal memory. The first appended character must be non-numeric (use a space or tab if a numeric value is needed).

Note that each line has a 60 character maximum. Exceeding this will generate a data error when loading the file into the DC215 (dErr line#).

Sequence Program Rules

- If there is no header line, the first data line will be ignored.
- When saving a sequence file, the header used is:
  `"V/I,Range,Source,SRS DC215 Sequencer File"`
- The Source Type (V/I) is set on the initial step (step 1). For the remaining steps, only the initial value or "*" is allowed. Any other value will generate an error.
- The Source Range is scanned for allowed values, based on the Source Type.
  - When reading the source range, the DC215 will interpret the value to be the lowest range that can support it. For example, voltage range values of 1.3, 2.7 or 12 would all use the 10V range.
  - When writing the source range, the DC215 outputs the nominal range values (1, 10, 30, 1e-3, 1e-2...).
- The Source Level is scanned for legal values based on the Source Type and Range.
- The file format does not allow blank lines; a blank line will generate a data error.
- Each line has a 60 character maximum; exceeding this will generate a data error.

Note: Saving or loading large sequence programs can take a substantial amount of time (over 1 minute). Do not remove the USB drive until this action is completed to avoid corrupting it. If you need to terminate a sequence program load or save, see the *Abort* (page 67).

Loading Sequence Programs

File "PRGM*i*.CSV" is selected using "L USB *i"* (page 51) or the <QSUL> command, where *i* is an integer between 0000 – 9999. The CSV file is converted to the internal sequence file format. Files are scanned line by line to ensure they only contain "legal" values that can successfully be processed by the DC215. If not, an error is produced and scanning is halted. Scanning continues until the <eof> character is read. After a file is successfully loaded, a "File Done" message will appear. If you need to terminate a sequence program load, see the *Abort* (page 67).

Saving Sequence Programs

File "PRGM*i*.CSV" is selected using "S USB *i"* (page 51) or the <QSUS> command, where *i* is an integer between 0000 – 9999.

Initially a file header line is written to the CSV file. Next the internal sequence file is converted line by line to CSV the added to the USB file. After the final sequence point is saved, an <eof> character is written. After a file has been successfully saved, a "File Done" message will appear. If you need to terminate a sequence program, see *Abort* (page 67).

Log Files

Log files consist of a several header lines, followed by a series of data lines, and terminated by an <eof> character. Log files are written from the DC215 to USB memory and cannot be read by the DC215. When viewed from a text editor, they appear like the following:

```
DC215 Log File
Stanford Research Systems DC215 s/n:123456 ver:1.00
01 January 2024 16:22 23.4C
VREL=0.00000E0 IREL=0.00000e-3

Time,V/I,Range,Source Value,Measured Voltage,Measured Current
1.0,V,10V,1.00000e+01,10.001119,0.01005706
2.0,V,10V,1.00000e+01,10.001115,0.01005688
3.0,V,10V,1.00000e+01,10.001119,0.01005701
…
<eof>
```

Header

The header at the top of each file contains the following:

- DC215 Log File
- ID string (Stanford Research Systems DC215 s/n:123456 ver:x.xx)
- Date, Time and Temperature
- VREL, IREL (set to zero if VREL & IREL are not set)
- Blank line
- "Time,V/I,Range,Source Value,Measured Voltage,Measured Current"

Data Line

Each Log file data line contain six items:

- Time elapsed since the start of logging (0.1 s resolution)
- Source Type (V/I)
- Range (text string)
- Source Value (floating point)
- Measured Voltage (floating point)
- Measured Current (floating point)

EOF

<eof> is a “Control-D”, which is the ASCII 10 (decimal) or 0A (hexadecimal) character.

Saving Log Files

File “LOG*i*.CSV” is selected using “File *i”* from *File Name* (page 55) or the <ULFN> command, where *i* is an integer between 0000 – 9999.

Initially the header lines are written to the CSV file. Then, each time the log buffer fills, it is added to the USB file. After the final log point is saved, an <eof> character is written. When logging is complete, a “Log Done” message will appear. If logging is halted due to an error, a “Log Err” or other error message will appear.

USB Drive Messages

There are several different operations performed with the USB drives. Errors and Status messages are reported on the front panel or over the remote interfaces.

Read-Write Error Messages

The following messages can appear for either a USB read or write.

USB Disabled (USB diSAb)

The USB interface is disabled.

Drive Detection (USB FAIL)

Before a file can be read, or headers written, a drive needs to be present. If a drive is not detected after several seconds, a “USB FAIL” error message is displayed.

Read Messages

The following messages are associated with reading USB sequence files.

File Detection (FiLE Err)

If the file to be read is not on the USB drive, a “File Err” message is displayed.

Data Error (dAtA Err)

If the file being read has an incorrect format or error not specific to a particular line, a “data error” message is displayed and the read operation is aborted.

Data Error line # (dErr line#)
If there is a data error specific to a particular line, a “data Error (*line number*)” error message is displayed and the read operation is aborted.

USB Error (USB Err)
If data cannot be read after drive detection, but prior to <EOF>, a “USB Err” message is displayed and the read operation is aborted.

File load successful (“FILE donE”)
After a file is successfully loaded, a semi-sticky “File Done” message is briefly displayed.

Write Messages

The following messages are associated with writing sequence or logging files to the USB.

Write Error (USB Err)
If data cannot be written to the USB drive due to write protect or other reasons, a “USB Err” message is displayed and the write operation is aborted. This can occur if the USB device is too slow to respond.

Drive Full (USB FAIL)
If there isn’t room on the USB drive to save the file, a “USB Full” error message is displayed and the write operation is aborted.

USB Time Out (TimE Out)
The local log buffer cannot be written to the USB before it is overwritten.

No Program (NO PrGM)
If there is no sequence present on the DC215 while attempting to save a sequence file to USB, a “No Program” message is displayed and the write operation is aborted.

Sequence file written successfully (FILE donE)
After a file is successfully loaded, a semi-sticky “File Done” message is briefly displayed.

Log file written successfully (LoG donE)
After a Log file has been written successfully, a “LoG donE”.

Communications

Settings and control of the GPIB, RS-232, Ethernet and USB ports is done from the Communications Menu. Each of the interfaces can be switched on or off to enhance low noise operation. See *Remote Programming* (page 111) for details on remote programming and commands.

Note that the USB port is only used for USB memory devices and does not support remote commands.

Comm Menu

The Comm menu is a multi-level menu that controls the configuration of the each of the communication interfaces. It is selected by [SHIFT] [5] (Comm). There are 5 top level selections: GPIB (**GPIB**), RS-232 (**rS232**), Network (**nEt**) and USB (**USB**). These are accessed using the cursor keys and [Enter] or directly from the remote interface commands.

Note that after changing a comm parameter, the changes will not take effect until the interface has been reset or power is cycled. Take care when changing comm parameters, as changes may disable the interface you are actively using.

GPIB

The GPIB menu has three submenus: Enable (**EnAbl**), Address (**Addr**) and Reset (**rESEt**) accessed using the cursor keys plus [Enter].

Enable (Off|On)

This enables (on) or disables (off) the GPIB interface.

When disabled, the GPIB function is powered down and does not respond to communications. Upon enabling, all buffers are cleared and the interface is reset.

GPIB Enable is set by the cursor keys plus [Enter] or by the <IFCF> command.

Address (0..30)

This sets the GPIB address for the interface.

The GPIB address is set by the cursor or numeric keys plus [Enter] or by the <IFCF> command.

Reset (no|yes)

This resets the GPIB interface.

After pressing [Enter] the interface is reset including clearing all buffers.

GPIB reset is set by the up and down cursor keys plus [Enter] or by the <IFRS> command.

RS-232

The RS-232 menu has three submenus: Enable (**EnAbl**), Baud rate (**bAud**) and Reset (**rESEt**) accessed using the cursor keys plus [Enter].

EnAbl (Off|On)

This enables (on) or disables (off) the RS-232 interface.

When disabled, the RS-232 does not respond to communications. Upon enabling, all buffers are cleared and the interface is reset.

RS-232 Enable is set by the cursor keys plus [Enter] or by the <IFCF> command.

Baud Rate (4800, 9600, 19.2k, 38.4k, 57.8k, 115.2k)

This sets the RS-232 baud rate to one of the allowed settings.

The RS-232 baud rate is set by the cursor keys plus [Enter] or by the <IFCF> command.

rESEt (no|yes)

This resets the RS-232 interface.

After pressing [Enter] the interface is reset including clearing all buffers.

RS-232 reset is set by the up and down cursor keys plus [Enter] or by the <IFRS> command.

Net

The LAN has a number of submenus under the Net menu. This includes different IP modes, speed and addresses.

Net Menu

The Net menu has 21 submenus, accessed using the cursor keys and [Enter] or directly from the remote interface commands.

- Address 1-4 (**Addr1**, **Addr2**, **Addr3** & **Addr4**) (most to least significant)
- Subnet 1-4 (**SnEt1**, **SnEt2**, **SnEt3**, **SnEt4**)
- Gateway 1-4 (**GatE1**, **GatE2**, **GatE3**, **GatE4**)
- Link (**Linc**)
- TCP/IP Enable (**tcPiP**)
- DHCP Enable (**dHCP**)
- Static IP Enable (**Stati**)
- Auto IP Enable (**Auto**)
- Bare Socket Enable (**bArE**)
- Telnet Enable (**tElnE**)
- Instrument IP Enable (**inSt**)

- Reset (**rESEt**)

Addr1, Addr2, Addr3, Addr4

Addr1|Addr2|Addr3|Addr4 make up the static IP address when manual configuration is active.

Addr1, Addr2, Addr3 & Addr4 are listed from most to least significant and each represent 2 bytes of the address.

Each pair of bytes is set as a decimal value (0-255) using the numeric keypad plus [Enter] or by the <IFCF> command.

SnEt1, SnEt2, SnEt3, SnEt4

SnEt1|SnEt2|SnEt3|SnEt4 make up the network subnet (mask) when manual configuration is active. This determines which IP addresses are on the local network.

SnEt1, SnEt2, SnEt3 & SnEt4 are listed from most to least significant and each represent 2 bytes of the subnet address.

Each pair of bytes is set as a decimal value (0-255) using the numeric keypad plus [Enter] or by the <IFCF> command.

GatE1, GatE2, GatE3, GatE4

GatE1|GatE2|GatE3|GatE4 make up the network gateway or router address when manual configuration is active. The gateway is the IP address that packets are sent to if the destination IP address is not on the local network.

GatE1, GatE2, GatE3 & GatE4 are listed from most to least significant and each represent 2 bytes of the gateway address.

Each pair of bytes is set as a decimal value (0-255) using the numeric keypad plus [Enter] or by the <IFCF> command.

Linc (10t, 100t)

Link sets the speed of the Ethernet physical layer to 10 or 100 Base-T.

Link is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

TCP/IP (Off|On)

This enables (on) or disables (off) all TCP/IP based interfaces (Raw Socket, Telnet & VXI-11) as they all operate over TCP/IP.

When disabled, the TCPIP interface does not respond to communications. Upon enabling, all buffers are cleared and the interface is reset.???

TCP/IP is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

DHCP (Off|On)

This enables (on) or disables (off) automatic network configuration via DHCP.

DHCP is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

Static IP (Off|On)

This enables (on) or disables (off) manual network configuration in the event that the automatic configuration fails or is disabled.

Static IP is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

Auto IP (Off|On)

This enables (on) or disables (off) automatic network configuration in the 169.254.x.x internet address space if DHCP fails or is disabled.

Auto IP is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

Bare Socket Port (Off|On)

This enables (on) or disables (off) raw socket access to the instrument via TCP port 5025.

When disabled, TCP port 5025 does not respond to communications. Upon enabling, all buffers are cleared and the interface is reset.

Bare Socket Port is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

Telnet Port (Off|On)

This enables (on) or disables (off) access via telnet at TCP port 5024.

When disabled, TCP port 5024 does not respond to communications. Upon enabling, all buffers are cleared and the interface is reset.

Telnet Port is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

Net Instrument Interface (Off|On)

This enables (on) or disables (off) access via VXI-11 net instrument protocols.

When disabled, VXI-11 does not respond to communications. Upon enabling, all buffers are cleared and the interface is reset.

VXI-11 is set by the up and down cursor keys plus [Enter] or by the <IFCF> command.

Reset (no|Yes)

This resets the Ethernet interface.

After pressing [Enter] the interface is reset including clearing all buffers.

Ethernet reset is set by the up and down cursor keys plus [Enter] or by the <IFRS> command.

USB

The USB menu has two submenus: Eject (**EjEct**) and Enable (**EnAbl**), selected by the cursor keys plus [Enter]. This command is not accessible from the remote interface.

Eject

Pressing the [→] or [Enter] ejects the USB drive.

After the drive has been ejected, a “rEmv” message is briefly displayed indicating it is safe to remove the drive.

Note: Failing to eject a USB memory device prior to physically disconnecting it can damage the file system, making it impossible to recover data from the device.

Enable (Off|On)

This enables (on) or disables (off) the USB port.

When not enabled the USB port does not detect USB memory devices. Upon enabling, all buffers are cleared and the interface is reset.

USB Enable is set by the cursor keys followed by [Enter] or by the <EUSB> command.

Chapter 4: Application Guide

This section provides information on using the DC215. It includes details on wiring, analog performance, digital timing, sequences and logging. See the *Operation Guide* (page 19) for details on configuring the DC215.

Wiring

Follow these precautions when connecting the DC215 to a device or load.

Precautions

Turn off the DC215 output before connecting the device being used.

Use wires and accessories rated for the appropriate voltage and current with respect to the voltages and currents to be used. Take into account any common floating voltages.

Do not directly connect the DC215 voltage source to a voltage source or the DC215 current current to a current source. Improper connections may damage the DC215.

Take care not to connect loads that exceed ±32 V or ±240 mA across either the Hi/Lo Output terminals or Hi/Lo Sense terminals.

Ensure that the voltage across the Hi Output/Sense terminals or Lo Output/Sense terminals does not exceed ±0.5 V_{peak}.

The maximum voltage from any terminal to chassis ground is ±250 V_{peak}.

Take care to not allow the sense connections to be broken when using 4-wire sensing. If the voltage is not sensed correctly, the output may be an incorrect value.

Do not select 4-wire sensing while using only 2 wire connections as this may lead to incorrect output values.

To minimize the possibility of oscillations due to stray capacitance or inductance, it is advisable to use twisted pairs for the Output Hi & Lo leads and the Sense Hi & Lo leads.

It is possible for thermal electric (thermal couple) voltages to introduce errors between the DC215 and the device under test on the 10 mV and 100 mV ranges. Take care to avoid any temperature differences between the Hi and Lo terminals and associated wiring.

Remote Sensing

When working with larger currents or large lead resistances there may be a voltage drop across the connection wiring between the DC215 and the load. This can be eliminated using remote sensing. Remote Sensing can be used for the voltage output or measuring voltage for both voltage and current output. See *Sense* (page 32) for details.

The DC215 senses voltage in either 2-wire (local sensing) or 4-wire (remote sensing) mode. With remote sensing a separate pair of connections (Kelvin leads) is made from the DC215 to the load. The voltage is regulated and monitored from the second pair of wires, rather than the current carrying wires.

Be certain the Sense wires are properly connected when in 4-wire mode. If not, the output and measured voltage may be incorrect.

Note: In 4-wire sense mode the Sense terminals are loosely connected to the Hi and Lo outputs through 1 MΩ resistors. This is to provide some control of the output in case the sense leads are broken.

2 Wire Sensing

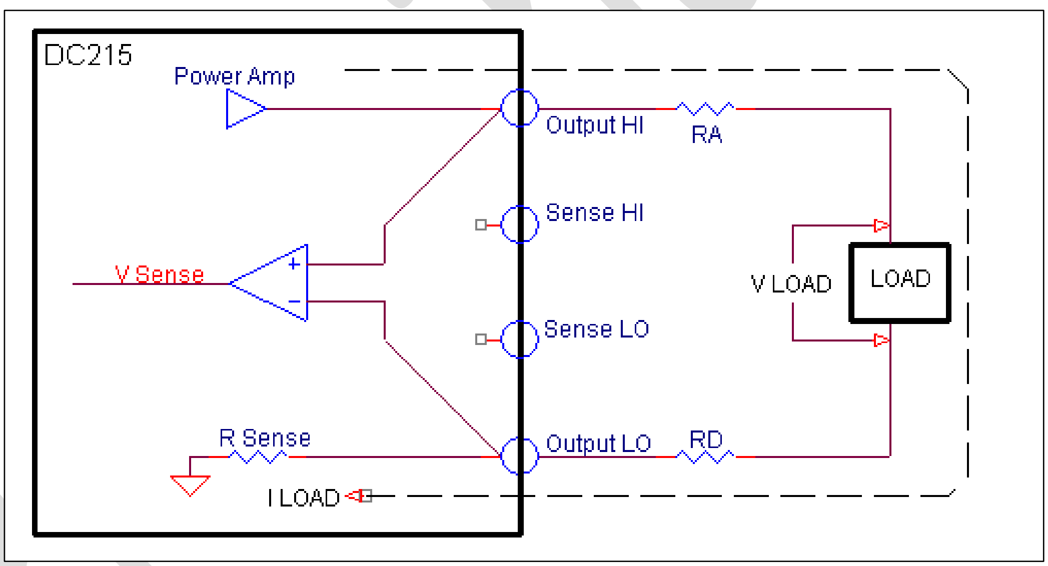


FIGURE 15: TWO WIRE SENSING

In this case V_{LOAD} (voltage at load) is less than V_{SENSE} (controlled and measured voltage) by:

$$V_{SENSE} - V_{LOAD} = I_{LOAD} * (RA + RD)$$

In most cases this voltage drop is unimportant, but for large currents or large lead resistances it can be significant.

4 Wire Sensing

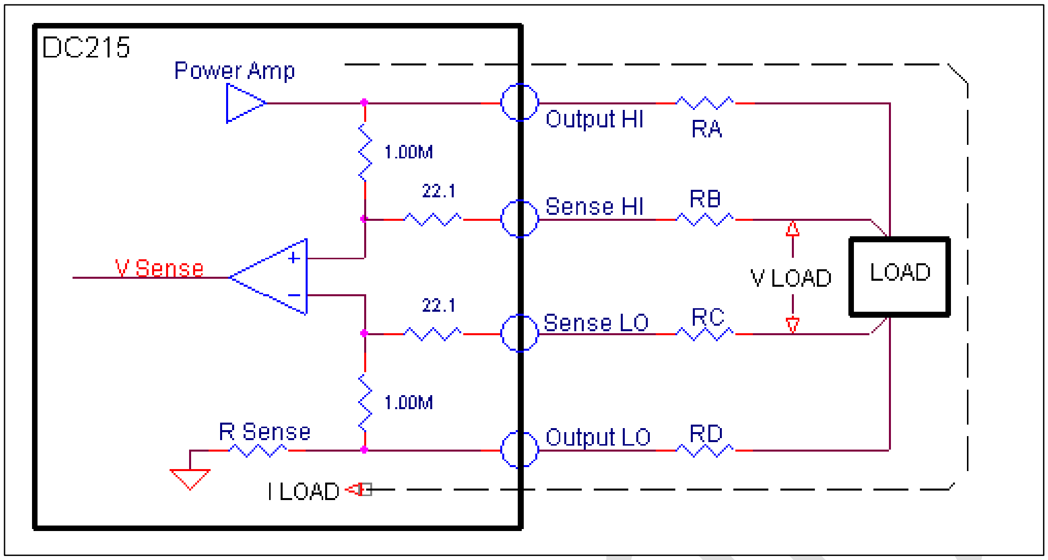


FIGURE 16: FOUR WIRE SENSING

Four wire sensing largely removes the effects of lead resistance by sensing through non current carrying leads.

Assuming RA = RD = RDrive and RB = RC = RSense the voltage drop is:

$$VSense - VLoad = 2 * ILoad * \frac{RDrive\ (RSense + 22.1\ \Omega)}{1M\ \Omega + 22.1\ \Omega + RSense + RDrive}$$

Further assuming that RDrive and RSense are small relative to 1 MΩ, this reduces to:

$$VSense - VLoad = 2 * ILoad * \frac{RDrive\ (RSense + 22.1\ \Omega)}{1\ M\Omega}$$

Examples

Assume RDrive = RSense = 1 Ω, and ILoad = 100 mA

For 2-Wire Sensing: VSense – VLoad = 200 mV

For 4-Wire Sensing: VSense – VLoad = 4.6 µV

Limitations

The voltage across the Output Hi to Output Lo terminals must be larger than the voltage delivered to the load. This limits the maximum output voltage delivered to the load to something less than the ±32 V maximum.

The voltage difference across Output to Sense terminals is limited to ±0.5 V. So the maximum lead resistance that can be compensated for is:

$$Rmax = \frac{0.5V}{Iout}$$

So for 100 mA out, the maximum lead resistance is 5 Ω.

Remote sensing is inactive for the 10 mV and 100 mV ranges. These ranges use an internal voltage divider, which precludes remote sensing.

Shielding, Guarding and Ground

There are several different techniques used to reduce external noise coupling into the DC215.

Please note that each configuration is somewhat unique and different approaches may be required for optimal results.

Shielding

Shielded cables can be used to minimize coupling from external sources. This is particularly important for low voltages or currents. Typically the following configurations will yield best results.

- Voltage Out: Low Side Shielding
- mV Out: High Side Shielding
- Current Out: High Side Shielding

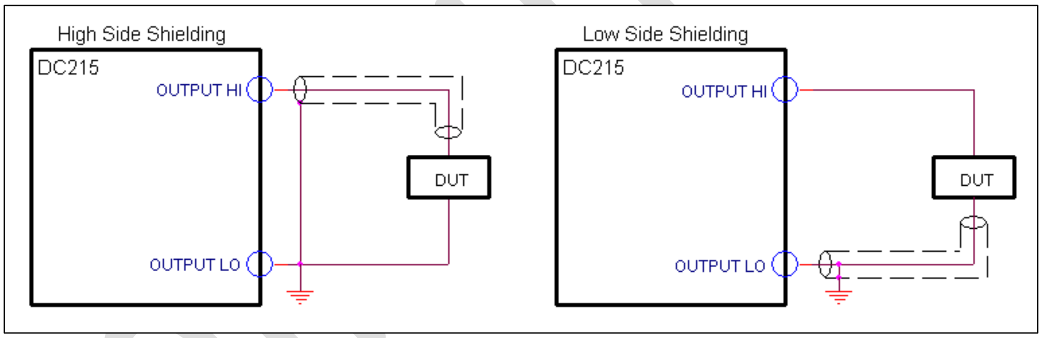


FIGURE 17: SHIELDING

Guarding

The common ground point for mains power of the DC215 and device under test (DUT) may be a substantial distance from each other which can introduce common mode noise between the two. This noise can generate small currents that appear on the DC215's output, even though it is floating. This is frequently referred to as a ground loop and its effect may be significant for small voltages and currents. See *Guard* (page 32) for details.

Even through the DC215 is floating, common mode noise can couple to the floating DC215 output through stray capacitance and insulation resistance. Internal shielding and a guard terminal are included to minimize this.

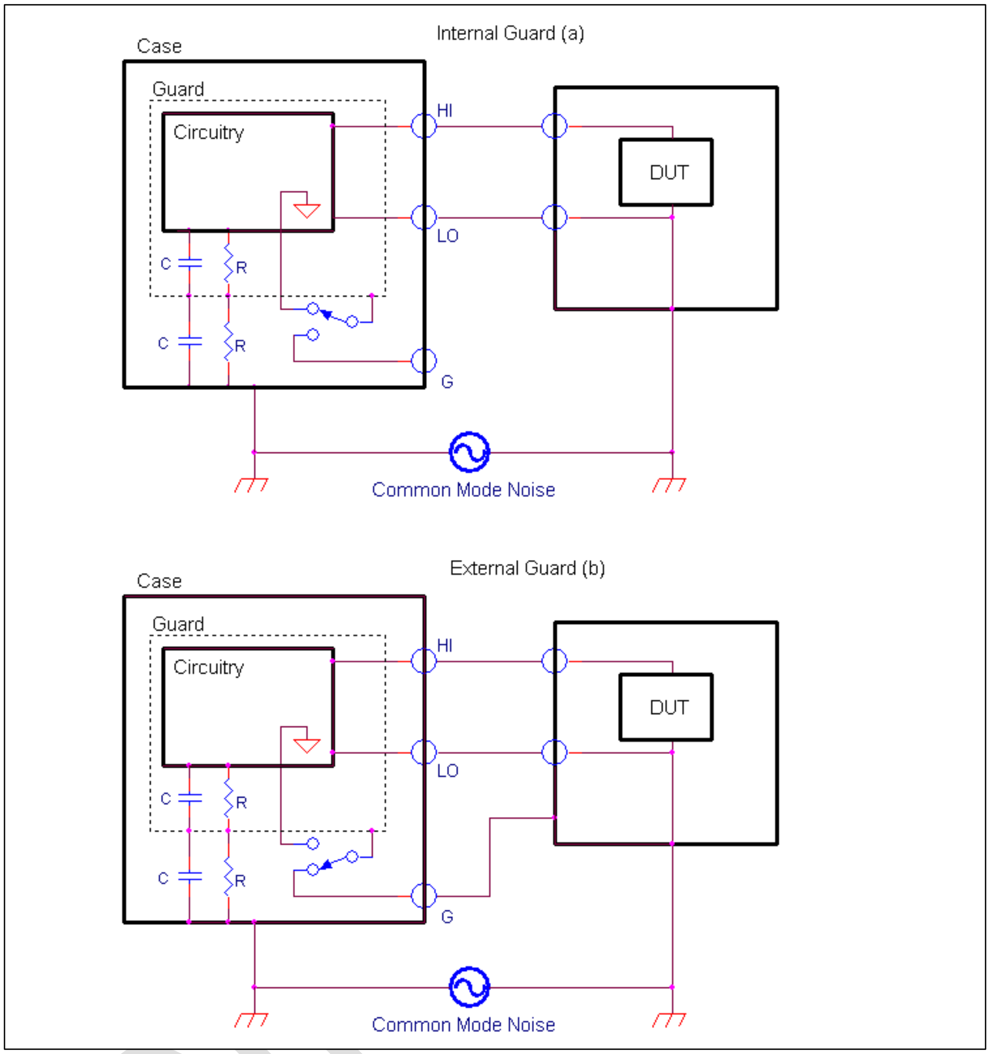


FIGURE 18: INTERNAL AND EXTERNAL GUARDING

When the Guard is set to Internal (a), the shield is connected to the DC215 internal common. In most cases the DC215's sensing circuitry acts to maintain a constant, low noise output across its HI and LO terminals.

When the Guard is set to external (b), the shield can be connected to the DUT's ground or other reference point. This provides a path shunting the noise away from the DC215's outputs.

Ordinarily the DC215 operates best using the Internal Guard. However there are some circumstances where using the External Guard may be beneficial.

Grounding

Another way to minimize common mode noise between the DC215 and the DUT is by connecting their chassis grounds together. This connection is typically a much lower impedance than the ground available from the mains power and can significantly reduce any common mode voltage between the two. Connect the rear panel ground terminal on the DC215 to a ground on the DUT.

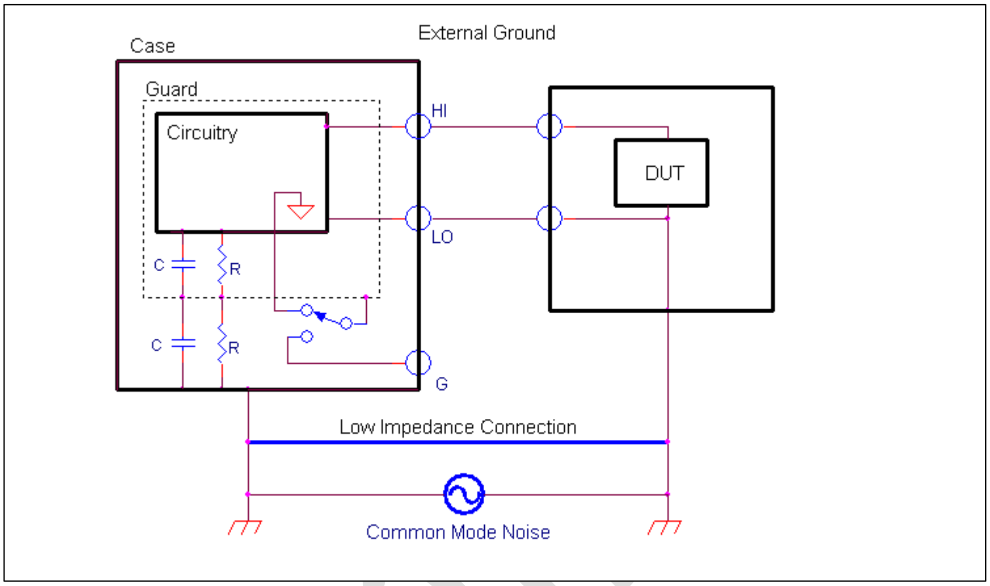


FIGURE 19: EXTERNAL GROUNDING

Output Timing

Output timing is made up of several different elements, including command time and response time.

Command Time

This refers to the time to receive a command over a remote interface and parse it or enter a command from the front panel.

Receiving the command consists of the time to transmit a command and input it to the DC215 command buffer. This is effected by the external computer real time performance, interface type & its speed. Values can range from <1 ms to >100 ms.

Note: There can be significant latencies from remote computers and other IT devices like routers. These can introduce delays on the order of 100s of ms, depending on the specific equipment and configuration.

Note: There is no command time for sequences. They should be used when fast or accurate real time response is needed.

Response Time

This is the time required to configure and set the output hardware, plus the output settling time. The required time depends on what needs to be set for the new value. This time may be increased if the DC215 processor is heavily loaded. Processor loading can be minimized by avoiding extraneous remote interface traffic and not ramping unless necessary.

Note: Response time changing source values within a range is significantly shorter than when changing source values on a different range. Changing the bandwidth, source type and turning the output on add additional time. See *Timing Diagrams* (page 85) for specific values.

Timing Diagrams

Output Response Time

The following graphs show typical response times for different output changes.

Events are something that will initiate the behavior shown in the timing diagram, but do not include the Command Time. They include ON/OFF actions, step triggers or other output changes.

The Output traces show the behavior of the output, but do not include any ramping or effects due to the Bandwidth setting. The Ready traces show the behavior of the DIO {Ready} signal. Note that this is dominated by R_{delay}.

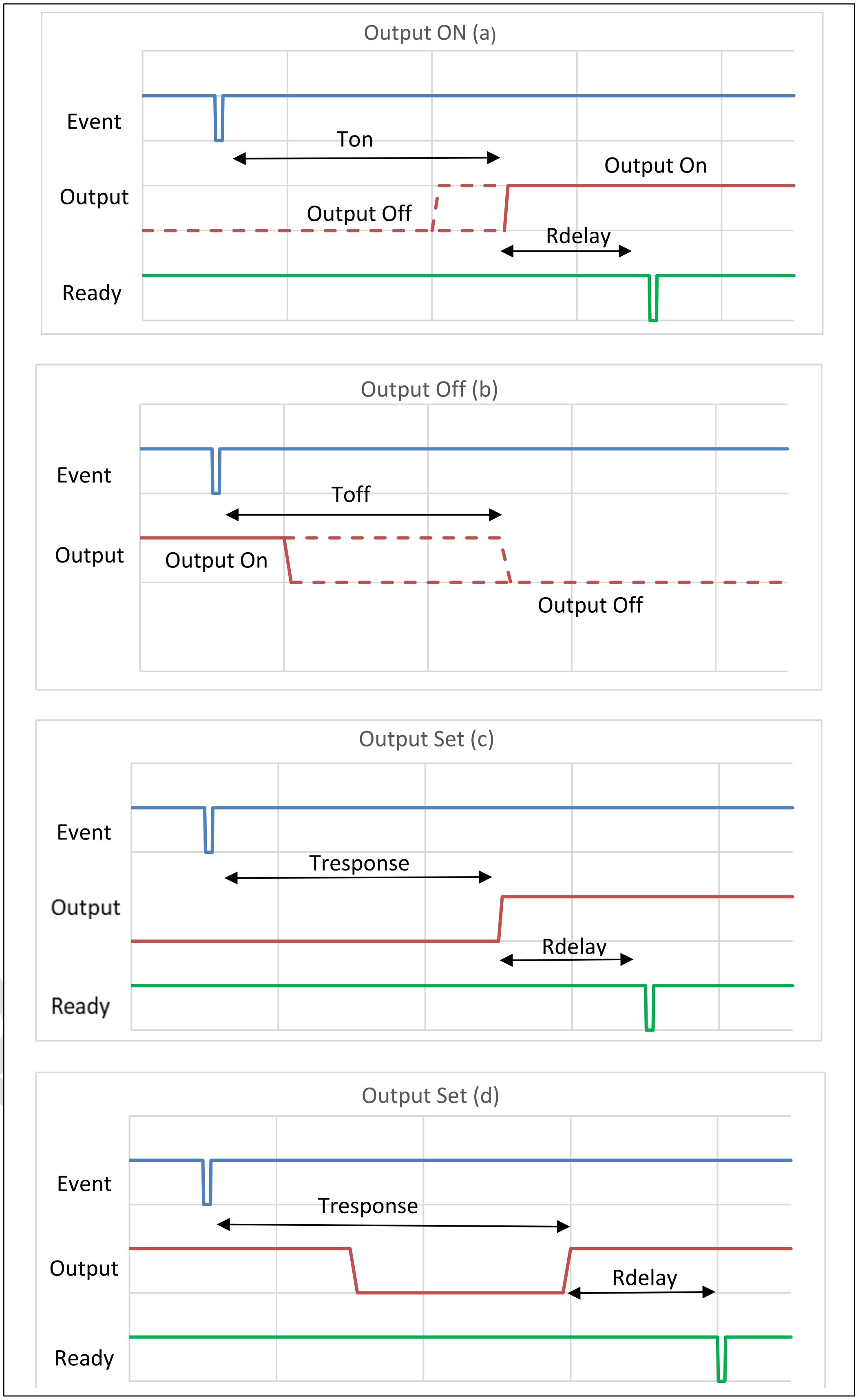


FIGURE 20: EVENT, OUTPUT, READY TIMING DIAGRAMS

- Output ON (a): The output relay is closed during Ton. Shortly after this the output DAC is set from its initial zero setting to the output value. Ready goes active Rdelay seconds after the DAC is set.
- Output OFF (b): The output DAC is immediately set to zero, followed by the output relay being opened. Ready is not active for Output OFF.

Bandwidth	Output ON (a)	Output OFF (b)
HiBW	6 ms (typ)	6 ms (typ)
LoBW	12 ms (typ)	6 ms (typ)

- Output Set (c): This is the response time for an output change within a given range to 99% of the final value. This is significantly faster than changing ranges, as only the Output DAC setting is changed. Ready goes active Rdelay seconds after the DAC is set.

Bandwidth	Response Time
HiBW	<1 ms
LoBW	<10 ms

- Output Set (d): This is the response time for an output change to 99% of the final value in a different range.

  There are two groups each with their own timing. Changes within the 1, 10 and 30 V ranges do not involve mechanical relay changes so they have significantly shorter response times.

  All other ranges involve mechanical relay changes and have longer response times.

  In all cases, the output DAC is set briefly to zero as the range change occurs. Following this the DAC is set to its value. Ready goes active Rdelay seconds after the DAC is set.

Bandwidth	1, 10, 30 V ranges	All other ranges
HiBW	<4 ms	<10 ms
LoBW	<10 ms	<15 ms

Current Output Response Time

For current output, small currents and large resistances can significantly extend the output rise and response times. The current response time for the DC215 is specified for full scale steps into low resistances. Operating into large resistances or at very low fraction of full scale can increase this value significantly. When practical, operate at a range where the set current is a reasonable fraction of full scale.

The following table shows a step from 0 to 1mA, settling to 99% of the final value for different ranges and load resistors on HiBW setting.

TABLE 12: CURRENT RESPONSE TIME

Output Range	100 Ω load	1 kΩ load	10 kΩ load	30 kΩ load
1 mA	0.22 ms	0.22 ms	0.30 ms	0.63 ms
10 mA	0.23 ms	0.28 ms	1.5 ms	4.5 ms
100 mA	0.28 ms	1.5 ms	13 ms	48 ms
200 mA	0.4 ms	2.9 ms	26 ms	80 ms

Noise Reduction

Ordinarily the DC215 provides excellent noise performance without any special attention. For extremely sensitive applications there are a few different approaches to further reduce the output noise. Note that the efficacy of these techniques depends heavily on the particular application. Experimentation may be required to determine the optimum configuration.

Shielding, Guarding and Ground

Properly shielding, guarding and grounding can minimize noise in the device under test. Ordinarily, changes to these are most likely to improve performance, compared with other possible techniques. See the *Shielding, Guarding and Ground* (page 82) for details.

Bandwidth

Low bandwidth typically has about 3 dB less broad band noise than high bandwidth. See *Bandwidth* (page 31) for details.

Note that the DC215 can suppress external noise within its bandwidth (either high or low). In some cases, the high bandwidth setting may give better performance. Experimentation may be needed to obtain the best performance.

Measurements

Measurements can inject small amounts of noise to the DC215 output in certain circumstances. Turning off measurements will eliminate this. See *Measurement Enable* (page 36) for details.

Display

Similarly updating the display can also inject small amounts of noise to the output in certain circumstances. Turning off the display update eliminates this. See *Front Panel Update* (page 65) for details.

Computer Interfaces

Noise can couple from any of the computer interfaces to the DC215 outputs. This noise can be introduced by cabling even if the interface is not active. To minimize these noise sources, do not connect a computer interface unless it is active.

The internal circuitry associated with each of the computer interfaces has the potential to generate unwanted noise. They can be separately disabled. See *Communications* (page 73) for details.

RTC

The Real Time Clock has an active oscillator that may induce a small amount of noise in some circumstances. Disabling the t-d function will stop this oscillator. See *Time-Date* (page 65) for details.

Note that stopping the RTC oscillator will stop the real time clock from keeping time. This will cause USB files to be written with the incorrect date. After restarting the RTC oscillator, it is necessary to update the RTC to the correct the t-d parameters.

Driving Reactive Loads

Large reactive can extend the response time by either overshoot, ringing and oscillation, or by activating the limiter.

Bandwidth

The DC215 has two bandwidth modes separated by a factor of 10. High bandwidth has a faster rise time and is able to drive modest reactive loads. Low bandwidth has a slower rise time and is able to drive much larger reactive loads. See *Bandwidth* (page 31) for details.

Limiter Behavior

In some cases, the step response time may be extended due to the limiter behavior. Depending on the load, this can be substantial. See *Limits* (page 29) for details.

- Capacitive loads for voltage output: The current limiter may increase the response time depending on the current limit setting.
- Inductive loads for current output: The voltage limiter may increase the response time depending on the voltage limit setting.

Figure 21 shows a 0 to 10V step into a 1000 µF capacitor with the current limit set to 50 mA. The trace clearly shows a rise time of ~200 ms due to the 50 mA current limit. Unloaded the rise time would be ~1 ms.

Besides increasing the limit values or reducing the reactive load there isn't much that can be done to mitigate this.

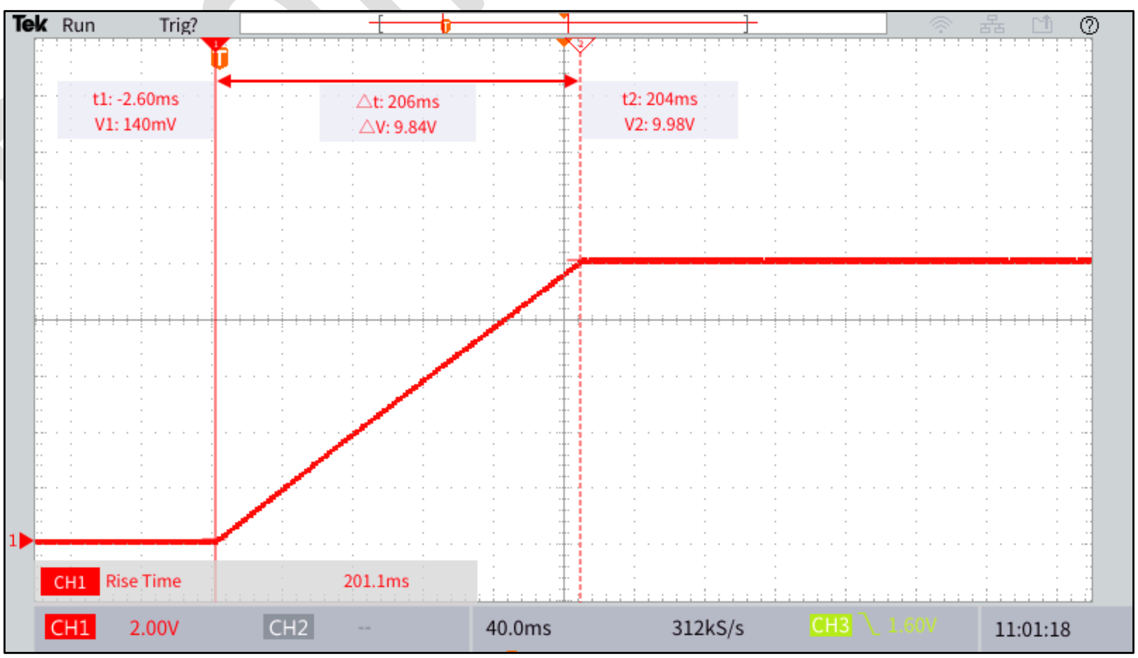


FIGURE 21: VOLTAGE STEP INTO A CAPACITOR

Using Digital IO

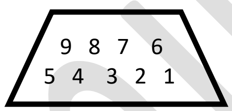
There are a number of different input and output signals that allow a DC215 to synchronize with other instruments or with other DC215s. The majority of these signals are available on a multi-pin DB-9 male connector on the rear panel. There are also input and output BNC connectors that can select any of the different input or output signals. See *Digital IO Signals* (page 56) for details on these signals and the *Utilities* menu (page 63) for configuring them.

Timing information for the DIO signals is located in the *Specifications* (page xi) and *Output Timing* (page 85).

Connectors

DB-9 Connector

The commonly used Digital IO signals are present on the rear panel DB-9 male connector.



DIGITAL IO DB-9 MALE CONNECTOR

TABLE 13: DIGITAL IO DB-9 PINOUT

Pin #	Signal Name	In/Out	Function
1	Output ON	Output	Active low when the output is on. See *Output ON* (page 56) for details.
2	Ready	Output	Pulses low for ~1 µs, R_{delay} sec after Source Change Complete. See *Ready* (page 56) for details.
3	Step Trigger Out	Output	Pulses low for ~1 µs for each valid step trigger. See *Trigger Out* (page 56) for details.
4	Step Trigger In	Input	Triggers on falling edge. See *Trigger In* (page 57) for details.
5	Output ON	Input	Either Output On or Output Enable. See *Output Control Input* (page 57) for details.
6, 7, 8, 9	Ground	-----	Signal Return

Output BNC

The Output BNC source can be selected from the *Digital IO* menu (page 64) to one of the following output signals: Output ON, Step Trigger Out, Ready, Measurement Active or Step Active.

Input BNC

The Input BNC can be selected from the *Digital IO* menu (page 63) to one of the following input signals: None, Output Control or Step Trigger In.

Note: If an input signal is selected on the BNC Input, it is made inactive on the DB-9 connector to avoid conflicting behavior.

Signals

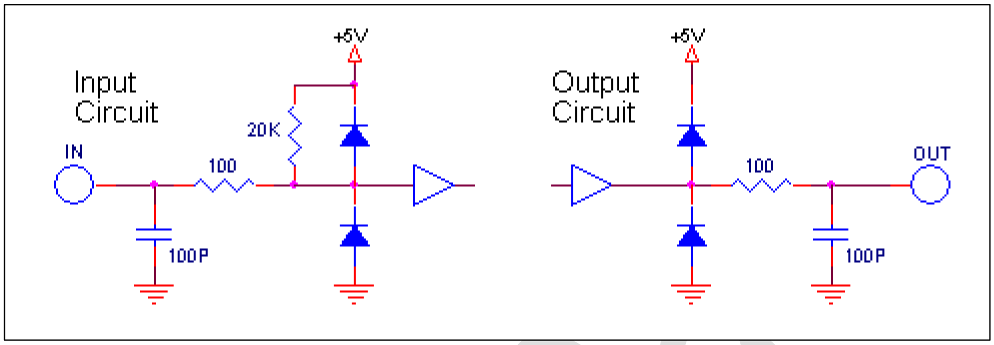


FIGURE 22: DIO SCHEMATICS

TABLE 14: SIGNAL LEVELS

Signal	Nominal Voltage	Limits	Pulse Width
Inputs	Low < 0.8 V Hi > 2.4 V	Low ≥ -0.5 V Hi ≤ 6.5 V	≥ 10 µs
Outputs	Low < 0.4 V Hi: > 2.0 V	±50 mA	~1 µs

Caution:

- Only apply signals between 0 – 5 V to inputs.
- Do not apply an external signal to the outputs.

Debounce

Debounce control should be selected when using a mechanical switch or relay for Output Control or Step Trigger. Debounce pauses input sampling for 10 ms after an initial edge to eliminate multiple hi/low cycles due to contact chatter. Select the appropriate connector & enable Debounce from the *Digital IO* menu (page 63). See Figure 23: Debounce Timing.

Note: If selected, debounce is active for all input signals.

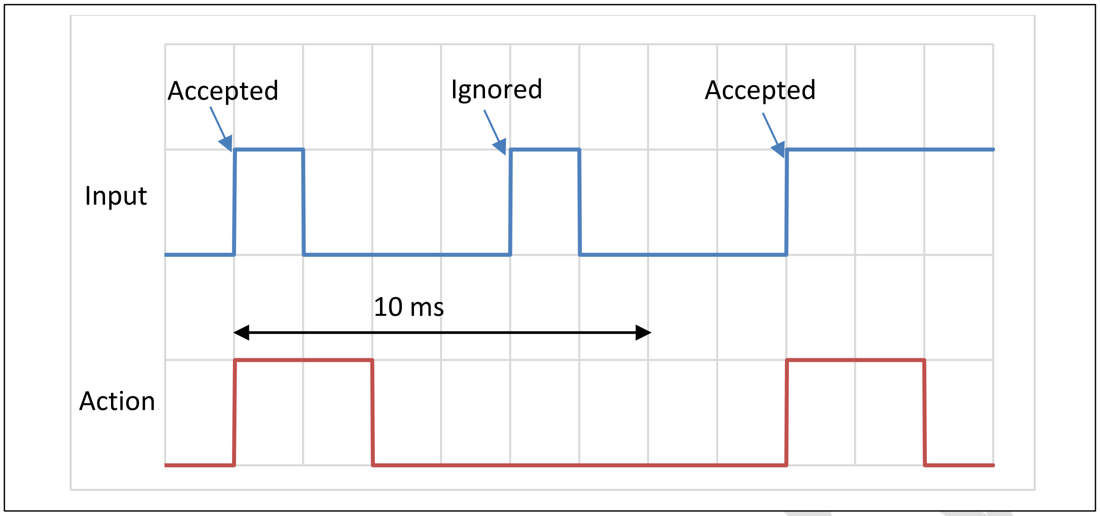


FIGURE 23: DEBOUNCE TIMING

Synchronizing Devices using DIO

If there is only a single input/output function, it is simpler to use the BNC input and output connectors rather than build a DB-9 cable.

A single DC215 output can drive several inputs. So it is possible to connect multiple secondary units in a tree configuration from a single primary output. Conversely you can daisy chain multiple units, where the outputs of a given unit connect to the inputs of the following unit.

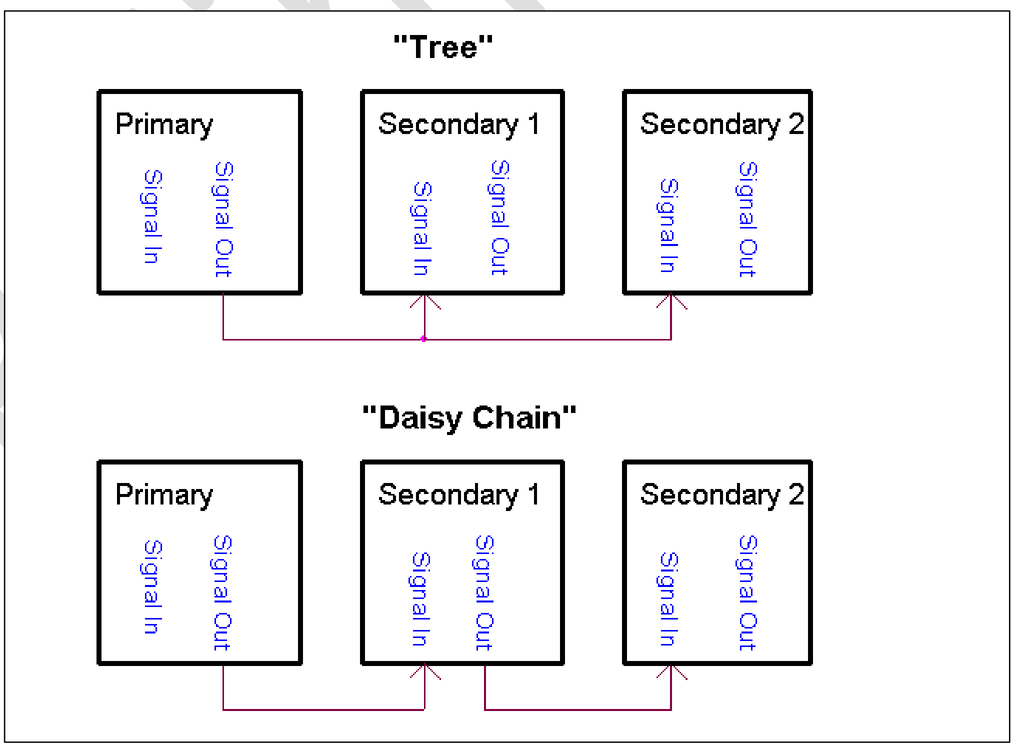


FIGURE 24: TREE VS DAISY CHAIN CONNECTIONS

Multiple functions can be simultaneously connected using either a DB-9 cable or a combination of BNCs and a DB-9 cable. See *Cables* (page 97) for more details.

Triggering an External DMM

A common application is to use the DC215 Ready output to trigger an external DMM to make measurements. R_{delay} can be set to the appropriate vales to allow the output to settle to the desired amount. If you are unsure about the appropriate R_{delay} value, start at 0.020 s.

This is usually implemented using the output BNC. See Ready/R_{delay} (page 30) and *Digital* IO (page 63) for configuration details.

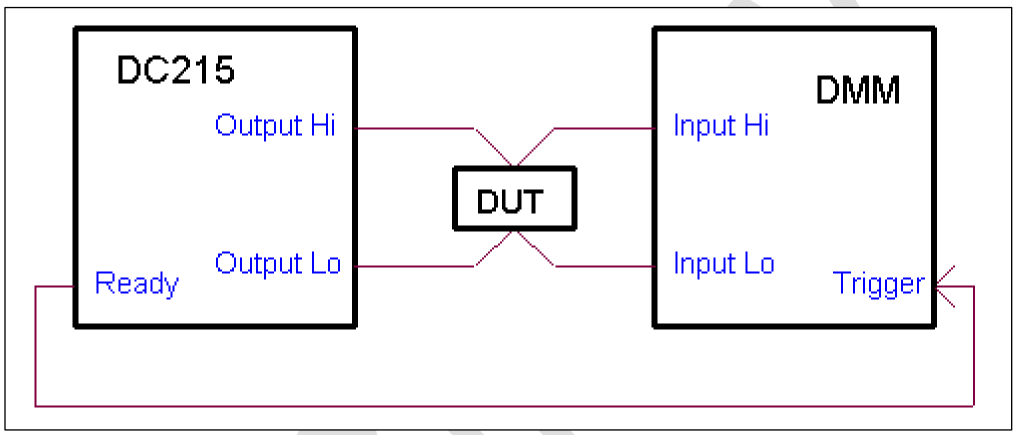


FIGURE 25: TRIGGERING A DMM

Synchronous Step Triggers

Step triggers on multiple DC215s can be synchronized using the Step Trigger In and Step Trigger Out functions. This can be implemented using either BNCs or a DB-9 cable.

Be sure to disable all other step triggers on secondary DC215s (Normal Trigger, Step Time = 0, no remote interface triggers, don't press [STEP]).

For BNC connectors do the following. The BNC I/O functions can be set in the *Digital IO* menu (page 63).

- Connect BNC Out (primary) to BNC In (secondary) in either a tree or daisy chain configuration.
- Primary: Set BNC Out to (Step) Trigger.
- Secondary: Set BNC In to (Step) Trigger.
- If daisy chaining multiple units, set BNC Out to (Step) Trigger for each secondary unit.

For DB-9 connectors, do the following:

- Build a cable as described in *Cables* (page 97) connecting Step Trigger Out (pin 3) and a ground to Step Trigger input (pin 4) and a ground, in either a tree or daisy chain configuration.
- Ensure that BNC In is not selecting Trigger In.

Output ON/OFF

A primary DC215 can turn on and off secondary DC215s using the Output ON input/output functions. This can be implemented using either BNCs or a DB-9 cable.

For BNC connectors do the following. The BNC I/O functions can be set in the *Digital IO* menu (page 63).

- Connect BNC Out (primary) to BNC In (secondary) in either a tree or daisy chain configuration.
- Primary: Set BNC Out to Output On.
- Secondary: Set BNC In to OCtrl and OControl to Ctrl.
- If daisy chaining multiple units, set BNC Out to Output On for each secondary unit.

For DB-9 connectors do the following:

- Build a cable as described in *Cables* (page 97) connecting Output_on Output (pin 1) and a ground to Output_on input (pin 5) and a ground, either in a tree or daisy chain.
- Secondaries: Set OControl to Ctrl from *Digital IO* (page 63).
- Ensure that BNC In is not set to OControl.

Output Enable

The DC215 output can be disabled by an external circuit or switch. If the output is disabled:

- The output will turn off
- The output will not be turned on by any method until the output is enabled

Note: If Output Enable is selected and not pulled low, the output **will** be disabled and remain off regardless of any "Output On" events. When using a DB-9 cable to connect to Output Enable, be certain that the BNC Input is not set to OCtrl or it will override the DB-9 signal.

Output Enable can be used as an interlock with a mechanical switch, relay or external circuit. If using a relay or switch, the internal pull up resistor can be used to eliminate the need for an external power supply and pull up resistor.

- For BNC connectors do the following. The BNC I/O functions can be set in the *Digital IO* menu (page 63).
- Connect BNC In to the switch, relay or external circuit.
- Set BNC In to OCtrl and OControl to Enab.
- If using a switch or relay set Debounce ON.

For DB-9 connectors do the following:

- Build a cable as described in *Cables* (page xx) connecting Output_on input (pin 5) and a ground to the external switch, relay or circuit.
- Set BNC In to None or Trigger from *Digital IO* (page 63).
- If using a switch or relay, set Debounce ON.

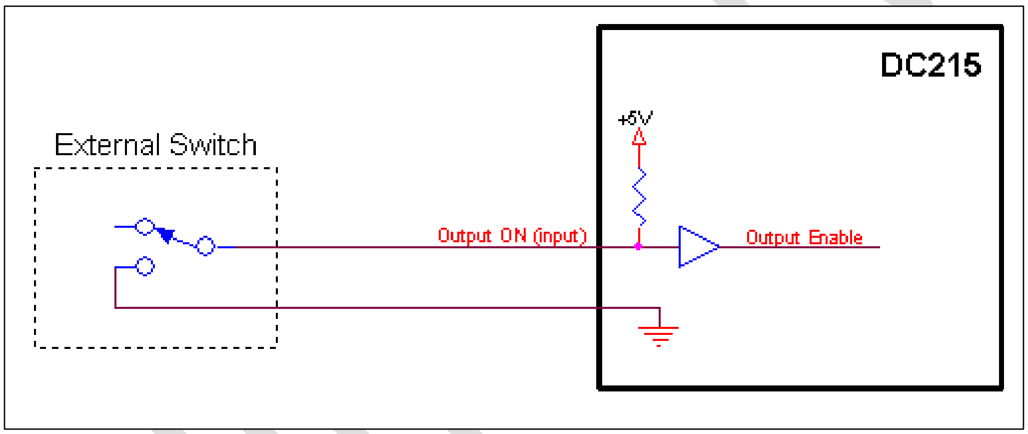
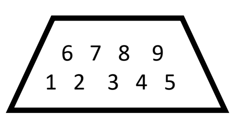


FIGURE 26: OUTPUT ENABLE

Cables

The BNC connectors can be used for a single input and single output connection. Anything beyond this requires building a cable.

The DC215 Digital IO output connector is a DB-9 male connector. Mating connectors are female. Remember that the pin locations for a female connectors are mirrored relative to male connectors.



MATING FACE OF DB-9 FEMALE CONNECTOR

The easiest way to make a cable is with a DB-9 female connector with solder cups and multiconductor cable. Solder the connections as required, including several ground connections. A sample Primary/Secondary system is shown, where the primary generates the outputs and the secondary receives them. This can be extended to multiple units as required.

TABLE 15: SAMPLE PRIMARY/SECONDARY CABLE

Signal	Primary pin	Secondary pin
Output ON	1 (output)	5 (input)
Step Trigger	3 (output)	4 (input)
Ground	6	9
Ground	8	7

Sequences

Step Alignment

When operating multiple DC215s synchronized by the DIO it may be necessary to align step counts between units. There are several different methods that can be used for this.

Step Key

[STEP] is one of the step triggers for normal trigger mode. Pressing it advances the sequencer one step and generates Step Trigger outputs. See *Step Triggers* (page 38) for details.

For each [STEP] on the primary DC215, a step is generated for that unit, plus other units via the Step Trigger Output.

For each [STEP] on a secondary DC215, the Step Trigger is only generated for that unit (and possibly other secondary units if connected with a daisy chain configuration).

Step Adjust Mode

The step count can be independently adjusted for each DC215 from the Step Adjust Mode. Changes made from the Step Adjust mode change the output to that step, but do not generate ramps or Step Trigger Output pulses. See *Step Adjust Mode* (page 44) for details.

Example:
See Figure 27. When the Run mode is entered the output goes to the first point of the sequence and produces a Ready pulse, but no Trigger Out pulse.

The next two step triggers (denoted by Ts) advance the sequence and produce both Ready and Trigger Out pulses.

Next the Pause mode is entered. This suppresses any step triggers.

Next, the Step Adjust mode is entered and the step count is decremented by two, taking the sequence back to step 1. Ready pulses are generated for each adjusted step, but Trigger Out pulses are suppressed.

Finally the Pause and Step Adjust modes are exited and the Sequencer returns to the Run mode. Step triggers are again processed and Ready and Trigger Out pulses are generated.

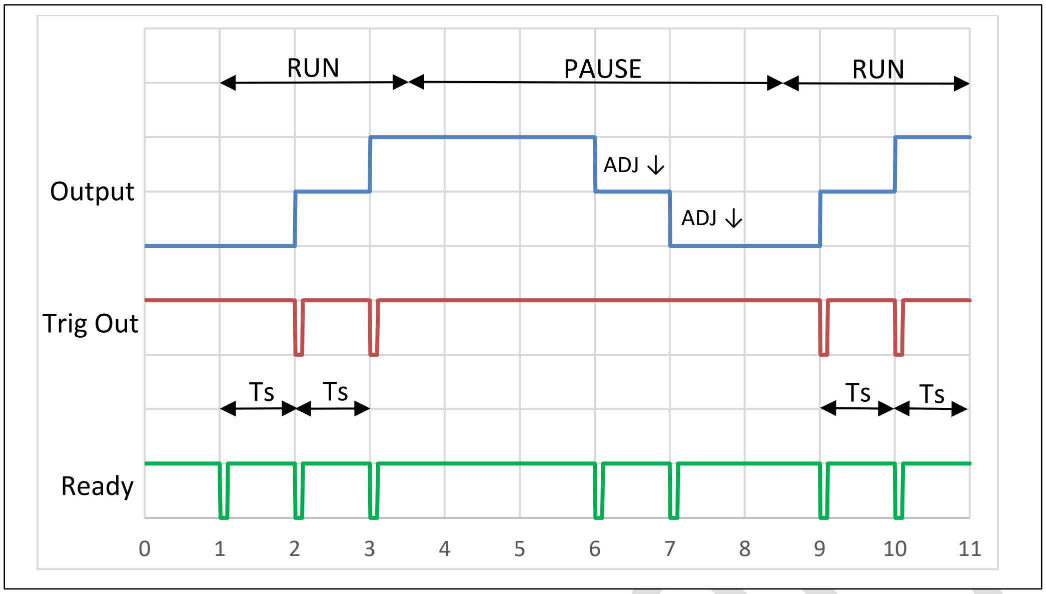


FIGURE 27: STEP ADJUST MODE

Complex Waveforms

Most sequencer programs are made from simple steps and ramps. But there are several techniques that can be used to make more complex waveforms.

Triangle wave

Triangle waves are generated if $T_{ramp} = T_{step}$.

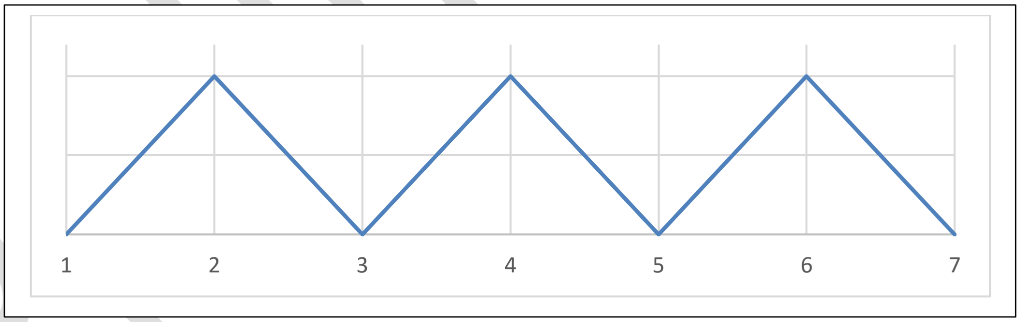


FIGURE 28: TRIANGLE WAVE

Step trigger during ramping

Ramps are terminated (jump to the final value of the ramp and reset the ramp timer) if a step trigger occurs while the ramp is active. This creates a partial ramp.

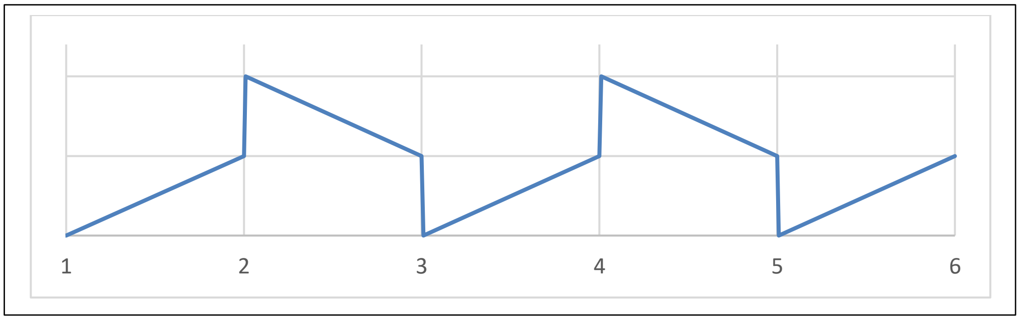


FIGURE 29: STEP TRIGGER DURING RAMP

Repeating a step value

Repeating a step causes the output to dwell at a particular output value for an extended period of time. This can be used to create trapezoid or pulsed waveforms.

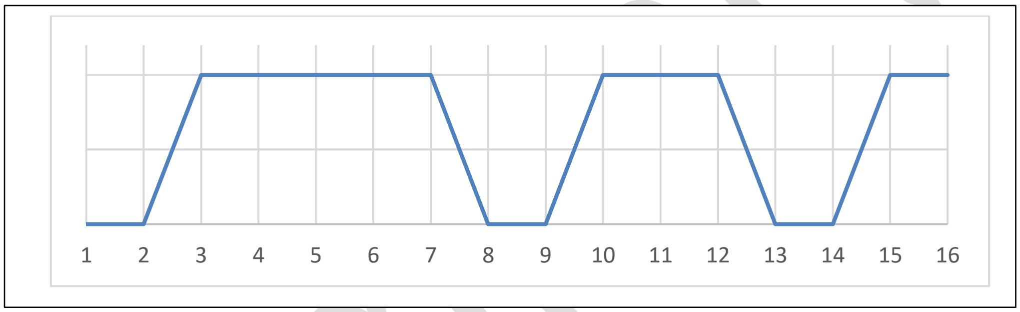


FIGURE 30: REPEATED VALUES

Range changes to skip ramps

A range change will immediately terminate a ramp (jump to the final value and reset the ramp timer) for that step. This can be used to create a waveform with ramps on some steps and no ramps on others. The following program will produce the waveform shown.

Step	Range	Source
1	1 V	0
2	1V	1
3	10V	0
4	10V	0
5	1V	1
6	1V	0
7	10 V	1

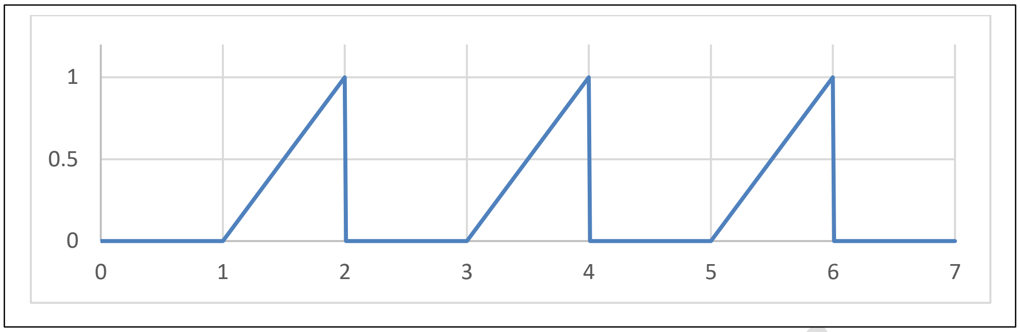


FIGURE 31: RANGE CHANGES TO SKIP RAMPS

Sequences and Measurements

Sequences combined with measurements and logging can introduce time delays due to finite resolution of internal timers. Triggering measurement on Ready and the sequence step on Measurement End (MEnd) eliminates the dead time due to internal timer resolution. This is the fastest that sequence steps plus measurements (and optionally logging) can operate. To configure the sequence and measurements, see *Measurements* (page 33) and *Sequencer* (page 37).

Ordinarily either fast or very fast *Integration time* (page 35) are used when trying to maximize the step rate. R_{delay} should be optimized so the output is settled before the measurement begins.

Example

A sample waveform and the parameters that control it are shown in the following figure.

1) The ramp is initiated by the completion of the previous measurement with its duration determined by T_{ramp}.
2) At the ramps completion (SCC), R_{delay} begins.
3) At the conclusion of R_{delay}, the Ready pulses, beginning the measurement integration time (Tint).
4) At the conclusion of the measurement, a step trigger is generated and the next step begins.

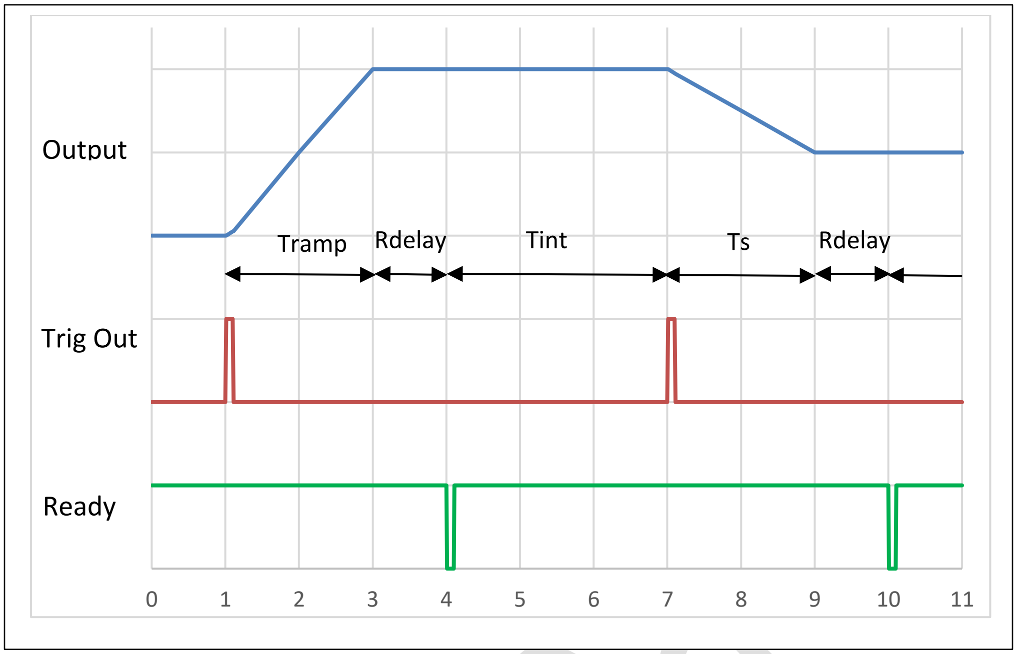


FIGURE 32: READY/MEND TRIGGERING

External Step Triggers

External triggers can operate at a significantly faster rate than the 100 ms maximum internal trigger rate (10 Hz). The external trigger rate can exceed 1 ms (1 kHz) when operating within a single range. A sustained trigger rate of ~0.5 ms (2 kHz) can be obtained if all of the following techniques are used. (Although this is limited by the ~1 ms signal response time).

When optimizing external step trigger rates, pay attention to the SRate Warning (front panel indicator or bit 6 of LSER). It activates if the external step trigger rate is faster than the DC215 can process the triggers for the sequence. See *Trigger and Flag Timing* (page 49) for a more detailed description. If you encounter this limitation, use the following techniques to optimize the DC215 step response rate.

Ramping

Ramping does not make sense for step rates exceeding 100 ms (10 Hz) as the minimum ramp time is 100 ms. Ramps update at 1 ms intervals and don't work well unless there is at least 20 update points per ramp.

Measurements

Measurements generally don't make sense for fast sequence trigger rates, as they take a minimum of 75 ms to complete. For extremely fast trigger rates (>1 kHz) it is useful to disable measurements to reduce processor and bus loading. See *Measurement Enable* (page 36) for details.

Remote Interface Traffic

Remote interface traffic can load the processor, making it difficult to trigger sequence steps at the fastest rate. If practical, disconnect the remote interface cables to eliminate any spurious bus traffic.

High Bandwidth

High Bandwidth should be used for fast sequences. The high bandwidth rise and fall times are roughly 10x faster Low Bandwidth. See *Specifications* (page xi). See *Bandwidth* (page 31) for details on setting the band width.

Operating within a single range

Range changes add to the step processing time. See *Output Timing* (page 85) for details. Operating within a single range is significantly faster. This only has a significant effect for external triggering.

Range changes within the 1V, 10V and 30 V ranges add only about 1/3 the of the time of other ranges changes. This is due to the fact that no mechanical relays involved when changing between these ranges.

Freeze the Front Panel

The final thing you can do to increase external step trigger rates is to halt updates to the front panel. These occupy a measurable amount of processor and bus time. See *Front Panel Update* (page 65) for details.

Note: The front panel Step Rate indicator will no longer update when the front panel is frozen. Monitor bit 6 of the LSER register to detect any SRate warnings.

Measurements and Logging

There are a series of different settings that can be used to optimize measurements, listed in *Measurements* (page 33).

Measurement Range

Note that the DC215 measurement range depends on the output range selected as described in *Measurement Ranges* (page 33).

REL

REL can be used to make measurements form a reference value or to correct small measurement offsets. Be sure to allow the units temperature to fully stabilize before performing a REL to avoid introducing systematic measurement errors. See *REL V, REL I* (page 34) for details.

Integration Time

The different integration options offer different pros and cons. See *Integration Time* (page 35) for details.

Setting	Max Rate	Pro	Con
Slow	1.7 Hz	Lowest Noise/Bawble Easy front panel viewing	Slowest measurement rate
Medium	3.3 Hz	Good compromise	Fairly Slow
Fast	6.6 Hz	Good compromise	Good for remote measurements or logging
Very Fast	13.3 Hz	Fastest Measurement Rate	Highest Noise/Bawble

It is generally recommended to use the Slow or Medium setting when viewing from the front panel and Fast or Very Fast setting for remote measurements or logging.

All measurements include 50/60 Hz frequency notches to suppress line voltage pickup by >80 dB.

Triggering

The different measurement trigger sources enable measurements to be made for a variety of different circumstances. See *Trigger Source* (page 35) for details.

- Auto: Useful when viewing measurements on the front panel. It is less useful for measurements over the remote interface, while running sequences or when logging, as it updates asynchronously with those events.
- Timer: Useful for logging when sequences aren't active as it generates regular measurements to be logged.
- Ready: Useful when making measurements while running sequences or for measurements taken after the output has settled.
- Command: Useful for remote interface measurements.

Ready Timing/R_{delay}

The output of the DC215 continues to change after its value has been set (Source Change Complete or SCC). This is due to the output slew rate and output settling time.

When using Ready Trigger, R_{delay} can be used to optimize when the measurement should begin. R_{delay} is typically chosen so the output has settled to 0.1% or 0.01% of the final value. See *Specification* (page xi) for typical 0.1% settling times for high and low bandwidths.

Measurement/Logging Timing with Sequences

A combination of sequences, step triggers, ramp times and R_{delay} can all be used to control outputs, measurements and logging. See *Sequences* (page 37) and *Measurements* (page 33) for details.

- Step Trigger: Timed triggers are ordinarily used, but MEnd or external trigger could also be used. When not using Mend trigger, be sure that the step rate allows for the source response time, R_{delay}, plus the selected measurement integration time.
- Measurement Trigger: Ready trigger is normally used.
- R_{delay}: This should be long enough to allow the output to fully settle for the longest settling time expected.
- If selected, logging can be to either the remote interface or a USB file.

Configure the relevant sequence, measurement, R_{delay} and logging parameters. Enable logging (remember to start the logging program if using the remote interface). Start the sequence to begin the operation.

When testing your configuration, be sure to monitor SRate and Mrate (either on the front panel or LSER and OMER) to be sure there is sufficient time for each action. If there isn't sufficient time, either slow the step rate or speed up measurements or ramping time.

Example

The following example is of a 4 point sequence (1, 1, 1, 1), with a ramp time = T_{ramp}.

1) The ramp is initiated by the first trigger and has a duration of T_{ramp}.

2) At the ramps completion (SCC), R_{delay} begins.

3) At the conclusion of R_{delay}, the Ready pulses, beginning the measurement integration time (Tint).

4) At the conclusion of the measurement, a step trigger is generated and the next step begins. As this step is the same amplitude as the previous step, T_{ramp} = 0.

5) Steps 3 and 4 repeat for the last 2 steps.

The log file will contain 4 measurements showing the measured values as a function of time after the ramp completed.

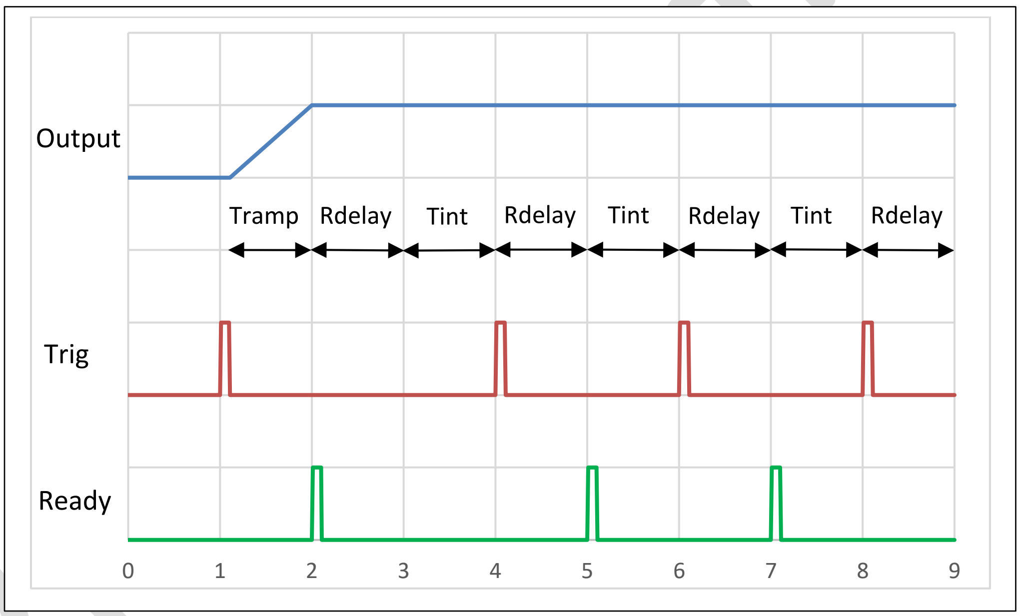


FIGURE 33: SEQUENCE AND MEASUREMENT EXAMPLE

Output Relay

Note that the Output Relay has a life span of ~200,000 cycles. As the number of ON/OFF cycles increases, the relay ON resistance will increase, as will the time it takes the relay to stabilize.

While this life span ordinarily won't matter for manual operation, it can become an issue in automated systems.

Using Limits in place of ON/OFF

By briefly setting the output and voltage limits to their minimum values, a load can ordinarily be safely disconnected from the DC215 without turning the output off. These settings have the effect of changing the source to a high impedance state. This can significantly extend the ON/OFF relays life time.

For the given source type and range, set the following:

Range	**Source Value**	**Limits**	**Output status**
10/100 mV	0 V	n/a	0 V, ~2Ω
1/10/30 V	0 V	±1 mA	0 V, Hi Z
1/10/100/200 mA	0 mA	Working V Limits	0 mA, Hi Z

Set the source and limits back to their normal values after the load is reconnected.

Environment

The DC215 is designed to operate in the following environment.

- Ambient Temperature: 0 – 40 °C (23 °C ±5 °C for best accuracy)
- Humidity: <85% RH (Non condensing)
- Operate in a well ventilated location with a minimum of 2” clearance on both sides and 4” clearance to the rear of the unit.

Never operate the DC215 resting on the rear panel, or with the rear panel vent blocked. This may lead to overheating and could cause a fire if the instrument malfunctions.

Do not install the DC215 in the following locations

- In direct strong sunlight or near sources of heat
- In the presence of steam, dust or corrosive gases
- Near strong electric or magnetic fields
- Near high voltage equipment
- Areas of high vibration
- Unstable surfaces

ALLOW PROPER WARM UP TIME

The unit may not meet all specifications unless sufficient time is allowed for the unit to stabilize at the designed operating temperature for 1 hour.

Performing REL prior the unit warming up may lead to errors in the measured values.

Chapter 5: Remote Programming

Introduction

The DC215 can be remotely programmed over the LAN, the RS-232 serial interface, or the GPIB (IEEE-488) interface. Any host computer interfaced to the instrument can easily control and monitor its operation.

Interface Configuration

The interface configuration parameters can be set from the Comm menu for each interface. See *Communications* (page 73) for details on configuring the interfaces.

The following interface parameters can be set:

- RS-232: Baud rate
- GPIB: Address
- Net: Address, Subnet, Gateway, 10/100 Base T

All interfaces are enabled by default, but may be disabled individually if desired. Interfaces are reset separately. Any modification made to an interface does not take effect until the interface is reset or the unit is power cycled.

Responses to commands are returned to the interface that sent the command. For example if you query "*ESE?" over RS-232, the reply will only be sent back over the RS-232 interface.

Front-Panel Indicators

Three front panel LED indicators located above the USB connector help assist with programming: Rem, Act and Err. The Rem LED indicates the unit is in remote mode. To return it to front panel mode press [CLR] (Local). The Act LED is an activity indicator that flashes every time a character is received or transmitted over one of the remote interfaces. The Err LED will light when a remote command fails to execute due to illegal syntax or invalid parameters.

USB

The front panel USB Type A connector is used to interface with USB storage devices and cannot be used to control the DC215. See *USB Memory Device Interface* (page 67) for details.

RS-232

An RS-232 communication port is included on the rear panel of the instrument. This is a standard DB-9 pin, female connector configured as a DCE (transmit on pin 2, receive on pin 3). The configuration parameters are shown in the table below.

TABLE 16: RS-232 CONFIGURATION

Interface Parameter	Default	Meaning
RS-232 enable/disable	Enabled	Enable or disable the interface
Baud Rate	9600	RS-232 baud rate
Reset Interface (yes/no)	No	Force an interface reset

In order to communicate properly over RS-232, both the DC215 and the host computer must be set to the same configuration. The following baud rates are supported: 4800, 9600 (default), 19.2k, 38.4k, 57.6k and 115.2k. The remaining communication parameters are set as follows: no parity, 8 data bits, 1 stop bit and CTS/RTS hardware flow control.

GPIB

An IEEE-488 (GPIB) communication port is included on the rear panel of the instrument. See *Communications* (page xx) for details. The configuration parameters are shown in the table below.

TABLE 17: GPIB CONFIGURATION

Interface Parameter	Default	Meaning
GPIB enable/disable	Enabled	Enable or disable the interface
GPIB Address	30	Primary GPIB Address
Reset Interface (yes/no)	No	Force an interface reset

LAN

A RJ-45 connector is included on the rear panel of the instrument. See *Communications* (page xx) for details. The configuration parameters are shown in the table below.

TABLE 18: LAN CONFIGURATION

Interface Parameter	Default	Meaning
TCP/IP Enable/Disable	Enabled	Enable or disable all TCP/IP based interfaces.
DHCP Enable/Disable	Enabled	Enable or disable automatic network configuration via DHCP.
Static IP Enable/Disable	Enabled	Enable manual configured network configuration in the event that the automatic configuration fails or is disabled.
Auto-IP Enable/Disable	Enabled	Enable or disable automatic network configuration in the 169.254.x.x internet address space if DHCP fails or is disabled
Bare Socket Enable/Disable	Enabled	Enable or disable raw socket access to the instrument via TCP port 5025.

Telnet Enable/Disable	Enabled	Enable or disable access via telnet at TCP port 5024.
Instrument IP Enable/Disable	Enabled	Enable or disable access via VXI-11 net instrument protocols.
Address	0.0.0.0	Static IP address to use when manual configuration is active.
Subnet	0.0.0.0	Network mask to use when manual configuration is active. The network mask is used to determine which IP addresses are on the local network.
Gateway	0.0.0.0	Default gateway or router to use when manual configuration is active. The gateway is the IP address that packets are sent to if the destination IP address is not on the local network.
Ethernet Speed (10/100)	100 Base-T	Ethernet physical layer link speed.
Reset Interface (yes/no)	No	Force an interface reset

Before connecting the instrument to your LAN, check with your network administrator for the proper method of configuration of networked instruments on your network.

Both automatic and static network configuration is supported. When more than one configuration is enabled, the instrument selects network configuration parameters with the following priority: DHCP, Auto-IP and Manual. Since Auto-IP will virtually always succeed, it should be disabled if static configuration is desired. Any changes made to the interface configuration will not take effect until the interface is reset or the unit is power cycled.

Network Security

Network security is an important consideration for all TCP/IP networks. Please bear in mind that the DC215 does NOT provide security controls, such as passwords or encryption for controlling access. If such controls are needed, you must provide it at a higher level on your network. This can be achieved by setting up a firewall and operating the instrument behind it.

Command Syntax

The DC215 commands follow IEEE-488.2 Standard. All commands use ASCII characters, are 4-characters long, and are case-insensitive. Standard IEEE-488.2 defined commands begin with the '*' character followed by 3 letters. Instrument specific commands are composed of 4 letters.

The four letter mnemonic (shown in capital letters) 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 *query optional* 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.

The command buffer is limited to 270 bytes, with 25 byte buffers allocated to each of up to 3 parameters per command. If the command buffer overflows, both the input and output buffers will be flushed and reset. If a parameter buffer overflows, a command error will be generated and the offending command discarded.

Commands are terminated by a semicolon, a <CR> (ASCII 13), or a <LF> (ASCII 10). Execution of the command does not begin until a command terminator is received. The response terminator is set by the XTRM command (default <CR> <LF>).

If the communications interface is GPIB, the terminating character may optionally be accompanied by an EOI signal. If the EOI accompanies a character other than a <LF>, a <LF> will be appended to the command to terminate it.

Errors

Aside from communication errors, commands may fail due to either syntax or execution errors. Syntax errors can be detected by looking at bit 5 (CME) of the event status register (*ESR?). Execution errors can be detected by looking at bit 4 (EXE) of the event status register. In both cases, when an error occurs the red ERROR LED will flash and an error code indicating the specific cause of the error is placed in the error buffer. The error buffer may be queried with the LERR? command. If more than 19 errors occur without being queried, the 20th error will be #254 (too many errors), indicating that errors have been dropped. Descriptions of all error codes can be found in the *Error Codes* (page 161) section of this chapter.

Parameter Conventions

The command descriptions use parameters, such as i, d, and v. These parameters represent integers or floating point values expected by the command. The parameters follow the conventions summarized in Table 19.

TABLE 19: COMMAND PARAMETER CONVENTIONS

<table>
<tr><th>Parameter</th><th>Meaning</th></tr>
<tr><td>i, j, k</td><td>An integer value</td></tr>
<tr><td>x, y, z</td><td>A real value</td></tr>
<tr><td>s</td><td>An ASCII string</td></tr>
<tr><td>w</td><td>Token or integer</td></tr>
<tr><td>u</td><td>An identifier of units. Allowed units depend on the type as identified below:
<table>
<tr><th>Type</th><th>Allowed Units</th></tr>
<tr><td>Floating point notation</td><td>‘e’ (scientific) or ‘f’ (fixed point)</td></tr>
<tr><td>Tokens</td><td>‘n’ (number) or ‘t’ (token)</td></tr>
</table>
</td></tr>
</table>

Numeric Conventions

Floating point values may be decimal (‘123.45’) or scientific (‘1.2345e2’). Integer values may be decimal (‘12345’) or hexadecimal (‘0x3039’).

Measurement Errors

If an error in a measurement query occurs, the unit will return an overload value (9.999999E3) to inform the user that there was something wrong with the measurement. The controlling program should test for this value and check the appropriate Status bytes to determine what the problem is. This typically occurs when the output is off or measurements are disabled.

Abridged Index of Commands

Common IEEE-488.2 Commands

Instrument Status Commands

Interface Commands

NAME(?){s}	Page 131	Device Name
XTRM i{,j,k}	Page 131	Interface Terminator

Output and Related Commands

BAND(?){i}	Page 133	Output Bandwidth
GARD(?){i}	Page 133	Guard
LIMI(?) i{,x,y}[,u]	Page 134	Limits
OUTP(?){i}	Page 134	Output ON/OFF
RANG(?) i{,x}[,u]	Page 134	Range
RCTL i	Page 135	Ramp Control Set
RCTL?	Page 135	Ramp Control Query
RDLY(?){x}	Page 135	Ready Delay
REAL?	Page 136	Real Time Value
RTIM(?){x}	Page 136	Ramp Time
SENS(?){i}	Page 136	2/4 Wire Sense
SORC(?) i{,x}[,u]	Page 137	Source Value
VORI(?){i}	Page 137	Voltage or Current Output

Measurement Commands

INTG(?){i}	Page 138	Integration Time
MEAS(?){i}	Page 139	Measurement Enable
MONO? i[,u]	Page 139	Get Last Monitor Measurement
MREL(?) i{,x}	Page 140	Measurement REL
MTIM(?){x}	Page 140	Measurement Timer
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Digital IO Commands

BISO(?){i}	Page 141	BNC Input Source
BOSO(?){i}	Page 141	BNC Output Source
DEBO(?){i}	Page 141	Debounce Enable
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Logging Commands

ELOG(?){i}	Page 143	Logging Enable
LHOE(?){i}	Page 144	Halt on Error
NMPT(?){i}	Page 144	Number of Points to be Logged
RLOG?	Page 145	Retrieve Log Record
ULFN(?){i}	Page 145	USB Log File Number

Sequencer Commands

QCLR	Page 146	Clear Sequencer Program
QDAT(?) i{,j,x}	Page 147	Program Sequencer Step
QEND(?) i	Page 148	Last Step of Program
QLIN(?){i}	Page 148	Step Number
QMOD(?){t}[,u]	Page 148	Sequencer Mode
QNPT(?){i}	Page 150	Number of Points Limit
QREP(?){i}	Page 150	Repeat Mode
QSTP	Page 150	Step Trigger
QSUL i	Page 151	Load Sequence Program from USB Drive
QSUS i	Page 151	Save Sequence Program to USB Drive
QTIM(?){x}	Page 151	Step Timer
QTRG(?){i}	Page 152	Step Timer

Miscellaneous Commands

BEEP(?){i}	Page 153	Enable Key Clicks
DISP(?) i{,j}	Page **Error! Bookmark not defined.**	Display Setting
KEYS i	Page 155	Simulated Key Press
TDAT?	Page 156	Time – Date Query
TDAT i,j	Page 156	Time – Date Set
TEMP?	Page 156	Query Instrument Temperature

Detailed Command List

Common IEEE-488.2 Commands

***CLS** — **Clear Status**

Clear Status immediately clears the ESR, OMER, LSER registers as well as the LERR error buffer.

See *DC215 Status* (page 157).

***ESE(?){i}** — **Standard Event Status Enable**

Set (query) the Standard Event Status Enable register {to i}. Bits set in this register cause ESB (in STB) to be set when the corresponding bit is set in the ESR register.

See *DC215 Status* (page 157).

***ESR?** — **Standard Event Status Register**

Query the Standard Event Status Register. Upon executing a *ESR? query, the returned bits of the *ESR register are cleared. The bits in the ESR register have the following meaning.

Bit	Meaning
0	OPC – operation complete
1	Reserved
2	QYE – query error
3	DDE – device dependent error
4	EXE – execution error
5	CME – command error
6	Reserved
7	PON – power-on

Example

*ESR? — A return of ‘176’ would indicate that PON, CME, and EXE are set.

See *DC215 Status* (page 157).

***IDN?** — **Identification String**

Query the instrument identification string.

Example

*IDN? — Returns a string similar to ‘Stanford Research Systems,DC215,s/n000000,ver0.000’

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

The set form sets the OPC flag in the ESR register when all prior commands have completed, which can in tern, generate a service request if the appropriate bits are set in the *ESE and *SRE registers.

The query form returns '1' when all prior commands have completed, but does not affect the ESR register.

Note that *OPC does not work properly during self test as all commands are then refused.

See *DC215 Status* (page 157).

***PSC(?){i}** **Power-on Status Clear**

The set form sets the Power-on-Status-Clear flag to i. This flag control the behavior of several status registers upon power on.

PSC	Meaning
0	The instrument preserves *SRE, *ESE, OMER and LSER event enable registers upon power on.
1	The instrument clears these registers upon power on.

The query form returns the value of the PSC flag.

See *DC215 Status* (page 157).

***RCL i** **Recall Instrument Settings**

Recall instrument settings from location i. The parameter i may range from 0 to 9. Location 0 is reserved for the recall of factory default instrument settings. Locations 1 to 9 are user configurable.

Example

*RCL 3 Recall instruments settings from location 3.

Related commands: *RST, *SAV

See *System Settings* (page 58).

***RST** **Reset the Instrument**

Reset the instrument to default settings. This is similar to *RCL 0.

Example

*RST Resets the instrument to default settings

Related commands: *RCL

See *Default Instrument Setup* (page 61) for a list of the default settings.

***SAV i** **Save Instrument Settings**

Save instrument settings to location i. The parameter i may range from 1 to 10 as listed.

i	File
1 - 9	User stored setups
10	Settings recalled upon start up

Settings are periodically saved to location 10 during front panel activity. Remote commands do not trigger auto-save to location 10, so it must be done explicitly if desired.

Note: It is possible to exceed the memory life span in ATE applications with excessive saving of settings. This begins to become a concern at about 100,000 saves for locations 1-9 and around 1,600,000 saves for location 10. Recalls do not impact memory lifespan.

Example

*SAV 3 Save current settings to location 3

Related commands: *RCL

See *System Settings* (page 58).

***SRE(?){i}** **Service Request Enable**

Set (query) the Service Request Enable register {to i}. (i = 0 to 255).

The event enable registers allow an IEEE-488 service request to be generated if a matching event bit and enable bit are set. Note that bit 6 of *SRE can never be set.

Related commands: *STB, *ERE, OMEE, LSEE, *PSC

See *DC215 Status* (page 157).

***STB?** **Status Byte**

Query the standard IEEE 488.2 serial poll status byte. A service request is generated if matching bits in both the *STB and *SRE registers are set. The bits in the STB register have the following meaning:

Bit	Meaning
0	OSMB summary bit
1	LSSB summary bit
2	unused
3	ERQ = Errors in error queue
4	MAV – message available
5	ESB – ESR summary bit
6	MSS – master summary bit
7	unused

Example

*STB? A return of '113' would indicate that OMER, MAV, ESB, and MSS are set. OSMB indicates that an enabled bit in OMER is set. MAV indicates that a message is available in the output queue. ESB indicates that an enabled bit in ESR is set. MSS reflects the fact that at least one of the summary enable bits is set and the instrument is requesting service.

Related commands: *SRE, *ESR, OMER, LSER, *CLS

See *DC215 Status* (page 157).

***TRG** **Trigger**

Generates a measurement trigger if enabled. The IEEE-488 bus Group-Execute-Trigger (GET) also generates this trigger.

Related commands: MTSO

See *Measurement Trigger Source* (page 3535).

***TST?** **Self Test**

Runs the instrument self test. Returns 0 if successful or code 17 (Self Test Error) if one or more of the self tests fail. The Self Test error can be read using LERR? and decoded using EDCD?

Note that Self Test takes several seconds to complete. It turns off the output, stops logging, ramps and sequences.

See *Self Tests* (page 64) and *Error* Codes (page 161) for more details.

***WAI** **Wait for Command Execution**

This causes the interface to not process any commands until all pending operations are complete. There are no arguments or returned values. When pending operations are complete, the OPC flag in the ESR register will be set to 0.

Example

*WAI	Complete all pending operations before processing any more commands.

Related commands: *OPC

See *DC215 Status* (page 157).

Instrument Status Commands

LSEE(?){i} **Logging & Sequencer Enable register**

Set (query) the LSEE register {to i}. Bits set in this register cause the LSER bit (in STB) to be set when the corresponding bit is set in the LSER register. This allows an IEEE-488 service request to be generated. See the LSER register for bit definitions.

Related commands: *SRE, *ESE, LSER, LSEE, LSSR, *PSC

See *DC215 Status* (page 157).

LSER?[i] **Logging & Sequencer Status Register (latched)**

Query the LSER register. If i is included, the query returns the bit indicated by i ($0 \le i \le 15$). This register is sticky (i. e. the bits latch when set). Upon executing an LSER? query, either the register or the selected bit is cleared. If a corresponding bit is set in both the LSER & LSEE registers, it will set bit 1 of *STB.

The definition of the LSER register is similar, but not identical to the LSSR register.

The bits in the LSER register have the following meaning:

Bit	Meaning
0	USB Logging Done
1	Logging Error
2	Logging COM point available
3	Sequence Start
4	Sequence Done
5	Sequence Step
6	Step Trigger Warning
7	Sequencer Load/Save Done
8	Sequencer Load/Save Error
9-15	unused

Example

LSER? A return of '1' indicates that USB logging is complete.

Related commands: *SRE, *ESE, LSSR, LSEE

See *DC215 Status* (page 157) for a detailed description of the different conditions reported.

LSSR?[i] **Logging & Sequencer State Register**

Query the LSSR register. If i is included, the query returns the bit indicated by i ($0 \leq i \leq 15$). This register is not latched and reflects the value of the register the instant it was read. The definition of the LSSR register is similar, but not identical to the LSER register.

The bits in the LSSR register have the following meaning:

Bit	Meaning
0	USB Logging Inactive
1	Logging Error
2	Logging COM point available
3	Sequence is Running
4	Sequence is not running
5	Sequence is not Stepping
6	Step Trigger Warning
7	Sequencer is not Loading/Saving to/from USB
8	Sequencer Load/Save Error
9-15	unused

Example

LSSR? A return of '16' indicates that a sequence is not running.

Related commands: *SRE, *ESE, LSER, LSEE

See *DC215 Status* (page 157) for a detailed description of the different conditions reported.

OMEE(?){i} **Output and Measurement Enable register**

Set (query) the OMEE register {to i}. Bits set in this register cause OMER (in STB) to be set when the corresponding bit is set in the OMER register. This allows an IEEE-488 service request to be generated.

Related commands: *SRE, *ESE, OMER, OMSR, *PSC

See *DC215 Status* (page 157).

OMER?[i] **Output and Measurement Status Register (latched)**

Query the OMER register. If i is included, the query returns the bit indicated by i ($0 \le i \le 15$). This register is sticky (i. e. the bits latch when set). Upon executing an OMER? query, either the register or the selected bit is cleared. If a corresponding bit is set in both the OMER & OMEE registers, it will set bit 0 of *STB. The meaning of the OMER register is the same as the OMRR register.

The definition of the OMER register is similar, but not identical to the OMSR register.

The bits in the OMER register have the following meaning:

Bit	Meaning
0	Trip
1	+Limit
2	-Limit
3	Output is disabled
4	Output on
5	Output off
6	Ramping done
7	Ready
8	Measurement done
9	Measurement overrange
10	Measurement trigger warning
11	Output coerced
12	Ramp paused
13	REL active
14-15	unused

Example

LSER? A return of '1' indicates that the output has tripped.

Related commands: *SRE, *ESE, OMER, OMSR, *PSC

See *DC215 Status* (page 157) for a detailed description of the different conditions reported.

OMSR?[i] **Output and Measurement State Register**

Query the OMSR register. If i is included, the query returns the bit indicated by i ($0 \le i \le 15$). This register is not latched and reflects the value of the register the instant it was read.

The definition of the OMSR register is similar, but not exactly the same ass the OMER register.

The bits in the OMER register have the following meaning:

Bit	Meaning
0	Trip is active
1	+Limit is active
2	-Limit is active
3	Output is disabled
4	Output is on
5	Output is off
6	Ramping is active
7	Ready has completed all changes
8	Measurement done
9	Measurement is overrange
10	Measurement Trigger Warning
11	Output coerced
12	Ramp paused
13	REL Active
14-15	unused

Example

OMSR? A return of '336' (binary 0001 0101 0000) indicates that the output is on, the ramp is active and measurement is done.

Related commands: *SRE, *ESE, OMER, OMEE, *PSC

See *DC215 Status* (page 157) for a detailed description of the different conditions reported.

Interface Commands

EDCD? i — **Error Number Decode**

Translate error code i into human readable text. Parameter i = any error code reported over the remote interface or Self Test errors.

Example

EDCD? 111 Returns “Parse Error”

Related commands: LERR?

See *Error Codes* (page 161).

EMAC? — **Ethernet MAC Address**

Queries the Ethernet MAC address in the form: “xx:xx:xx:xx:xx:xx”

Example

EMAC? Returns “00:19:B3:0C:4A:F2”

Related commands: IFCF, IFRS, IPCF

See *Net* (page 74).

EUSB(?){i} — **Enable USB Port**

Set (query) the USB port enable (to i}. i = 0 for disabled; i = 1 for enabled.

Example

EUSB 1 Enable the USB port.

Related commands: IFRS

See *USB* (page 77).

IFCF(?) i{,j} — **Remote Interface Configuration**

Set (query) interface parameter i {to j}. Parameter i {& j} are per the following tables:

i	Parameter	j
0	RS-232 Enable	0 = disable; 1 = enable
1	RS-232 baud rate	See baud rate table
2	GPIB Enable	0 = disable; 1 = enable
3	GPIB Address	1 - 30
4	TCP/IP Enable	0 = disable; 1 = enable
5	DHCP Enable	0 = disable; 1 = enable
6	Auto-IP Enable	0 = disable; 1 = enable
7	Static IP Enable	0 = disable; 1 = enable
8	Raw Socket Enable	0 = disable; 1 = enable
9	Telnet Enable	0 = disable; 1 = enable

10	VXI-11 Enable	0 = disable; 1 = enable
11	10/100 Base-T	0 = 10 BaseT; 1 = 100 BaseT
12	Static IP Address	See below
13	Static Sub netmask	See below
14	Static Gateway	See below

Note: Disabling TCP/IP disables *all* ethernet interfaces (Raw Socket, Telnet & VXI-11) as they all operate over TCP/IP.

Note: Changes do not take effect until the instrument is rebooted or the specific interface is reset.

Take care as it is possible to disable the interface you are actively using.

Baud Rate Table

j	Baud Rate
0	4800
1	9600
2	19200
3	38400
4	57600
5	115200

IP Address Format
Static IP Address, Sub netmask, Gateway are all in the format: "xxx.xx.xxx.xxx"

Example

IFCF 0, 1 Enable the RS232 serial interface

IFCF? 0 Return if RS232 is disabled

IFCF 1, 5 Set the RS232 baud rate to 115200

Related commands: EMAC, IRFS, IPCF

See *Net* (page 74).

IFRS i — Interface Reset

Reset interface i, where i is listed in the following table:

i	Interface
0	RS-232
1	GPIB/IEEE488
2	TCP/IP

Note that by it is possible to disable the interface you are actively using.

Example

IFRS1 Reset the GPIB interface.

Related commands: IFCF

See *Comm Menu* (page 73).

IPCF? i — Query the active TCP/IP Configuration

Query the Ethernet parameter i, for the active last error in the error buffer. Parameter i and the return value are per the following table:

i	Interface	Return
0	Link	0 for no link; 1 if link
1	IP Address	xxx.xx.xxx.xxx
2	Subnet Mask	xxx.xx.xxx.xxx
3	Gateway	xxx.xx.xxx.xxx

Example

IPCF?0 Returns a 1 if link is present.

Related commands: IFCF, IRFS

See *Net* (page 74).

LERR? — Last Error (Inspect Error Buffer)

Query the last error either the command error buffer or Self Test error buffer. Upon executing a LERR? the returned error is removed from the buffer. 0 indicates “no error”. The command Error Buffer can store up to 20 errors. If more than 19 errors occur without being queried, the 20th error will be 254 (too many errors), indicating that errors may have been dropped.

See errors for instructions on use: read till 0...

Example

LERR? A return of 110 indicates there was a bad command.

Related commands: EDCD, *CLS

See *Error Codes* (page 161).

LOCK(?){i} **Lock Instrument to Interface**

Set (query) Interface Lock Mode {to i}. The value of i is determined from the following table.

i	Behavior
2	Locks the instrument in local mode. Remote commands are still received, but the instrument will not enter remote mode.
1	Locks out the front panel regardless of [Local] or <LOCL>.
0	Undoes Lock 1 or 2. Sets the instrument back to the default state.

Example

LOCK2 Locks the front panel in local mode.
LOCK? A return of 1 indicates the front panel is in Lockout mode.

Related commands: LOCL

LOCL **Local**

Set the instrument to local mode.

Example

LOCL Sets the instrument to Local, enabling the front panel. Mimics front panel Local function.

Related commands: LOCK

NAME(?){s} **Device Name**

Sets (queries) the device name {to s}.

An instrument name can be stored to aid in identifying the instrument over the remote interfaces. The name must be 7 alphanumeric characters or less. It cannot contain commas, spaces, tabs, carriage returns or any non printable characters. It may contain letters, numbers and special characters (besides commas).

In general, it is best to assign a name with that can be displayed on the front panel (5 digits). Note that the front panel cannot display all symbol characters, so it is best to use letters, numbers, dashes and periods as these can be represented on the of the 7 segment characters on front panel.

Example

NAME DC215_1 Sets the device name to DC215_1

XTRM i {,j,k} **Interface Terminator**

Set the interface terminator that is appended to each response to i, j, k. Parameters i, j and k are the numeric values of ASCII characters.

The default terminator is 13, 10, which is a carriage return followed by a line feed.

Example

XTRM13 Sets the terminator to carriage return (ASCII 13)

Related commands: *RST

Output and Related Commands

Output commands configure and set the output of the DC215. Some commands may set parameters that are not currently relevant depending on the unit's operating configuration. If so the newly set parameters will be applied when the configuration is changed to make them relevant.

Example
If the DC215 source type is set to voltage and the source range for current is set it will have no effect on the instrument until the source type is changed to current.

Note that there are different allowed source values for each range. If a range change takes the present source value out of the range, the DC215 will set the source value to 0. When this occurs, Output Coerced (bit 11) of the OMER/OMSR registers will be set.

Certain functions cannot be modified when the DC215 is in specific modes. Doing so will generate an illegal mode error (#11). Other functions may generate other errors. See the Operations Guide for information on what can and can't be modified in particular operating modes.

BAND(?){i} **Output Bandwidth**

Set (query) the Output Bandwidth {to i}. i = 0 for high bandwidth; 1 for low bandwidth (both set and query).

Example
BAND? Query the output bandwidth.

Related commands: RANG

See *Bandwidth* (page 31).

GARD(?){i} **Guard**

Set (query) the Guard {to i}. i = 0 for internal guard; i = 1 for external guard (both set and query).

Example
GARD? Query the Guard setting.

Related commands: SENS

See *Guard* (page 32).

LIMI(?) i{,x,y}[,u] **Limits**

Set (query) limit i {to x, y}. Parameter i = 0 for voltage limits; i = 1 for current limits. Parameter x refers to positive limits and parameter y refers to negative limits. Both are set in volts or amps.

For queries, parameters x, y can be returned in the format specified by [u], with 'e' denoting scientific format and 'f' denoting fixed point notation. If [u] is omitted, units default to scientific format (i.e. 1.2e-2).

Example

LIMI 1, 100e-3, -200e-3	Set the Current Limits to +100mA, -200mA.
LIMI? 0, f	Query the Voltage Limits in fixed point notation.

See *Limits* (page 29).

OUTP(?){i} **Output ON/OFF**

Set (query) the Output mode {to i}. i = 0 for OFF; i = 1 for ON.

Note that if the Digital IO has disabled the output, this command will return an "Output Disabled" error (#65). Output disable can be detected by 4 of the OMSR/OMER register.

Example

OUTP 1	Turn output ON.

Related commands: SORC, OMSR, OMER

See *Output ON/OFF Behavior* (page 22).

RANG(?) i{,x}[,u] **Range**

Set (query) source range i {to x}. Parameter i = 0 for voltage; i = 1 for current. Parameter x refers to the range value in volts or amps.

For set values, x sets the output range to the smallest value that can output |x| in either fixed or floating point units. For voltage out, 'x' values of 130E-3, -1.0 or 1.2 would all select the 1V range, while an 'x' value of 1.3 would select the 10V range. Similarly for current, 3E-3 and -0.011 would all select the 10mA range.

For queries, parameter x returns the nominal range values (30, 10, 1, 0.1, 0.01 or 0.2, 0.1, 0.01, 0.001) in the format specified by [u], with 'e' denoting scientific format and 'f' denoting fixed point notation. If [u] is omitted, units default to scientific format (i.e. 1.2e-2).

Example

RANG 0, 15	Set the Voltage range to 30 V.
RANG? 1,f	Query the current output range in fixed point units.

Related commands: SORC, BAND

See *Range* (page 24).

RCTL i **Ramp Control (set)**

Controls output ramping. Parameter i sets ramping behavior per the following table:

i	Behavior
0	Cancels the ramp & reverts to the start value
1	Cancels the ramp & sets the source value to the present value
2	Cancels the ramp & sets the source value to the final value of the ramp
3	Pauses the Ramp at the present value
4	Resumes a paused ramp

Example

RCTL3 Pause the ramp at its present value.

Related commands: RCTL?, RTIM

See *Ramping* (page 25).

RCTL? **Ramp Control (query)**

Query the output ramping state. Returns i per the the following table:

i	Behavior
0	Not ramping
1	Ramping but paused
2	Ramping

Example

RCTL? Returns the ramping state.

Related commands: RCTL, RTIM, REAL

See *Ramping* (page 25).

RDLY(?){x} **Ready Delay**

Set (query) Ready Delay {to x}. x = 0.002 to 100.000 seconds with 0.001 second resolution. Returns Ready Delay as a floating point value.

Example

RDLY1.23 Sets Ready Delay to 1.23 seconds.

Related commands: OMER, OMEE

See *Ready Delay* (page 31).

REAL?[u] **Query Real Time Value**

Query the Real Time value. The return value can be in the format specified by [u], with 'e' denoting scientific format and 'f' denoting fixed point notation. If [u] is omitted, units default to scientific format (i.e. 1.2e-2).

The Real Time value is the instantaneous value being output in volts or amps. If the output is off it Is zero. If the output is on, but not ramping it will be the source value. If the output is ramping it will be the at the time the query was received.

Example

REAL?	Returns the real time value in scientific notation.
REAL? f	Returns the real time value in fixed point notation.

Related commands: SORC, DISP, RTIM, RCTL

See *Real time Display* (page 28).

RTIM(?){x} **Ramp Time**

Set (query) Ramp Time {to x}. x = 0 to 3600.0 in 0.1 second resolution. Returns Ramp Time as a floating point value.

Example

RDLY 5.1	Sets Ramp Time to 5.1 seconds.

Related commands: RCTL, REAL

See *Ramp Time* (page 26).

SENS(?){i} **Sensing**

Set (query) the Sense {to i}. i = 0 for 2-wire voltage sensing; i = 1 for 4-wire voltage sensing.

Example

SENS?	Query the Sensing setting.

Related commands: GARD

See *Sense* (page 32).

SORC(?) i{,x}[,u] **Source Value**

Set (query) source value i {to x}. Parameter i = 0 for voltage; i = 1 for current. Parameter x refers to the source value in volts or amps. Note that x must be within the selected range or an out of range error will be generated.

For queries, parameter x can be returned in the format specified by [u], with 'e' denoting scientific format and 'f' denoting fixed point notation. If [u] is omitted, units default to scientific format (i.e. 1.2e-2).

Example

SORC 0, 15	Set the Voltage range to 15 V.
SORC? 1	Query the current value.

Related commands: VORI, OUTP, RANG, REAL

See *Value* (page 25).

VORI(?){i} **Voltage or Current Output**

Set (query) the Source Type {to i}. i = 0 for voltage; i = 1 for current.

Example

VORI 0	Set the output to voltage.

Related commands: OUTP, SORC, RANG

See *V/I* (page 24).

Measurement Commands

Measurement Commands report results from the DC215s voltage and current monitors.

If a measurement query cannot return a value, the unit will return an overload value (9.999999E3) to inform the user that the measurement could not be returned. Measurements queries cannot be returned if the output is off, measurements are off or if the initial measurement is not yet complete. The controlling program should identify if the overload value is returned. Read the OMER/OMSR registers to determine the cause of an overload value. See *DC215 Status* (page 157) for more information.

Note that a measure triggers initiate a measurement, which will then take a significant amount of time to complete, 75 – 300 ms or longer, depending on the configuration. But monitor queries report the most recent measurement, which may not be from the "just received" trigger. Use *WAI, *OPC or time delays between triggers & queries to ensure that the returned data is from the appropriate measurement.

Note that measurements can be triggered at a much faster rate than they can be completed. When a measure trigger (including *TRG or GPIB Group Execute Trigger) occurs before the previous measurement is complete, the following occurs:

- The MRate warning indicator will flash
- Measurement Trigger Warning (bit 10) in the OMSR/OMER status registers will be set
- The trigger will be ignored.

INTG(?){i} **Measurement Integration Time**

Set (query) Measurement Integration Time {to i}. The value of i is determined from the following table.

i	Integration Time
0	Very fast (74 ms)
1	Fast (147 ms)
2	Medium (294 ms)
3	Slow (588 ms)

Example

INTG 2 Set the integration time to medium (294 ms)

Related commands: MEAS, MONO, MTSO

See *Integration Time* (page 35)

MEAS(?){i} **Measurement Enable**

Set (query) the Measurement Enable Mode {to i}. i = 0 for disabled; i = 1 for enabled.

Example

MEAS 1 Enable Measurements

Related commands: MONO

See *Measure Enable* (page 36)

MONO? i[,u] **Get Last Monitor Measurement**

Query last measurement i. The value of i is determined from the following table.

i	Integration Time
0	Voltage w/ VREL
1	Current w/ IREL
2	Voltage w/o VREL
3	Current w/o IREL

For parameter i = 0/1, the return value is that shown on the front panel, including VREL and IREL, if set. For parameter i = 2/3, the return value is the measurement excluding VREL and IREL.

The returned value format can be specified by [u], with 'e' denoting scientific format and 'f' denoting fixed point notation. If [u] is omitted, units default to scientific format (i.e. 1.2e-2).

Example

MONO?1 Query the last current measurement.
MONO?0,e Query the last voltage measurement in scientific format.

Related commands: MEAS, MREL

See *Measurement Display* (page 34).

MREL(?) i{,x} — **Measurement REL**

Set (query) the monitor i rel value {to x}. i = 0 for VREL; i = 1 for IREL. x (or the returned value) is the specified REL value in volts or amps.

Note that any non zero VREL or IREL puts puts both monitors into REL mode. Setting both VREL and IREL to zero takes both monitors out of REL mode.

The returned value format can be specified by [u], with 'e' denoting scientific format and 'f' denoting fixed point notation. If [u] is omitted, units default to scientific format (i.e. 1.2e-2).

Example

MREL 0, 1E-3	Set VREL to 1 mV
MREL? 1, f	Query IREL in fixed point notation.

Related commands: MONO, MEAS

See *REL Mode* (page 34).

MTIM(?){x} — **Measurement Timer**

Set (query) the Measurement Timer {to x}. x = 0.2 to 3600.0 with 0.1 second resolution. Returns Measurement Timer as a floating point value in seconds.

Example

MTIM 100.1	Set the Measure Timer to 100.1 seconds.

Related commands: MONO, MTSO

See *Measure Timer* (page 35).

MTSO(?){i} — **Measurement Trigger Source**

Set (query) the Measurement trigger source {to i}. Parameter i selects one of the following trigger sources.

i	Trigger Setting	Trigger Source
0	Auto	Automatic Retrigger
1	Timer	Triggers upon Timer
2	Ready	Triggers upon Ready signal
3	Interface	*TRG or GET (group execute trigger) command

Example

MTSO 1	Set the Measurement Trigger Source to Timer.

Related commands: MONO, MTIM, RDLY

See *Measure Trigger Source* (page 35).

Digital IO Commands

Digital IO signals are used to synchronize with other instruments or between multiple DC215s. There are 5 different output signals and 2 different input signals.

BISO(?){i} **BNC Input Source**

Set (query) the BNC input source {to i}. Parameter i selects one of the following choices.

i	Input
0	Nothing
1	Output Control
2	Step Trigger In

Example

BISO? Queries the BNC Input Source.

Related commands: BOSO, OCTL

See *BNC Input* (page 63).

BOSO(?){i} **BNC Output Source**

Set (query) the BNC output source {to i}. Parameter i selects one of the following choices.

i	Output
0	Output ON
1	Step Trigger Out
2	Ready
3	Measure Active
4	Step Active

Example

BOSO 1 Set the BNC Output Source to Trigger Out.

Related commands: BISO

See *BNC Output* (page 64).

DEBO(?){i} **Debounce Enable**

Set (query) the Digital Input Debounce mode {to i}. i = 0 for OFF; i = 1 for ON.

Example

DEBO 0 Disable digital input debounce.

Related commands: BISO, OCTL, OUTP, QSTP, QTRG

See *Debounce* (page 64).

OCTL(?){i} **Output Control**

Set (query) Output Control {to i}. Parameter i selects one of the following choices.

i	Output	Woof woof
0	None	Disables output control function
1	Enable	Sets output control to enable
2	Control	Sets output control to ON/OFF

Example

OCTL? Query Output Control

Related commands: BISO, OUTP, DEBO

See *Output Control* (page 63).

Logging Commands

The DC215 can log output settings and measurements to either an external USB memory device or over any of the remote interfaces. Once started, logging will continue until halted by one of the following conditions:

- The set number of points is completed
- Logging is Disabled
- Measurements are turned off
- The Output is turned off
- A Logging Error occurs

As these conditions occur long after logging was enabled, logging status is reported by status bits in the LSSR register. Note that logging is disabled (ELOG = 0) whenever logging Is halted, either due to completion or something that halts it.

Logging takes place to an internal 100 point buffer. This buffer services either the remote interface (via the RLOG command) or a USB memory device. If this buffer ever overruns, a logging error (#40) is generated.

When logging over the remote interface, RLOG or LSSR/LSER shouldn't be queried more often than about once every 25 ms to avoid overloading the instrument processor.

ELOG(?){i} **Logging Enable**

Set (query) the Measurement Enable Mode {to i}. Parameter i selects one of the following logging interface choices.

i	Interface
0	Disabled
1	USB
2	Remote Interface

Note that logging is disabled (ELOG = 0) whenever logging is halted.

Example

ELOG 1 Enable USB Logging

Related commands: RLOG, NMPT

See *Logging Enable* (page 54).

LHOE(?){i} **Halt on Error**

Set (query) the Logging Halt on Error Mode {to i}. i = 0 for continue; i = 1 for halt.

For Continue on Error, sequences will continue to operate if a logging error occurs even though logging has stopped.

For Halt on Error, both sequences and logging will stop if a logging error occurs.

Example

LHOE?	Queries Logging Halt on Error mode.

Related commands: ELOG, RLOG

See *Logging, Error Behavior* (page 55).

NMPT(?){i} **Number of Points to be Logged**

Set (query) the number of points to be logged {to i}. i = 0 (continuous logging), or i = 1 - 100000.

Example

LLIM 100	Set Number of Points to log to 100.
LLIM 0	Set continuous logging.

Related commands: ELOG, RLOG

See *Number of Points* (page 54).

RLOG? **Retrieve Log Record**

Query the log record buffer. Returns a log record formatted as shown below.

Note that ELOG must be set to 2 for this command to operate. Bit 2 (log point available) of the LSER register is set whenever a new log record is saved to the buffer.

If there is one or more log records in the buffer, the oldest record is returned and removed from the buffer. If there are no log records in the buffer, '!' is returned. If the 100 point log buffer is not read before it overflows, an error is generated and bit 1 of the LSSR/LSER resisters are set.

Log records consist of 6 comma delimited fields:

Time	Time since logging started, in seconds
Source Type	V or I
Source Range	Present range, with units
Source Value	Source value in amps or volts
Measured Voltage	Measured voltage in volts
Measured Current	Measured current in amps

The example below represents a log record taken at 19.2 s, volts out, 10V range, source = 3.2000 V, measured voltage = 3.199871 V, measured current = 1.234 mA.

Example

RLOG? Returns 19.2,V,10V,3.20000E0,3.199871E0,1.2345E-3 for the example above.

RLOG? Returns '!' if no log record is available.

Related commands: ELOG, NMPT

See *Logging over Remote Interface* (page 54).

ULFN(?){i} **USB Log File Number**

Set (query) the USB Log File Number {to i}. i = 0 to 9999.

Files are stored on the USB storage device as LOGi, where i = 0 – 9999. When logging starts, any existing file with the same file number will be overwritten. Each time logging is disabled (either deliberately or by an error), the USB log file is auto incremented.

Example

ULFN 13 Set the USB log file number to 13 (logging to LOG0013.CSV)

Related commands: ELOG

See *Logging to a USB Device* (page 53).

Sequencer Commands

The Sequencer plays out a series of source values (steps) from a file stored in memory. These source values are stepped through by a step trigger. For each step trigger, the source range and source level is set from the sequence file, for a fixed source type (V or I). Sequences can be set to repeat, allowing them to run continuously until halted.

Note that the program source type is determined by the source type of step 1 when creating or editing a sequence. If a different source type is attempted for a subsequent step, a VI Type error (#191) will be generated. Source values must be within the selected source range or an illegal value (#10) error will be generated.

Sequence programs can be 1-10000 steps long and can be entered in multiple ways, including over the remote interface. The sequencer must be in the program mode to enter a program over the remote interface.

Example

QMOD 1	Set the sequencer to program mode.
QDAT 1, 0, 2.7	Program step 1 to 30V range, 2.7 V out
QDAT 2, 0, 3.1	Program step 2 to 30V range, 3.1 V out
QDAT 3, 1, -9	Program step 3 to 10V range, -9 V out
QMOD 0	Set the sequencer to normal mode. Program is saved to internal memory

Step Triggers can occur at a faster rate than a step can be completed. When a step trigger (including QSTP) occurs before the previous step is complete, the following occurs:

- The SRate warning indicator will flash
- Step Trigger Warning (bit 6) in the LSSR/LSER status registers will be set
- The trigger will be ignored.

Certain functions cannot be modified when in most sequencer modes besides normal. Doing so will generate an error. Depending on the operating mode and action this includes: 187, 188, 189, 190, 196, 197, 198. See the Operations Guide for information on what can and can't be modified in particular operating modes.

QCLR Sequencer Program Clear

Erases and initializes the sequencer memory.

The host should use *WAI, *OPC or wait several seconds after sending this command.

See *Clear Program* (page 51).

QDAT(?) i{,j,x} **Sequencer Program Step**

Set (query) the program step i {to j, x}. Parameter i selects the step number. Parameter j is the source type plus source range per the table below. Parameter x is the source value for the selected source type and source range.

For the set form parameter i can vary from 1 to the last programmed step +1. Step values outside this range will generate a Buffer Overflow/Invalid Step error (#181).

The query form returns the program data for step i including j (source type/range) and x (source level). Parameter i can vary between 1 and the last programmed step. Values outside this range will generate a Buffer Overflow/Invalid Step error (#181).

Parameter j encodes both the source type and source range. Remember that the entire sequence can have only a single source type. Using a value for j from a different source type will generate a Bad Program Step error (#184).

Parameter x is a floating point value that is within the selected range. Values outside of the selected range will generate a Bad Program Step error (#184).

Note: An Illegal Mode error (#11) will be generated if QDAT is set from any sequencer mode besides Program.

j	**Source Range (Source Type = V)**	**Source Range (Source Type = I)**
0	30 V	---
1	10 V	---
2	1 V	---
3	100 mV	---
4	10 mV	---
5	---	200 mA
6	---	100 mA
7	---	10 mA
8	---	1 mA

Example

QDAT 12,2,2.7   Set the program step 12 to volts, 10V range, 2.7 V
QDAT?3   Returns data for step 3.

Related commands: QMOD, QLIN

See *Program Mode* (page 40).

QEND? i **Last Step of Program**

QEND?0: Returns the number of lines in the program from any mode.

QEND?1: Erases the last programmed step, then returns the new number of lines of the program. QEND?1 can only be invoked from the Program mode. It returns a “Lockout Unless Program Mode” error (#197) if invoked from any other mode.

Related commands: QLIN, QDAT, QMOD

See *Editing an Existing Sequence* (page 42).

QLIN(?){i} **Step Number**

Sets (queries) the step number {to i}.

QLINi: Sets the step count to i from the Step Adjust mode. It returns an execution error for any other mode. Note that i must be a legal step value (between 1 and the last step step of the sequence) or an Illegal Mode error (#11) will be returned.

QLIN?: Returns the step number of the present step to be executed from the run, pause or step adjust modes. It returns an an Illegal Mode error (#11) for any other mode.

Related commands: QMOD

See *Step Adjust Mode* (page 44).

QMOD(?){w}[t] **Sequencer Mode**

Set (query) the sequencer mode {to w}. The mode is selected by parameter w.

Sequencer Mode	Integer	Token
Normal	0	NORM
Program	1	PRGM
Run	2	RUN
Pause	3	PAUSE
Step Adjust	4	STEPADJ

For set values, parameter w can be either an integer or token. For queries, parameter w is returned in the format specified by [t], with 'n' denoting integers and 't' denoting tokens. If [t] is omitted, units default to integer.

Certain sequencer modes can only be reached from specific other modes, as described in the following state table. Attempting to transition to a "not allowed" mode will generate an Illegal Mode error (#11). Attempting to run a sequence with an inappropriate source type will generate a V/I Mismatch error (#191).

	Next State				
Current State	Norm	Prgm	Run (*)	Pause	Step Adj
Normal	OK	OK	OK	No	No
Program	OK	OK	OK	No	No
Run	OK	No	OK	OK	No
Pause	OK	No	OK	OK	OK
Step Adjust	OK	No	OK	OK	OK

* Attempting to enter the Run mode with no sequence program in memory will generate a No Program error (#185).

Example

QMOD2	Sets the sequencer to the Run Mode.
QMOD NORM	Sets the sequencer to the Normal Mode
QMOD?	Returns '1' when in the Program Mode.
QMOD?n	Returns '2' when in the Run Mode.
QMOD?t	Returns 'NORM' when in the Normal Mode.

Related commands: QRPT, LSSR, QSTP, QTRG

See *Sequencer Operating* Modes (page 39).

QNPT(?){i} **Number of Points Limit**

Set (query) the point limit parameter {to i}. i = 0 to enable all programmed steps, or 1 – 10000 to limit the number of steps. Returns the value of Point Limit.

The sequencer plays the smaller of point limit or the total number steps of the complete program.

Example

QNPT 0	Set the number of points to zero, enabling all programmed points for playback.
QNPT 33	Limits the number of points for playback to 33.

Related commands: QEND, QREP

See *Point Limit* (page 50).

QREP(?){i} **Repeat Mode**

Set (query) the repeat mode {to i}. i = 0 to disable repeat mode; i = 1 to set repeat mode.

Example

QREP?	Query the repeat mode. A return of 1 indicates repeat is active.

Related commands: QMOD

See *Repeat* (page 50).

QSTP **Step Trigger**

Generates a step trigger, assuming the sequencer is in the Run mode. This trigger is ignored if the unit is not in the run mode or trigger mode is set to Measurement End Trigger.

Example

QSTP	Generates a step trigger when in the Run Mode.

Related commands: QMOD, QTRG, QTIM

See *Step Triggers* (page 38).

QSUL i **Load Sequence from USB**

Load sequence program PRGMi.CSV from an external USB drive. Parameter i is the sequence program ID and can vary from 0 to 9999.

Sequence files stored on a USB memory device use the following name convention: PRGMi.CSV, where i is the file number displayed on the front panel or used in this command.

USB operations may take a long time to complete. This depends on the device type, number of files on the drive and the size of the program being saved. Errors are not returned over the interface; instead they are reported in the LSER/LSSR status registers.

It is generally advisable to clear the sequencer memory using QCLR before loading a file.

Example

QSUL 123	Load sequencer program PRGM0123.CSV from the installed USB memory device to the DC215 memory.

Related commands: QSUS, LSER/LSSR

See *Saving and Loading Sequence Programs to USB* (page 51).

QSUS i **Save Sequence Program to USB Drive**

Save sequence program to location PRGMi.CSV on an external USB drive. Parameter i is the sequence program ID and can vary from 0 to 9999.

Sequence files stored on a USB memory device use the following name convention: PRGMi.CSV, where i is the file number displayed on the front panel or used in this command.

USB operations may take a long time to complete. This depends on the device type, number of files on the drive and the size of the program being saved. Errors are not returned over the interface; instead they are reported in the LSER/LSSR status registers.

Example

QSUS 14	Save the sequencer program stored in DC215 memory to PRGM0014.CSV on the installed USB memory device.

Related commands: QSUL, LSER/LSSR

See *Saving and Loading Sequence Programs to USB* (page 51).

QTIM(?){x}

Step Timer

Set (query) the step timer {to x}. x = 0 to disable the Step timer, or 0.1 – 3600.0 seconds in 0.1 s increments.

The step timer generates a step trigger each x seconds, assuming the sequencer is in the Run mode. This trigger is ignored if x = 0 or the unit is set to measurement end trigger.

Example

QTIM 12.1 Set the step timer to 12.1 seconds.

Related commands: QSTP, QTRG

See *Step Timer* (page 50).

QTRG(?){i}

Sequencer Trigger Mode

Set (query) the Trigger Mode {to i}. i is set per the following table.

i	Trigger Mode
0	Normal
1	Measure End

Normal Trigger Mode allows timed, remote interface (QSTP), Digital IO or [STEP] to generate a step trigger. Measure End Mode only allows end of measurements to generate a step trigger.

Example

QTRG? Queries Step Trigger mode.

Related commands: QSTP, QTIM, QMOD

See *Step Trigger Mode* (page 50).

Miscellaneous Commands

These commands control functions that aren't described elsewhere.

BEEP(?){i} **Enable Key Clicks**

Set (query) the Key Click Enable {to i}. i = 0 for disable (no sound); i = 1 for enable (sound).

Enables or disables the key click

Example

BEEP 1 Enable the Key Click

See *Key Click* (page 64).

DISP(?) i{,j} **Display Setting**

Set (query) the Display i to Setting {to j}. Parameters i and j are defined per the following tables.

i	**Display**
0	Source Display
1	Monitor Display
2	Sequence Display
3	Display Freeze

For Source Display (i = 0), j selects what appears in the left side display.

j	**Source**
0	Source
1	Real Time
2	+Limit
3	-Limit
4	T_{ramp}
5	R_{delay}

Example

DISP 0,1 Display Real Time on the left display.

Related commands: SORC, REAL

See *Left Display* (page 10).

For Monitor Display (i = 1), j selects the right side monitor display.

j	Monitor
0	Voltage
1	Current

Example

DISP 1,1 Display Current on the right display

Related commands: MONO

See *Measurement Display* (page 34).

For Sequencer Display (i = 2), j selects the right side sequencer display.

j	Monitor
0	Monitor
1	Step Number

Example

DISP 2,0 Display the selected monitor for sequence on the right display.

Related commands: QMOD

See *Sequencer, Display* (page 50).

For Sequencer Display (i = 3), j selects the if the display is frozen.

j	Monitor
0	Freezes Display
1	Unfreezes Display

Example

DISP 3,0 Freezes the display, halting any updates.
DISP 3,1 Unfreezes the display allowing it to update normally.

Related commands: MEAS

See *Front Panel Update* (page 65).

KEYS i **Simulated Key Press**

Simulate a key press i. Parameter i selects one of the key codes per the following table.

i	Key Codes
0	No key
1	3
2	Enter (V/A)
3	6
4	Enter (mV/mA)
5	PRGM
6	SHIFT
7	9
8	CLR
9	1
10	2
11	4
12	5
13	PAUSE
14	STEP
15	8
16	7
17	Range ↓
18	Range ↑
19	Setting ↓
20	Setting ↑
21	RUN
22	+/-
23	. (decimal point)
24	0
25	Cursor ↓
26	Cursor →
27	Cursor ↑
28	Cursor ←
29	V/I
30	On/Off

Example

KEYS 21 Simulate pressing the RUN key.

TDAT? **Query Time - Date**

Query the instruments time and date. Returns time-date string.

The time and date is returned in a string in the format: "date month year hour:min". Hour is in 24 hr format.

Example

TDAT? Returns: "24 April 2024 13:33"

Related commands: TDAT

See *Time – Date* (page 65).

TDAT i,j **Set Time - Date**

Set the Time – Date parameter i to j. Parameters i and j are set per the following table:

i	Parameter	Allowed values
0	Year	2000 - 2099
1	Month	1 – 12 (January – December)
2	Day	1 – 31 (only dates valid for the particular month/year)
3	Hour	0 – 23
4	Minute	0 – 59

Example

TDAT 1,6 Set the month to June.

Related commands: TDAT?

See *Time – Date* (page 65).

TEMP? **Query Instrument Temperature**

Query the DC215 internal temperature. The return value is in °C.

Temperature measurements can only be made when the Sequencer is in the normal mode and logging is disabled.

Note: The TEMP? query takes ~0.5 s to complete.

Example

TEMP? Make a temperature measurement.

Related commands: MONO, MTSO

See *Temperature* (page 64).

DC215 Status

The DC215 reports on its status by means of several status registers. These include the serial poll status byte, the standard event status register (*ESR) and several additional instrument status registers (INSRs). These read-only registers record the occurrence of defined events inside the unit. If the event occurs, the corresponding bit is set to one. Bits in the status registers are latched. Once an event bit is set, subsequent state changes do not clear the bit. All bits are cleared when the registers are queried, with a *ESR?, for example. The bits are also cleared with the clear status command, *CLS. The bits are not cleared, however, with an instrument reset (*RST) or a device clear (break signal).

Besides the latched INSRs, there are unlatched (or immediate) copies of some of the status registers that reflect the value of the bits the instant the register was read. Having both the latched and unlatched copies of the registers can make it easier to determine the state of the DC215.

Each of the unit's event status registers has an associated enable register. The enable registers control the reporting of events in the serial poll status byte (*STB). If a bit in the event status register is set and its corresponding bit in the enable register is set, then the summary bit in the serial poll status byte (*STB) will be set. The enable registers are readable and writable. Reading the enable registers or clearing the status registers does not clear the enable registers. Bits in the enable registers must be set or cleared explicitly. To set bits in the enable registers, write an integer value equal to the binary weighted sum of the bits you wish to set.

The serial poll status byte (*STB) also has an associated enable register called the service request enable register (*SRE). This register functions in a similar manner to the other enable registers, except that it controls the setting of the master summary bit (bit 6) of the serial poll status byte.

Power On Behavior of Status Registers

All Enable Registers are cleared on power on. These include the following registers: *SRE, *ESE, OMER, OMSR, OMEE, LSER, LSSR and LSEE.

Serial Poll Status Byte

Bit	Name	Meaning
0	OMEW	An unmasked bit in the OMER status register has been set.
1	LSEW	An unmasked bit in the LSER status register has been set.
2		Unused
3	ERQ	The error queue is non-empty
4	MAV	The interface output buffer is non-empty
5	ESB	An unmasked bit in the standard event status register (*ESR) has been set.
6	MSS	Master summary bit. Indicates that the instrument is requesting service because an unmasked bit in this register has been set.
7		Unused

The serial poll status byte may be queried with the *STB? Command.

Standard Event Status Register

Bit	Name	Meaning
0	OPC	Operation complete. All previous commands have completed. See command *OPC.
1	Reserved	
2	QYE	Query error occurred.
3	DDE	Device Dependent error.
4	EXE	Execution error. A command failed to execute correctly because a parameter was invalid.
5	CME	Command error. The parser detected a syntax error.
6	Reserved	
7	PON	Power on. The unit has been power cycled.

The standard event status register may be queried with the *ESR? command. The standard event status enable register (*ESE) may be used to control the setting of the ESB summary bit in the serial poll status byte.

Instrument Status Register Model

The DC215 has two groups of Instrument Status Registers (INSRs): Output/Measurement and Logging/Status. Each group contains three separate 16 bit registers. The first register contains a latched copy of each bit. The second register is an enable register for the first register and is used as a mask for the summary bits in the Status Byte register. The third register contains the unlatched version of each bit. The unlatched (or immediate) register shows the value of the bits at the instant it was read. Each Status Register is described below, together with the page in the *Operations Guide* that refers to specific meaning of each bit.

Logging & Sequencer Status Registers

Bit	Meaning	See
0	USB Logging Done	Page 53
1	Logging Error	Page 52
2	Logging COM point available	Page 54
3	Sequence Start	Page 38
4	Sequence Done	Page 38
5	Sequence Step	Page 38
6	Step Trigger Warning	Page 49
7	Sequencer Load/Save Done	Page 51
8	Sequencer Load/Save Error	Page 51
9 – 15	unused	

Output & Measurement Status Registers

Bit	Meaning	See
0	Trip	Page 30
1	+Limit	Page 29
2	-Limit	Page 29
3	Output Disabled	Page 23
4	Output On	Page 22
5	Output Off	Page 22
6	Ramping	Page 25
7	Ready	Page 30
8	Measurement Done	Page 33
9	Measurement Overrange	Page 33
10	Measurement Trigger Warning	Page 34
11	Output Coerced	Page 25
12	Ramp Paused	Page 26
13	REL Active	Page 34
14-15	unused	

Status Register Model

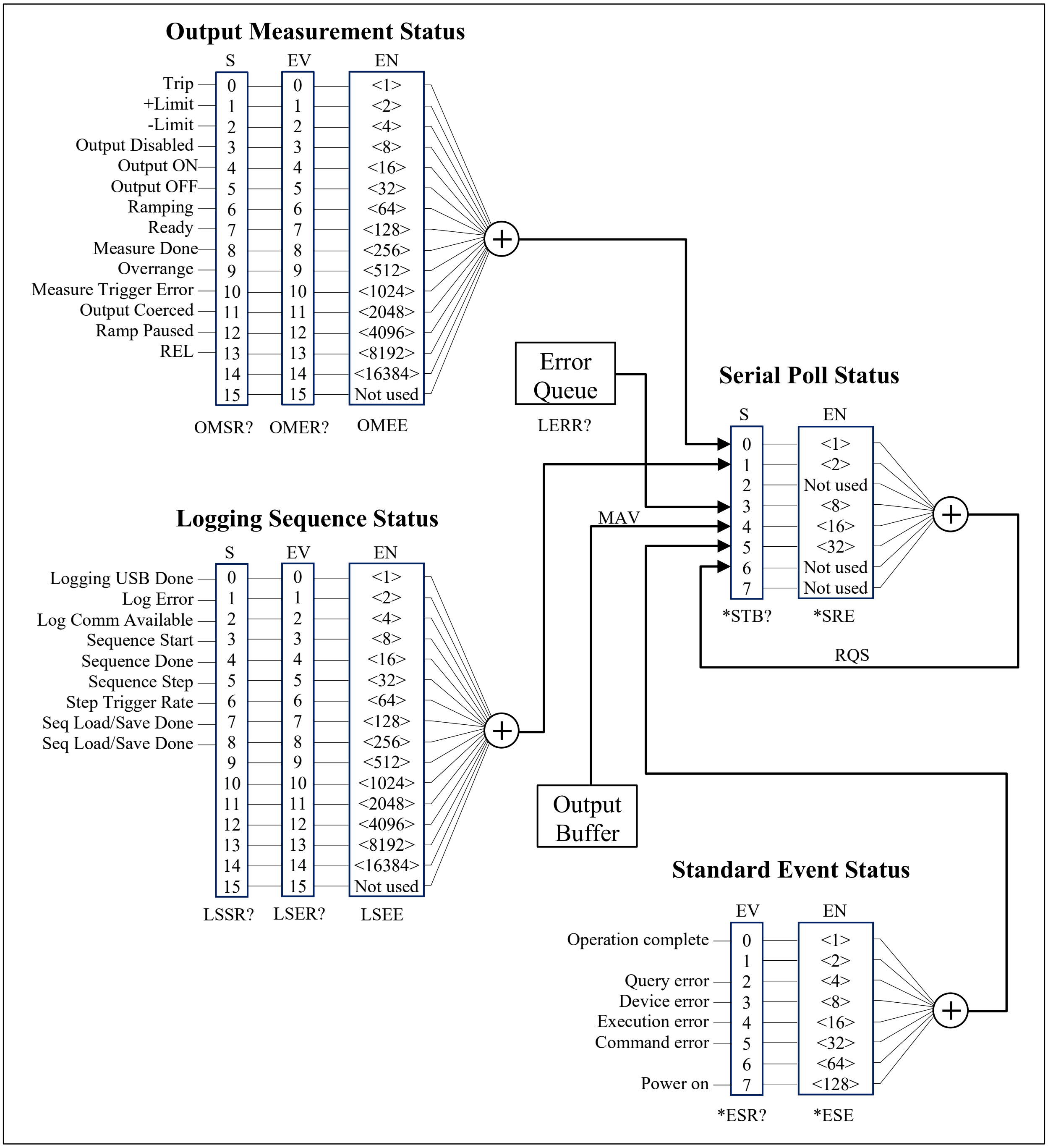

FIGURE 34: STATUS REGISTER MODEL

Error Codes

The instrument contains an error buffer that may store up to 20 error codes associated with errors encountered during power-on self tests, command parsing, or command execution. The ERR LED will flash when a remote command fails for any reason. The errors in the buffer may be read one by one, by executing successive LERR? commands. The meaning of each of the error codes is described below.

Errors are grouped in four categories. Any error in the group will set the associated status bit in the Standard Event Status register.

TABLE 20: ERROR TYPES

Error Type	Status bit	Error Group
Execution	EXE (bit 4)	Execution Errors
Query	QYE (bit 2)	Query Errors
Command	CMD (bit 5)	Parsing or Command Errors
Device Dependent	DDE (bit 3)	Misc Errors, File System Errors, USB Host Errors, Self Test Errors, Communication Errors, Sequencer Errors, Other Errors

Execution Errors

0 No Error

No more errors left in the queue.

2 Busy

The resource was busy and this action was ignored.

10 Illegal Value

A parameter was out of range.

11 Illegal Mode

The action is illegal in the current mode.

12 Not Allowed

There was an unspecified error while attempting executing a command.

13 Recall Failed

The recall of instrument settings from nonvolatile storage failed because its instrument settings were invalid.

16 Execution in Progress

The function called was already in process. The command was likely called twice in quick succession.

17 Self Test Error

There was an error when running Self Test.

19 Time Out Error

The requested action failed because of a Time Out error.

21 Output Off

The requested action failed because the output is off or disabled.

24 Checksum Error

A checksum didn't match the expected value. Typically from USB files.

26 Bad Length

The length of a parameter was incorrect.

27 Log Disabled

The requested action failed because Logging is disabled.

28 Measurements Disabled

The requested action failed because the measurements are disabled.

29 USB Disabled

The requested action failed because USB is disabled.

Query Errors

30 Lost Data

Data in the output buffer was lost. This may occur if:

- A reply from a query is not read before another query is received.
- The output buffer overflows or if a communications error occurs and data in output buffer is discarded.

32 No Listener

Communications error that occurs if the unit is addressed to talk on the GPIB bus, but there are no listeners. The unit discards any pending output.

Device Dependent Errors

40 Logging Error

A logging error occurred.

42 EEPROM Error

An error occurred while communicating with the serial EEPROM.

Misc Errors

60 Not While Logging
This action can't be done while logging.

65 Output Disabled
The output is disabled by the Digital IO.

File System Errors

All of these errors relate to accessing files on a USB memory device.

80 File Error
Error accessing a file on the USB memory device.

81 File Already Open
The selected file is already open.

82 Can't Open File
Unable to open the selected file.

83 File Not Open
Attempted to access a closed file.

84 End of File Error
Attempted access past the end of the file.

85 Read Only File
Attempted to write to a read only file.

86 Write Only File
Attempted to read from a write only file.

87 Data Error
Data error accessing the USB drive

88 No Media
There is no recognizable memory device on the USB port.

USB Host Errors

90 Operation Failed
There is no recognizable memory device on the USB port.

96 USB Time Out
The USB device did not respond to the host prior to time out.

98 Data Line Error

There was an error on a specific line of a sequence program being loaded. The line is reported on the front panel or with the EDCD? Command.

EDCD?98 will return dErr xxxx, where xxxx is the line the error occurred.

99 USB Fail

Unable to communicate with the USB device.

Parsing or Command Errors

110 Illegal Command

The command syntax used was illegal. A command is normally a sequence of four letters, or a '*' followed by three letters.

112 Illegal Query

The specified command does not permit queries

113 Illegal Set

The specified command can only be queried.

115 Missing Parameters

The parser detected missing parameters required by the command.

116 Extra Parameters

The parser detected more parameters than allowed by the command.

117 Command Buffer Overflow

The command exceeded 256 characters and the buffer overflowed.

118 Invalid Floating Point Number

The parser expected a floating point number, but was unable to parse it or it was out of range.

120 Invalid Integer

The parser expected an integer, but was unable to parse it or it was out of range.

123 Invalid Hexadecimal

The parser expected a hexadecimal number but was unable to parse it or it was out of range.

125 Unknown Token

The parser doesn't recognize the token.

126 Syntax Error

The parser detected a syntax error in the command.

Self Test Errors

135 RS-232 Error
A RS-232 error was detected during Self Test.

136 GPIB Error
A GPIB error was detected during Self Test.

139 Net Error
A Network error was detected during Self Test.

140 USB Error
A USB error was detected during Self Test.

141 Front Panel Error
A Front Panel error was detected during Self Test.

142 RTC Error
A Real Time Clock error was detected during Self Test.

143 EEPROM Error
A Flash Memory or Serial EEPROM error was detected during Self Test.

145 Output DAC Error
A Output DAC error was detected during Self Test.

146 Limit DAC Error
A Limit DAC error was detected during Self Test.

148 Voltage ADC Error
A Voltage ADC error was detected during Self Test.

149 Current ADC Error
A Current ADC error was detected during Self Test.

150 Temperature Error
A Temperature error was detected during Self Test.

151 Measurement Error
The measurement system self test failed.

154 Time-Date Error
The real time clock isn’t reporting a reasonable time & date. Allow the battery backup to recharge, then set the time & date.

Communication Errors

170 Communication Error

A communication error was detected. This is reported if the hardware detects a framing, or parity error in the data stream.

171 Over Run

The input buffer of the remote interface overflowed. All data in both the input and output buffers will be flushed.

Sequencer Errors

180 Sequencer Not Running

The sequencer is not running.

181 Sequence Buffer Overrun

Access past end of program buffer.

184 Bad Program Step

An invalid program step was encountered. See Data Line Error.

185 No Sequence Program Loaded

There is no sequence program in memory.

187 Memory Write Protect

Sequence program cannot be modified while saving to/from Flash/USB.

188 Lockout While Running

This operation cannot be performed while the sequencer is running.

190 Lockout While Running, Not Paused

This function cannot accessed while the sequencer is running and not paused.

191 VI Mismatch Error

The instrument and Sequencer program must have the same source type.

196 Exit Sequencer

This operation cannot be completed unless the sequencer is in the normal mode.

197 Lockout Unless Program Mode

Sequencer must be in program mode to perform this operation.

198 Lockout While Programming

This operation cannot be performed from the program mode.

Other Errors

254 Too Many Errors

The error buffer is full. Subsequent errors have been dropped.

Chapter 6: Service

Self Tests

Self Test checks operation of many important internal components and sub-systems. It is automatically run upon power on. It can also be invoked from the Utility menu or by the <*TST> command. See *Self Test* (page 64) or <*TST> (page 122) for details.

Self Test reports either Test Pass or Test Fail. If the tests fail, error codes are loaded into the Self Test Error Queue. This can be read from the Utility menu or by <LERR?>. See *StErr* (page 65) for details.

In most cases the DC215 will not operate correctly after a failed Self Test. Occasionally a test will fail due to some transient condition, so the first step is to re-run it. Either power cycle the unit or start the Self Test from the front panel or over the computer interface.

See *Troubleshooting* (page **Error! Bookmark not defined.**) for possible solutions to any Self Test failures.

Self Test Error Codes

TABLE 21: SELF TEST ERROR CODES

Code	Name	Description
135	RS-232 Error	A test of the RS-232 failed
136	GPIB Error	A test of the GPIB failed
139	Net Error	A test of the network sub-system failed
140	USB Error	A test of the USB controller failed
141	Front Panel Error	A test of the front panel failed
142	RTC Error	A test of the Reat Time clock failed
143	EEPROM Error	A test of the Flash memory or Serial EEPROM failed
145	Output DAC Error	A test of the Output DAC failed
146	Limit DAC Error	A test of the Limit DAC failed
148	Voltage ADC Error	A test of the Voltage ADC failed
149	Current ADC Error	A test of the Current ADC failed
150	Temperature Error	A test of the Temperature failed
151	Measurement Error	A test of the Measurement sub-system failed
154	Time-Date Error *	The Real time clock didn’t return a reasonable time & date.

* A time-date error is normally not fatal. Allow the battery back up to recharge over a few hours, then set the time and date.

USB Drive Errors

The DC215 USB interface can report the following error messages if there is a problem communicating with the USB drive. These error messages can be cleared by pressing any key.

- **USB diSAb** (USB Disabled): The USB interface is disabled.
- **USB FAIL** (Drive Detection): A USB drive is not detected after several seconds or the detected drive is full.
- **USB Err** (USB Error): After file detection, but prior to <eof> the USB drive cannot be written/read within the expected time. May be caused by write detect or too slow of a drive.
- **File Err** (File Error): The selected file to be read isn't on the drive.
- **dAtA Err** (Data Error): The file being read has an incorrect format without an associated line number.
- **dErr XXX** (Data Error line #): The file being read has an illegal entry on line XXX, where XXX represents the line number of the first data error.
-
- **No Prog** (No Program): There is no sequence file in the DC215 to be saved to USB.
- **TimE Out** (Time Out): The local log buffer cannot be written to the USB before it is overwritten. (This should be Log Error)

Fuse Installation and Line Select

The DC215 operates from 100V, 120V, 220V, or 240V nominal AC power with a line frequency of 50 Hz or 60 Hz. It requires two (2) metric size dual fuses for operation. This section provides detailed instructions for modifying the input voltage selection and changing the line fuse.

Power Entry Module

The line cord receptacle, fuse holder, and line voltage selector are all part of the ”power entry module” located on the rear panel of the DC215.

FIGURE 35: DC215 POWER ENTRY MODULE

AC Voltage Selector

The DC215 line voltage selection is indicated by the white number visible near the top of the power entry module. In the image above, the line voltage selection is showing 120V. Available settings are 100V, 120V, 220V, and 240V.

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

1) Disconnect and remove the power cord.

2) Open the fuse cover using a small blade screwdriver or similar tool, inserted at the point shown.

FIGURE 36: POWER ENTRY MODULE VOLTAGE SELECTOR

3) Insert the tool into the voltage selection slot and remove the selector wheel from the housing.

4) Orient the selector wheel so that the desired line voltage will show through the window.

5) Replace the wheel into the power entry module and close the cover door, ensuring the selected voltage appears in the window.

6) If necessary, replace *both* fuses for the appropriate rating based on line voltage, as described in the following section.

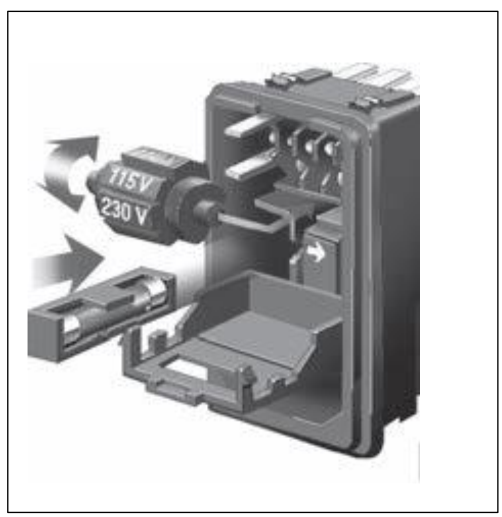

FIGURE 37: CHANGING VOLTAGE SELECTOR

Fuse Installation

The DC215 uses a metric (5 x 20 mm) dual fuse installation. When installing or replacing, be sure to replace both fuses.

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

1) Disconnect and remove the power cord.

2) Open the fuse cover using a small blade screwdriver or similar tool.

3) Insert the tool into the right-hand side of each of the fuse holders, at the locations shown circled below. Gently extract the two fuse holders.

FIGURE 38: FUSE HOLDERS

4) Gently pry the old fuses out of the holders, and insert the new fuses in their place. Be sure to use two (2) metric size 5×20 mm fuses. The fuse should sit in the holder as shown:

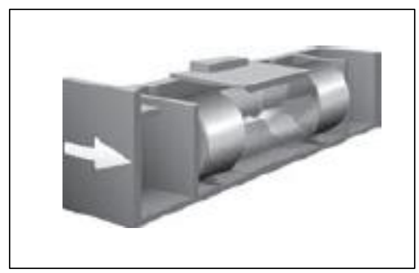

FIGURE 39: FUSE HOLDERS

5) Re-insert the fuse holders into the power entry module, being sure to orient the white arrows as shown on the door. Push the fuse holders all the way into the module.

6) Swing and push to snap the door back in place.