RIGOL

Performance Verification Manual

DP1116A
Programmable Linear DC Power Supply

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RIGOL Technologies, Inc.

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If you have any problem or requirement when using our products or this manual, please contact **RIGOL**.
E-mail: service@rigol.com
Website: www.rigol.com

General Safety Summary

Please review the following safety precautions carefully before putting the instrument into operation so as to avoid any personal injuries or damages to the instrument and any product connected to it. To prevent potential hazards, please use the instrument only specified by this manual.

Use Proper Power Cord.
Only the power cord designed for the instrument and authorized for use within the local country could be used.

Ground The Instrument.
The instrument is grounded through the Protective Earth lead of the power cord. To avoid electric shock, it is essential to connect the earth terminal of power cord to the Protective Earth terminal before any inputs or outputs.

Connect the Probe Correctly.
If a probe is used, do not connect the ground lead to high voltage since it has the isobaric electric potential as ground.

Observe All Terminal Ratings.
To avoid fire or shock hazard, observe all ratings and markers on the instrument and check your manual for more information about ratings before connecting.

Use Proper Overvoltage Protection.
Make sure that no overvoltage (such as that caused by a thunderstorm) can reach the product, or else the operator might expose to danger of electrical shock.

Do Not Operate Without Covers.
Do not operate the instrument with covers or panels removed.

Do Not Insert Anything into the Holes of Fan.
Do not insert anything into the holes of the fan to avoid damaging the instrument.

Use Proper Fuse.
Please use the specified fuses.

Avoid Circuit or Wire Exposure.
Do not touch exposed junctions and components when the unit is powered.

Do Not Operate With Suspected Failures.

If you suspect damage occurs to the instrument, have it inspected by qualified service personnel before further operations. Any maintenance, adjustment or replacement especially to circuits or accessories must be performed by **RIGOL** authorized personnel.

Keep Well Ventilation.

Inadequate ventilation may cause increasing of temperature or damages to the device. So please keep well ventilated and inspect the intake and fan regularly.

Do Not Operate in Wet Conditions.

In order to avoid short circuiting to the interior of the device or electric shock, please do not operate in a humid environment.

Do Not Operate in an Explosive Atmosphere.

In order to avoid damages to the device or personal injuries, it is important to operate the device away from an explosive atmosphere.

Keep Product Surfaces Clean and Dry.

To avoid the influence of dust and/or moisture in air, please keep the surface of device clean and dry.

Electrostatic Prevention.

Operate in an electrostatic discharge protective area environment to avoid damages induced by static discharges. Always ground both the internal and external conductors of the cable to release static before connecting.

Proper Use of Battery.

If a battery is supplied, it must not be exposed to high temperature or in contact with fire. Keep it out of the reach of children. Improper change of battery (note: lithium battery) may cause explosion. Use **RIGOL** specified battery only.

Handling Safety.

Please handle with care during transportation to avoid damages to buttons, knob interfaces and other parts on the panels.

Do Not Provide Power for the Active Load.

In order to avoid the anti-irrigation current which leads to the power control loop out of control and damages the powered device, this power supply can only provide power for the pure load without the current output function.

Allgemeine Sicherheits Informationen

Überprüfen Sie diefolgenden Sicherheitshinweise sorgfältigumPersonenschädenoderSchäden am Gerätundan damit verbundenen weiteren Gerätenzu vermeiden. Zur Vermeidung vonGefahren, nutzen Sie bitte das Gerät nur so, wiein diesem Handbuchangegeben.

Um Feuer oder Verletzungen zu vermeiden, verwenden Sie ein ordnungsgemäßes Netzkabel.
Verwenden Sie für dieses Gerät nur das für ihr Land zugelassene und genehmigte Netzkabel.

Erden des Gerätes.
Das Gerät ist durch den Schutzleiter im Netzkabel geerdet. Um Gefahren durch elektrischen Schlag zu vermeiden, ist es unerlässlich, die Erdung durchzuführen. Erst dann dürfen weitere Ein- oder Ausgänge verbunden werden.

Anschluss einesTastkopfes.
Die Erdungsklemmen der Sonden sindauf dem gleichen Spannungspegel des Instruments geerdet. SchließenSie die Erdungsklemmen an keine hohe Spannung an.

Beachten Sie alle Anschlüsse.
Zur Vermeidung von Feuer oder Stromschlag, beachten Sie alle Bemerkungen und Markierungen auf dem Instrument. Befolgen Sie die Bedienungsanleitung für weitere Informationen, bevor Sie weitere Anschlüsse an das Instrument legen.

Verwenden Sie einen geeigneten Überspannungsschutz.
Stellen Sie sicher, daß keinerlei Überspannung (wie z.B. durch Gewitter verursacht) das Gerät erreichen kann. Andernfallsbestehtfür den Anwender die GefahreinesStromschlages.

Nicht ohne Abdeckung einschalten.
Betreiben Sie das Gerät nicht mit entfernten Gehäuse-Abdeckungen.

Betreiben Sie das Gerät nicht geöffnet.
Der Betrieb mit offenen oder entfernten Gehäuseteilen ist nicht zulässig. Nichts in entsprechende Öffnungen stecken (Lüfter z.B.)

Passende Sicherung verwenden.
Setzen Sie nur die spezifikationsgemäßen Sicherungen ein.

Vermeiden Sie ungeschützte Verbindungen.
Berühren Sie keine unisolierten Verbindungen oder Baugruppen, während das Gerät in Betrieb ist.

Betreiben Sie das Gerät nicht im Fehlerfall.
Wenn Sie am Gerät einen Defekt vermuten, sorgen Sie dafür, bevor Sie das Gerät wieder betreiben, dass eine Untersuchung durch qualifiziertes Kundendienstpersonal durchgeführt wird.Jedwede Wartung, Einstellarbeiten oder Austausch von Teilen am Gerät, sowie am Zubehör dürfen nur von **RIGOL** autorisiertem Personal durchgeführt werden.

Belüftung sicherstellen.
Unzureichende Belüftung kann zu Temperaturanstiegen und somit zu thermischen Schäden am Gerät führen. Stellen Sie deswegen die Belüftung sicher und kontrollieren regelmäßig Lüfter und Belüftungsöffnungen.

Nicht in feuchter Umgebung betreiben.
Zur Vermeidung von Kurzschluß im Geräteinneren und Stromschlag betreiben Sie das Gerät bitte niemals in feuchter Umgebung.

Nicht in explosiver Atmosphäre betreiben.
Zur Vermeidung von Personen- und Sachschäden ist es unumgänglich, das Gerät ausschließlich fernab jedweder explosiven Atmosphäre zu betreiben.

Geräteoberflächen sauber und trocken halten.
Um den Einfluß von Staub und Feuchtigkeit aus der Luft auszuschließen, halten Sie bitte die Geräteoberflächen sauber und trocken.

Schutz gegen elektrostatische Entladung (ESD).
Sorgen Sie für eine elektrostatisch geschützte Umgebung, um somit Schäden und Funktionsstörungen durch ESD zu vermeiden. Erden Sie vor dem Anschluß immer Innen- und Außenleiter der Verbindungsleitung, um statische Aufladung zu entladen.

Die richtige Verwendung desAkku.
Wenneine Batterieverwendet wird, vermeiden Sie hohe Temperaturen bzw. Feuer ausgesetzt werden.Bewahren Sie es außerhalbder Reichweitevon Kindern auf.UnsachgemäßeÄnderung derBatterie(Anmerkung:Lithium-Batterie)kann zu einer Explosion führen. VerwendenSie nur von RIGOLangegebenenAkkus.

Sicherer Transport.
Transportieren Sie das Gerät sorgfältig (Verpackung!), um Schäden an Bedienelementen, Anschlüssen und anderen Teilen zu vermeiden.

Vermeiden Sie das einprägen von Strom und Spannung an den Testklemmen.
Das DP800 Power Supply kann hierdurch zerstört werden, keine akive Last. Das DP800 kann nur Strom und Spannungen leifern.

Document Overview

DP1116A is a single channel programmable DC power supply with up to 160W power and two output scales. This manual introduces the performance verification test methods of DP1116A. The performance verification test mainly verifies whether DP1116A programmable linear DC power supply can work normally and is within specifications.

Main topics of this manual:

Chapter 1 Test Overview
This chapter mainly introduces the test preparations, the recommended test devices and the test precautions.

Chapter 2 Constant Voltage Tests
This chapter introduces the specification test methods of DP1116A under constant voltage (CV) mode.

Chapter 3 Constant Current Tests
This chapter introduces the specification test methods of DP1116A under constant current (CC) mode.

Appendix
A test result record form and DP1116A performance specifications are provided.

Contents

Chapter 1 Test Overview

Topics of this chapter:

- Test Preparations
- Voltage and Current Values
- Recommended Test Devices
- Test Precautions
- Test Result Record

Test Preparations

You need to make the following preparations before performing the performance verification test.

1. Perform self-test to make sure that the instrument can work normally.

   Connect the instrument to AC power supply using the power cord provided with the accessories. Turn on the power switch at the rear panel; then press the power key at the front panel; the instrument starts and performs self-test. If the instrument passes the self-test, the user interface is displayed; otherwise, the self-test error prompt message is displayed. You can press **Utility** → → → **SelfTest** → **Test** to perform self-test after the instrument starts. If the self-test fails, make sure that the problems are found and solved and the instrument passes the self-test before performing the performance verification test.

   Note:
   - Before connecting the power, make sure that the setting of the voltage selector at the rear panel of the power supply matches the AC power supply to be connected. DP1116A supports the following input voltages.
     100: 100 Vac±10%, 50 Hz to 60 Hz, T4 A fuse
     115: 115 Vac±10%, 50 Hz to 60 Hz, T4 A fuse
     220: 220 Vac±10%, 50 Hz to 60 Hz, T2.5 A fuse
     230: 230 Vac±10%, 50 Hz to 60 Hz, T2.5 A fuse
   - Before performing self-test, make sure that there is no connection at the front and rear panel terminals of the power supply.

2. Make sure that the power supply is within the calibration period (1 year). If calibration is required, please contact **RIGOL**.

3. Run the instrument for at least 30 minutes.

4. Make sure that the environment temperature is between 20℃ and 30℃ and the relative humidity is less than 80%.

5. The test connecting wires used should be as short as possible. Before performing the test, press **Sense** to enable the Sense mode.

Note:

The test introduced in this manual should be done by professionals. During the test, there might be dangerous voltage at the output terminal of the power supply and some test devices.

Voltage and Current Values

During the test, you need to set the voltage and current of the output scale of the power supply to specified values. Table 1-1 lists the rated output values and maximum output values of the voltage and current of the two scales.

Table 1-1 Voltage and Current Values of the Two Scales of DP1116A

Scale	Rated Output Voltage	Max Output Voltage	Rated Output Current	Max Output Current
+32V/5A	+32 V	+33.6 V	5 A	5.25 A
+16V/10A	+16 V	+16.8 V	10 A	10.5 A

Recommended Test Devices

Please use the recommended test devices in Table 1-2 to test the performance specifications of DP1116A. If these devices are not present, use devices that fulfill the “Performance Requirement” in the table below instead.

Table 1-2 Recommended Test Devices

Instrument	Performance Requirement	Recommended Instrument	Usage
Digital Oscilloscope	Bandwidth: ≥20MHz Min Vertical Scale: ≤1 mV/div	**RIGOL** DS2202	Measure the ripple and noise Measure the transient response time
Digital Multimeter	Readout Resolution: 5½ bit	**RIGOL** DM3068	Measure the DC voltage
RMS Voltmeter	Sensitivity: 1 mV Bandwidth: ≥10 MHz	Agilent 3458A	Measure the RMS ripple and noise
Electronic Load	Voltage Range: 60 Vdc Current Range: 60 Adc Transient On/Off	Agilent 6060B	Measure the load regulation rate, linear regulation rate and transient response time
AC Power Supply	Regulation rate greater than 1%	Agilent 6811B	--
Resistive Load R_L	--	--	Measure the ripple and noise
Current Sampling Resistor R_M	0.01Ω (Accuracy: 0.1%, temperature drift: 10 ppm)	--	--
Multimeter Test Probe	--	--	--
Probe	--	--	--
USB Cable	USB Device to USB Host, for connecting the power supply and PC	--	Measure the programming accuracy and readback accuracy
Coaxial Cable	--	--	--
Short-circuit Device	2	--	Used to short-circuit the (S+) terminal and (+) terminal, the (S-) terminal and (-) terminal

Test Precautions

The output terminal of the power supply is as shown in Figure 1-1. The output terminal is a metal conductor with certain contact resistance (Δr) and when the output current of the power supply is I, the voltage of this terminal is $Ve = \Delta r \times I$. Therefore, during the test, the voltage test point is always located at A to reduce the error caused by the terminal voltage as far as possible. Besides, the contact resistance between this terminal and the power output wire/the voltage feedback wire inside the instrument chassis can also cause error (about 2 mV, called U_{offset}).

When testing the load regulation rate, voltage peak-peak value and transient response time, the test devices are connected to the output terminal via A and the load resistor is connected to the output terminal via B.

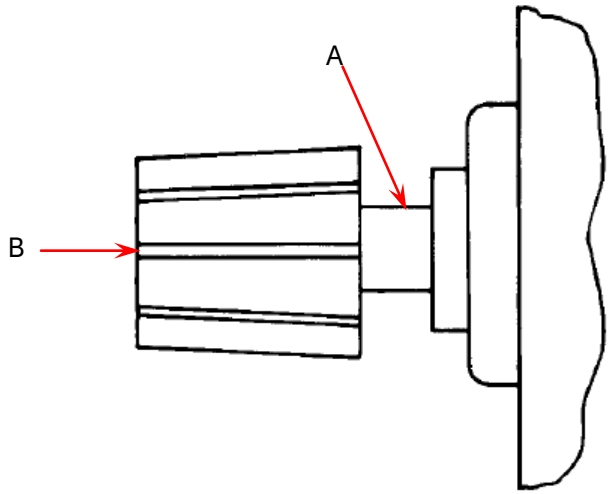


Figure 1-1 Output Terminal

Test Result Record

Record and keep the test result of each test item. A test result record form which provides all the test items and their corresponding performance specification limits as well as spaces for users to record the test results, is provided in Appendix.

Tip:

It is recommended that you photocopy the test results record form before each test and record the test results on the copies so that this form can be used repeatedly.

Chapter 2 Constant Voltage Tests

Topics of this chapter:

- Environmental Preparations
- CV Load Regulation Rate (CV Load Effect)
- CV Linear Regulation Rate (CV Source effect)
- CV Ripple and Noise
- Transient Response Time
- CV Programming and Readback Accuracy

Preparations

When the power supply is in CV state, the main parameters to be tested include the CV load regulation rate, CV linear regulation rate, CV ripple and noise, transient response time, CV programming accuracy and readback accuracy.

Before performing the tests, select the appropriate voltage via the “voltage selector” at the rear panel of the power supply according to the AC line voltage of the country (220 will be selected in all the tests in this guide). Under normal temperature (about 25℃), make connections according to the figure below using the devices recommended in “**Recommended Test Devices**”. During the test, please set the voltage of the AC power supply according to the voltage setting selected.

Note:
During the test, if two multimeters or a multimeter and an oscilloscope need to be connected to the power supply, please connect the two instruments to the (+) terminal and (-) terminal of the output terminal of the power supply respectively using separate connecting wires to avoid coupling effect. It is recommended to use coaxial cable or shielded two-wire cable to avoid causing noise.

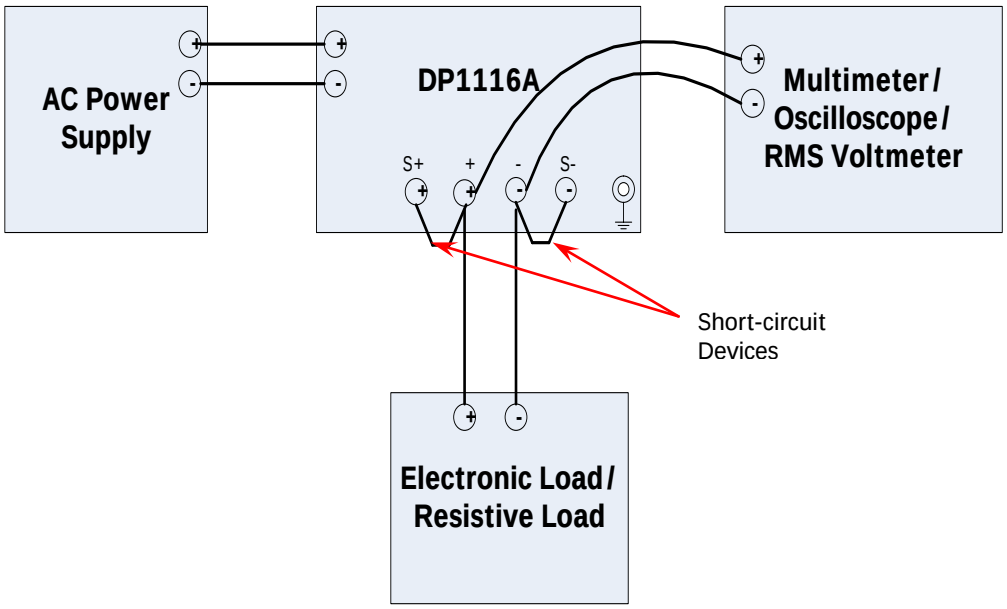


Figure 2-1 Test Connections (CV)

Explanation:

The short-circuit devices in Figure 2-1 are used to short-circuit the (S+) terminal and (+) terminal as well as the (S-) terminal and (-) terminal respectively. Before performing the test, press **Sense** to enable the Sense mode. The performance test measures the specifications under Sense mode (with short-circuit devices).

CV Load Regulation Rate (CV Load Effect)

CV load regulation rate refers to the variation of output voltage when the load changes from full load to no load while the power supply is in CV mode. In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Load Regulation Rate, ±(Output Percentage+Offset)	
Voltage	< 0.01% + 2 mV

Test Procedures:

1. Turn off DP1116A. Connect DP1116A, AC power supply, electronic load and multimeter according to Figure 2-1.

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage and current of the scale to be tested according to Table 2-1. Press **On/Off** to enable the output of the power supply.

4. Turn on the electronic load. Adjust the current of the electronic load to 0 A or do not connect any load device (no load).

5. Turn on the digital multimeter and select DC voltage measurement function. Make sure that the power supply is in CV mode. Read and record the current reading (U_0) of the multimeter.

6. Adjust the electronic load to make the load current equal the rated output current of the scale under test. Make sure that the power supply is in CV mode and record the reading (U_1) of the multimeter.

7. Calculate the voltage variation (namely the CV load effect, $|U_1 - U_0|$) and campare it with the specification.

8. Turn off the output of the power supply. Press **32V/5A** at the front panel and set the voltage and current of the scale to be tested according to Table 2-1. Press **On/Off** to enable the output of the power supply.

9. Repeat steps 4 to 7 to test the CV load regulation rate at 32V/5A scale.

Test Record Form:

Table 2-1 CV Load Regulation Rate Record Form

Scale		16V/10A	32V/5A
Specification		<0.01%*Volt+2 mV=3.6 mV	<0.01%*Volt+2 mV=5.2 mV
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Measurement Value	U_0		
	U_1		
	$\|U_1 - U_0\|$		

CV Linear Regulation Rate (CV Source effect)

CV linear regulation rate refers to the variation of output volatage when the input power changes while the power supply is in CV mode. In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Linear Regulation Rate, ±(Output Percentage+Offset)	
Voltage	< 0.01% + 2 mV

Test Procedures:

1. Turn off DP1116A. Connect DP1116A, AC power supply, electronic load and multimeter according to Figure 2-1. Set the voltage selector (100, 115, 220 or 230) at the rear panel of the power supply according to your need and make sure that the fuse currently installed matches the input voltage. As the voltage test methods of the four specifications are the same, 220 is taken as an example for illustration.

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage and current of the scale to be tested according to Table 2-2. Press **On/Off** to enable the output of the power supply.

4. Turn on the electronic load. Adjust the electronic load to make the load current equal the rated output current of the scale under test.

5. Turn on the digital multimeter and select DC voltage measurement function. Make sure that the power supply is in CV mode. Read and record the current reading (U_0) of the multimeter.

6. Adjust the AC power supply to undervoltage state (namely the amplitude reduces by 10%, refer to Table 2-2); read and record the current reading (U_1) of the multimeter. Adjust the AC power supply to overvoltage state (namely the amplitude increases by 10%, refer to Table 2-2); read and record the current reading (U_2) of the multimeter.

7. Calculate the voltage variations ($|U_1 - U_0|$ and $|U_2 - U_0|$) and compare them with the specification.

8. Turn off the output of the power supply. Press **32V/5A** at the front panel and set the voltage and current of the scale to be tested according to Table 2-2. Press **On/Off** to enable the output of the power supply.

9. Repeat steps 4 to 7 to test the CV linear regulation rate at 32V/5A scale.

Test Record Form:

Table 2-2 CV Linear Regulation rate Test Record Form

Scale		16V/10A				32V/5A			
Specification		<0.01%*Volt+2 mV=3.6 mV				<0.01%*Volt+2 mV=5.2 mV			
DP1116A Setting	Volt (V)	16				32			
	Current (A)	10.5				5.25			
	Voltage Selector	100	115	220	230	100	115	220	230
	Fuse	T4 A		T2.5 A		T4 A		T2.5 A	
AC Power Supply Setting	Undervoltage (Vac)	90	103	198	207	90	103	198	207
	Overvoltage (Vac)	110	127	242	253	110	127	242	253
Measurement Value	U_0								
	U_1								
	U_2								
	$\lvert U_1 - U_0 \rvert$								
	$\lvert U_2 - U_0 \rvert$								

CV Ripple and Noise

Periodic and random deviations (PARD) in the output combine to produce a residual AC voltage superimposed on the DC output voltage when the power supply is operating in CV mode. This residual AC voltage, namely the ripple and noise (usually, ripple is periodic offset while noise is random offset) can be expressed in RMS or peak-to-peak value form. In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

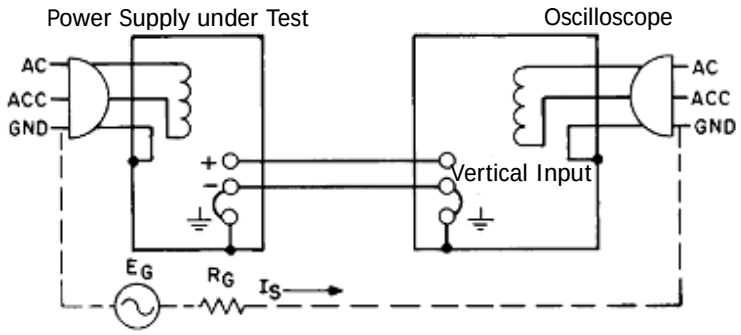
Ripple and Noise (20 Hz to 20 MHz)	
Normal Mode Voltage	< 350 μV rms/3 mVpp

Test Procedures:

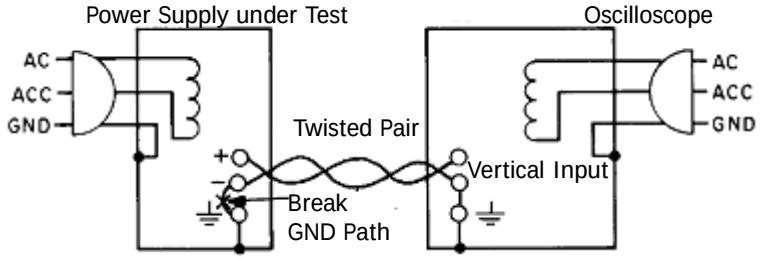
1. Turn off DP1116A. Connect DP1116A, AC power supply and oscilloscope (connect the positive terminal of the oscilloscope probe to the positive terminal of the output scale of the power supply, connect the ground terminal of the oscilloscope probe to the negative terminal of the output scale of the power supply. Note that you are recommended to use ground spring as ground wire so as to minimize the current coupling area between the probe tip and the ground wire and to minimize the space radiation interference.) according to Figure 2-1.

Note:

- Do not connect the negative terminal of the output terminal to the shielding ground; otherwise, a ground loop would be formed. The A connection in Figure 2-2 forms a ground loop while B connection is correct.
- Use resistive load instead of electronic load to avoid affecting the noise measurement of the power supply by the electronic load noise.



A. Incorrect Connection



B. Correct Connection

Figure 2-2 Peak-peak Value Measurement Connections

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage of the scale to be tested to the rated output value and the current to the maximum output value by referring to Table 2-3. Press **On/Off** to enable the output of the power supply.

4. Set the oscilloscope: set the timebase to 5 ms/div, the vertical scale to 2 mV, the sample mode to peak detect, the coupling mode to AC and the input impedance to 1 MΩ; turn on the 20 MHz bandwidth limit. Enable the peak-peak value measurement function of the oscilloscope. Make sure that the power supply is in CV mode. Read and record the peak-peak value (Vpp) measured by the oscilloscope.

5. Disconnect the oscilloscope and connect the RMS voltmeter according to Figure 2-1. Note that the measurement wires of the voltmeter should be twisted together to minimize the effect of the space radiation noise on the test. Make sure that the power supply is in CV mode. Read and record the Vrms measured.

6. Press **32V/5A** at the front panel and repeat steps 1 to 5 to test the ripple and noise at 32V/5A scale.

Test Record Form:

Table 2-3 CV Ripple and Noise Test Record Form

Scale		16V/10A	32V/5A
Specification		< 350 μV rms/3 mVpp	
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Measurement Value	Vpp		
	Vrms		

Transient Response Time

Transient response time refers to the time required for the output voltage of the power supply to recover to within 15 mV following a transient variation in the load current (50% transient variation, the output current changes from full load to half load or vice versa). As shown in Figure 2-3, **t** is the transient response time. In the following section, the transient response times at 16V/10A scale and 32V/5A scale are tested.

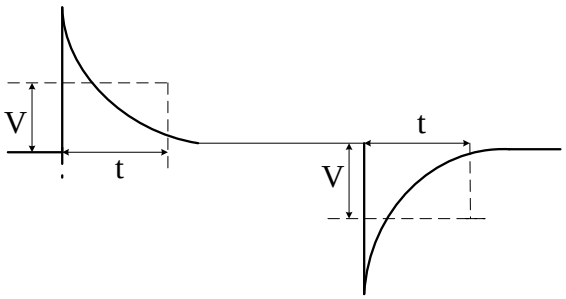


Figure 2-3 Transient Response Time

Specification:

Transient Response Time
Less than 50 μs for output voltage to recover to within 15 mV following a change in output current from full load to half load or vice versa.

Test Procedures:

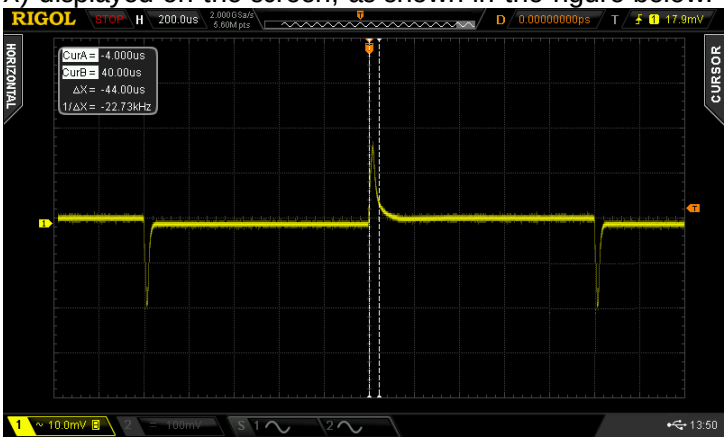
1. Turn off DP1116A. Connect DP1116A, AC power supply, electronic load and oscilloscope according to Figure 2-1. Make sure that the programmable electronic load is in CC mode.

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage and current of the scale to be tested according to Table 2-4. Press **On/Off** to enable the output of the power supply.

4. Set the parameters of the electronic load:
   Dynamic response mode; rising edge and falling edge time: 250 mA/us; frequency: 1 kHz; duty cycle: 50%; two current values: High Level is the rated output current and Low Level is the half-load current of the scale to be tested (refer to Table 2-4). Turn on the electronic load.

5. Set the oscilloscope to AC coupling mode and set the bandwidth limit to 20 MHz. Enable the cursor measurement function and measure the value of t (namely ΔX) displayed on the screen, as shown in the figure below.



6. Press **32V/5A** at the front panel and repeat steps 1 to 5 to test the transient response time at 32V/5A scale.

Test Record Form:

Table 2-4 Transient Response Time Test Record Form

Scale		16V/10A	32V/5A
Specification		<50 μs	
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Electronic Load Current (A)	High Level	10	5
	Low Level	5	2.5
Measurement Value	t		

CV Programming and Readback Accuracy

In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Annual Accuracy [1] (25℃±5℃) ±(Output Percentage+Offset)	
Programming	0.05% + 10 mV
Readback	0.05% + 5 mV
Note[1]: The accuracy parameters are acquired via calibration under 25℃ after 1-hour warm-up.	

Test Procedures:

1. Turn off DP1116A. Connect DP1116A, AC power supply and multimeter according to Figure 2-1 and use USB cable to connect the power supply and PC.

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Measure the CV programming accuracy and readback accuracy when the voltage is 0V.
   1) Turn on DP1116A. Send commands via the remote interface to select the scale to be tested, set the voltage and current of the scale to be tested (refer to Table 2-5) as well as enable the output. Here, the 16V/10A scale is taken as an example.
      OUTPut:RANGe 16 (command 1)
      APPLy 0,10.5 (command 2)
      OUTPut:STATe ON (command 3)

   2) Turn on the digital multimeter and select the DC voltage measurement function. Make sure that the power supply is in CV mode. Read and record the current reading (U_1) of the multimeter.

   3) Send the MEASure:VOLTage? command via the remote interface (USB, LAN or GPIB). Read and record the returned voltage (U_2).

   4) Calculate the programming accuracy: $|U_1-0|$; calculate the readback accuracy: $|U_2-0|$.

4. Measure the CV programming accuracy and readback accuracy when the voltage is the rated output value.
   1) Turn on DP1116A. Send commands via the remote interface to set the

voltage and current of the scale under test (refer to Table 2-5).
OUTPut:RANGe 16V (command 1)
APPLy 16,10.5 (command 2)
OUTPut:STATe ON (command 3)

2) Make sure that the power supply is in CV mode. Read and record the current reading (U_3) of the multimeter.

3) Send the MEASure:VOLTage? command via the remote interface (USB, LAN or GPIB). Read and record the retuned voltage (U_4).

4) Calculate the programming accuracy: |U_3-rated output voltage of the scale under test|;
Calculate the readback accuracy: |U_4-rated output voltage of the scale under test|.

5. Press **32V/5A** at the front panel and repeat steps 1 to 4 to test the programming and readback accuracy at 32V/5A scale. The commands in step 3 and step 4 need to be replaced by the following commands respectively.
OUTPut:RANGe 32V
APPLy 0,5.25
OUTPut:STATe ON
and
OUTPut:RANGe 32V
APPLy 32,5.25
OUTPut:STATe ON

Test Record Form:

Table 2-5 CV Programming and Readback Accuracy Test Record Form

Scale		+16V/10A	+32V/5A
Specification		Programming: 0.05%*Volt+ 10 mV=18 mV Readback: 0.05%*Volt+ 5 mV=13 mV	Programming: 0.05%*Volt+ 10 mV=26 mV Readback: 0.05%*Volt+ 5 mV=21 mV
Output voltage is 0			
DP1116A Setting	Volt (V)	0	0
	Current (A)	10.5	5.25
Measurement Value Test Result	U_1		
	U_2		
	Programming Accuracy: $\|U_1-0\|$		
	Readback Accuracy: $\|U_2-0\|$		
Output voltage is the rated output voltage			
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Measurement Value Test Result	U_3		
	U_4		
	Programming Accuracy: $\|U_3$-rated output voltage of the scale under test$\|$		
	Readback Accuracy: $\|U_4$-rated output voltage of the scale under test$\|$		

Chapter 3 Constant Current Tests

Topics of this chapter:

- Environmental Preparations
- CC Load Regulation Rate (CC Load Effect)
- CC Linear Regulation Rate (CC Source Effect)
- CC Ripple and Noise (Normal Mode)
- CC Programming and Readback Accuracy

Preparations

When the power supply is in CC mode, the main parameters to be tested include CC load regulation rate, CC linear regulation rate, ripple and noise, programming accuracy and readback accuracy.

Under normal temperature (about 25℃), make connections according to the figure below using the devices recommended in "**Recommended Test Devices**". Before performing the tests, press **Sense** to enable the Sense mode. Note that a current sampling resistor (R_M=0.01 Ω) should be connected between the power supply under test and the electronic load serially to convert the current signal under test to voltage signal for the measurement of related parameters.

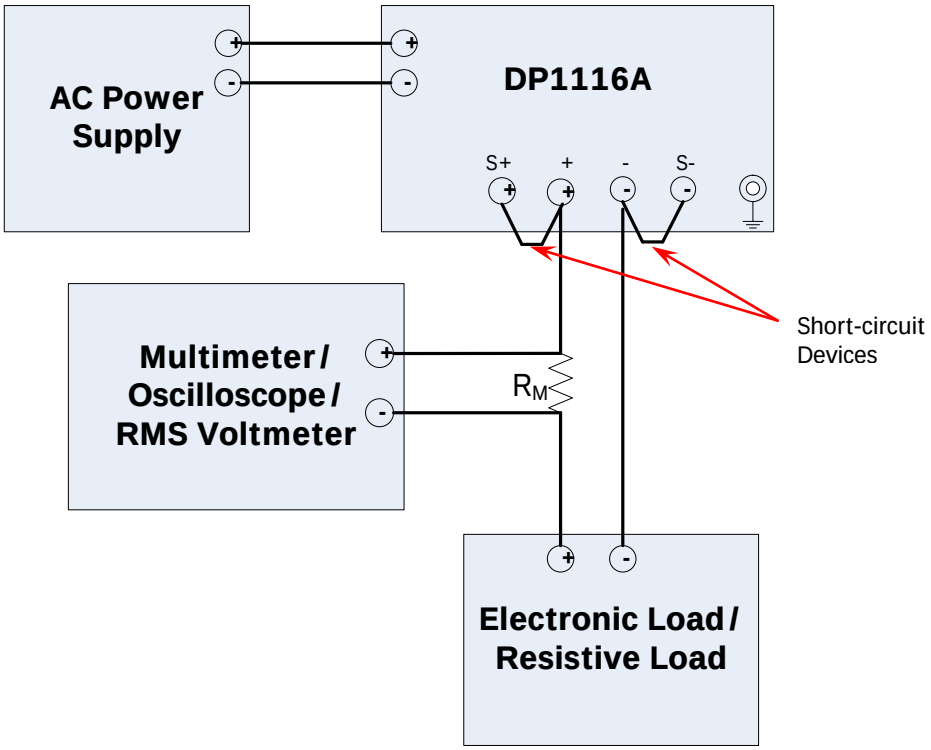


Figure 3-1 Test Connections (CC)

Note:
The R_M in the figure above is a 0.01 Ω 4-wire current sampling resistor. As shown in Figure 3-2, C represents the current measurement terminal and S represents the voltage measurement terminal. During the test, please make correct connections.

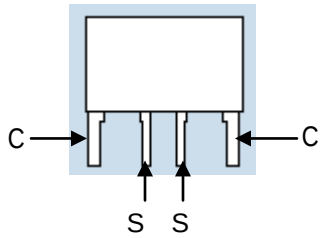


Figure 3-2 4-wire Current Sampling Resistor

CC Load Regulation Rate (CC Load Effect)

CC load regulation rate refers to the variation of output current when the load changes from full load to no load while the power supply is in CC mode. In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Load Regulation Rate, ±(Output Percentage+Offset)	
Current	< 0.005% + 250 μA

Test Procedures:

1. Turn off DP1116A. Connect DP1116A, AC power supply, current sampling resistor, electronic load and multimeter according to Figure 3-1.

2. Turn on the AC power supply and set its voltage to 220 V. Set the electronic load to short-circuit mode. At this point, the power supply scale to be tested is in CC mode.
   Note: the voltage of the AC power set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A

3. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage and current of the scale to be tested according to Table 3-1. Press **On/Off** to enable the output of the power supply.

4. Turn on the digital multimeter and select the DC voltage measurement function. Make sure that the power supply is in CC mode. Read the current reading (U_0, namely the voltage of the current sampling resistor) of the multimeter.

5. Adjust the electronic load to make it work in CV mode and adjust its voltage to make it approximate the rated output voltage of the scale under test. At this point, the power supply scale under test is still in CC mode and is near full load output. Read the current reading (U_1, namely the voltage of the current sampling resistor) of the multimeter.

6. Calculate the current variation $|U_1/R_M - U_0/R_M|$ and compare it with the specification.

7. Press **32V/5A** at the front panel and repeat steps 1 to 6 to test the CC load regulation rate at 32V/5A scale.

Test Record Form:

Table 3-1 CC Load Regulation Rate Test Record Form

Scale		16V/10A	32V/5A
Specification		<0.005%*Current+250 μA =750 μA	<0.005%*Current+250 μA=500 μA
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	10	5
Measurement Value	U_0		
	U_1		
	$\lvert U_1/R - U_0/R \rvert$		

CC Linear Regulation Rate (CC Source Effect)

CC linear regulation rate refers to the variation of output current when the input power changes while the power supply is in CC mode. In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Linear Regulation Rate, ±(Output Percentage+Offset)	
Current	< 0.01% + 250 μA

Test Procedures:

1. Turn off DP1116A. Connect the power supply, AC power supply, current sampling resistor, electronic load and multimeter according to Figure 3-1. Set the voltage selector (100, 115, 220 or 230) at the rear panel of DP1116A according to your need and make sure that the fuse currently installed matches the input voltage. As the voltage test methods of the four specifications are the same, 220 is taken as an example for illustration.

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage and current of the scale to be tested according to Table 3-2. Press **On/Off** to enable the output of the power supply.

4. Turn on the electric load. Set the electronic load to CV mode. Adjust its voltage to make it approximate the rated output voltage of the power supply scale under test and make sure that the power supply scale under test is still in CC mode.

5. Turn on the digital multimeter and select the DC voltage measurement function. Read and record the current reading (U_0, namely the voltage of the current sampling resistor) of the multimeter.

6. Adjust the AC power supply to undervoltgae state (namely the amplitude reduces by 10%, refer to Table 3-2); read and record the current reading (U_1) of the multimeter. Adjust the AC power supply to overvoltage state (namely the amplitude increases by 10%, refer to Table 3-2); read and record the current reading (U_2) of the multimeter.

7. Calculate the current variations $|U_1 - U_0|/R_M$ and $|U_2 - U_0|/R_M$ and compare them with the specification.

8. Turn off the output of the power supply. Press **32V/5A** at the front panel and set the voltage and current of the scale to be tested according to Table 3-2. Press **On/Off** to enable the output of the power supply.

9. Repeat steps 4 to 7 to test the CC linear regulation rate at 32V/5A scale.

Test Record Form:

Table 3-2 CC Linear Regulation Rate Test Record Form

Scale		16V/10A				32V/5A			
Specification		<0.01%*Current+250 μA =1.25 mA				<0.01%*Current+250 μA =0.75 mA			
DP1116A Setting	Volt (V)	16.8				33.6			
	Current (A)	10				5			
	Voltage Selector	100	115	220	230	100	115	220	230
	Fuse	T4 A		T2.5 A		T4 A		T2.5 A	
AC Power Supply Setting	Undervoltage (Vac)	90	103	198	207	90	103	198	207
	Overvoltage (Vac)	110	127	242	253	110	127	242	253
Measurement Value	U_0								
	U_1								
	U_2								
	$\lvert U_1 - U_0 \rvert / R_M$								
	$\lvert U_2 - U_0 \rvert / R_M$								

CC Ripple and Noise (Normal Mode)

The current ripple and noise are usually expressed in RMS form. In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Ripple and Noise (20 Hz to 20 MHz)	
Normal Mode Current	< 2 mA rms

Test Procedures:

1. Turn off DP1116A. Connect DP1116A, AC power supply, current sampling resistor and RMS voltmeter according to Figure 3-1.

2. Connect the RMS voltmeter across the current sampling resistor.

3. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

4. Turn on DP1116A. Press **16V/10A** at the front panel to set the scale to be tested to 16V/10A. Set the voltage and current of the scale to be tested according to Table 3-3. Press **On/Off** to enable the output of the power supply.

5. Turn on the RMS voltmeter and select ACV measurement mode. Make sure that the power supply is in CC mode and measure the RMS voltage (V_{rms}) on the current sampling resistor.

6. Calculate the CC ripple and noise ($Vrms/R_M$).

7. Press **32V/5A** at the front panel and repeat steps 1 to 6 to test the ripple and noise at 32V/5A scale.

Test Record Form:

Table 3-3 CC Ripples and Noise Test Record Form

Scale		16V/10A	32V/5A
Specification		< 2 mA rms	
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	10	5
Measurement Value	Vrms		
	$Vrms/R_M$		

CC Programming and Readback Accuracy

In the following section, the specifications at 16V/10A scale and 32V/5A scale are tested.

Specification:

Annual Accuracy [1] (25℃±5℃) ±(Output Percentage+Offset)	
Programming	0.2% + 10 mA
Readback	0.15% + 5 mA
Note[1]: The accuracy parameters are acquired via calibration under 25℃ after 1-hour warm-up.	

Test Procedures:

1. Turn off DP1116A. Connect DP1116A, AC power supply, current sampling resistor (0.01 Ω) and multimeter according to Figure 3-1 and use USB cable to connect the power supply and PC.

2. Turn on the AC power supply and set its voltage to 220 V.
   Note: the value set in this step should be accordance with the value selected by the voltage selector in the rear panel of DP1116A.

3. Measure the programming and readback accuracy when the current is 0 A.
   1) Turn on DP1116A. Send commands via the remote interface to select the scale to be tested, set the voltage and current of the scale to be tested (refer to Table 3-4) as well as enable the output. Here, the 16V/10A scale is taken as an example.
      OUTPut:RANGe 16V (command 1)
      APPLy 16.8,0 (command 2)
      OUTPut:STATe ON (command 3)

   2) Turn on the digital multimeter and select the DC voltage measurement function. Make sure that the power supply is in CC mode. Read and record the current reading (U_1) of the multimeter. Calculate the current $I_1=U_1/R_M$.

   3) Send the MEASure:CURRent? command via the remote interface. Read and record the returned current I_2.

   4) Calculate the programming accuracy: $|I_1-0|$;
      Calculate the readback accuracy: $|I_2-0|$.

4. Measure the programming and readback accuracy when the current is the rated output value.
   1) Turn on DP1116A. Send commands via the remote interface to set the

voltage and current of the scale under test (refer to Table 3-4).

OUTPut:RANGe 16V (command 1)
APPLy 16.8,10 (command 2)
OUTPut:STATe ON (command 3)

2) The electronic load is still in short-circuit mode. Make sure that the power supply is in CC mode. Read and record the measurement value (U_3) of the multimeter. Calculate the current $I_3=U_3/R_M$.

3) Send the MEASure:CURRent? command via the remote interface. Read and record the returned current (I_4).

4) Calculate the programming accuracy: $|I_3$-rated output current of the scale under test|;
Calculate the readback accuracy: $|I_4$-rated output current of the scale under test|.

5. Press **32V/5A** at the front panel and repeat steps 1 to 4 to test the programming and readback accuracy at 32V/5A scale. The commands in step 3 and step 4 should be replaced by the following commands respectively.

OUTPut:RANGe 32V
APPLy 33.6,0
OUTPut:STATe ON
and
OUTPut:RANGe 32V
APPLy 33.6,5
OUTPut:STATe ON

Test Record Form:

Table 3-4 CC Programming and Readback Accuracy Test Record Form

Scale		+16V/10A	+32V/5A
Specification		Programming: 0.2%*Current+ 10 mA=30 mA Readback: 0.15%*Current+ 5 mA=20 mA	Programming: 0.2%*Current+ 10 mA=20 mA Readback: 0.15%*Current+ 5 mA=12.5 mA
Output current is 0			
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	0	0
Measurement Value	U_1		
	$I_1=U_1/R_M$		
	I_2		
	Programming Accuracy: $\|I_1-0\|$		
	Readback Accuracy: $\|I_2-0\|$		
Output current is the rated output value			
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	10	5
Measurement Value	U_3		
	$I_3=U_3/R_M$		
	I_4		
	Programming Accuracy: $\|I_3$-rated output current of the scale under test$\|$		
	Readback Accuracy: $\|I_4$-rated output current of the scale under test$\|$		

Appendix

Appendix A: Test Result Record Form

RIGOL DP1116A Series Programmable Linear DC Power Supply
Performance Verification Test Record Form

CV Load Regulation Rate Test Record Form

Scale		16V/10A	32V/5A
Specification		<0.01%*Volt+2 mV=3.6 mV	<0.01%*Volt+2 mV=5.2 mV
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Measurement Value	U_0		
	U_1		
	$\|U_1 - U_0\|$		

CV Linear Regulation Rate Test Record Form

Scale		16V/10A				32V/5A			
Specification		<0.01%*Volt+2 mV=3.6 mV				<0.01%*Volt+2 mV=5.2 mV			
DP1116A Setting	Volt (V)	16				32			
	Current (A)	10.5				5.25			
	Voltage Selector	100	115	220	230	100	115	220	230
	Fuse	T4 A		T2.5 A		T4 A		T2.5 A	
AC Power Supply Setting	Undervoltage (Vac)	90	103	198	207	90	103	198	207
	Overvoltage (Vac)	110	127	242	253	110	127	242	253
Measurement Value	U_0								
	U_1								
	U_2								
	$\|U_1 - U_0\|$								
	$\|U_2 - U_0\|$								

CV Ripple and Noise Test Record Form

Scale		16V/10A	32V/5A
Specification		< 350 μV rms/3 mVpp	
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Measurement Value	Vpp		
	Vrms		

Transient Response Time Test Record Form

Scale		16V/10A	32V/5A
Specification		<50 μs	
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Electronic Load Current (A)	High Level	10	5
	Low Level	5	2.5
Measurement Value	t		

CV Programming and Readback Accuracy Test Record Form

Scale		**+16V/10A**	**+32V/5A**
Specification		Programming: 0.05%*Volt+ 10 mV=18 mV Readback: 0.05%*Volt+ 5 mV=13 mV	Programming: 0.05%*Volt+ 10 mV=26 mV Readback: 0.05%*Volt+ 5 mV=21 mV
Output voltage is 0			
DP1116A Setting	Volt (V)	0	0
	Current (A)	10.5	5.25
Measurement Value Test Result	U_1		
	U_2		
	Programming Accuracy: |U1-0|		
	Readback Accuracy: |U_2-0|		
Output voltage is the rated output value			
DP1116A Setting	Volt (V)	16	32
	Current (A)	10.5	5.25
Measurement Value Test Result	U_3		
	U_4		
	Programming Accuracy: |U_3-rated output voltage of the scale under test|		
	Readback Accuracy: |U_4-rated output voltage of the scale under test|		

CC Load Regulation Test Record Form

Scale		16V/10A	32V/5A
Specification		<0.005%*Current+250 μA =750 μA	<0.005%*Current+250 μA=500 μA
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	10	5
Measurement Value	U_0		
	U_1		
	|U_1/R - U_0/R|		

CC Linear Regulation Rate Test Record Form

Scale		16V/10A				32V/5A			
Specification		<0.01%*Current+250 μA =1.25 mA				<0.01%*Current+250 μA =0.75 mA			
DP1116A Setting	Volt (V)	16.8				33.6			
	Current (A)	10				5			
	Voltage Selector	100	115	220	230	100	115	220	230
	Fuse	T4 A		T2.5 A		T4 A		T2.5 A	
AC Power Supply Setting	Undervoltage (Vac)	90	103	198	207	90	103	198	207
	Overvoltage (Vac)	110	127	242	253	110	127	242	253
Measurement Value	U_0								
	U_1								
	U_2								
	$\lvert U_1 - U_0 \rvert / R_M$								
	$\lvert U_2 - U_0 \rvert / R_M$								

CC Ripple and Noise Test Record Form

Scale		16V/10A	32V/5A
Specification		< 2 mA rms	
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	10	5
Measurement Value	Vrms		
	$Vrms/R_M$		

CC Programming and Readback Accuracy Test Record Form

Scale		**+16V/10A**	**+32V/5A**
Specification		Programming: 0.2%*Current+ 10 mA=30 mA Readback: 0.15%*Current+ 5 mA=20 mA	Programming: 0.2%*Current+ 10 mA=20 mA Readback: 0.15%*Current+ 5 mA=12.5 mA
Output current is 0			
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	0	0
Measurement Value	U_1		
	$I_1=U_1/R_M$		
	I_2		
	Programming Accuracy: $\|I_1-0\|$		
	Readback Accuracy: $\|I_2-0\|$		
Output current is the rated output value			
DP1116A Setting	Volt (V)	16.8	33.6
	Current (A)	10	5
Measurement Value	U_3		
	$I_3=U_3/R_M$		
	I_4		
	Programming Accuracy: $\|I_3$-rated output current of the scale under test|		
	Readback Accuracy: $\|I_4$-rated output current of the scale under test|		

Appendix B: Specifications

The following parameters can only be guaranteed when the instrument has been operated continuously for more than 30 minutes under the specified operating temperature.

Note: All the specifications below apply to both the **16V/10A** and **32V/5A** scales unless otherwise noted.

Model		DP1116A	
Output Scale		16 V/10 A	32 V/5 A
Rated DC Output (0℃ to 40℃)			
Voltage		0 to 16 V	0 to 32 V
Current		0 to 10 A	0 to 5 A
Overvoltage Protection		0.1 V to 35.2 V	
Overcurrent Protection		0 .1 A to 11 A	
Load Regulation rate, ±(Output Percentage+Offset)			
Voltage		< 0.01% + 2 mV	
Current		< 0.005% + 250 μA	
Linear Regulation Rate, ±(Output Percentage+Offset)			
Voltage		< 0.01% + 2 mV	
Current		< 0.01% + 250 μA	
Ripple and Noise (20 Hz to 20 MHz)			
Normal Mode Voltage		< 350 μV rms/3 mVpp	
Normal Mode Current		< 2 mA rms	
Annual Accuracy [1] (25℃±5℃) ±(Output Percentage+Offset)			
Programming	Voltage	0.05% + 10 mV	
	Current	0.2% + 10 mA	
Readback	Voltage	0.05% + 5 mV	
	Current	0.15% + 5 mA	
Resolution			
Programming	1 mV/1 mA		
Readback	1 mV/1 mA		
Meter	1 mV/1 mA		
Transient Response Time			
Less than 50 μs for output voltage to recover to within 15 mV following a change in output current from full load to half load or vice versa.			
Remote Sense (Sense)			
The maximum voltage drop on the load wire that each Sense lead can compensate for is 1 V.			
Command Processing Time [2]			
< 50 ms			
Temperature Coefficient, ±(Output Percentage+Offset) (The maximum variation of the output/readback per 1℃ temperature variation after 30-minute warm-up)			
Voltage		0.01% + 3 mV	
Current		0.02% + 3 mA	
Stability [3], ±(Output Percentage+Offset)			
Voltage		0.02% + 1 mV	
Current		0.1% + 1 mA	

Voltage Programming Control Speed (1% within the total variation range)		
Rise	Full Load	50 ms
	No Load	20 ms
Fall	Full Load	45 ms
	No Load	400 ms
OVP/OCP		
Accuracy ±(Output Percentage+Offset)		0.5% + 0.5 V/0.5% + 0.5 A
Activation Time		1.5 ms (OVP ≥ 3 V); < 10 ms (OVP < 3 V) < 10 ms (OCP)
Mechanical		
Dimensions		235 mm(W) x 155 mm(H) x 384 mm(D)
Weight		11 kg
Power		
AC Input (50Hz to 60Hz)		100 Vac ± 10%, 115 Vac ± 10% 220 Vac ± 10%, 230 Vac ± 10%
Environment		
Working Temperature		Full Rated Value Output: 0℃ to 40℃ Under Relatively Higher Temperature: the linearity of the output current reduces to 50% at the highest temperature 55℃
Cooling Method		Fan Cooling
Conformity		CE, cTUVus

Note[1]: The accuracy parameters are acquired via calibration under 25℃ after 1-hour warm-up.

Note[2]: The maximum time required for the output to change accordingly after receiving the APPLy and SOURce commands.

Note[3]: The variation of the output within 8 hours after 30-minute warm-up when the load circuit and environment temperature are constant.