AC/DC Resistance Standard

DRR-112

Operator's Manual

www.dtminstruments.com

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Introduction

The AC/DC resistance standard DRR-112 is used to calibrate resistance meters with an accuracy of 1000ppm or better. It contains eleven inductance-free, highly stable and accurate resistors, which can be selected with a dial switch at the front panel.

It is especially designed to calibrate AC earth resistance meters, but it can be used to test and calibrate all types of DC and AC resistance meters with an AC test frequency of up to 100kHz and a test power of up to 10 Watts.

For maximum accuracy, the DRR-112 offers four shielded terminals. Shielded and unshielded measurements with four-, three- and two-wire connections can be performed. A built-in guard amplifier can be used for measurements of up to 100kHz.

Content of delivery

- One AC/DC resistance standard DRR-112
- One switched mode power supply 12V/0.5A
- One RG-58/U BNC cable, 1ft.
- Operator's manual
- Calibration certificate

Table of Contents

1.Safety instructions

1.1.Grounding

Grounding is not required for the operation of the AC/DC resistance standard DRR-112. Nevertheless, it is strongly recommended to ground the housing via the grounding post to protect the operator from dangerous voltages, which might be created by faulty equipment.

1.2.Maximum voltage and current values

- maximum voltage: **100V**
- maximum current: **0.5 A**
- maximum power dissipation per resistor: **10 W**

The values in the following table are derived from the above limits:

Selected Resistor	***Max. Current***	***Max. Voltage***	***Dissipated Power***
1 Ω	**500 mA**	0.5 V	*0.25 W*
5 Ω	**500 mA**	2.5 V	*1.25 W*
10 Ω	**500 mA**	5 V	*2.5 W*
50 Ω	**447 mA**	**22.3 V**	*10 W*
100 Ω	**316 mA**	**31.6 V**	*10 W*
500 Ω	**141 mA**	**70.7 V**	*10 W*
1,000 Ω	**100 mA**	**100 V**	*10 W*
1,500 Ω	66.7 mA	**100 V**	*6.7 W*
1,900 Ω	52.6 mA	**100 V**	*5.3 W*
10,000 Ω	10.0 mA	**100 V**	*1.0 W*
18,000 Ω	5.6 mA	**100 V**	*0.56 W*

2.Operation of the DRR-112

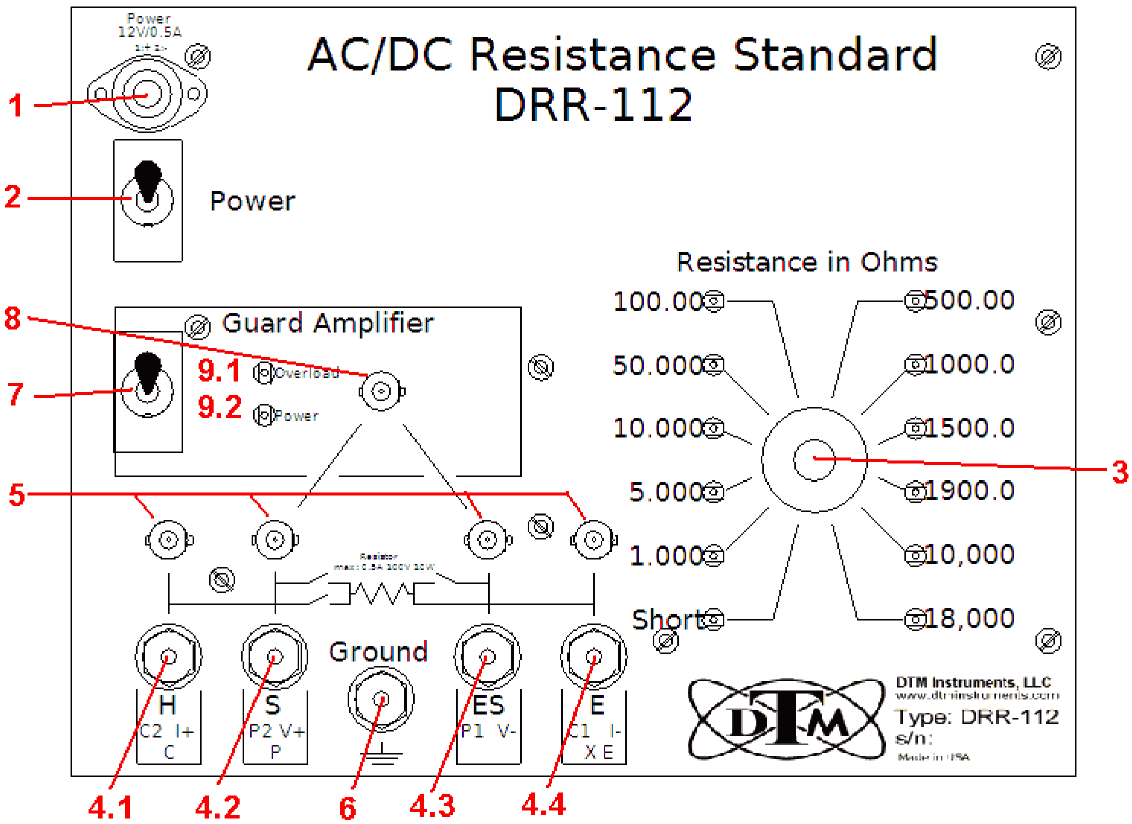

Fig 1 Operators Panel DRR-112

1: Power Supply connector, 12V/0.5A
2: Main power switch
3: Resistance selector switch
4.1: High-side current terminal
4.2: High-side voltage sensing terminal
4.3: Low-side voltage sensing terminal
4.4: Low-side current terminal
5: Shielded BNC terminals for 4.1 – 4.4
6: Grounding terminal
7: Power switch for guard amplifier
8: BNC jack for guard amplifier
9.1: Indicator “Overload” for guard ampl.
9.2: Indicator “Power” for guard ampl.

2.1.Preparation for operation

- Connect the external 12V power supply to the power supply terminal at the DRR-112 (1) and plug it into the power outlet.
- Connect the device under test to the appropriate terminals (4.1 – 4.4), see chapter 3.
- Switch on the mains power (2), a warm-up time is not required if the DRR-112 is already at room temperature.
- Select the “Short” setting at the selector dial (3) and check that the device under test reads Zero.
- Select the desired resistance settings at the selector dial (3) and record the readout of the device under test. Check that the current and voltage output of the device under test does not exceed the limits given in chapter 1.2

2.2.Taking out of operation

- Switch off the device power (2, 7)
- Remove the external power supply from the mains power outlet and the power supply terminal at the DRR-112 (1)
- Remove the test leads
- Close the lid and store the resistance standard DRR-112 in a dry place.

3.Connecting to the device under test

3.1.Four-wire (Kelvin) connection

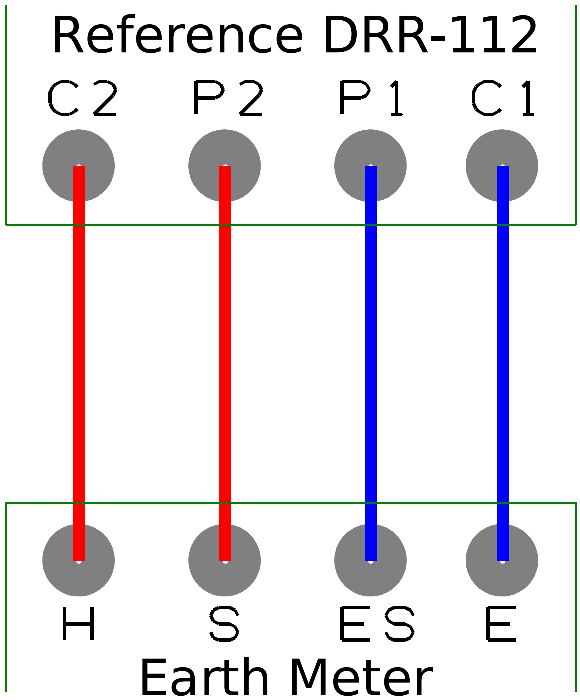

Fig 2   4-Wire Connection

The four wire connection is a straight one-to-one connection of the meter terminals with the terminals of the resistance standard DRR-112.

Sometimes it is difficult to figure out which terminal corresponds to which. Naming of the terminals seems to follow no standard. Several common terminal names are printed on the front plate to guide with the connections. In doubt, check the manual of the resistance meter or contact the manufacturer.

3.2.Four-wire connection with guard

For very accurate measurements it is recommended to use shielded connection cables to connect to the BNC jacks instead of the binding posts at the resistance standard DRR-112. See chapter 4.44.4 for more information.

3.3.Three-wire connection

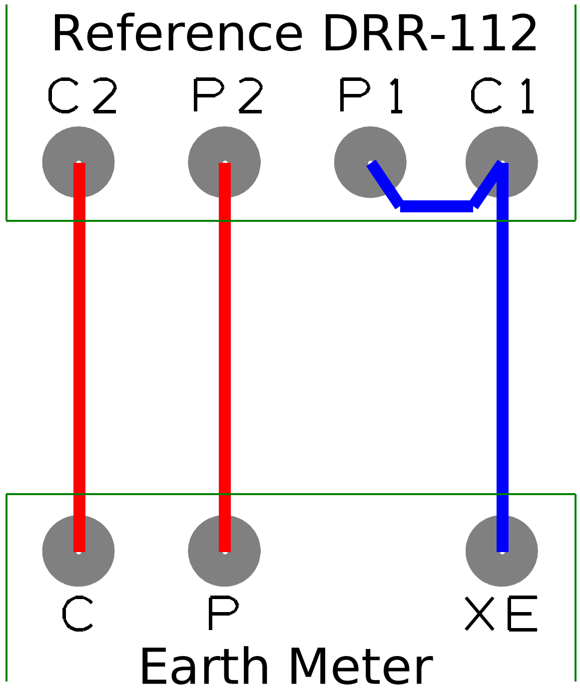

Fig 3 3-Wire Connection

The three-wire method of measuring resistances is less accurate than the four-wire method. Still, many earth resistance meters use this method. The standard connection setup is shown in Fig 5. The terminals of most three-wire meters are labeled as shown in the picture.

At low values, the reference resistors used in the DRR-112 have additional resistance when used in the three-wire and two-wire connection. Refer to the calibration certificate for the actual resistance values between 1Ω and 50Ω.

To avoid the error caused by the additional resistance of the relay contacts, all resistors are hard wired and no relay contacts are used at the terminal C1. The terminal C1 serves as the common ground connector.

3.4.Two-wire connection

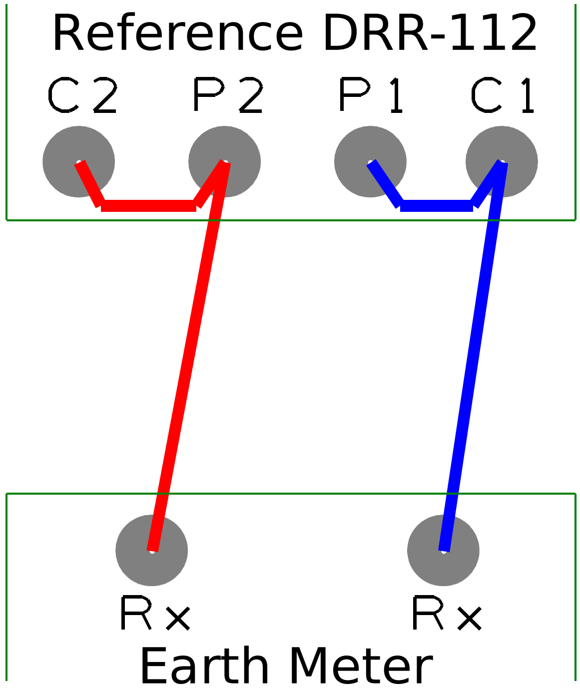

Fig 4 2-Wire Connection

Digital Multimeter and many other test systems have only two connectors to measure the resistance. In this case, all wiring and contact resistances add to the measurement result. To keep these errors as small as possible, it is recommended to short connect the terminals C1 and P1 as well as C2 and P2 as shown in Fig 6.

If used without this short, special care must be taken since some terminals of the four-terminal resistors exhibit an additional resistance.

At low values, the reference resistors used in the DRR-112 have additional resistance when used in the three-wire and two-wire connection. Refer to the calibration certificate for the actual resistance values between 1Ω and 50Ω.

4.Reducing measurement errors

Every measurement is subject to interference which introduces errors to the measurement result. These errors must be kept small enough so that they don't falsify the calibration results. The higher the required accuracy of the calibration and the higher the frequency of the AC measurement signal, the more important are the following guidelines.

4.1.Connections

It should go without saying that all connectors have to be clean and free of oxides and other residues as well as that the connection leads don't have broken wires or loose plugs.

It is also important to keep the length of the connection leads as short as practically possible. A long lead will pick up more interference, have a higher inductance and stray capacitance than a shorter one. For the calibration of earth testers and other resistance meters with up to 0.1% accuracy, unshielded connection cable is usually sufficient. For very sensitive and accurate measurements (e.g. to calibrate the resistance standard DRR-112 itself) it is recommended to use short shielded cable (e.g. RG-58/U) connected to the BNC jacks.

4.2.Thermal offset voltage

If a junction of different metals is on a different temperature than the rest of the metals, a thermal voltage will be produced. This junction acts as a tiny battery which creates a DC offset voltage within the test circuit.

Only measurements with DC voltage are affected by thermal voltages. To test for thermal offset voltages, connect the voltage measurement terminals to the P1 and P2 terminal at the resistance standard DRR-112 and short the current terminals of the resistance meter (Fig 7). A reading different than Zero indicates a thermal offset voltage. To verify that the thermal offset voltages is created within the resistance standard box, swap the voltage leads between the P1 and P2 terminal and observe the change in the readout.

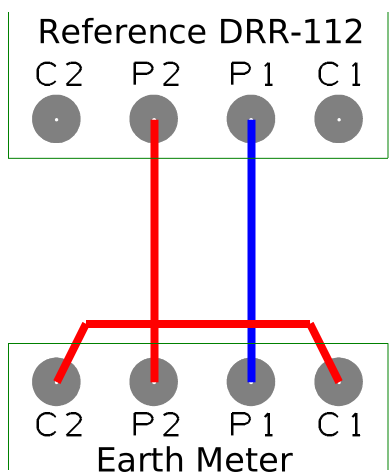

Fig 5 Test for Thermal Offset

4.3.Measurement errors caused by inductive coupling

Every closed electric circuit exhibits an inductance, it could be seen as a choke with one turn. It is of concern only for test with AC voltages and currents (e.g. earth tester), DC is not affected.

This inductance creates an additional voltage drop that affects two- and three-wire measurements with AC signals. It also creates a magnetic coupling between the current and potential leads that falsifies the measured voltage at three- and four-wire measurements .

Inside the resistance standard DRR-112 the connections are carefully laid out to minimize the inductive effect and inductance-free resistors are used. The external connection leads should be as short as practically possible and twisted to minimize the inductance and the magnetic field coupling (see Fig 8 and Fig 9).

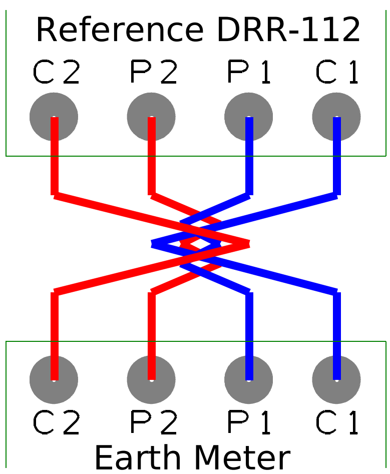

Fig 6 4-Terminal Connection to minimize interference

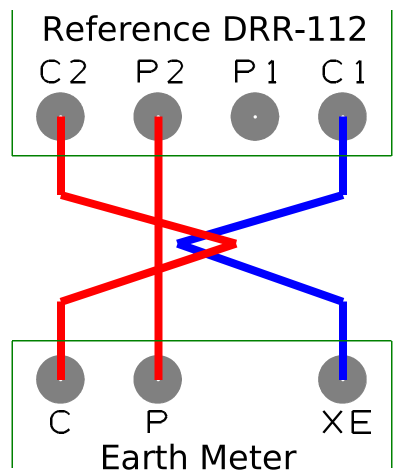

Fig 7 3-Terminal Connection to minimize interference

The interference created by the circuit inductance and magnetic coupling is affecting the measurement more at low resistance values and higher test signal frequency. To determine if the measurement setup is affected by the circuit inductance, select the “Short” position at the selector switch. The instrument should read “Zero” within its measurement accuracy.

4.4.Measurement errors caused by stray capacitance

Electrical leads with a different electrical potential create a small capacitor, the so-called “stray capacitance”. This capacitor lies in parallel to the reference resistor and tends to reduce the overall AC impedance (the measured “resistance”). The longer the leads get and the closer they are, the larger the stray capacitance becomes.

Stray-capacitance affects only AC measurements. The higher the signal frequency and the larger the reference resistor is, the more the measurement will be affected by the parasitic stray capacitance. As an example, at 10kHz and 18kΩ, the internal stray capacitance of 52.5pF will create a measurement error of approximately 1700ppm (0.17%).

To minimize the stray capacitance, the internal wiring, relay switches and circuit board are equipped with a guard shield. The guard shield is accessible at the outside of the BNC connectors. The stray capacitance inside the reference resistors can not be shielded out.

Without shielding, a stray capacitance of 250pF can be roughly estimated. With this, a measurement error below 1000ppm (0.1%) will be reached if the AC test frequency is below 1.6kHz. For earth resistance meters, this is usually the case and guarding is not necessary.

For more accurate measurements, e.g. to calibrate the resistance standard DRR-112, guarding might be required. To determine if guarding is necessary, connect two capacitors 470pF/100V to the terminals P1 and P2. Compare the reading of the 18kΩ resistor with and without the two capacitors connected (see Fig 10). If the reading is less when the capacitors are connected, guarding is strongly recommended.

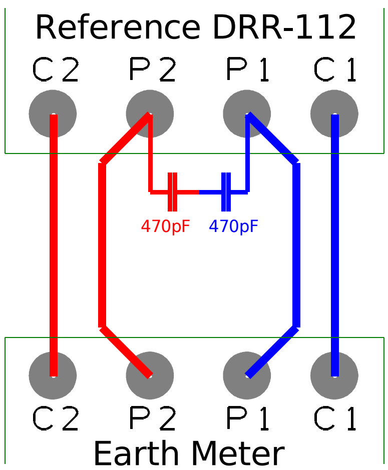

Fig 8 Stray Capacitance Test

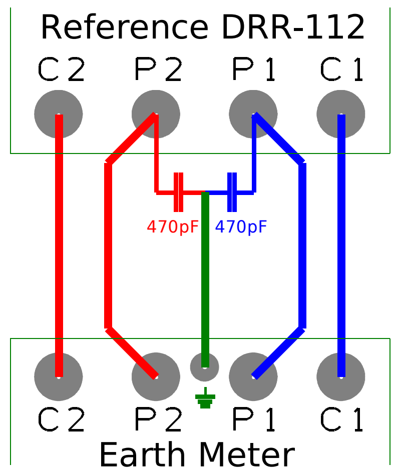

Fig 9 Guard Grounding Test

4.4.1.Using guard terminals

The preferred way of guarding out the stray capacitance uses the guard circuit of the resistance meter. Reference resistance meters and bridges usually use guard circuits. Simply connect the shielded terminals of the resistance meter with the BNC connectors at the resistance standard DRR-112 via shielded cables. The outside of the BNC connectors is connected to the internal guard shields of the high and low side.

4.4.2.Grounding of the guard shield

If no guard output is available at the resistance meter, maybe a ground terminal (or a DC charger terminal) is accessible. Connect the center point of the two 470pF capacitors to the ground terminal and see if the 18kΩ reading goes back to the value without the capacitors (Fig 11). If so, remove the capacitors and connect the ground terminal to the outer BNC conductor on the left (P2) or right (P1) side. Check which connection gives the highest reading, this is the best connection for the guard shield.

4.4.3.Using the guard amplifier

If the other two methods do not work, the built-in guard amplifier can be used. Switch on the guard amplifier and check that the LED “Power” (green) is on. Connect the guard amplifier BNC output to the BNC connectors P1 or P2 via a short BNC cable. Also connect the center point of the two 470pF capacitors to the outer conductor of the BNC connector and see if the 18kΩ reading goes back to the value without the capacitors. If so, remove the capacitors and check which connection gives the highest reading without the LED “Overload” (red) lighting up. This is the best connection for the guard shield.

Troubleshooting:

- If the LED “Power” (green) does not light up, the guard amplifier might be damaged by input over voltages. The internal operational amplifier can be replaced by opening the front cover and exchanging it with a new OP249GP.
- If the LED “Overload” (red) lights up, this is an indication that the guard amplifier output is saturating. Try connecting the ground terminals at the DRR-112 and the device under test or use the other P1/P2 terminal.

5.Technical data

DRR-112 Box

- Dimensions: 29 x 25 x 16 cm (11.5 x 10 x 6.25 inch)
- Weight: 2.7kg (6 lbs)
- Operating temperature: 10 – 30ºC (50 – 86 F), 30 – 70 %RH
- Storage temperature: 0 – 40ºC (32 – 104 F), not condensing
- Supply current: 130mA (Relays: 50mA, Guard Amplifier 80mA)

Reference Resistors

- maximum circuit current: 0.5A
- maximum circuit voltage: 100V
- maximum applied power: 10W
- annual stability: 100ppm (0.01%) p.a.
- temperature coefficient: ±5ppm/K (±2.8ppm/F)
- resistance material: NiCr-Foil
- frequency range: 0 – 10 kHz
- accuracy:

Range	***Accuracy***
1.0 Ω – 5.0 Ω	1000ppm (0.1%)
10 Ω – 1.9 kΩ	500ppm (0.05%)
10 kΩ – 18 kΩ	750ppm (0.075%)

- stray capacitance:

Resistance	***C Stray***	***10kHz error***	***100kHz error***
500Ω	300pF	44ppm	0.4%
1,000Ω	208pF	85ppm	0.8%
1,500Ω	165pF	121ppm	1.2%
1,900Ω	170pF	206ppm	2.0%
10,000Ω	68.5pF	925ppm	8.1%
18,000Ω	52.5pF	1760ppm	14.0%

Guard Amplifier

- Output voltage swing: ±12V
- Operating frequency: 30Hz – 300kHz

External Power Supply

- Input Voltage: 100 – 240 V, 50 – 60 Hz, 0.3A
- Output Voltage: 12 V DC, 0.5A
- DC Power connector: 5.5/2.1mm Barrel Plug, center positive