

## Earth Loop Impedance, RCD, and Insulation Test Best Practices

---

This app note explains Lutron's recommendations when performing earth-loop impedance, Residual Current Device (RCD), and insulation tests. These recommendations will eliminate any interactions with the dimming equipment to help ensure reliable measurements.

### Earth-Fault Loop Impedance Measurements

IEE regulations require Earth-fault loop impedance measurements in electrical installations. The loop impedance includes the resistance of phase and earth conductors within the installation. A measurement within the installation will give the complete earth-fault loop impedance from the point it is measured. Typically, the highest value measurements occur farthest from the incoming supply where the conductors are the longest.

The method of measurement for the phase-to-earth loop impedance is to connect a resistor from phase to earth so that a significant amount of current flows for a short period of time. The impedance of the loop is calculated within the test equipment by measuring the difference between the supply voltage both before and while the loop current is flowing. The difference in the voltage drop in the loop is divided by the current to derive the loop impedance. The test current duration must be limited to two cycles or 40 msec for a 50 Hz line. During this pulse, the voltage is sampled very close to the zero crossing so that the measured difference between the supply voltage with and without the current is large relative to the supply voltage.

Dimming equipment uses semiconductor devices to switch the AC supply voltage thus controlling the power delivered to the load. This switching occurs once every half-cycle and synchronized to the AC power source. In a 3-phase system, it is possible to have the switching edge occur at the zero-crossing position of an alternate phase. These edges are filtered to meet the EMC limits for dimming equipment. However, there is still some level of voltage generated on the conductors because of the switching transition. This voltage is additive when multiple dimmers are being operated at the same conduction angle. When switching transitions align at the tested phase's zero-cross, it is possible that the test equipment will detect this additional voltage and interpret it as a higher impedance value.

Remove the additional voltage by either turning the dimmer off or changing the dimmer levels to move away from the zero-cross point. The dimmer does not affect the actual loop impedance, as this is purely wiring impedance. It is a result of the test method and sensitivity of the test equipment. The dimming equipment does not change the system impedance, as can be shown by changing the dimming level. Lutron recommends to either bypass the dimmers if control is not available or turn them off if control is available when performing the earth-loop impedance measurement (see Figure 1). This will eliminate any interactions with the dimming equipment and the test equipment and guarantee reliable measurements.

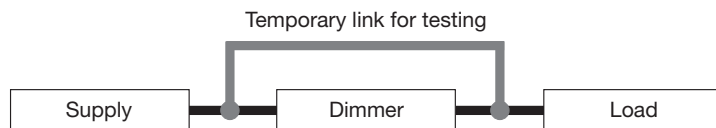


Figure 1

There is another condition that will result in invalid measurements: if the receptacles or lighting fixtures are being measured for their earth-fault loop impedance on the output of a dimmer circuit, then the added dimmer impedance will cause the measurement to be invalid. Again, the dimmer needs to be bypassed to perform a proper test under these conditions.

## RCD Protection and Testing

A Residual Current Device (RCD) is used to break an electric circuit if current is not balanced between the supply and return conductors. The primary intent is to prevent harm from an ongoing shock or equipment damage caused by earth faults.

In many cases, a single RCD is mounted at the input of a Lutron dimmer which meets the requirements listed in the “BS 7671:2018 Requirements for Electrical Installation. IET Wiring Regulations Eighteenth Edition” in paragraph 411.3.4 entitled “Final circuits supplying luminaires in domestic premises”. Please note most RCDs are designed to operate under a fully sinusoidal waveform and should not be wired at the output of a dimmer without checking with the RCD’s manufacturer first.

When testing the RCD that is protecting a circuit controlled by one of Lutron’s devices, the test should be performed directly at the output of the RCD with the Lutron device fully disconnected. This meets the requirements for the operational and functional test of RCDs: the test is made on the load side of the RCD between the line conductor of the protected circuit and the associated circuit protective conductor (CPC). The load should be disconnected during the test<sup>1</sup>.

## Insulation Resistance Testing

When testing insulation resistance, disconnect the dimmers, switches, delay timers, power controllers, emergency lighting, RCDs and similar equipment so that they are not subjected to the test voltage. The functional earthing leads of Residual Current Circuit Breakers with Over Current Protection (RCBOs) should also be disconnected so that a low insulation resistance reading or damage to an RCBO will not be caused<sup>2</sup>.

<sup>1</sup> DEWA Regulations for Electronic Installations, 2017.

<sup>2</sup> BS 7671:2018 Requirements for Electrical Installation. IET Wiring Regulations Eighteenth Edition, Section 2.6.7 of “Guidance Note 3: Inspection & Testing.”

Lutron is a trademark of Lutron Electronics Co., Inc., registered in the U.S. and other countries.

---

## Lutron Contact Numbers

### WORLD HEADQUARTERS

**USA**  
Lutron Electronics Co., Inc.  
7200 Suter Road  
Coopersburg, PA 18036-1299  
TEL: +1.610.282.3800  
FAX: +1.610.282.1243  
support@lutron.com  
www.lutron.com/support

**North & South America  
Customer Assistance**  
**USA, Canada, Caribbean:**  
1.844.LUTRON1 (1.844.588.7661)  
**Mexico:**  
+1.888.235.2910  
**Central/South America:**  
+1.610.282.6701

### EUROPEAN HEADQUARTERS

**United Kingdom**  
Lutron EA Limited  
125 Finsbury Pavement  
4th floor, London EC2A 1NQ  
**United Kingdom**  
TEL: +44.(0)20.7702.0657  
FAX: +44.(0)20.7480.6899  
FREEPHONE (UK): 0800.282.107  
Technical Support: +44.(0)20.7680.4481  
lutronlondon@lutron.com

### ASIAN HEADQUARTERS

**Singapore**  
Lutron GL Ltd.  
390 Havelock Road  
#07-04 King’s Centre  
**Singapore 169662**  
TEL: +65.6220.4666  
FAX: +65.6220.4333  
Technical Support: 800.120.4491  
lutronsea@lutron.com

### Asia Technical Hotlines

Northern China: 10.800.712.1536  
Southern China: 10.800.120.1536  
Hong Kong: 800.901.849  
Indonesia: 001.803.011.3994  
Japan: +81.3.5575.8411  
Macau: 0800.401  
Taiwan: 00.801.137.737  
Thailand: 001.800.120.665853  
Other Countries: +65.6220.4666