

# Design Verification

## - Circuit Testing

General Tips

- From unit/module testing to integration/system testing
- Start with low voltage/current
- Define testing procedure and measurement method
- Identify testing tools and equipment
- Log results
- Don't forget about **SAFETY**

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# Circuit Testing

## - Types of Tests

### ▪ Visual Inspection

Looking for missing parts, wrong parts, incorrect orientations, solder defects, loose connections, etc.

### ▪ Functional Tests

Checking against electrical specifications, temperature requirements, etc.

### ▪ Non-Functional Tests

Including performance testing, stress testing, reliability testing, compliance testing, etc.

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# Test Setup and Equipment

### ▪ Device Under Test (DUT)

Your power supply / battery charger

*Tip:* add test points on your board

### ▪ Test Bench

Input (120V/variatic/PV panel), Load (resistive load/battery under charging), Operating environment (temperature, humidity, etc.), Expected results (specs, design requirements)

### ▪ Measurement Equipment

Multimeter, Voltmeter, Ammeter, Ohmmeter, Wattmeter, LCR meter, Oscilloscope, Thermometer, IR Camera, etc.

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# Voltage Measurement



- ✓ Voltage **must** be measured between 2 points. It's potential difference.
- ✓ A voltmeter has very high input impedance so that it does not impact the circuit under test (only draws a negligible amount of current).
- ✓ Select appropriate AC/DC mode and range.
- ✓ **Red (+)**, **Black (-)**



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## True RMS Meter

Normal meters detect the peak or rectified average value and convert it to RMS.

e.g.  $RMS = 0.707 * peak$  (only valid on pure sinusoidal)

True RMS meters calculate the RMS by definition (root mean square). So they work for all shapes of waveforms.

Multimeter type	Response to sine wave	Response to square wave	Response to single phase diode rectifier	Response to 3 $\phi$ diode rectifier
Average responding	Correct	10 % high	40 % low	5 % to 30 % low
True-rms	Correct	Correct	Correct	Correct

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## Current Measurement

Current **must** be measured in series by interrupting the current loop and inserting the meter, unless using a clamp meter/probe.

Current meters have very low impedance (nearly 0). **Never** use a current meter to measure voltage (it will short the circuit).

This multimeter has 2 different probe ports for different current ranges (400mA and 20A). Use the right one. If not sure, try the **higher** current setting first.

The current ports are fused. You can use another Ohmmeter to check the fuse.



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## Resistance Measurement

Disconnect the resistor from the circuit and then measure it.

If measuring in-circuit resistance, turn the power off and discharge any capacitors first.

Do not touch the bare leads, your body resistance may affect the readings.

For very low resistance measurements, you need to offset the probe resistance.

You can always use Ohm's law to calculate the resistance.



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## Other Measurements

**Continuity test mode:** Use it to check wiring and connections, or detect soldering defects (e.g. short-circuit bridges).

The beep is useful, but remember to check it before measuring.

**Diode test mode:** Measure the voltage drop of a forward-biased diode. (red +, black -) Also can test a LED or find its polarity. (usually longer leg is +)

May need to remove at least one end of the diode from the circuit.



**L, C Measurements:** A basic LCR meter outputs a AC voltage stimulus (1kHz or configurable) and measures the current/impedance.



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# Temperature Measurement

## WARNING:

Do **NOT** use your finger to test temperature of components!



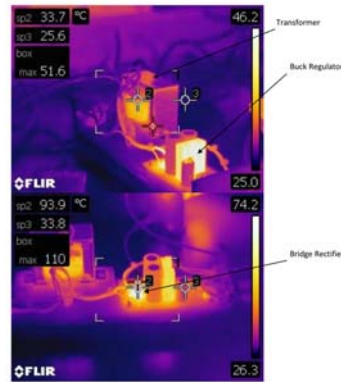
Multimeter with thermocouple



Infrared thermometer



Infrared camera

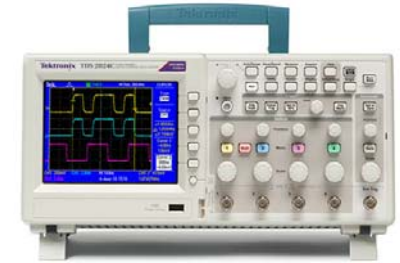


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# Oscilloscope

## Basic Measurements:

- Voltage Measurements
- Time Measurements



Every other measurement/calculation is based on these 2 measurements.

Fluke 43B Single Phase Power Quality Analyzer



It combines the most useful capabilities of a power quality analyzer, multimeter and scope.



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# Oscilloscope

**IMPORTANT**

- ◆ Normally, multiple channels share a common ground;
- ◆ And this ground is the protective earth except for some hand-held scopes.

- Calibrate probes before use.
- There are other useful features such as triggering, cursors, math functions, X-Y mode.

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