Technical Information

Optoelectronics Test

Active optoelectronic device characterization requires more than a current source

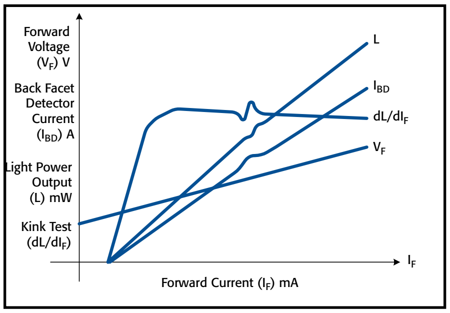

Figure 1. Classic LIV curves associated with semiconductor laser diodes.

Active optoelectronic devices are basic semiconductor junctions. To be fully tested, they require not only forward I-V characterization, but also reverse I-V characterization. While conventional laser diode drivers are valuable for providing drive current in the optics lab, these current sources aren't suitable for developing a complete understanding of a semiconductor device. The SourceMeter® line provides a full range of source and measure capability optimized for semiconductor characterization.

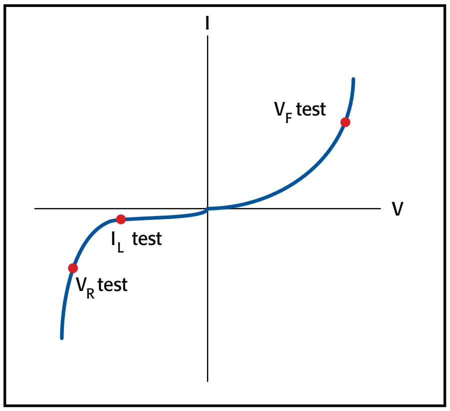

Figure 2. Characterization of semiconductor junctions requires measuring reverse breakdown (V_R), leakage current (I_L), and forward voltage (V_F).

A complete characterization of an active optoelectronic device requires forcing both forward and reverse currents and voltages. For instance, the reverse breakdown test requires sourcing a very small, precise reverse current (10nA) while measuring the voltage. The limited current prevents permanent damage to the device, while allowing a precise breakdown voltage to be measured. Given the breakdown voltage, it's now possible to force a reverse bias that won't harm the device while leakage is measured. This leakage current value is often used to qualify the device for further testing.

Four-quadrant source capabilities

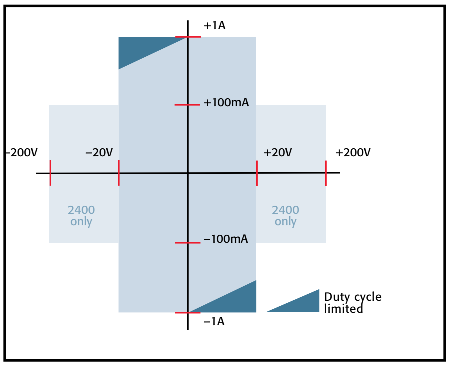

Figure 3. The Model 2400 can source or sink either current or voltage. Other SourceMeter SMU instruments offer different ranges, providing a very wide dynamic range from as low as a 1µA range or 200mV to 5A or 1000V.

The SourceMeter product line combines a full four-quadrant precision source (see **Figure 3**) with measurement capability. Source and measure ranges provide a very wide dynamic range from as low as a 1µA range or 200mV to 5A or 1000V. These very wide dynamic ranges allow testing diverse devices from delicate AlGaAs laser diodes to silicon avalanche photodiodes.

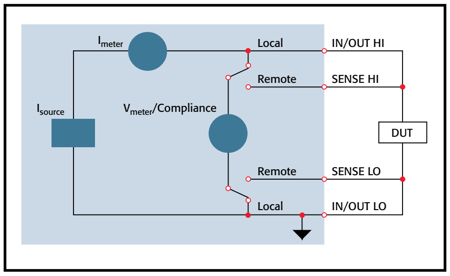

Figure 4. In current source mode, a SourceMeter SMU instrument can force current while measuring voltage. The remote voltage sense ensures the programmable voltage compliance isn't exceeded.

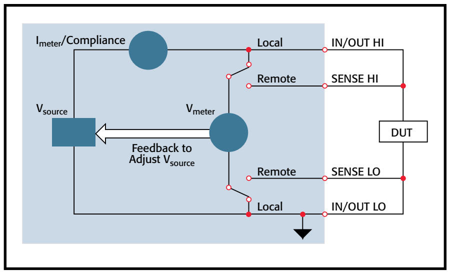

Figure 5. In voltage source mode, a SourceMeter SMU instrument forces a voltage and measures current. Remote sense of the voltage ensures the desired voltage at the DUT.

Verifying device connections

Series 2400 SourceMeter SMU instruments all offer the Contact Check option, which automatically verifies all test leads are connected to the DUT prior to energizing the test leads or executing a test sequence. **Figure 6** shows Contact Check identifying a disconnected remote sense test lead. Without the sense test lead connected, the voltage compliance couldn't be controlled during test execution.

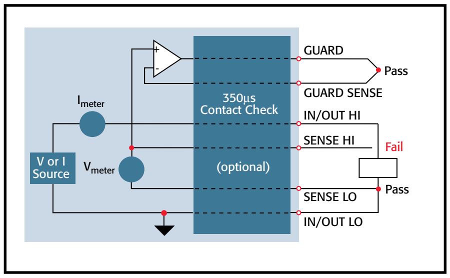

Figure 6. The contact check option verifies the force, sense, and guard test leads are properly connected to the DUT before testing begins.

Remote voltage measurement

SourceMeter SMU instruments offer two- or four-wire measurement configurations. Two-wire voltage measurement shares test leads with the source as shown in **Figure 7a**. When sourcing high currents, the voltage drop across the test lead becomes significant with respect to the forward voltage across the DUT.

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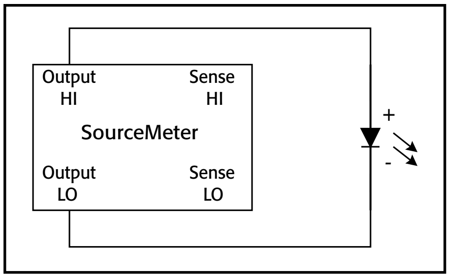

Figure 7a. Two-wire measurement

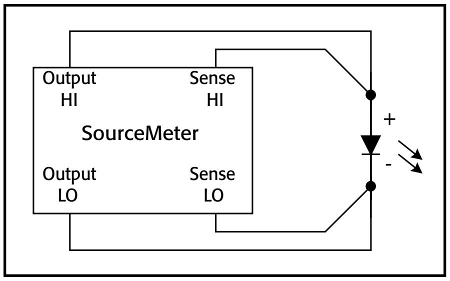

Figure 7b. Four-wire or Kelvin measurement

Four-wire voltage measurement uses dedicated test leads for measuring the voltage drop across the DUT. Since the voltage measurement circuit has very high impedance inputs, the current through the measuring test leads is low. The IR drop across the measurement test leads is an extremely small fraction of the voltage dropped across the DUT.

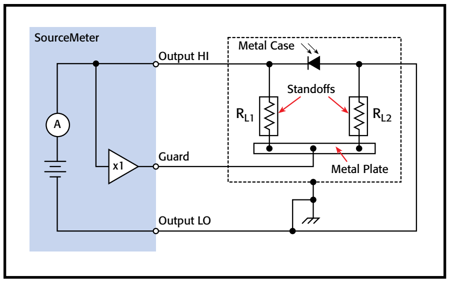

Figure 8. The cable guard circuit drives the guard conductor at the same potential as the output HI conductor.

Low level current measurements require a driven guard

Unique to precision measurement equipment, the driven guard minimizes the electrical potential difference between the conductors that surround the source test lead and the test lead (see **Figure 8**). When the electrical potential between the source test lead and guard test lead is low, the potential leakage paths are neutralized. This technique requires an additional instrumentation amplifier that senses the output of the programmed source and drives the guard circuit with the same potential with enough current to overcome any leakage between the guard components and ground.

Deterministic trigger I/O

Conventional instruments typically support a simple trigger in/trigger out convention. The challenge to the engineer is controlling the trigger interaction between instruments. It is often that case that simple trigger I/O doesn't allow for differences in instrument behaviors or synchronization of multiple instruments. **Figure 9** shows the trigger scheme available on most optoelectronic instrumentation.

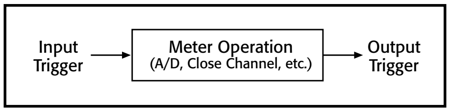

Figure 9. Typical trigger input/output scheme

A Series 2400 instrument breaks the measurement cycle into three parts, as shown in **Figure 10**. The three components are the source phase, delay phase, and measurement phase (also known as the SDM cycle.) The Series 2400 trigger model allows each phase in the SDM cycle to be programmed so that it can be gated by an input trigger and also to be programmed so that completion of each phase generates an output trigger.

While many instruments are limited to a single trigger in and single trigger out, Series 2400 instruments use a Trigger Link.

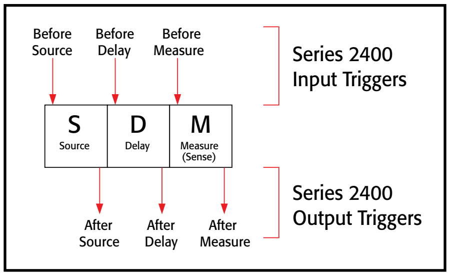

Figure 10. Series 2400 instrument's trigger input/output scheme

Precision characterization of active optoelectronic components often requires multiple instruments working together. For instance, two Series 2400 instruments can be used together: one SourceMeter SMU instrument to drive the device and another SourceMeter SMU instrument connected to a photodiode to record the optical output of the active device. **Figure 11** shows two Series 2400 instruments working synchronously together to characterize an LED.

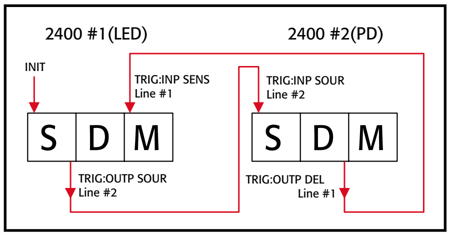

Figure 11. SDM triggers to synchronize two Series 2400 instruments.

Notice how trigger in and trigger out are tied to different parts of the SDM cycle to ensure that measurements on the LED and the PD are made at the same time. This same technique can be applied to ensure that the source current is stable prior to making an optical spectrum measurement with an additional instrument.

Complete DUT protection

DUT protection is a major concern for optoelectronic devices. SourceMeter SMU instruments are ideal for providing a safe electrical environment for delicate active optoelectronic devices.

- Normal output off mode drives the output terminals toward 0V. This action de-energizes the device and more importantly the inductive test leads. The rate of discharge can be controlled with the source range settings. This provides a better environment than shorting relays in conventional laser diode drivers.
- SourceMeter SMU instruments provide programmable compliance, range compliance, and voltage protection settings to ensure that the DUT isn't subjected to excess voltages or currents.
- Contact check ensures all test leads are in contact with the DUT prior to energizing the device.

In addition, the SourceMeter family is built on a heritage of precision semiconductor test and characterization of much more sensitive devices than active optoelectronic components.