KEITHLEY

Application Note Series

Number 2214

High-Throughput DC Production Testing of Telecommunications Laser Diode Modules

Introduction

The constantly growing need for greater communications bandwidth is accelerating the demand for telecom laser diode (LD) modules. As the volume of production and the complexity of the LD modules increases, greater emphasis must be placed on cost-effective and accurate production test strategies.

The typical LD module consists of a laser diode and a back facet monitor photodiode. Temperature-controlled LD modules also include a thermo-electric controller (TEC) and a thermistor to facilitate precise regulation of the LD's operating temperature, as illustrated in ***Figure 1***. (High-speed LD modules may also carry an integrated modulator chip that is not shown in ***Figure 1***.)

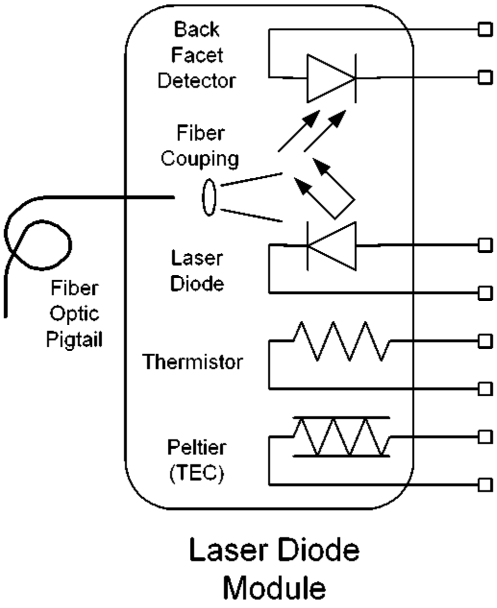


Figure 1. Typical Laser Diode Module

The value-added nature of the LD assembly dictates testing each component prior to the next assembly step. For example, the cost of scrapping a complete laser module due to a failed Back Facet Monitor photodiode is much greater than the cost of providing 100% testing of the photodiode component prior to the assembly step. High-speed, flexible test solutions are essential to minimize the cost of the test.

This note details a cost-effective DC test system that provides the high throughput required in today's telecom LD transceiver module production environments.

Test Descriptions

During DC testing, the specifications of interest for the typical distributed feedback (DFB) laser diode module include:

- Laser forward voltage
- Kink test or slope efficiency (*dL/dI*)
- Threshold current
- Monitor (back facet) reverse-bias voltage
- Monitor (back facet) current
- Monitor (back facet) dark current
- Optical output power

The most common subset of the DC characteristics can be measured in a test known as the *L-I-V test sweep*. This fast (less than four seconds for a 100-point sweep at 1NPLC, excluding analysis time) and inexpensive DC test identifies failed assemblies early in the test process, so expensive non-DC domain test systems are more cost-effective when testing the remaining higher yield components. ***Figure 2*** shows three instruments configured to perform the L-I-V test sweep.

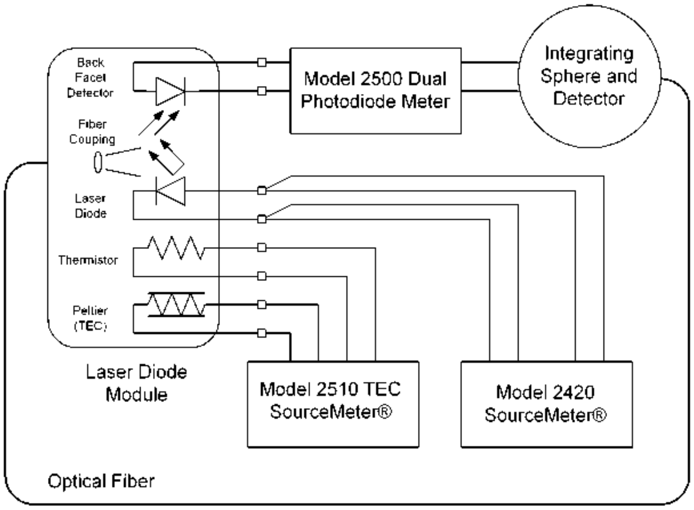


Figure 2. Block Diagram of L-I-V Instrumentation

L-I-V Test Sweep

- **Forward Voltage Test**

  The forward voltage (V_F) test verifies the forward DC characteristics of the LD. Current (I_F) is swept and voltage drop across the LD is measured. Some high-powered LDs may require current (I_F) sweeps up to 2–3A, usually in increments of 1mA. Most need sweeps up to 1A with 0.5mA or 0.25mA steps. Time per test sweep should be in the range of a few milliseconds. The typical measurement range is 0–10V and microvolt-level resolution is required.

- **Lasing Threshold Current Test**

  The threshold current is the current at which the LD starts lasing. The current threshold can be found by detecting the first maxima of the second derivative of the light output. ***Figure 3*** shows the graphical calculation of the threshold current of a LD. The top line is the light output of the LD as the current is sweep from zero to several tenths of an ampere. The middle line is the first derivative of the light output and shows a steep slope as the light output begins to intensify. The bottom line is the second derivative of the light output. Note the sharp peak of the second derivative line at the knee of the light intensity output. This peak denotes the location of the threshold current.

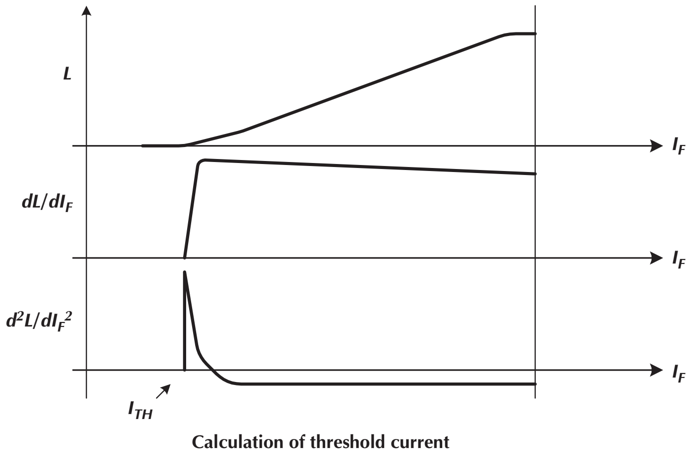


Figure 3. Graphical Calculation of Threshold Current

Light Intensity Measurement

Light intensity (L) measurements verify the light output of the LD. Light output power increases as drive current is increased. Output of this test is usually displayed in mW to Ws. The measurement may be AC- or DC-based. For AC-based measurement, an optical power meter is used. For DC-based measurement, a reverse-biased photodiode is exposed to the output of the laser diode and the resulting photodiode DC current is measured with a picoammeter or electrometer (highly refined DC multimeter). When optical power measurements are needed, a calibrated integrating sphere and detector are used. The system software then uses this current value and the PD calibration data to calculate the output power of the module. A typical photodiode current range is 0–3mA. Required resolution is 0.1mA. The DC approach is reported to be faster than the AC approach.

- **Back Facet Monitor Diode (BFMD) Test**

  This test verifies the response of the back facet detector photodiode (also reverse-biased) to increase light output of the LD as the drive current is increased. Typical current measurement range is 0–100mA and the required resolution is 0.1mA. This measurement is typically performed with a picoammeter or electrometer.

- **Kink Test/Slope Efficiency**

  This test verifies the proportionality of the relationship between the drive current (I_F) and the light output (L) as depicted in ***Figure 4***. The relationship between the drive current (I_F) and the light output power (L) should be linear about the nominal operating range. If the relationship is truly linear over the tested range, the first derivative of the curve will be a nearly horizontal line. This is graphed as dL/dI_F. The first derivative will tend to amplify any bumps or kinks in the L-(I_F) curve. If this curve has any significant "kinks" or, in other words, is not smooth, the laser is considered defective. If operated at the I_F value corresponding to the "kink," the light output will not be proportional. The maximum value of the second derivative of the L vs. I_F curve can be used to calculate the threshold current, which is the value of the drive current at which the LD starts "lasing" or outputting significant light.

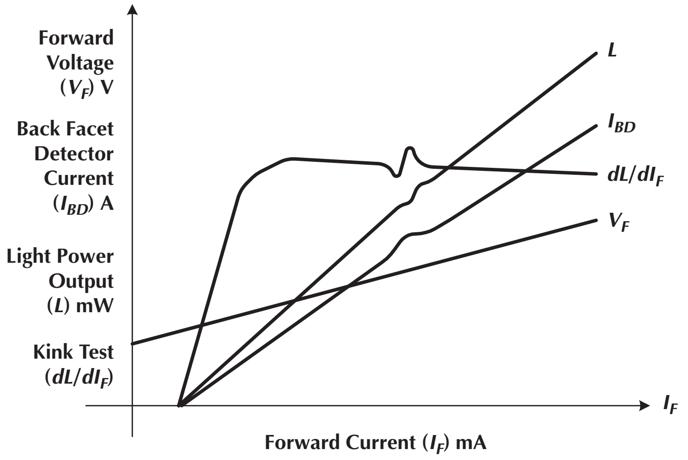


Figure 4. Typical Suite of L-I-V Curves

- **Temperature Testing**

  The L-I-V test is often performed at more than one laser diode temperature. In some cases, the LD is tested at both the nominal temperature and the extremes of the device specification, such at –40°C, 25°C, and 85°C. Another common strategy is to perform the L-I-V test at several temperatures, such as 5°C, 10°C, 15°C, 20°C, 25°C, 30°C, and 35°C. Then, these families of L-I-V curves are analyzed to ensure the device meets the specification.

Test System Configuration

Figure 5 shows an overview of an L-I-V test system that includes a Model 2420 SourceMeter instrument, a Model 2500 Dual Photodetector Meter (Dual Channel Electrometer), a Model 2510 TEC SourceMeter instrument, and a PC equipped with a

GPIB interface card. The Model 2420 is programmed to provide a current sweep to drive the LD and synchronize the measurements made by the Model 2500 Dual Photodiode Meter via the Trigger Link cable. The PC programs the meters via the GPIB bus, coordinates the execution of the test, collects, and analyzes the measurement results.

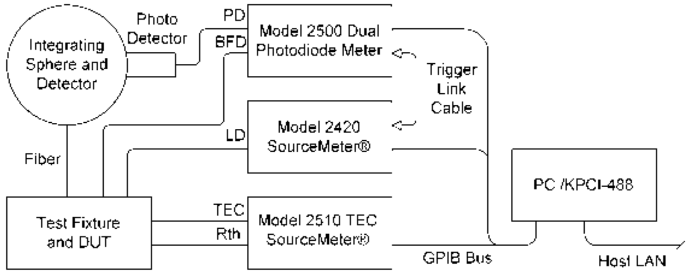


Figure 5. Block Diagram of Basic L-I-V Test System

Each instrument is equipped with trace memory that allows readings to be stored internally until the test is complete. In conjunction with Trigger Link, trace memory allows the L-I-V test sweep to run at hardware speeds, independent of the PC and GPIB interface. Once the test is complete, the readings in the trace memory are collected via the GPIB and analyzed in the PC.

Rack Mounted L-I-V System

Test Sequence

With the LD in the test fixture socket, the operator initiates the L-I-V test sequence via the computer controller.

1. The Model 2510 is commanded to set the desired temperature for the test
2. The computer configures the bias of the LD, LD BFMD, and external PD.
3. The Model 2420 and Model 2500 outputs are enabled and both instruments are armed.
4. The Model 2420 is then triggered and the sweep begins.
5. As the Model 2420 biases the LD, it sweeps from zero to 100mA in 1mA steps and it signals when the next bias current is stable by issuing a trigger to the Model 2500 Dual Photodiode Meter. The Model 2420 then records the current and voltage measurements in trace memory for later recall by the computer.
6. The Model 2500 measures the current flow in the photodiodes and issues triggers to the Model 2420. The measurements are recorded in trace memory.
7. The trigger signals from the Model 2500 tell the Model 2420 to increase the LD bias to the next step.
8. The exchange of triggers moderated by the Model 2420 repeats until all measurements in the sweep are complete.
9. When the Model 2420 issues a service request to the PC to signal the completion of the L-I-V test sweep. The computer disables the output of the instruments, reads the measurements from trace memory, and compiles the test results.

Model 2420 SourceMeter Setup

A linear staircase sweep is easily programmed using the following SCPI command sequences:

```
‘Reset 2420
 send (kth2420, “*rst”, status)
 send (kth2420, “:syst:beep:stat off”, status)
 send (kth2420, “:syst:azer:stat off”, status)

‘Use Rear Terminals
 send (kth2420, “:rout:term rear”, status)

‘Configure Source Circuit
 send (kth2420, “:sour:func curr”, status)          ‘source amps
 send (kth2420, “:sour:curr:start 0.001”, status)   ‘start at 10 milliamps
 send (kth2420, “:sour:curr:stop 0.1”, status)      ‘end at 1A
 send (kth2420, “:sour:curr:step 1e-3”, status)     ‘increment in 10mA
                                                    'stepsfor a total of
                                                    ‘100 steps
 send (kth2420, “:sour:curr:mode sweep”, status)
                                                    ‘set sweep mode
 send (kth2420, “:sour:swe:rang auto”, status)
 send (kth2420, “:sour:swe:spac lin”, status)       ‘set step spacing to
                                                    ‘linear
 send (kth2420, “:sour:del 0.002”, status)          ‘set delay before
                                                    ‘trigger is sent to the
                                                    ‘2500


‘Configure Sense Circuit
 send (kth2420, “:sens:volt:nplc 0.01”, status)
 send (kth2420, “:sens:func:conc off”, status)
 send (kth2420, “:sens:func volt:dc’”, status)
 send (kth2420, “:sens:volt:prot 5.0”, status)
 send (kth2420, “:form:elem volt”, status)
```

```
'Configure Arm Layer Setup
send (kth2420, “:arm:sour imm”, status)          ‘Trigger Link will be
                                                 ‘trigger source
 send (kth2420, “:arm:count 1”, status)          ‘trigger count =
                                                 ‘number of
                                                 ‘measurements

'Configure Trigger Layer Setup
 send (kth2420, “:trig:clear”, status)           ‘clear triggers
 send (kth2420, “:trig:sour tlink”, status)      ‘Trigger Link will be
                                                 ‘trigger source
 send (kth2420, “:trig:ilin 1”, status)          ‘input trigger will be
                                                 ‘line 1
 send (kth2420, “:trig:olin 2”, status)          ‘output trigger will be
                                                 ‘line 2
 send (kth2420, “:trig:outp delay”, status)      ‘send trigger after
                                                 ‘source and delay
                                                 ‘steps
 send (kth2420, “:trig:dir source”, status)      ‘bypass trigger once
 send (kth2420, “:trig:count 100”, status)       ‘trigger count =
                                                 ‘number of
                                                 ‘measurements
‘Configure Trace
 send (kth2420, “:trace:feed:cont never”, status)
 send (kth2420, “:trace:points 100”, status)     ‘store 100 readings
 send (kth2420, “:trace:feed sens”, status)      ‘store readings
 send (kth2420, “:trace:feed:cont next”, status) ‘enable trace
```

The Model 2420 is programmed to sweep from 0mA to 100mA in 100 steps of 1mA each. After each new current value is applied to the LD, a trigger is issued on Trigger Link line 2 to start the measurement sequence on the Model 2500 that measures light output by measuring photodiode current. The Model 2420 then waits for a trigger from Trigger Link line 1 from the Model 2500.

Model 2500 Dual Photodiode Meter Setup

The Model 2500 is programmed to wait for a trigger on Trigger Link line 2 from the Model 2420 to begin a measurement cycle. Upon the receipt of the trigger, the Model 2500 measures both light channels. Once the measurement cycle is complete, the Model 2500 issues a trigger on Trigger Link line 1 to continue the sweep to the next current step in the sequence. Note that the Model 2500 makes both light channel measurements simultaneously with independent analog-to-digital converters.

```
‘Reset Instrument
 send (Kth2500, “*rst”, status)
 send (Kth2500, “*cls”, status)

' General instrument configuration
 send(kth2500, ":form:elem curr1,curr2", status) 'output only current
                                                 ‘readings

' ******* Configure Channel 1 of 2500 **********

' Setup sense circuitry for 20mA range
 send(kth2500, ":sens1:curr:nplc 1.0", status)   'set NPLC
 send(kth2500, ":sens1:curr:rang 0.020", status) '20 mA range

'Setup source to bias the front facet photodiode.
 send(kth2500, ":sour1:volt:range 10", status)   'set range to 10V
 send(kth2500, ":sour1:volt 5.0", status)        'set bias output
 send(kth2500, ":sour1:delay 0", status)         'set source delay to
                                                 ‘zero
 send(kth2500, ":sour1:gcon 1", status)          'enable ground
                                                 ‘connect relay

' ******* Configure Channel 2 of 2500 **********

' Setup sense circuitry for 20mA range
 send(kth2500, ":sens2:curr:nplc 1.0", status)   'set NPLC
 send(kth2500, ":sens2:curr:rang 0.020", status) '20 mA range

'Setup source to bias the photodiode with 5V.
 send(kth2500, ":sour2:volt:range 10", status)   'set range to 10V
 send(kth2500, ":sour2:volt 5.0", status)        'set bias output
 send(kth2500, ":sour2:delay 0", status)         'set source delay to
                                                 ‘zero
 send(kth2500, ":sour2:gcon 1", status)          'enable ground
                                                 ‘connect relay

'Setup Trigger Model: Bypass both arm layers      ‘and use trigger layer
                                                 ‘to synch with trigger
                                                 ‘from ‘2420.

 send(kth2500, ":arm:sour imm", status)        'bypass arm layer 1
 send(kth2500, ":arm:coun 1", status)          'set scan count
 send(kth2500, ":arm:dir acc", status)         'wait for trigger event
 send(kth2500, ":trig:clear", status)          'clear triggers
 send(kth2500, ":trig:sour tlink", status)     'use trigger link
 send(kth2500, ":trig:ilin 2", status)         'input trigger on line 2
 send(kth2500, ":trig:olin 1", status)         'output trigger on line 1
 send(kth2500, ":trig:input sense", status)    'wait for input trigger before
 send(kth2500, ":trig:outp sense", status)     'output trigger after setting
 send(kth2500, ":trig:dir acceptor", status)   'do not bypass on first pass
 send(kth2500, ":trig:coun 100", status)       'number of measurements
```

The bias value for both photodiodes is assumed to be 5V. Some detectors will require different bias voltages. The bias source is programmable from 0V to 100V. The current ranges for both channels are set to 20mA. This is a typical back facet detector current range for an LDM. When using an integrating sphere/detector pair, the range limit is likely to be 20µA or 200µA.

Model 2510 TEC SourceMeter Instrument Setup

The Model 2510 is programmed for a given temperature sensor, TEC, and set point temperature. Before the controller brings the laser diode module to the target temperature, the AC resistance of the TEC is measured and displayed.

```
'Reset Instruments
 send(kth2510, "*rst", status)                   'reset TEC controller

'Setup Peltier Current Limit
 send(kth2510, ":sens:curr:prot:lev 1.0", status)

'Setup Temperature Sensor
 send(kth2510, ":sens:temp:tran ther", status)   'use thermistor
 send(kth2510, ":sens:temp:curr:auto on", status)
                                                 'auto sensor current
                                                 ‘level
 send(kth2510, ":sens:temp:ther:range 1e4", status)
                                                 ‘10K ohm Ther.
```

```
 send(kth2510, ":sour:temp:spo 25.0", status)    'set temp. to 25C

'Read Peltier AC Ohms
 send(kth2510, ":outp on", status)               'turn on output
 send(kth2510, ":meas:res:ac?", status)          'measure AC ohms
 enter(strData, 100, intLength, kth2510, status) 'enter reading
 txtTECRes.Text = strData                        'display on screen

'Begin controller Laser Diode Temperature
 send(kth2510, ":outp on", status)
```

Start Sweep

To start the sweep, the outputs of all the instruments are first turned on. Then the Model 2500 is armed and waiting for a trigger from the Model 2420. Finally, the Model 2420 is triggered by issuing the “:init” over the GPIB bus.

```
‘Enable outputs
send(kth2500, ":outp1:stat on", status)   'turn off front facet bias
send(kth2500, ":outp2:stat on", status)   'turn off back facet bias
send(kth2420, “:outp on”, status)         ‘bias LD

send(kth2500, “:init”, status)            ‘arm
send(kth2420, “:init”, status)            ‘trigger sweep

send(kth2500, ":outp1:stat off", status)  'turn off front facet bias
send(kth2500, ":outp2:stat off", status)  'turn off back facet bias
send(kth2420, “:outp off”, status)
```

Read Trace Buffers

```
‘query trace buffers
send(kth2500, “:fetch?”, status)
send(kth2420, “:trace:data?”, status)

‘enter data
enter(strData, 4000, intLength, kth2500, status)
enter(strData, 2000, intLength, kth2420, status)
```

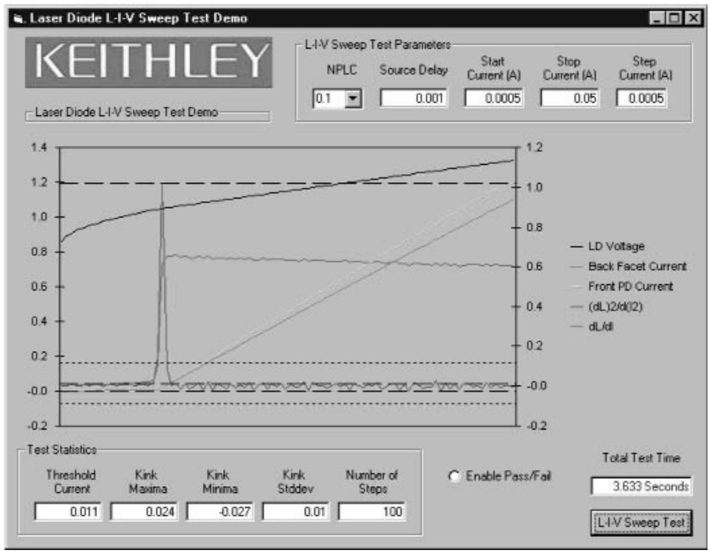
Pass/Fail Analysis

The three data streams that make up the forward voltage trace, the LD back facet detector current trace, and the external photodiode current trace are mathematically manipulated to quantify the threshold current, quantum efficiency, and maximum differential ohms excursion. These numbers are compared to expected values to determine the quality of the LD.

Depending on the noise content of the data streams, it may be necessary to perform filtering operations before performing calculations such as dL/dI_F. The low-noise characteristics of the Model 2420 and Model 2500 Dual Photodiode Meter reduce the need for noise compensation techniques.

Example Program

Keithley Instruments has developed an example program in Microsoft Visual Basic in order to perform an L-I-V test. To obtain a copy of the program (LIV25TestSweep.zip), visit Keithley’s World Wide Web site (http://www.keithley.com).



L-I-V Sweep Test Parameters

NPLC	Source Delay	Start Current (A)	Stop Current (A)	Step Current (A)
0.1	0.001	0.0005	0.05	0.0005

Test Statistics

Threshold Current	Kink Maxima	Kink Minima	Kink Stddev	Number of Steps
0.011	0.024	-0.027	0.01	100

Total Test Time: 3.633 Seconds

Laser Diode L-I-V Sweep Test Demo Screen

System Expansion

Telecom LD Module Pin-Outs

Telecom LD modules from a given manufacturer often have more than one pin-out configuration. A variety of LD module pin-outs can be easily accommodated via computer control by routing all the instrumentation signals through the Keithley 7002 Switch Mainframe and the appropriate plug-in switch cards. The switch also allows the instruments to make complex isolation and quiescent power measurements.

Modulation Inputs

LD modules are often equipped with modulation or attenuation control inputs. The addition of a second Model 2400 SourceMeter instrument to bias the attenuation input may be required to perform the basic L-I-V test sweep. Since the bias value is held constant during the L-I-V test sweep, the SourceMeter instrument should not be part of the Trigger Link interconnect.

Forward Voltage Test

The forward voltage is the result of the majority carrier current flow and is therefore a function of the semiconductor material and the temperature of the junction.

The forward voltage test can be performed on the LD as well as the back facet photodiode to determine the forward operating voltage of the semiconductor junction. Typically, a Series 2400 SourceMeter instrument is configured to source a sufficiently small current (to prevent damage), then measure the resulting voltage across the junction. Given that most detectors use semiconductor materials with temperature coefficients of about 2mV/°C, the temperature of the junction must be known or controlled.

Reverse Breakdown Voltage Test

As the reverse bias voltage is increased, the velocity of the minority carriers crossing the junction is increased. At a given reverse voltage, the energy of the charge carriers is sufficient to result in ionization by collision. This voltage is known as the reverse breakdown voltage. If the current at this voltage is carefully limited, the junction will not be destroyed.

The reverse breakdown voltage test can be performed on the LD and the back facet photodiode. A non-destructive reverse breakdown test can be performed by sourcing –10µA and measuring the resulting junction voltage. The Model 2400 SourceMeter instrument is ideal for this measurement.

Leakage Current Test

The reverse-biased semiconductor junction (at a lower potential than the breakdown voltage) has a leakage current made up of minority carriers crossing the depletion region. The magnitude of the leakage current is dependent on electronic charge, doping density, junction area, and temperature.

Leakage currents of the laser diode and the back facet photodiodes can be tested with a Model 2400 SourceMeter instrument. Typically, 80% of the reverse breakdown voltage is applied to the junction and the resulting leakage current is measured.

For the photodiode, this test also serves as the dark current measurement. With the LD bias held to zero, the dark current is measured by applying a bias to the junction and measuring the current flow. During this measurement, it is critical that stray photons don't impinge upon either the LD or back facet photodiodes.

Thermistor Test

The thermistor of a typical LD module has a nominal resistance of 10kΩ at 25°C. In normal operation, the thermal stability of the module is more critical than the absolute temperature value. A number of techniques can be used to test the thermistor:

1. Hold the temperature of the LD module to a known value and simply measure the resistance of the thermistor.
2. Thermally couple a characterized thermistor to the LD module, allow the assemblies to reach a thermal equilibrium, and compare the characterized thermistor's resistance with the LD thermistor's resistance.
3. Set a range of resistance values that is wide enough to accommodate the temperature of the LD module in the manufacturing process.

To avoid self-heating of the thermistor, it is important to keep the power dissipation to a minimum. Typically, a constant current of 10µA to 100µA is sourced and the resulting voltage measurement is used to derive resistance.

TEC Test and Control

Many LD modules are equipped with a thermoelectric cooler (Peltier device). Typically, a TEC controller is used to control the temperature of the module during the L-I-V test sweep. It is also possible to verify the functionality of the TEC device by modulating the temperature set point and verifying the thermistor resistance after the new temperature is reached.

Excessive mechanical shear loads are probably the most common failure mechanisms in Peltier devices. During handling and mounting of the Peltier device, mechanical shear loads can cause de-lamination or breakage of some or all of the elements in the device. A simple AC or reversing DC resistance test can determine the health of the Peltier before and after mounting in the LD module. A direct current resistance measurement would be inaccurate due to self-heating of the elements and the resulting thermal offsets. The Model 2510 TEC SourceMeter instrument can provide the necessary bipolar current source and voltage measurement capability to facilitate this measurement.

Isolation Test

Use of a switch matrix facilitates isolation tests between the various components of the LD module. For instance, the thermistor's electrical isolation from the LD can be tested by applying a potential between the thermistor and the LD while holding both terminals of the thermistor and both terminals of the LD at the same potential to prevent current flow through the individual components.

Methods and Techniques

Model 2361 Trigger Controller

As additional test capabilities are added to the basic test system, the control and coordination of triggers grows beyond the capability of the trigger control circuits supported in the individual instruments. The Model 2361 Trigger Controller provides system-wide trigger control with a dedicated programmable trigger control micro-sequencer, six input trigger lines, and six output trigger lines. The Trigger Controller's micro-sequencer provides high level control, including looping, loop repeat, trigger repeat, memory control, etc. Once programmed, the Trigger Controller executes independently of the host computer. This allows faster and more predictable operation than GPIB bus commands allow.

Contact Check

The Contact Check option, available on the Series 2400 SourceMeter line, helps eliminate measurement errors and false failures by verifying the resistance between Output HI/Sense HI, Output LO/Sense LO, and Guard/Guard Sense connections. Contact Check uses a pulse scheme that minimizes the potential at the DUT during the resistance measurement, verifies all three resistance values simultaneously, and requires less than 1ms per DUT.

Cabling

Cabling must be optimized for accuracy and test speed. High-quality, low-noise cable is required for all measurements. The cable characteristics for the LD drive signal are much different from those of the photodiode signals.

The photodiode signal is generated by sourcing several volts and measuring the current flow in the nanoampere range with the Model 2500. At such low currents, it is critical to use a low-noise shielded cable to optimize the signal-to-noise ratio. Using the shortest length of cable will also improve the signal-to-noise ratio by reducing leakage and induced currents, as well as minimizing capacitance.

The slew rate (*dV/dt*) of the LD drive signal is a function of the semiconductor junction. The junction voltage will change only a few millivolts for a current change of tens of milliamps. As a result of the low slew rate requirements, the capacitance of the LD drive signal cable is not as critical to the application as the voltage drop across the cable as it carries up to 3A. A large gauge cable will help reduce the voltage drop over the length of the cable while having minimal impact on the speed of the test.

In all cases, the cabling must be shielded and as short as possible to reduce noise and capacitance. Lower noise means less integration time is required for each measurement and the test sweep will be faster.

Typical Sources of Error

Leakage Currents

In addition to the nominal leakage characteristics of the cabling and DUT fixturing, conductive contamination of the fixture will increase over time, producing leakage currents. Techniques to minimize leakage may be required when measuring low currents or when using low current photodiodes.

One technique for minimizing leakage current is to use a guarded fixture. In a guarded fixture, the region near the DUT is held at the same potential as the Output HI signal. This reduces the potential difference between the DUT and the leakage paths.

For a more detailed explanation of the Guard and Guard Sense signals, see the Keithley white paper titled "Obtaining More Accurate Resistance Measurements Using the 6-Wire Ohms Measurement Technique," available on Keithley's web site.

Electrostatic Interference

High resistance measurements, like those made using photodiodes, may be affected by electrostatic interference from charged objects. It may be necessary to use an electrostatic shield (Faraday cup) to eliminate electrostatic effects. For more information, see the section titled "*Low Current Measurements*" in the fifth edition of Keithley's handbook *Low Level Measurements – Precision DC Current, Voltage and Resistance Measurements.*

(*Low Level Measurements* is available at no charge. See *www.keithley.com* or contact your local Keithley Sales Representative to request a copy.)

Light Interference

Stray light entering the optical fiber or the integrating sphere will skew the test results. Take care to ensure that all components are properly shielded at all wavelengths that could affect the conductance of the semiconductor junctions. This is especially critical for dark current measurements of the photodiode.

Equipment List

Basic Equipment:

- Model 2420 High Current SourceMeter instrument (laser diode bias)
- Model 2500 Dual Photodiode Meter (light output power for front and back photodetector)
- Model 2510 TEC SourceMeter instrument (laser diode temperature control)
- 7008-3 IEEE-488 (GPIB) Cable (3 required)
- KPCI-488.2AT (or other IEEE-488 interface card)
- 8501-1 Trigger Link Cable
- Integrating sphere and detector (calibrated as needed)

Expansion Equipment:

- Model 2400 SourceMeter instrument (modulator bias)
- Model 2000 DMM (resistance/voltage measurements)
- Model 7001 (2-slot) or Model 7002 (10-slot) Switching System Mainframe
- Model 7053 High Current Switch Card (to route Model 2420 and Model 2510 output)
- Model 7012 4X10 Matrix Switch Card (to route Model 2400 output)
- Model 7058 Low Current Scanner Card (to route Model 2500 input)
- Model 2361 Trigger Controller
- Model 8503 DIN to BNC Trigger Cable (2 required)

A suitable PC and software are also required to implement an L-I-V test sweep.

Note: For certain photodetector current measurement ranges, a Model 2400 SourceMeter instrument can be substituted for the Model 2500 Dual Photodiode Meter.

Test System Safety

Under normal operating conditions, optical fiber communications systems employing a laser diode module are considered safe. However, during the testing of laser diode modules, care must be taken to ensure operator safety. Please consult your facilities laser safety officer or appropriate regulatory, health, and safety organizations.

Many electrical test systems or instruments, including the L-I-V System, are capable of measuring or sourcing hazardous voltage and power levels. It is also possible, under single fault conditions (e.g., a programming error or an instrument failure), to output hazardous levels even when the system indicates no hazard is present.

These high voltage and power levels make it essential to protect operators from any of these hazards at all times. Protection methods include:

- Design test fixtures to prevent operator contact with any hazardous circuit.
- Make sure the device under test is fully enclosed to protect the operator from any flying debris.
- Double insulate all electrical connections that an operator could touch. Double insulation ensures the operator is still protected, even if one insulation layer fails.
- Use high-reliability, fail-safe interlock switches to disconnect power sources when a test fixture cover is opened.
- Where possible, use automated handlers so operators do not require access to the inside of the test fixture or have a need to open guards.
- Provide proper training to all users of the system so they understand all potential hazards and know how to protect themselves from injury.

It is the responsibility of the test system designers, integrators, and installers to make sure operator and maintenance personnel protection is in place and effective.

Conclusions

Not only does DC testing of LD modules reduce manufacturing cost by identifying failed components early in the manufacturing process, it can also play a critical role in accelerated lifecycle testing. Many LD manufacturers offer high reliability LD parts that have successfully endured days of L-I-V type testing at elevated operating temperature to identify unstable parts prior to incorporation in subsystems destined for undersea operation.

KEITHLEY

Keithley Instruments, Inc. 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168
1-888-KEITHLEY (534-8453) www.keithley.com

BELGIUM:	**Keithley Instruments B.V.**	Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02/363 00 40 • Fax: 02/363 00 64
CHINA:	**Keithley Instruments China**	Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-6202-2886 • Fax: 8610-6202-2892
FRANCE:	**Keithley Instruments Sarl**	3, allée des Garays • 91122 Palaiseau Cédex • 01 64 53 20 20 • Fax: 01 60 11 77 26
GERMANY:	**Keithley Instruments GmbH**	Landsberger Strasse 65 • D-82110 Germering • 089/84 93 07-40 • Fax: 089/84 93 07-34
GREAT BRITAIN:	**Keithley Instruments Ltd.**	The Minster • 58 Portman Road • Reading, Berkshire RG30 1EA • 0118-9 57 56 66 • Fax: 0118-9 59 64 69
INDIA:	**Keithley Instruments GmbH**	Flat 2B, WILLOCRISSA • 14, Rest House Crescent • Bangalore 560 001 • 91-80-509-1320/21 • Fax: 91-80-509-1322
ITALY:	**Keithley Instruments s.r.l.**	Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
KOREA:	**Keithley Instruments Korea**	2FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-130 • 82-2-574-7778 • Fax: 82-2-574-7838
NETHERLANDS:	**Keithley Instruments B.V.**	Postbus 559 • NL-4200 AN Gorinchem • 0183-635333 • Fax: 0183-630821
SWITZERLAND:	**Keithley Instruments SA**	Kriesbachstrasse 4 • 8600 Dübendorf • 01-821 94 44 • Fax: 01-820 30 81
TAIWAN:	**Keithley Instruments Taiwan**	1FL., 85 Po Ai Street • Hsinchu, Taiwan, R.O.C. • 886-3-572-9077• Fax: 886-3-572-9031

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