

ODE5001-00

Opnext Laser Diodes

Surge Damage Prevention Manual



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Introduction

Nowadays laser diodes play an important role in our daily lives. In addition to the properties characteristic of lasers, such as monochromatic light, excellent beam focusing and coherence, laser diodes provide additional features such as compactness and lightness, low-power dissipation, and high-speed, direct modulation capability. They are used in many different applications, ranging from optical disk units to telecommunications. Opnext offers a full line of laser diode products, including models that produce laser light in the visible range (0.63 μm) and in the infrared range (0.83 μm).

Due to their excellent high frequency-response characteristics, the mirror facets of laser diodes can easily incur optical damage from to surges. Therefore, sufficient care should be exercised in their handling. This manual is intended to ensure that Opnext laser diode devices provide the full performance and high reliability they are capable of. It lists several problem points related to surge damage and provides information on destruction levels, examples of changes in properties, and examples of failure modes, with an emphasis on laser diodes that produce output in the visible and in the infrared range.

It is recommended that this manual be read before performing measurements on laser diodes or designing products incorporating laser diode devices. At a minimum, reading "Section 6 Measures to Prevent Surge Damage to Laser Diodes" as well as "Section 7 Surge Damage Examples", and performing the appropriate checks beforehand, should be sufficient to avoid surge-related failures.

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Section 1 Surge Damage and Evaluation Methods

Care must be taken in laser diodes handling to prevent damage to their facets (optical damage) caused by forward surges as well as damage caused by electrostatic discharge. Most cases of damage from forward surges are caused by design defects in the automatic power control (APC) circuit (incorrect offset adjustment, undesirable oscillation, poor contacts, drifting capacitance, etc.). (See below.)

The lower threshold current (I_{th}) and the higher slope efficiency (η_s) give laser diode the efficient and low voltage drivability. But this causes to reduce the ability of the laser diode to withstand low-level current surges and discharges of static electricity.

	Forward surge current	Electrostatic damage
Factor	Current	Charge (voltage)
Example	Surge inductance in power supply circuit	Electrostatic discharge from human body, etc.

1.1 Damage from Forward Surges

As laser diode differ from silicon devices, the area of safe operation (ASO) of laser diodes is not decided by power consumption alone, but optical output (P_o) must be considered from view point of optical damage. Since the area of safe operation for laser diodes has not been established, a provisional index is provided below.

Forward surge damage often is observed at a stage near the completion of driver circuit fabrication. The amount of forward surge a laser diode can withstand can be evaluated using a simple circuit like the one shown in figure 1.1. This measurement method uses a pulse generator ($t_r, t_f \leq 10$ ns). The output stage consists of a power MOS FET, a storage scope for output current monitoring and a power supply for the FET bias.

The pulse generator generates a 1-shot pulse for ASO evaluation. Figure 1.2 shows the operating area relative to the results obtained, however additional safety margin be applied in actual use. It should be noted that in this figure power of catastrophic optical damage (P_{COD}) is determined by equation (1). Therefore if the laser diode's threshold current (I_{th}) and slope efficiency (η_s) differ significantly from the measured sample distribution, it will be necessary to consider these deviation in the design.

$$(I_F - I_{th}) \times \eta_s = P_{COD} \quad (1)$$

I_F : Forward current

P_{COD} : Optical power of catastrophic damage

As seen in Figure 1.3, even if the P_{COD} value for LD-1 and LD-2 is the same, the I_F (surge) they can withstand will differ if I_{th} and η_s are different.

Actual measurement examples are shown in figure 1.4 and figure 1.5.

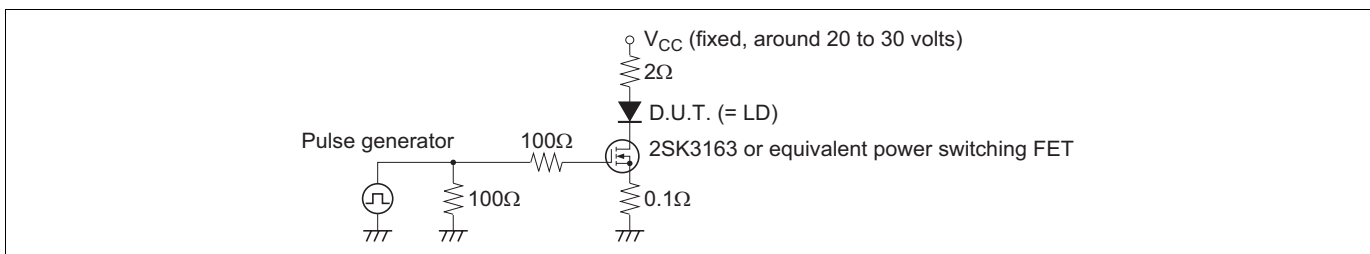


Figure 1.1 Circuit for Measuring Ability to Withstand Surges

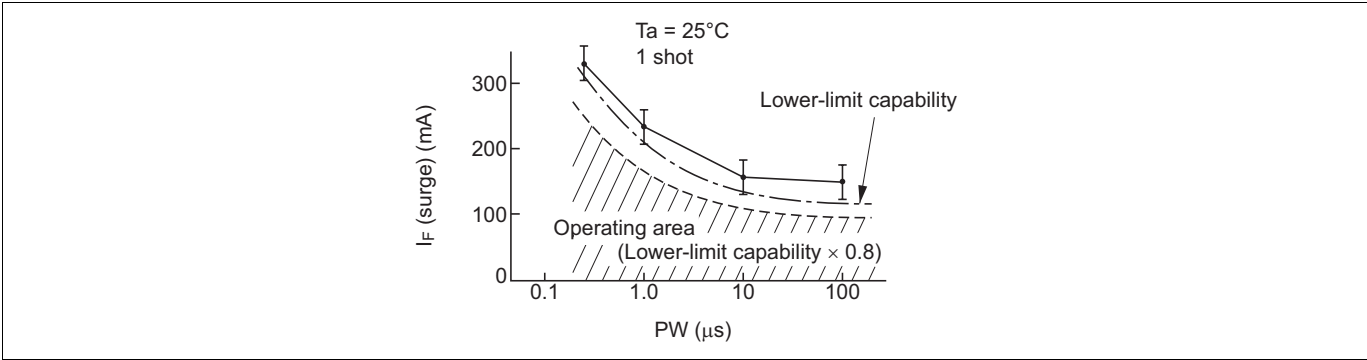


Figure 1.2 Measurement Examples Showing Ability to Withstand Surge

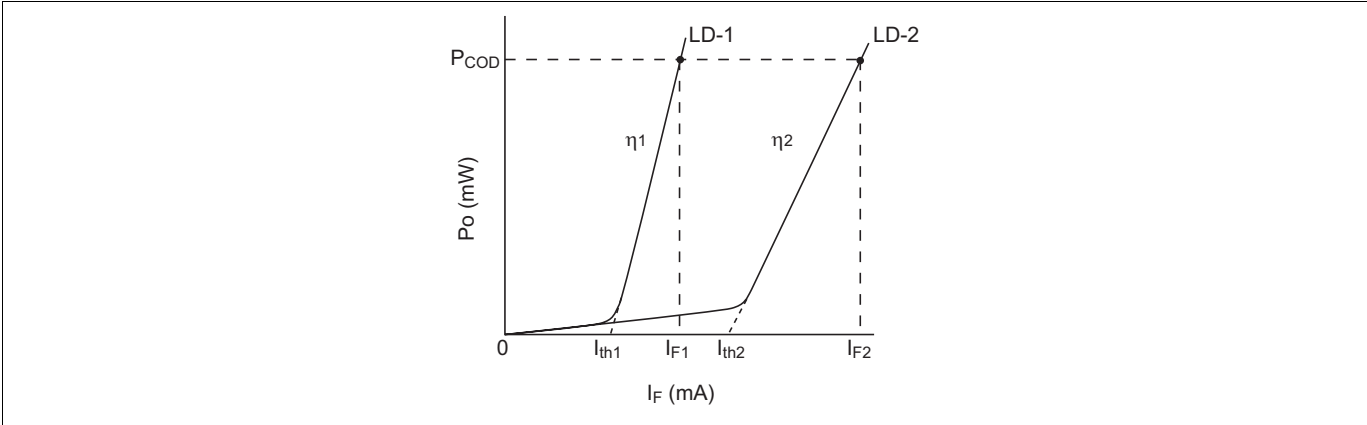


Figure 1.3 I_F - P_O Characteristics

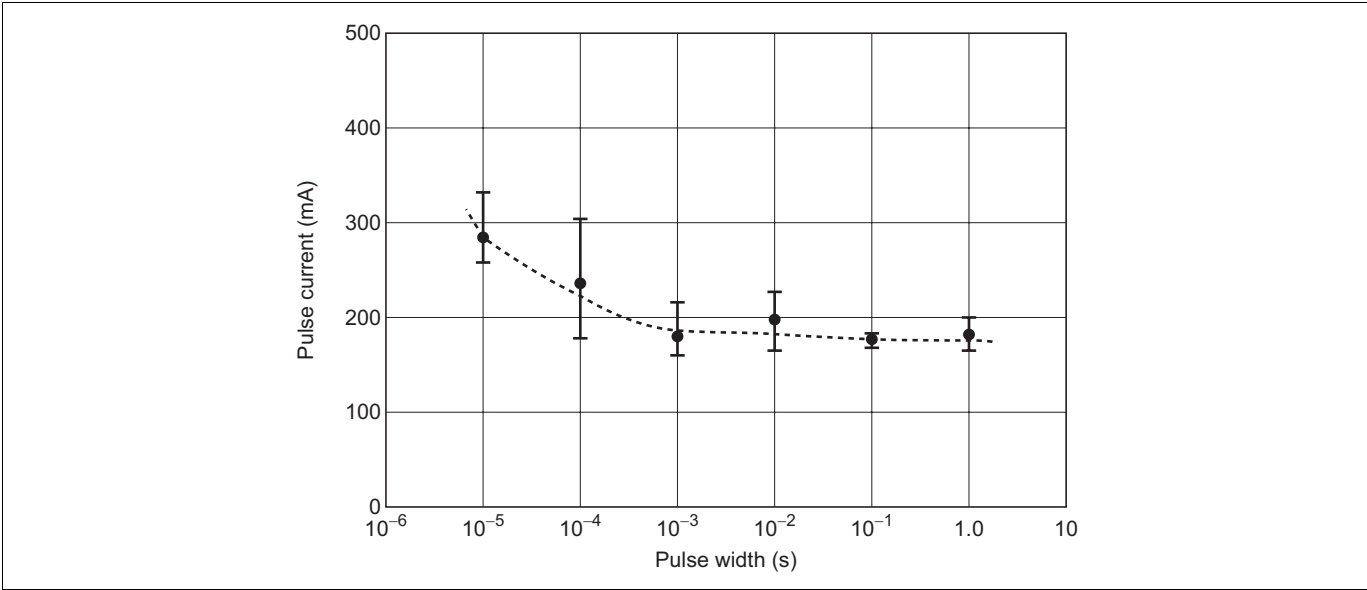


Figure 1.4 Forward Surge Strength Test of Visible Laser Diode

1.2 Electrostatic Damage

The ability of laser diodes to withstand electrostatic damage can be evaluated using a simple circuit of the sort shown below. It consists of a power supply, a capacitor and a switch (figure 1.5). The capacitor must be durable enough to withstand the used voltage levels. The switch must have high insulation resistance and be free of chattering (for example, a high-voltage mercury relay). Figure 1.6 actual measurement examples in different polarities.

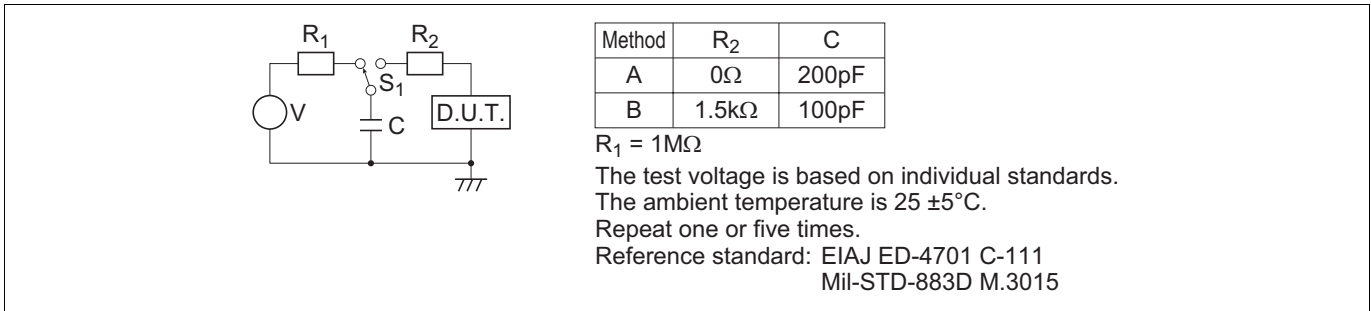


Figure 1.5 Electrostatic Discharge Test Circuit

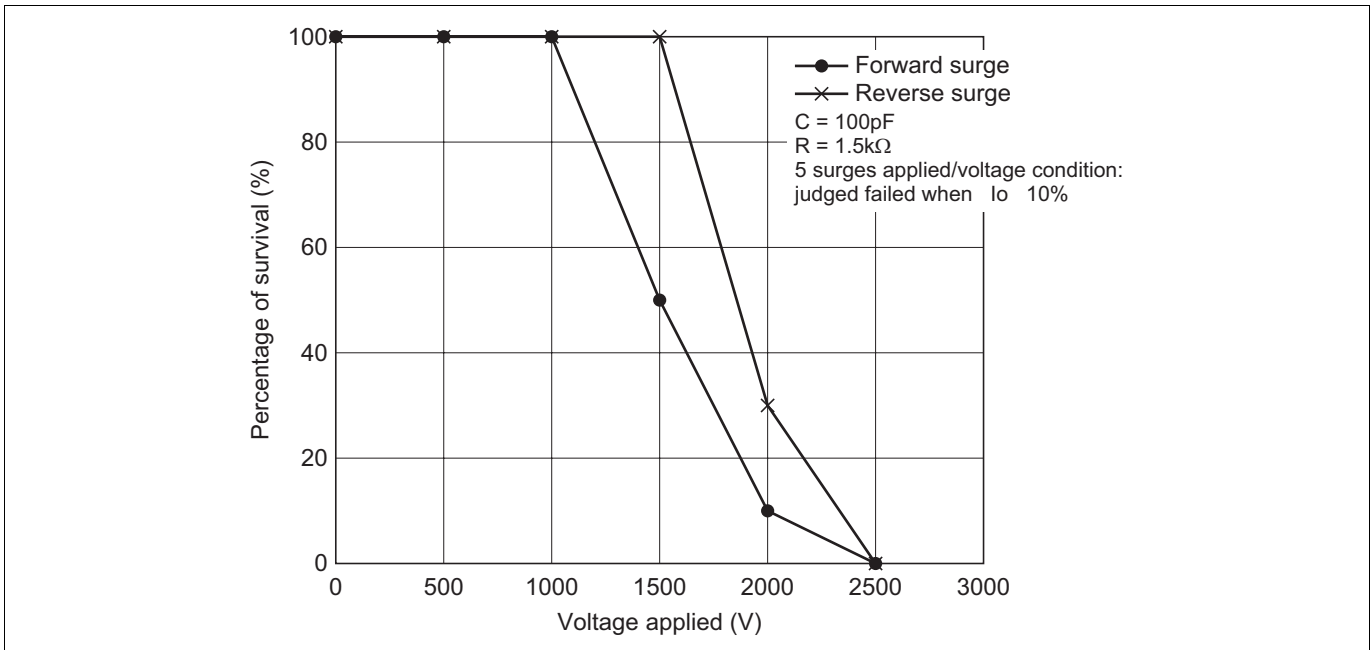


Figure 1.6 Electrostatic Damage Strength of Visible Laser Diode (Example)

Section 2 Precautions Related to Circuit Designs

In order to ensure reliability, some margin should be allowed in the circuit design by, either derating or taking characteristics deviation into account along with, of course, satisfying the initial specifications. With regard to surge damage, issues that should be taken into consideration include wiring problems, external surges, reactance load, noise margin, area of safe operation (ASO), reverse voltage, flyback pulse, static electricity, and pulse stress.

Generally speaking, the following points should be kept in mind:

- (1) That excessive voltage caused by undesirable noise or induced at input, output, or power supply terminals. Also, the circuit be free from strong electromagnetic waves.
- (2) That the circuit be ESD free while operating.
- (3) That a protective circuit be set in input or that make sure no electrostatic pulse be applied to input.
- (4) That there be no imbalance in the voltage supplied when the power supply is turned on and off.

For example, excessive stress will result if the circuit's ground terminal is in a floating state, when another terminal is accidentally grounded and voltage is applied to the input or power supply terminal.

The following precaution should be applied when installing semiconductor devices, including laser diodes, in circuits.

2.1 Countermeasures Against Noise and Voltage Surges

Electronic equipment is generally designed to have manage some voltage fluctuations (normally, it is $\pm 10\%$) in the commercial power supply. However, if other equipment generating voltage surges is in use around the device, the fluctuations in the power supply voltage may cause it to fail or malfunctions. Such surges can be reduced by adding a filter to the AC line, as shown in figure 2.1. However, even if surges or static electricity are not induced indirectly from the AC line, there may still be induced directly into the components or semiconductor devices on the circuit board. In such cases, it is necessary to shield semiconductor devices. Also, it is important that the impedance from the shield to the ground should be low for the effective shielding.

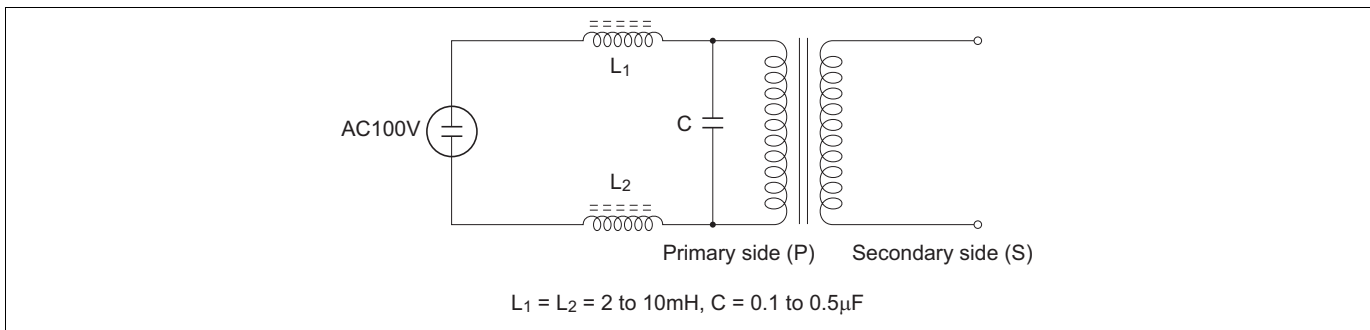


Figure 2.1 Surge-absorption Circuit Example

In cases where static electricity or surge pulses may be applied directly as noise, a protective circuit shown in figure 2.2 as a special example may be applied. The time constant, $R_i \times C_i$ should be set in a range where it will not affect operation but still allow good surge puls absorption.

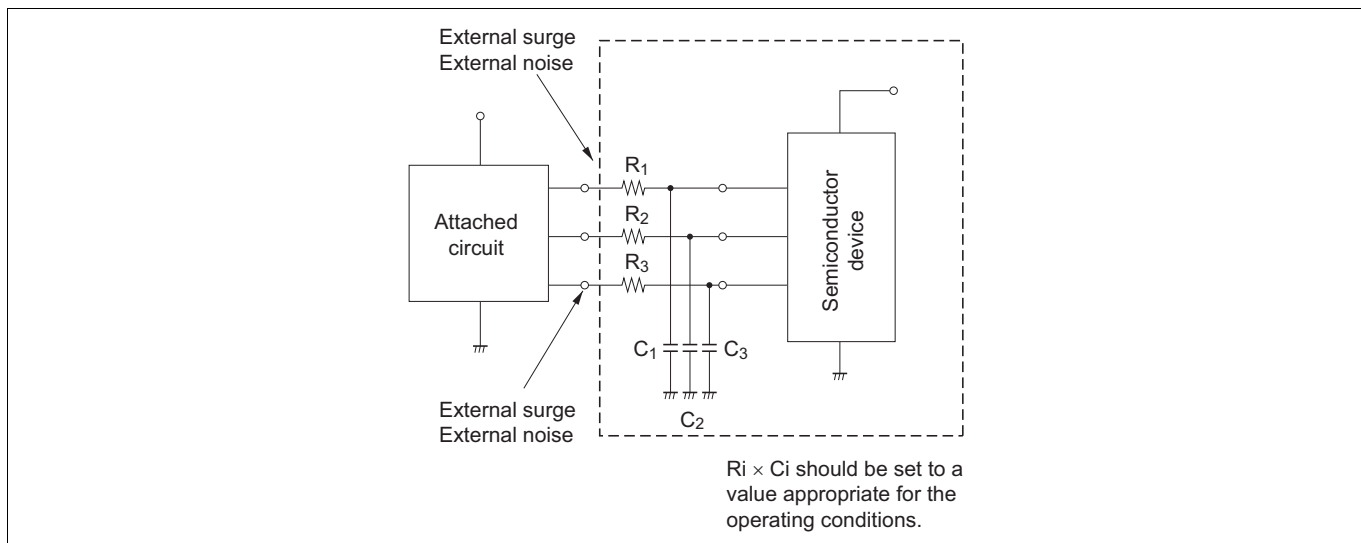


Figure 2.2 Surge Protection Circuit Example

2.2 Types of Noise

Noise that causes problems in actual circuit applications can be classified into two categories: (a) noise generated between the ground and signal lines, and (b) noise generated between signal lines (figure 2.3). The effects of each of these types of noise on semiconductor devices, and the countermeasures are different.

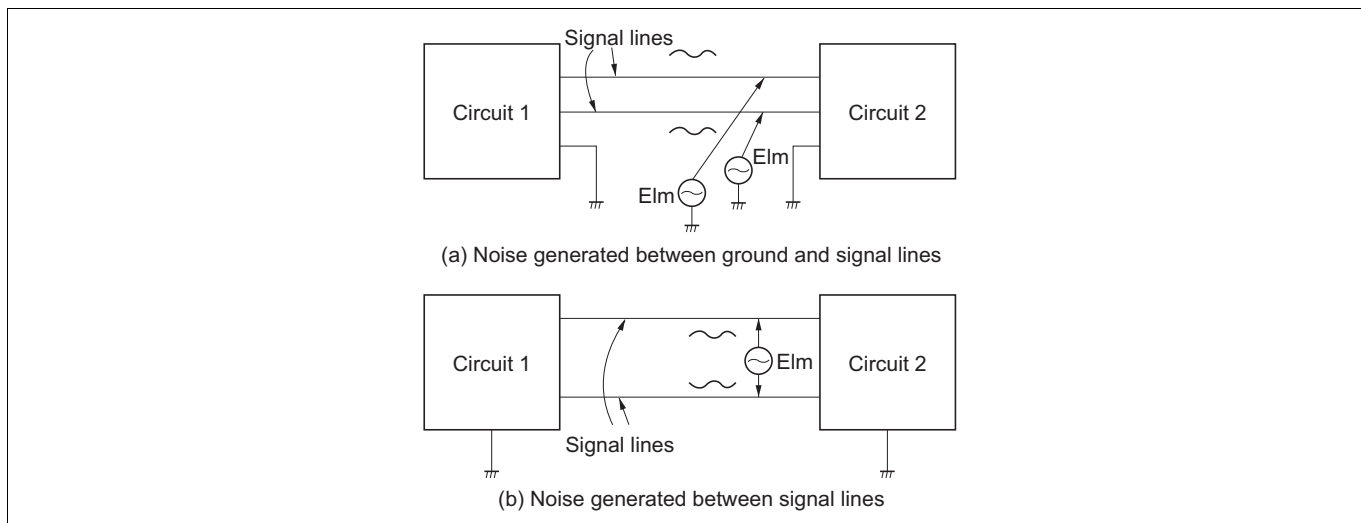


Figure 2.3 Types of Noise

Causes where a noise is generated are listed below:

- (1) Conduction:
When there is leakage impedance between the noise source and the signal line.
- (2) Electrostatic induction:
When there is an electrostatic capacitance between the noise source and the signal line.
- (3) Electromagnetic induction:
When there is mutual conductance between the noise source and the signal line.
- (4) Crosstalk:
When there are two or more adjacent signal lines, one passes noise voltage to another through electrostatic or electromagnetic induction.
- (5) Ground loop:
When the transmitting and receiving ends of signal line are both grounded, the potential difference between two may result in noise.
- (6) Reflection:
When the impedance of the signal line is not properly matched, reflected wave to be imposed on the signal may cause noise.

These concepts are shown in figure 2.4. (In this diagram, the power line is assumed to be the noise source.)

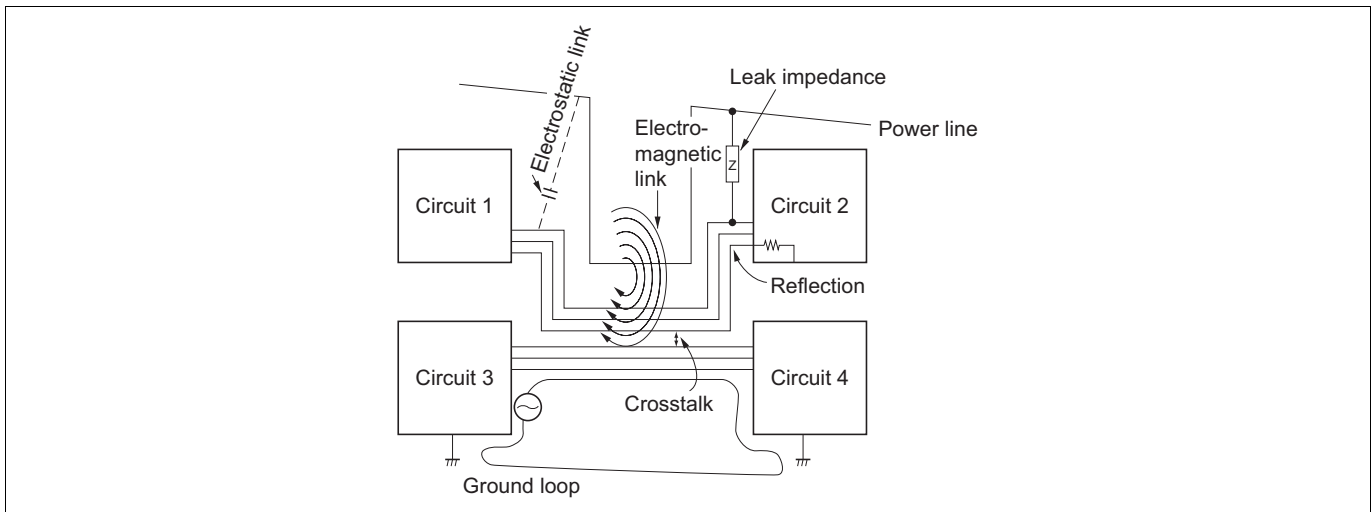


Figure 2.4 Links Between Noise Source and Signal

2.3 Noise Elimination Measures

To design systems free from noise problem, it is necessary to take such measures as remaining or decreasing noise source, making systems so they will not pick up noise, providing circuits with sufficiently large noise margins, or installing protective circuits.

(1) Prevention at the Noise Source:

The most effective measure is dealing directly with the noise source, if possible. As examples, adding a diode, resistor, or capacitor parallel to the relay coil to reduce surge voltages, or adding a filter to the supply line on the side the noise is generated to reduce noise running through the AC supply line. In the case of equipment generating a strong electric field, shielding is effective because it obviates other measures for the system on the affected side. Another possibility is to separate the affected system from the source of the noise.

(2) Prevention at the Ground Line:

To prevent current through the grounding system from interfering with the circuit system, the circuit system should be provided with an exclusive ground line, completely separated from other grounding systems, such as for power-supply lines. Also, there should be only one ground connection between the circuit system and the chassis to prevent the formation of a closed loop between them (figure 2.5).

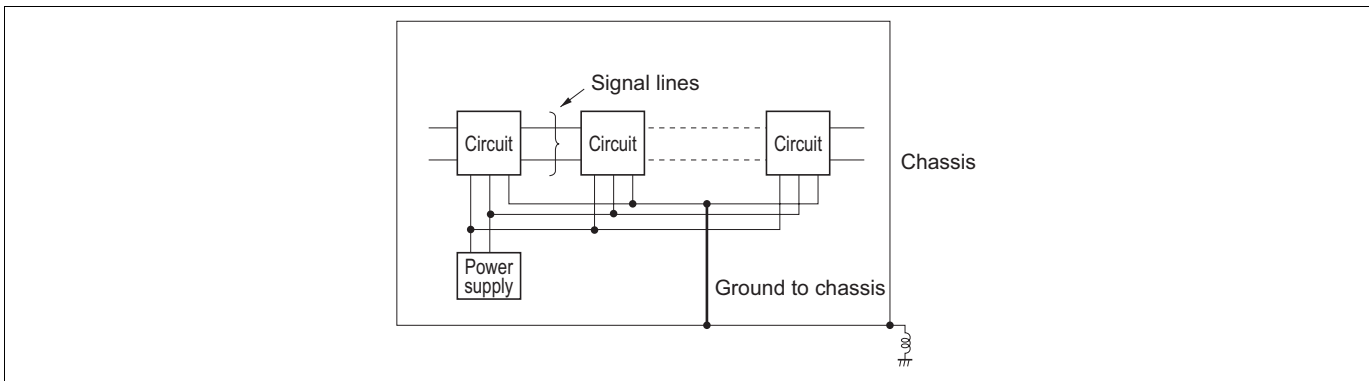


Figure 2.5 Grounding the Circuit System

(3) Prevention by Shielding:

Shielding both the signal lines and the whole system is an effective way to reduce external noise. To deal with noise caused by electrostatic induction, the circuit system should be covered with a good conductor, which should be grounded. In this way, noise induced to a signal line when no shielding is applied is pass to the shield line and bypass to the ground.

Another examples of shielding are the use of twisted pair wire. Noise is reduced if the signal lines are arranged symmetrically to the signal source, receiver, and ground noise source. Using twisted pair wire may form a ground loop, but this can be eliminated by the method shown in figure 2.6.

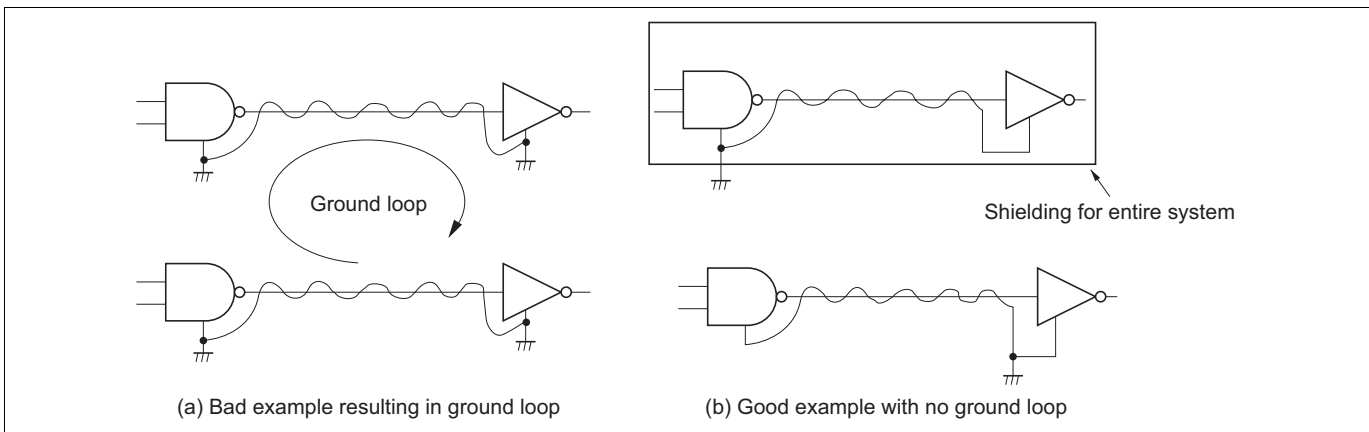


Figure 2.6 Twisted Pair Wiring Methods

(4) Prevention Using Filters:

Since noise from a power supply source generally enters the device through an AC line, an AC line filter can be added either on the side where the noise is generated or in the AC power supply side of the circuit system. Also, the power supply impedance must be much low relative to the circuit system side, so capacitors can be added to reduce the impedance where it's needed. In such cases, it is desirable to use two capacitors connected in parallel: one with a large capacitance as a bypass for comparatively low-frequency waves and one with low impedance and a small capacitance to deal with high-frequency.

(5) Surge Protection:

Circuit systems are sometimes placed in environments where they are surge voltage is generated. Some common examples are described here.

When a laser diode is located near a high-voltage circuit, such as a synchroscope, voltage surges may be induced into laser diode and be damaged. Figure 2.7 and figure 2.8 show examples where resistors and capacitors are inserted as surge absorbing or reducing circuits. The main factor in improving reliability is how to reduce this surge voltage. In figure 2.7, surge induced to the lead wire is reduced by using a capacitor and a resistor to protect the laser diode. Figure 2.8 shows an example in which surges entering the power supply are absorbed.

To prevent surge damage to laser diodes, it is necessary to find it intrusion pass and terminal such as those described above.

Another item that is sometimes overlooked is the possibility of damage caused by potential differences in power supply lines that had been assumed to have equal potential. To prevent this from happening, it is necessary to use a layout or wiring method that prevents inductance caused by surges, to provide shielding, or to devise appropriate grounding points.

(6) Method for Measuring Surges:

Some methods for eliminating noise that could result in surges are described in the preceding section. It is hoped that these methods will be borne in mind when designing and developing circuits and systems. Furthermore, it is necessary to check the current flow in the laser diode's drive circuit, under conditions as close as possible to actual drive conditions not to be surge potential during laser diode drive circuit design. This can be done by checking for the generation of surges using a setup of the sort shown in figure 2.9. It employs a current probe (Tektronix A6302 current probe and AM503 probe amplifier, or equivalent) and a digital storage oscilloscope (Tektronix TDS 460A digitizing oscilloscope, or equivalent), and uses the rolling mode. (In the diagram a noise source is assumed, but in some cases surges are generated by the drive circuit itself. The method shown here can also be detect this type of surge.)

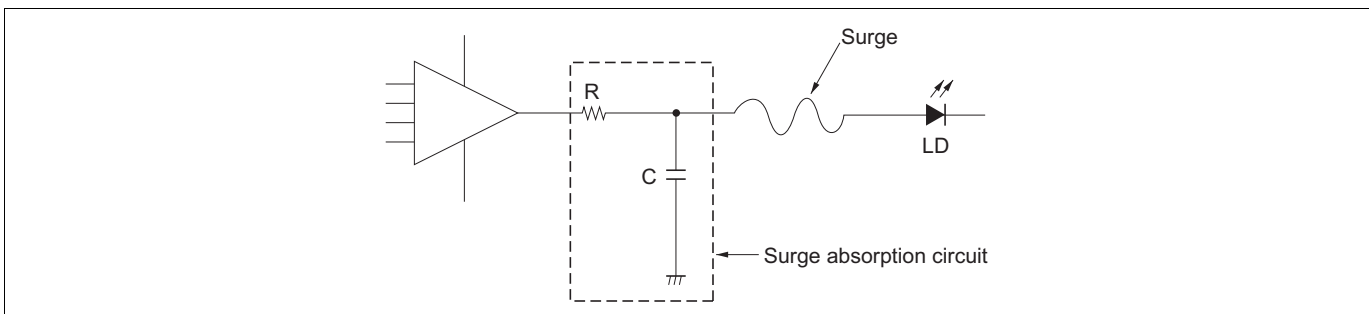


Figure 2.7 Surge Absorption Circuit Using Capacitor and Resistor

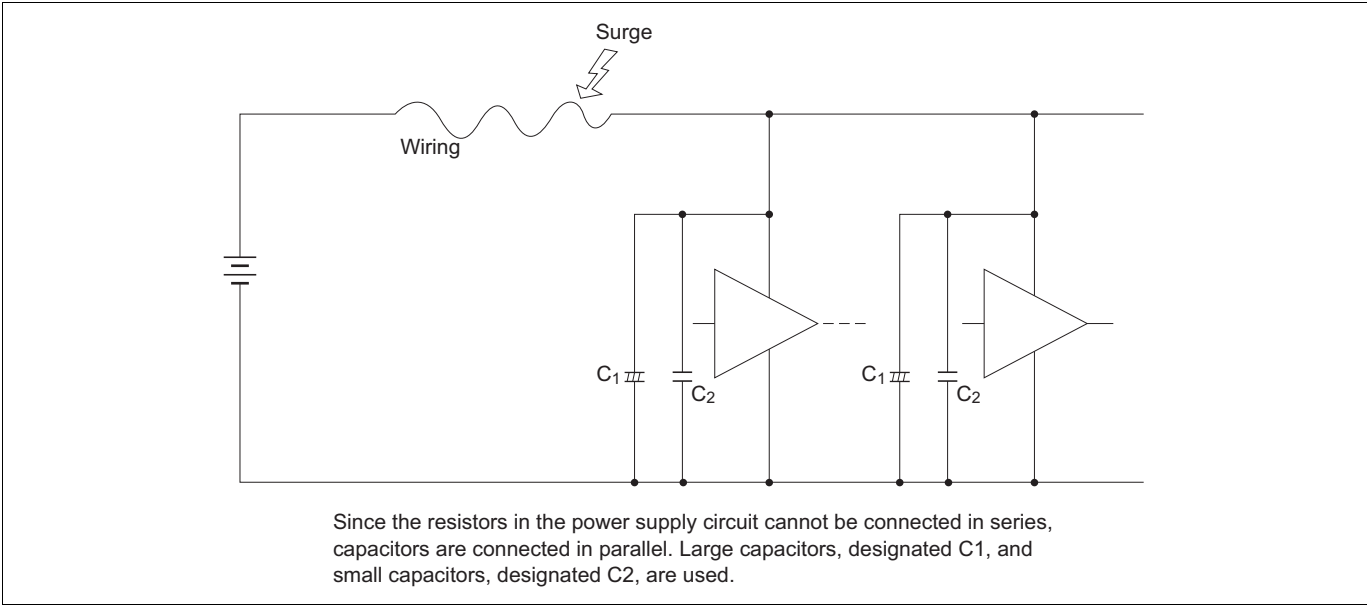


Figure 2.8 Absorbing Surges in the Power Supply Line

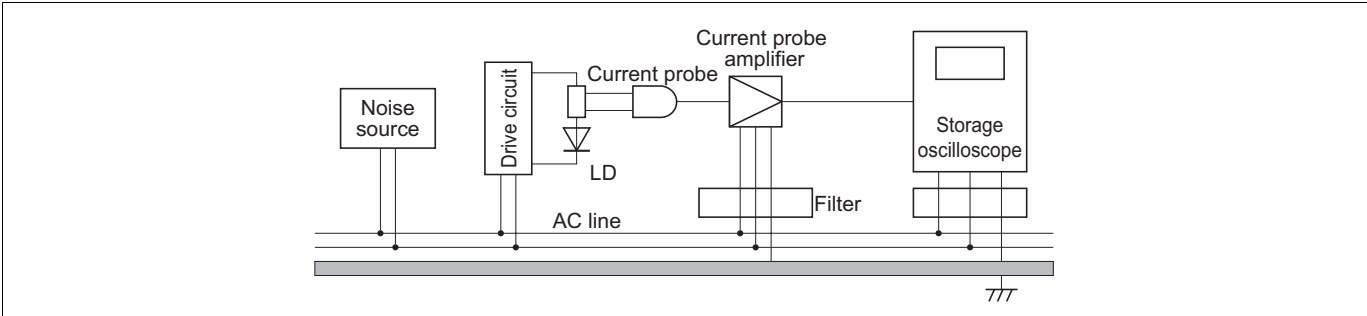


Figure 2.9 Method for Measuring Surges

Section 3 Precautions During Storage, Transport, and Measurement

The following special care during storage and transportation should be taken for optoelectronic devices besides the general handling precautions required to electronic components.

3.1 Laser Diode Storage Methods

Precautions listed below are carefully taken laser diode storage conditions. Insufficient care may result sometime in defects in electrical characteristics, solderability, external appearance, etc.

- (1) The storage place should be within a temperature range of 25 to 30°C and relative humidity should be 45 to 75%.
- (2) The storage place should be free of harmful gas and dust.
- (3) The storage containers should not be a type easily charged with static electricity.
- (4) No weight should be placed on the laser diode during storage.
- (5) If the laser diode will be stored for a long period of time, they should be unopened as shipped package.
- (6) The moisture condensation should not occur due to sudden changes in temperature.
- (7) The laser diode should be stored in a location exposed to radiation or strong electrical fields.

3.2 Precautions During Transport

- (1) The containers and jigs for laser diode must not be charged with or discharge static electricity during transport due to vibrations.
- (2) The operators' bodies should be grounded through a high resistance of about 1 MΩ while handling laser diode in order to prevent destruction from the induction of static electricity contained in their bodies and clothes.
- (3) When transporting a printed circuit boards with laser diodes mounted on, measures must be taken to prevent static electricity from collecting, such as by short-circuiting their terminals to make their electrical potential equal. Also, if a conveyor belt is used to move printed circuit boards, the rubber and other materials of the conveyor belt should be treated to prevent static buildup.
- (4) Measures should be taken to reduce mechanical vibration and bumps as much as possible when transporting laser diode or printed circuit boards.

Examples of typical electrostatic voltages are listed in the table below.

Table 3.1 Typical Electrostatic Voltage Examples

Static electricity source	Electrostatic voltage	
	10 to 20% RH	65 to 90% RH
Person walking on a carpet	35000 V	1500 V
Person walking on a vinyl floor covering	12000 V	250 V
Person working at a bench	6000 V	100 V
Vinyl covering	7000 V	600 V
Polyester bag lifted up from a bench	20000 V	1200 V
Chair stuffed with polyurethane foam	18000 V	1500 V

(From DOD-HDBK-263)

3.3 Precautions During Measurement and Handling

Since all terminals are exposed when testing or installing laser diodes, it is easily that the terminals will come into contact with the bodies of workers, measuring equipment, work tables, soldering irons, conveyor belts, etc. This means that there is a possibility of damage to laser diodes from either static electricity or leakage from electrical equipment. For this reason, sufficient care should be taken to prevent leakage from sources such as the AC power supply to the terminals or chassis of curve tracers, syncroscopes, pulse generators, DC regulated power supplies, etc.

In particular, during measurement it is important to make sure that surge voltages are not applied by the tester, or to insert clamp circuit into the tester. Also, it is necessary to make sure that there is no abnormal voltage apply due to poor contact during a current source driving. Furthermore, during testing care must be taken to prevent incorrect connection of terminals, reversed connections, and short circuiting of terminals. When checking the printed circuit board operation, confirm that there are no solder bridges or bridges made of foreign matter before turning power on.

Section 4 Failure Modes Classification

Figure 4.1 is a graph summarizing the ratio of various failure modes based on an analysis of laser diodes returned by customers. As seen in it, surge damage failure accounts for the majority of cases. This indicates that measures to deal with surge damage are essential to achieve a high reliability in laser diode applications.

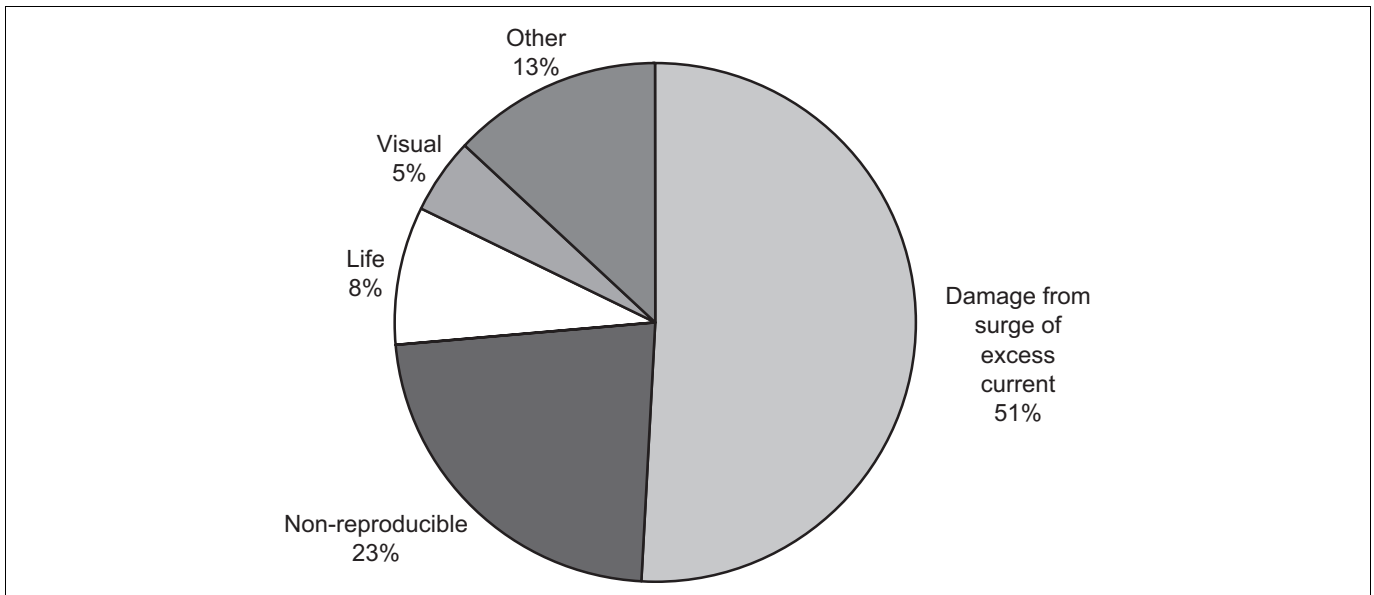


Figure 4.1 Classification of Failure Modes for Production Line and Market Defects

Section 5 Characteristics and Failure Analysis Examples

5.1 Relationship Between Characteristics and Reliability

Optical and electrical characteristics are provided for laser diodes depending on their functions and applications, and the ranges in which they must be met are specified. The importance of these characteristics in system design often varies with the application. Though it is impossible to generalize to all cases, it is necessary to allow in the design an adequate margin in the initial characteristics of important parameters, to perform derating, or the like.

The equation (2) can be used as a model of laser diode deterioration for the purpose of derating. This equation takes into account compound stress combining temperature stress and current stress and includes a parameter for variation over time. To achieve high reliability in applications employing laser diodes, it is important to perform derating using an equation such as this.

$$D_{lop} = A \cdot I_{op} \cdot \left(t \cdot \frac{\text{duty}}{100} \right)^m \cdot \exp\left(\frac{-E_a}{k \cdot T} \right) \dots\dots (2)$$

D_{lop} : changed rate (%) of operating current, A: deterioration constant (value based on experience),
 I_{op} : initial operating current value, m: change over time parameter (value based on experience),
k: Boltzmann's constant (8.617×10^{-5} eV/K), E_a : activation energy (eV) (value based on experience),
T: absolute temperature of junction during operation (K), duty: 100% during CW operation

With regard to important points, it is essential to select devices based on a consideration of the operating range limits for the system as a whole, to apply statistical design techniques, and to take into account in the design stage the failure judgement standards provided by the device supplier.

The following points should be borne in mind regarding parameters:

- (1) How important is the parameter? Could it result in a system failure?
- (2) What is the margin for the parameter's initial value?
- (3) Are changes that occur when the device is used with other devices within the permissible range or not?
- (4) Is it possible to design redundancy into the system?
- (5) Is it possible to introduce statistical design methods for parameters?

Special care needs to be taken when using laser diode devices for special applications such as medical equipment and satellite telecommunications equipment, as well as usage in environments prone to the generation of electromagnetic noise, such as in machine tools and automobiles. Please consult with an Opnext engineering specialist with regard to such applications.

5.2 Examples of Changes in Characteristics due to Surge Damage and Failure Mode Examples

Table 5.1 shows examples of changes in characteristics due to laser diode surge damage as well as failure modes; table 5.2 shows examples of failure analysis data. Since the active area of laser diodes is a microstructure on the sub-micron order, the application of excessive stress in the form of surge current, static electricity, or over current can result in fluctuations that dramatically degrade reliability, such as changes in optical and current characteristics, monitor current linearity, far field pattern, or generated wavelength. For this reason, sufficient attention must be paid to the possibility of surge damage.

The mechanism by which the damage occurs has been confirmed through failure analysis using, for example, the electron beam induced current (EBIC) method. It indicates that momentary excessive laser output due to the surge, which in the case of visible range laser diodes results in optical damage to the center of the active layer of the laser facet.

The electro-luminescence (EL) and electron beam induced current (EBIC) failure analysis methods are illustrated in figure 5.1 and figure 5.2, respectively.

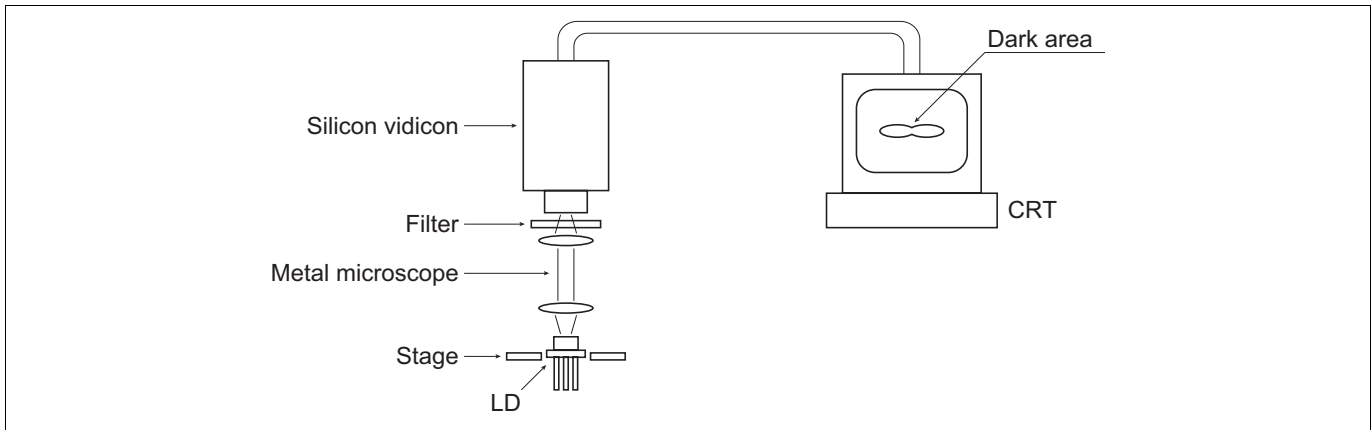


Figure 5.1 Electro-luminescence (EL) Method

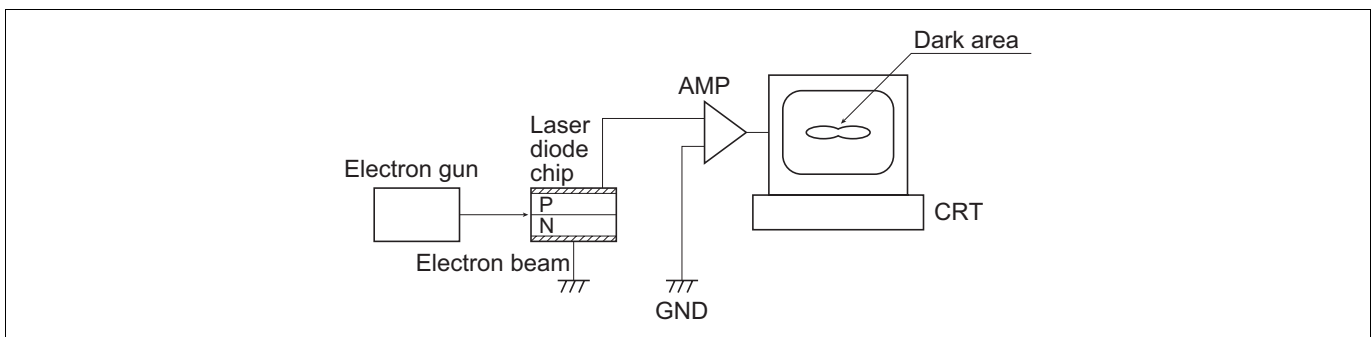


Figure 5.2 Electron Beam Induced Current (EBIC) Method

5.3 Effects of Surges and Static Electricity on Laser Diode Life

The tiny defects that occur when surges or static electricity are applied to a laser diode can cause a deterioration in the laser output of the device later on as the defect grows in size. Stress from surges or static electricity affect not only the initial optical characteristics of the laser diode, but its subsequent reliability as well. This is another reason why effective measures to prevent such damage are essential.

Figure 5.3 and figure 5.4 show examples of life test results following initial application of surges or static electricity to laser diodes.

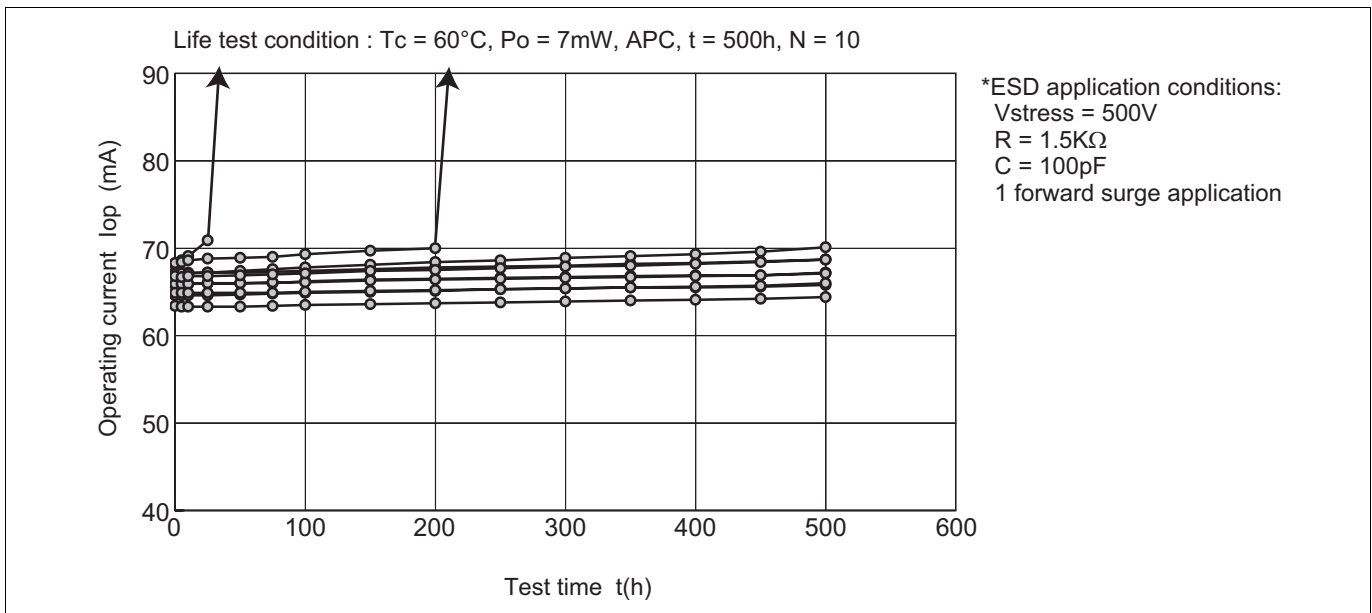


Figure 5.3 Example Test Results after ESD Application (670 nm Low-power Laser Diode)

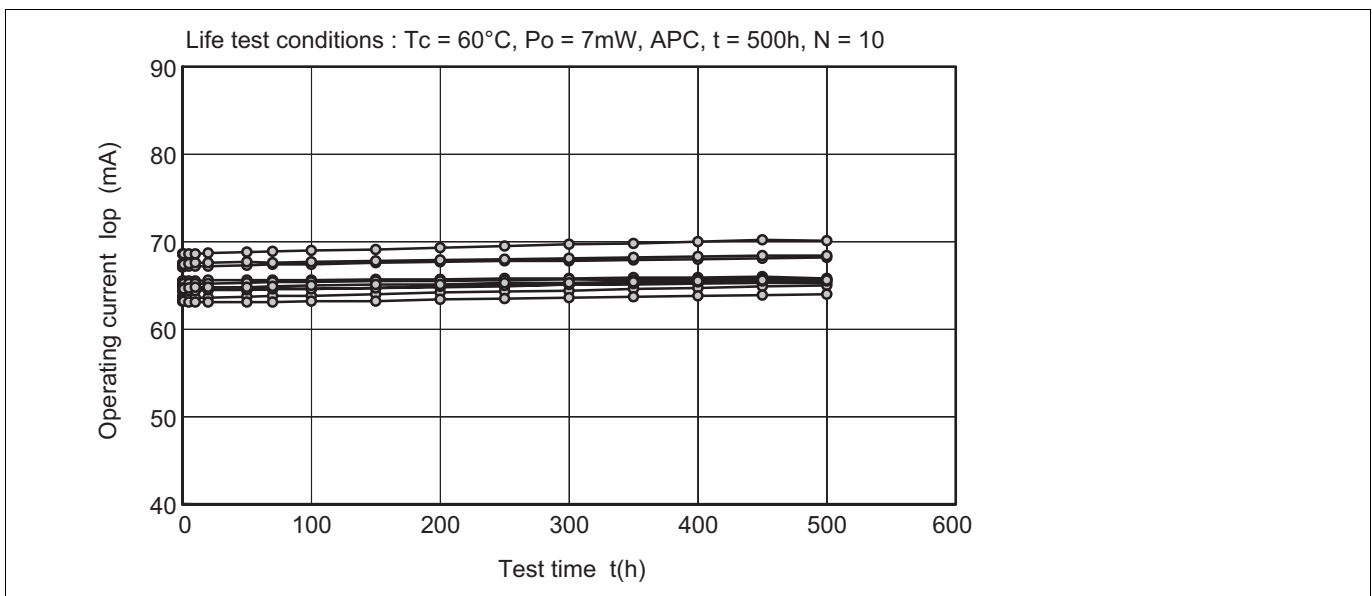


Figure 5.4 Example Test Results Without ESD Application (for Comparison) (670 nm Low-power Laser Diode)

Table 5.1 Examples of Surge Induced Facet Damage

No.	Surge type	Example of change in characteristics	Example failure mode
1	Electrostatic damage	<p>Symptoms 1</p> <ol style="list-style-type: none"> Saturation in high-output region PO-Is linearity degradation in high-output region 	<p>Optical damage to center of active layer of laser diode facet</p> <p>EBIC image</p>
2	Forward surge damage	<p>Symptoms 2</p> <ol style="list-style-type: none"> Kink or bad output in PO-If characteristics Change from fundamental to multimode in far field pattern 	<p>Optical damage to center of active layer of laser diode facet</p> <p>EL image</p>
3	Forward DC damage	<p>Symptoms 3</p> <ol style="list-style-type: none"> PO-If and PO-Is degradation. Change to multimode wavelength 	<p>Thermal and optical damage to center of active layer of laser diode facet</p> <p>EBIC image</p>

Table 5.2 Surge Damage Testing and Failure Analysis Data Examples

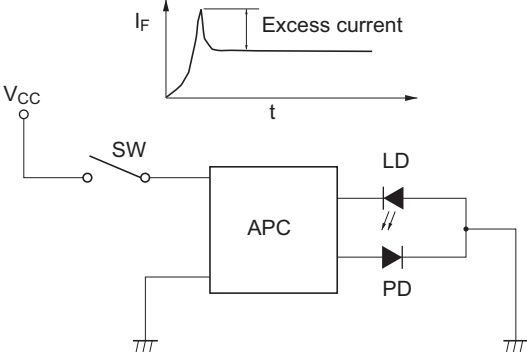
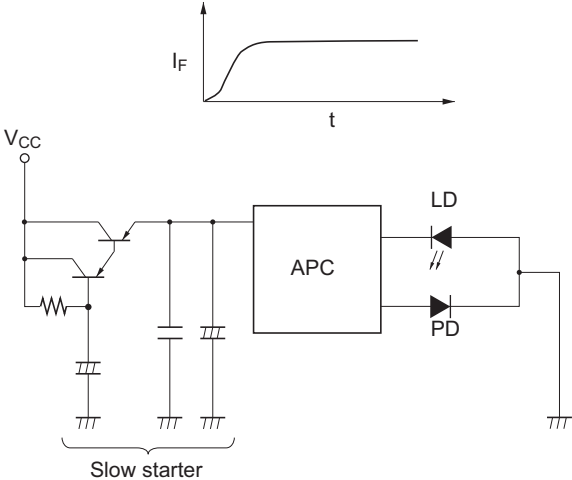
	Surge conditions	Representative characteristics					Failure modes		
		Optical output power Po	Monitor current Is	FFP	Wavelength	EL image	EBIC image	Staining-etch image	
Normal	—								
Light damage									
Critical damage									

Section 6 Measures to Prevent Surge Damage to Laser Diodes

Table 6.1 Measures to Prevent Surge Damage to Laser Diodes (Examples)

No.	Item	Description	Example countermeasure
1	Environment	Each operator should be properly grounded.	Wear a wristband connected to a 1 MΩ resistor.
		Use a common ground for the worktable and testing equipment.	A common ground should also be used for sealed rooms.
		Make sure work chair is anti-static processed and grounded.	Cover the chair with an anti-static cover and attach a chain ground.
		Use work clothes made of electrically conductive material.	
		Place a conductive mat under the shelf holding products.	
		Use trays made of a conductive material on the production line.	Resistance value: 10 ⁶ to 10 ⁹ Ω/□
		If the working environment is susceptible to static buildup, use an ion blower or work in a weakly ionized environment.	
2	Equipment	Manage the indoor humidity.	Relative humidity target: 50 ±10%
		Distribute power from the step-down power supply to the power supplies of the individual measuring devices via a noise filter.	Recommended filter example: Tokin noise filter, type LF-220 and G-2200
		Attach anti-static devices to conveyor belts that come into contact with products.	
		Ground the suction pads, etc., of products.	
		Make sure that relays connected to the power supply do not cause chattering.	
3	Operation	Use a power supply that does not generate ripples.	Recommended power supplies: • ILX Light Wave: LDC-3722B LD Controller • Advantest: TR6143 • HP: HP6655A
		When measuring electrical characteristics, do not switch power on or off while the rated voltage is being applied.	Always turn variable resistors down to the minimum setting before turning power off. Adjust to rated value after turning power on.
		Do not turn power on or off (to equipment or lights connected to the same line) within the same room during laser diode mounting and adjustment.	
4	Jigs, etc.	Adjust the variable resistors that control the power supply voltage to the minimum setting initially. (Variable resistors are often left set to intermediate values.)	
		Use gloves, finger socks, etc., made of electrically conductive material.	
		Connect the tip of the soldering iron being used to a ground.	Use a 3-terminal soldering iron.
		When using an ion blower, make sure to confirm that it is effective in eliminating static electricity.	
		Don't use variable resistors that stick.	Replace variable resistors periodically

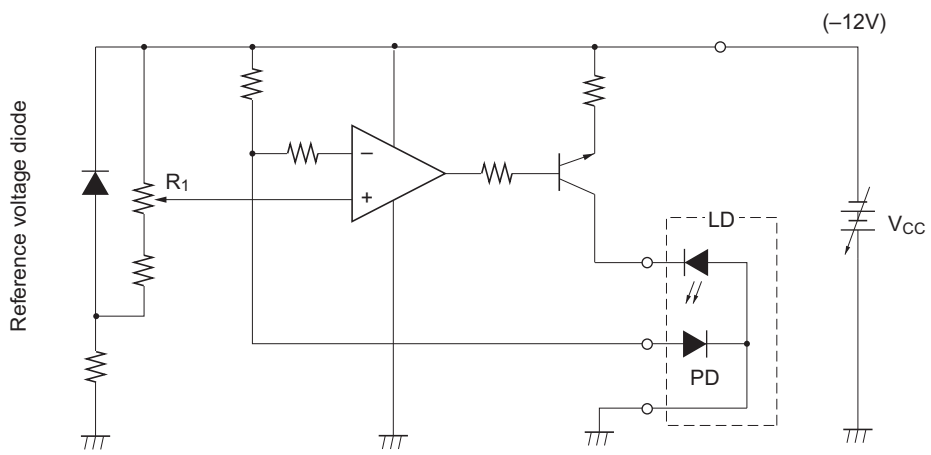
Section 7 Surge Damage Examples

No.1	Failure due to Excessive Current with Automatic Power Control (APC) Circuit Installed
<p>Description</p> <p>1. Symptom After being mounted on the circuit, laser diode failed when power was turned on.</p> <p>2. Cause Laser diode failed due to transient characteristics at power supply startup.</p> <div style="text-align: center; margin-top: 20px;">  </div>	
<p>Countermeasure</p> <p>Add a slow starter circuit to the APC circuit.</p> <div style="text-align: center; margin-top: 20px;">  </div>	

No.2	Failure due to Excessive Current During Measurement Using APC Circuit
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Description	
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1. Symptom
 After measuring laser diode characteristics using the circuit shown in the diagram below, laser output was reduced to 0 using R_1 . When the next laser diode was put in place, it failed.
2. Cause
 Because the circuit became open when the previous laser diode was removed, the output voltage increased to a V_{CC} voltage of 12 V, causing the next laser diode to fail due to excessive current.



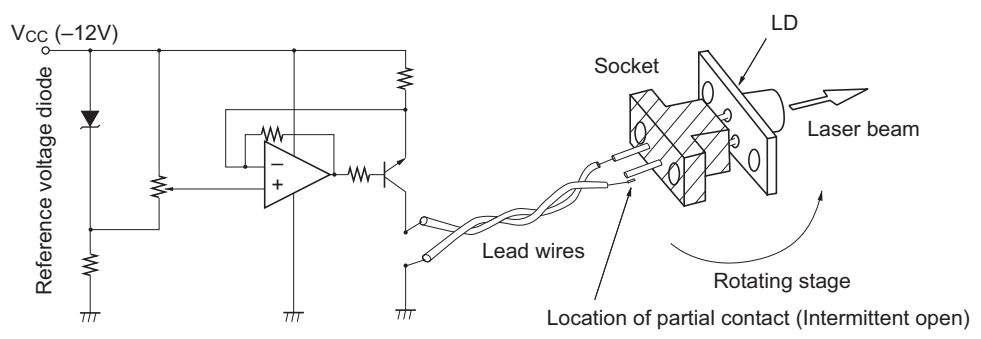
Countermeasure	
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Put the next laser diode in place after lowering laser output to 0 using R_1 and lowering V_{CC} so that the output voltage becomes 0.

No.3 Failure due to Excessive Current During Far Field Pattern Measurement

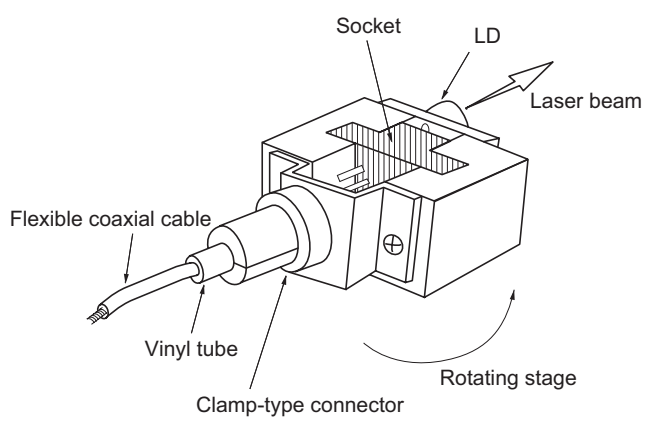
Description

1. Symptom
When operating the laser diode using a constant current circuit and measuring the far field pattern, laser output suddenly stopped.
2. Cause
When the stage turned, partial contact occurred with one of the lead wires soldered to the socket, causing the V_{CC} voltage (-12 V) of the constant current circuit to be applied intermittently to the laser diode.



Countermeasure

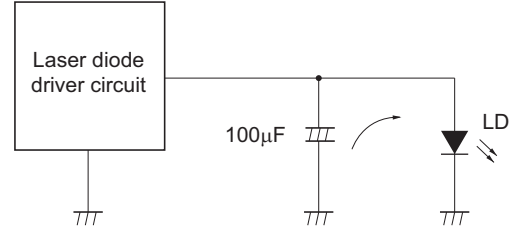
- (1) Use a clamp connector to make connections with the socket to prevent mechanical force from being applied to the solder points directly.
- (2) Check sockets and lead wires before use and replace with new ones regularly.



No.4 | **Failure due to Reverse Charge from Large Capacitor Connected to Power Supply Terminal**

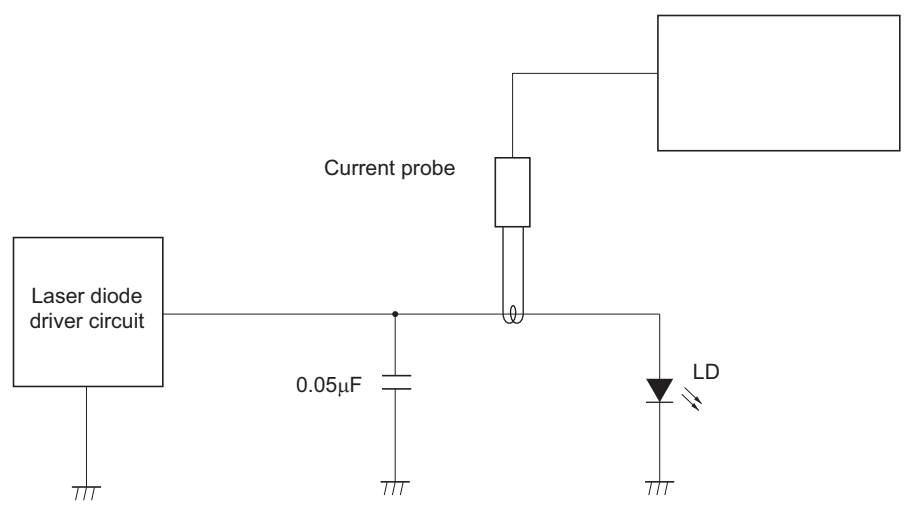
Description

- 1. Symptom
Laser diode failed because a large capacitor was connected to the power supply terminal.
- 2. Cause
The voltage charged in the capacitor when the power supply was turned on and off caused a reverse current to be applied to the terminal of the laser diode, causing it to fail.



Countermeasure

- (1) Make sure capacitor capacitance values are suitable.
- (2) Check whether transient surges are applied when the drive circuit is turned on and off.

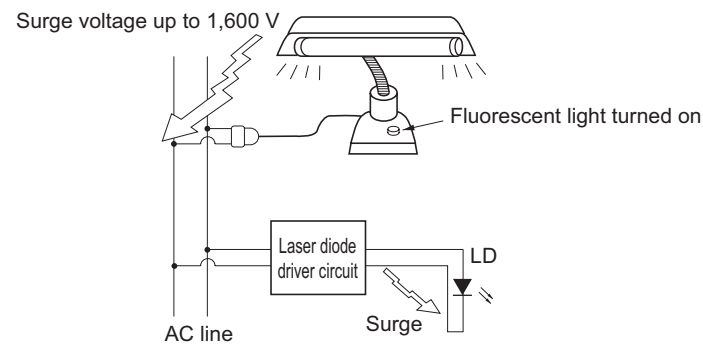


No.5	Failure due to Excessive Current During Laser Diode Measurement
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Description	
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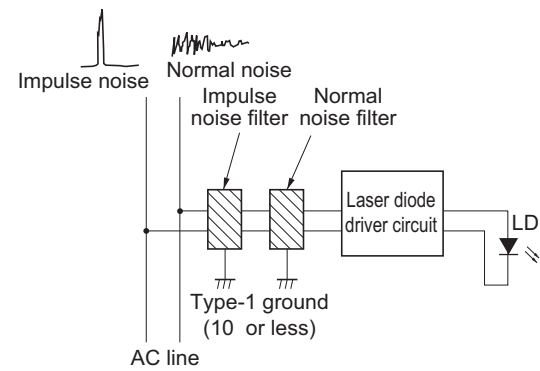
1. Symptom
Laser diode suddenly failed while conducting measurements of characteristics using a constant voltage power supply to drive the laser diode.

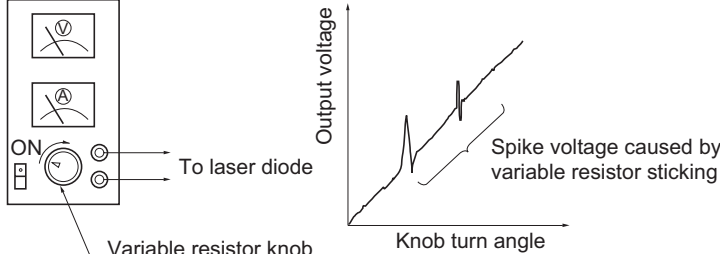
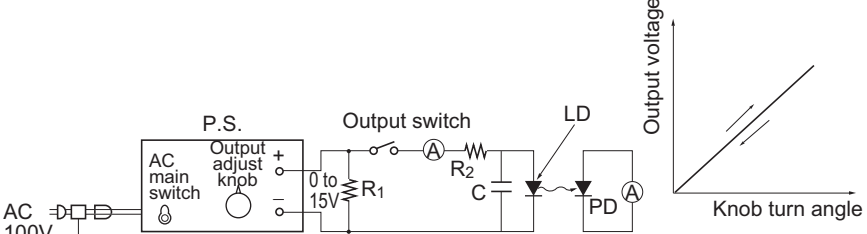
2. Cause
A surge voltage up to 1,600 V was generated when Mr. A, who was working nearby, turned on a fluorescent light connected to the same AC line. This surge entered the AC input of the laser diode's drive circuit and caused a momentary over current to the laser diode.



Countermeasure	
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- (1) Insert an impulse noise filter and a normal noise filter between the AC line and the laser diode's drive power supply.
- (2) Do not connect the laser diode's drive power supply to an AC line connected by equipment that is turned on and off frequently.



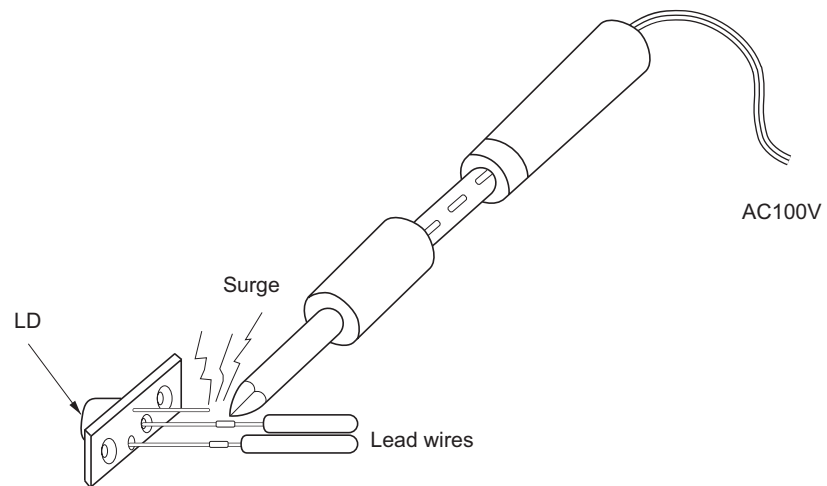
No.6	Failure due to Excessive Current when Adjusting Output after Installation
Description	
<p>1. Symptom After being mounted on a circuit board, laser diode failed while its laser output was being adjusted using a variable resistor (VR).</p> <p>2. Cause Sticking by the variable resistor caused excessive laser output, causing optical damage to the facet of the laser diode.</p> <div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>The diagram shows a control panel with a variable resistor knob, an 'ON' switch, and two meters (voltage and current). Two output lines are labeled 'To laser diode'. To the right, a graph plots 'Output voltage' against 'Knob turn angle'. The graph shows a linear increase in voltage with a sharp spike labeled 'Spike voltage caused by variable resistor sticking'.</p> </div> </div>	
Countermeasure	
<p>(1) Replace variable resistors regularly with units free of sticking and check them using an oscilloscope to make sure no voltage spikes are produced.</p> <p>(2) Maintain a clear environment for the laser output adjustment process and circuit assembly process so that no dust adheres to the variable resistors.</p> <p>(3) Before connecting a laser diode to a circuit of the sort shown in the diagram below, turn power on and adjust output to the minimum setting. Also, before removing the laser diode, once again adjust output to the minimum setting and switch the power off afterward.</p>	
<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>The circuit diagram shows an AC 100V input with a line noise filter, an AC main switch, a P.S. (0 to 15 V fixed-voltage power supply) with an output adjust knob, a resistor R1 (0 to 15V), an output switch, a resistor R2, a capacitor C, a laser diode (LD), and a photodiode (PD) with a receiver element. A graph to the right plots 'Output voltage' against 'Knob turn angle', showing a linear relationship.</p> </div> </div> <p style="margin-top: 10px;"> P.S.: 0 to 15 V fixed-voltage power supply R₁ = 100Ω, 2 W R₂ = 50Ω, 2 W C = 0.05μF PD: Receiver element </p>	

No.7	Damage to Laser Diode During Soldering
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Description	
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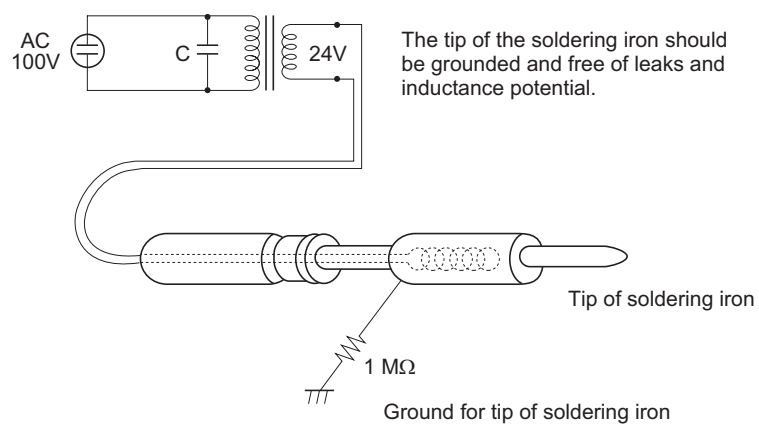
1. Symptom
 After soldering the laser diode to the laser diode drive circuit board and applying drive to the circuit, the laser diode did not work.

2. Cause
 A voltage surge from the commercially available AC 100 V soldering iron caused the laser diode to fail.



Countermeasure	
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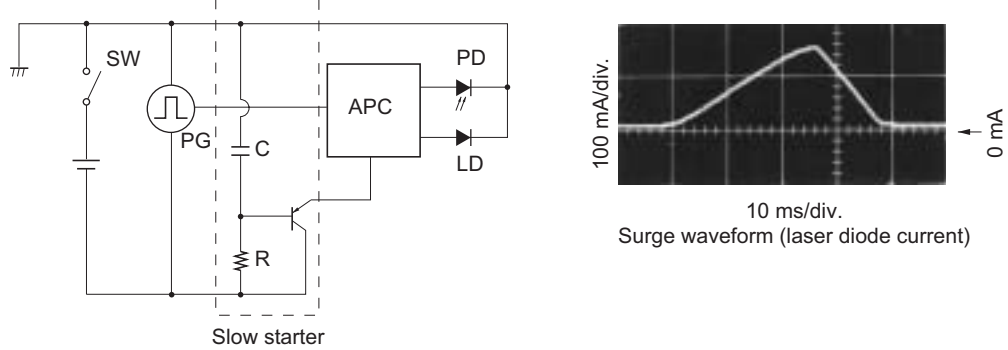
- (1) Use a grounded 3-terminal soldering iron.
- (2) Use a transformer to reduce the secondary voltage and ground the tip of the soldering iron.



No.8 | **Failure Caused by Excessive Current Due to Operation Timing Control Error**

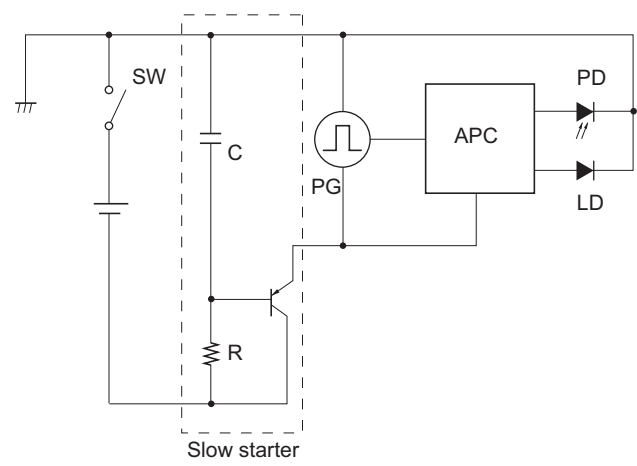
Description

1. Symptom
Laser diode failed when power was turned on in a circuit of the type shown in the diagram.
2. Cause
The CR time constant of the slow starter was too large, delaying the rise of the automatic power control (APC) circuit and causing excessive current to flow into the laser diode, which caused it to fail.



Countermeasure

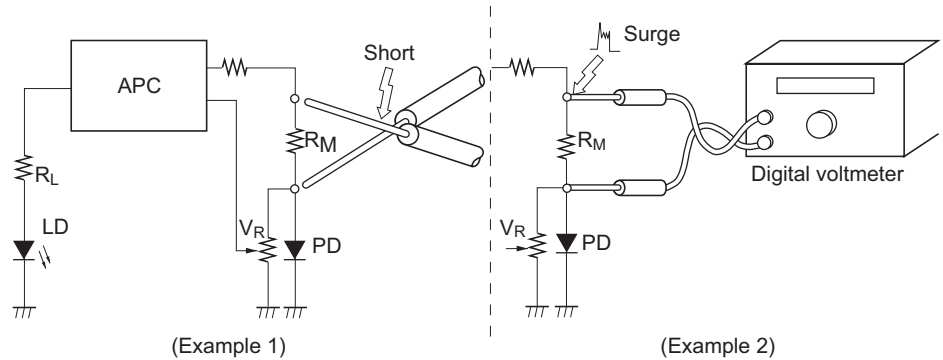
Pulse generator (PG) should be placed after the slow starter to get the same power on timing of APC and PG.



No.9 Failure due to Excessive Current During APC Circuit Check (1)

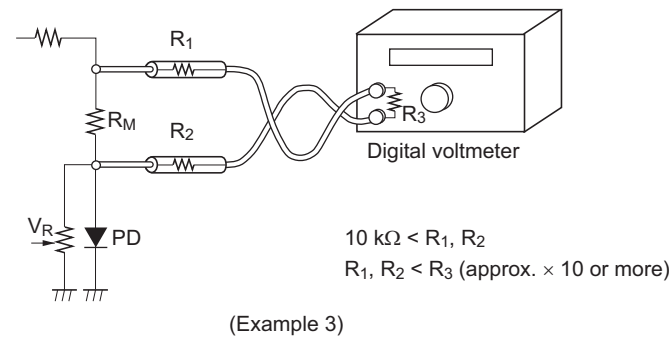
Description

1. Symptom
While using an APC circuit and a digital voltmeter to check laser output, laser diode failed while measuring the monitor voltage.
2. Cause
 - (1) Voltmeter probes (+ and -) came into contact with each other (shorted), causing excessive current to flow into the laser diode and making it fail. (Example 1)
 - (2) The response characteristics of the APC circuit are very sensitive, a surge resulted when the probes touched the circuit terminals, reducing monitor output and causing excessive current to flow into the laser diode, which caused it to fail. (Example 2)



Countermeasure

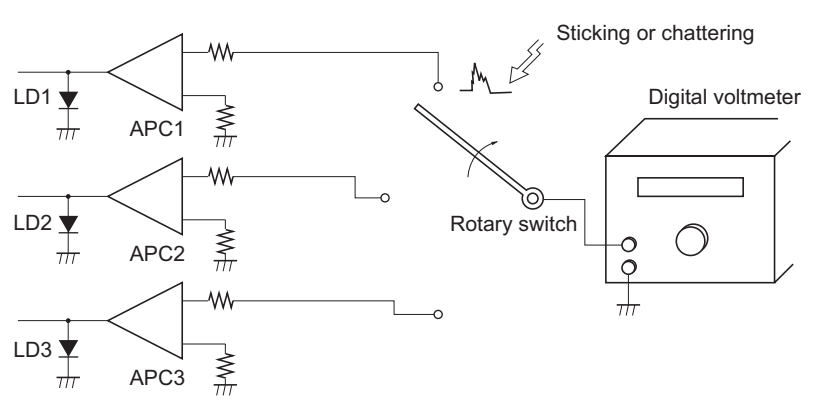
Do not check the circuit by bringing terminals of external equipment into contact with it while the APC circuit is operating. To perform monitoring, connect the measuring equipment to the appropriate terminals beforehand (before the circuit starts operating). (Example 3)



No.10	Failure due to Excessive Current During APC Circuit Check (2)
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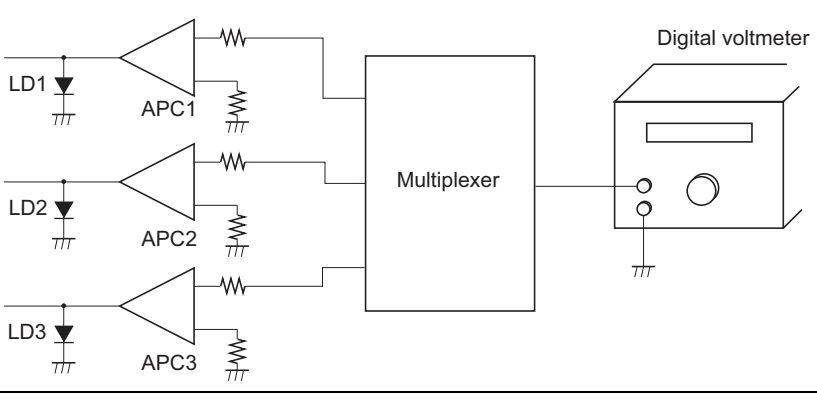
Description	
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1. Symptom
While using a rotary switch to check the operation of multiple APC circuits, laser diode failed when monitor terminals were switched.
2. Cause
During switching using the rotary switch, sticking or chattering occurred when contact was made with the terminals. This caused excessive current to flow into the laser diode and made it fail.



Countermeasure	
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Use a multiplexer or the like to check multiple APC circuits so that no mechanical contact is involved.



No.11	Failure due to Surge from AM Switch for Indoor Touch-tone Telephone
Description	
<p>1. Symptom</p> <p>The work area was equipped with a conductive mats and the workers were grounded, but laser diode failure occurred during laser diode assembly and operation testing.</p> <p>2. Cause</p> <p>An AM switch for the company's internal touch-tone telephone system was located nearby in the same work area. Surges were generated during circuit switching. The surges entered the laser diode drive circuit line and caused the laser diode to fail.</p> <div data-bbox="438 630 1185 1018" style="text-align: center;"> </div>	
Countermeasure	
<p>(1) Shield the AM switch to prevent surges from being propagated externally.</p> <p>(2) Do not install equipment such as AM switches, which employ electrical circuit switching functions, in the laser diode work area.</p>	

Surge Damage Prevention Manual

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