TUNABLE LD LIGHT SOURCE

TSL-210

Operation Manual

santec

Notes to Users

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2) Information in this Operation Manual is subject to change without notice.
3) Information of this Operation Manual is prepared with careful examination, however, in the event of any mistake, please contact us.

Notes in Bringing This Product Out of Japan

1) When this product is brought out of Japan, some laws or regulations of a destination country may prohibit this product from being used there. In such countries, the use of this product may lead to being punished, but the Company shall not be responsible for such a case at all, which please note.
2) When this product is exported (or brought out of Japan), if this product is applicable to a strategic material specified in "Foreign Exchange and Foreign Trade Control Law", then required is an export permit of the Japanese Government under the law.

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Introduction

Thank you very much for your having purchased our product, Tunable LD Light Source TSL Series. This Operation Manual contains information necessary for the operation of TSL-210, and it is intended for those with sufficient knowledge enough to of laser danger and its safe control. Before operating TSL-210, you should first read thoroughly through this Operation Manual and become familiar to its contents. After reading this Operation Manual, keep it at your fingertip for easy reference at any time.

NOTE !

The packing materials and box of this product are needed for long-term storage or transportation, therefore, keep them even after unpacking this product.

Constitution of this Operation Manual and How to Read it

This Operation Manual should be read before operating TSL-210.
This Operation Manual consists of 15 chapters, and the contents of each are as follows :
Chapters 1 through 8 describe the outline of the product, notes on safety,
and installation of the product.
Chapter 9 describes how to operate the product. Before reading
Chapter 9, you should read the descriptions from
Chapter 1 through Chapter 8.
Chapter 10 explains information on the communication function such as to
control TSL-210 from the outside.
Chapters 11 and 12 describe the maintenance and storage methods of this product.
Chapter 13 describes the options.
Chapter 14 describes troubleshooting in operation.

NOTE !

Before using this product, read this Operation Manual first.
This instrument uses a semiconductor laser. Caution-Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Marking on the instrument

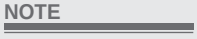
This indicates that caution is required. Please refer to the operation manual.

This indicates there is a danger due to laser radiation. Do not look directly at the laser beam or look at the beam by eye through any optical instrument.

Explanation of Terms

The meanings of the following terms used in this Operation Manual are defined as below :

(1) Meaning

	DANGER	This indicates pressing DANGER, and if it is not avoided, personnel death or serious injury results, therefore, it is the most emphasized special information.
	WARNING	This indicates potential danger, and if it is not avoided, personnel death or serious injury may result, therefore, it is a special information.
	CAUTION	This indicates potential danger, and if it is not avoided, mild or slight injury may result, therefore, it is special information. It also indicates potential danger leading to only physical damage.
	NOTE	This indicates supplementary explanation of the text, and thus other information than DANGER, WARNING, and CAUTION.

(2) Importance of Information

From the above meanings, the priority of the terms here are as shown below:

DANGER > WARNING > CAUTION > NOTE

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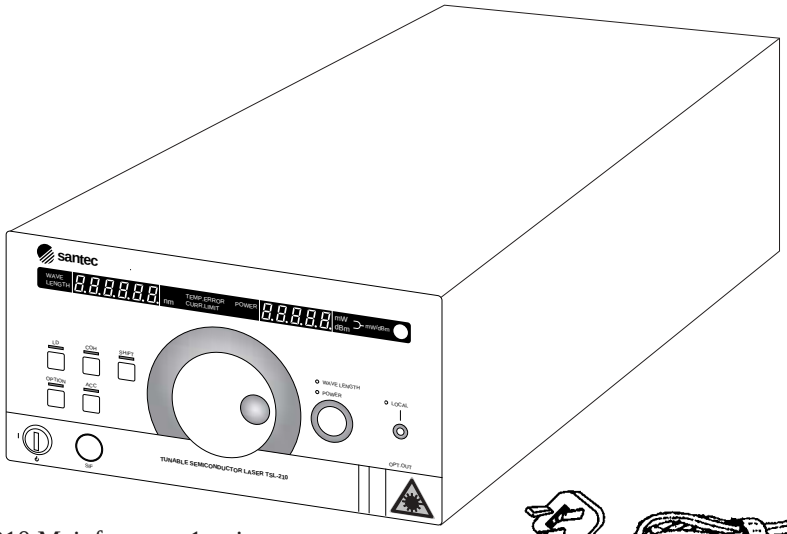
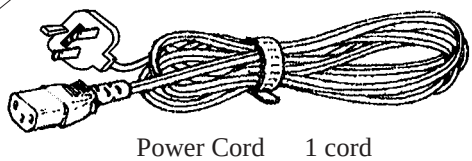
1 Outline of Product

The TSL-210 is an external cavity tunable semiconductor laser designed so that the user can easily tune wavelength and optical output power. With the growth of the telecommunications industry, there is a need for tunable light sources to evaluate optical components (optical band pass filter, AWG, fiber grating, etc.), EDFA, and DWDM. Santec designed the TSL-210 to meet this need with a unit that has precise wavelength tuning accuracy, excellent wavelength and power stability, and high optical output power. The unit also has many other features including full control through electronic interface (GPIB, RS-232, LabVIEW), ability to fix a constant power output across all wavelengths, a coherence control to change linewidth, as well as many additional optional features. Used as a stand-alone unit or as part of a larger test system, the TSL-210 is the wise choice for a tunable light source to use in optical research and development, inspection, and production testing.

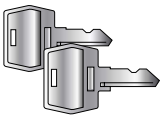
2 Configuration



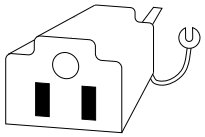
TSL-210 Mainframe 1 unit



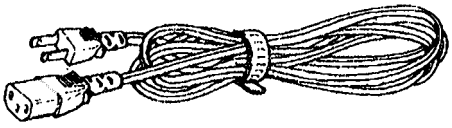
Power Cord 1 cord
(U.K. only)



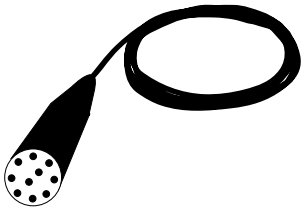
Power Key 2 units



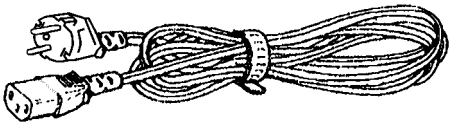
2P-3P Adapter 1 unit
(Japan only)



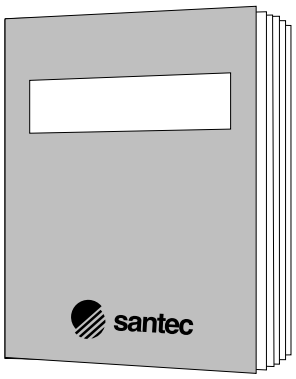
Power Cord 1 cord
(Japan, USA, Canada and other countries.)



AIF Exclusive Use Cable 1 cord



Power Cord 1 cord
(Europe only)



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Test Record 1 copy

Specifications

Specification

parameter	Unit	Min.	Spec.	Max.	Note
Wavelength					
Tuning range	nm	1530	-	1610	
Minimum tuning	nm	80	-	-	
Resolution	nm	-	-	0.01	<0.001nm When using fine tuning
Accuracy	nm	-	-	0.1	
Repeatability	nm	-	-	0.05	Number of times of measurement n=50, Measured at center wavelength
Stability	nm	-	-	0.01	1 hour, Measured at center wavelength
Fine tuning range	GHz	10	-	-	0.08nm(Typ.)
Tuning speed	ms/nm	170	-	-	
Power					
Maximum output power	mW	8	-	-	
		6	-	-	Minimum output power between a certain 40nm
		4	-	-	Minimum output power
Accuracy	%	-	-	5	
Repeatability	dB	-	-	0.01	Number of times of measurement n=50, Measured at center wavelength, +6dBm
Stability	dB	-	-	0.01	1 hour, Measured at center wavelength, +6dBm
Flatness	dB	-	-	0.2	Measured at +6dBm
Environmental condition					
Operating temp. range	°C	20	-	30	
Operating humidity range	%	-	-	80	No condensation
Storage temp. range	°C	10	-	40	
Storage humidity range	%	-	-	80	No condensation
Recalibration period	Year	1	-	-	Recommended
Spectrum					
Spectrum line width	MHz	-	-	1	Coherence control OFF
		1	-	500	Coherence control ON
SSR	dB	45	-	-	50dB(Typ.)
Interface					
Optical connector	-	-	FC	-	
Optical fiber	-	-	SMF	-	SM, 10/125-UV/UV-250
Connector polish	-	-	SPC	-	Supoer polish connector
GP-IB	-	-	Yes	-	IEEE-488
RS-232IF	-	-	Yes	-	Input from SIF interface on the front panel
LF Modulation					
Modulation range	KHz	0	-	10	Measured at -3dBm
Input level	V	-1	-	1	
Modulation coefficient	mA/V	-	100	-	
Input impedance	KΩ	-	4.7	-	
Modulation input	-	-	AIF	-	Input from the rear panel
Power supply					
Voltage	V	AC100/120/230/240			
Frequency	Hz	50/60			
Power consumption	VA	AC100/120:35 AC230/240:55			
Max. power consumption	W	80			40W(Typ.)
Laser safety class	-	3A			
Dimensions					
Width, Height, Depth	mm	210,110,370			Excludes the projection
Weight	kg	6			

Optiona List

parameter	Unit	Min.	Spec.	Max.	Note
Wavelength					
Tuning range	nm	1260	-	1640	Maximum tuning range: >80nm (choose from 1260~1640nm)
Power					
Maximum output power	mW	10	-	-	High power output
Built in attenuator	dB	0	-	20	Resolution 0.04dB(Typ.)
Built in tracking filter	nm	-	-	-	-3dB bandwidth: 3nm, Resolution 0.24nm(Typ.)*1
Interface					
Optical connector	-	-	SC	-	
Optical fiber	-	-	PMF	-	SLOW axis, Polarization extinction ratio>17dB,Polarization angle error<10°
Connector polish	-	-	APC	-	Angled polish connector*2
RF Modulation					
Modulation range	MHz	1	-	100	Measured at -3dB
input level	dBm	-	-	0	
Input impedance	Ω	-	50	-	
Modulation input	-	-	SMA	-	Input from the rear panel

*1: Output power decreases 20% with optical filter.

*2: Face of ferrule: SS-CS-001A FH(Protrusion): -100~100nm / ROC(Spherical radius): 5~12mm / AA(Polish angle): 7.7~8.3_/ AO(Elleptical center): ≤50μm / Key error: -0.5~0.5°

NOTE

The warranty for TSL-210 is one year. We recommend to have TSL-210 inspected and calibrated regularly (once a year recommended).

4 Principle of Operation

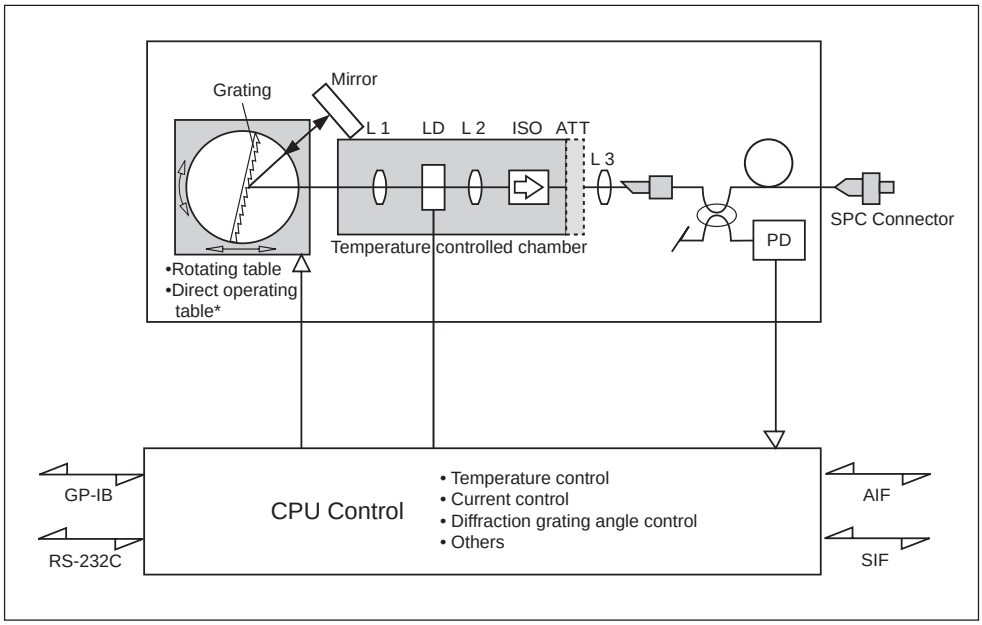


FIG.1 Structure diagram of TSL-210

The structure of the TSL-210 is shown in FIG 1. The basic design is a Fabry-Perot type where the semiconductor laser (LD) has one end Anti-Reflection (AR) coated. Within the LD chamber, the LD, a lens in cavity and an output lens (to make up the external cavity), while an isolator prevents light from re-entering the chamber. Temperature control of the chamber is accomplished via a Peltier device. As shown in FIG 1, the light emitted from the AR coated surface of the LD is collimated by the lens. The wavelength is then selected by the diffraction grating; the light is then reflected by mirror back through the diffraction grating where the wavelength is selected again, and then the wavelength component dissipated at the same angle as the incident angle is combined from the AR coated surface of the LD by the lens again. With current injected into the LD, if the return light from the diffraction grating and the gain inside of the LD are sufficient, laser oscillation will be carried out by the external cavity structure. The use of diffraction grating as a reflecting mirror to configure the external cavity structure enables oscillation in single vertical mode; high-precision control of the diffraction grating allows for tuning of the oscillated wavelength.

The output light from the external cavity semiconductor laser passes through a two-stage isolator that limits return light due to back-reflection to less than - 60 dB. The output light then passes through a variable optical attenuator and is input into the optical fiber. To limit the interference within the fiber caused by end reflections, the end of the fiber is obliquely polished and an SPC-type output connector is used. (APC is available as an option). The optical power is also monitored through a separate optical fiber coupler to compensate for wavelength sensitivity.

5 Safety Notes and Safety Devices

IMPORTANT! Please read the following for your safety and for trouble-free operation.

DANGER!!

This product employs a semiconductor laser. The laser beam may cause damage to your sense of sight if it comes in contact with your eyes. It is very dangerous. Therefore, pay sufficient attention to handling it. When not using the unit, be sure to close the protective shutter (shown in the figure below).
Do not open the instrument case. The laser beam used in this product is harmful to the eyes. There are no user servicable parts. Please refer all maintenance and repair to a Santec engineer.

CAUTION

When the unit is not in operation, be sure to disconnect the power cord.

In the event of any of the following, make sure that the injection current of the LD is zero, turn OFF the main switch and then disconnect the power cord.

- Spilling liquid into this product
- Rain getting into this product, or excessive humidity
- Cleaning or moving the product
- Damage or scratch found on the cord or plug of this product.
- Dew or other moisture accumulation.

Please follow the following safety guidelines :

- Avoid impact or shock.
- Keep this product away from water.
- Do not disassemble this product.
- Do not place anything on this product.
- Do not block the ventilation hole or impede the operation of the fan in any manner.
- Avoid placing this product under direct sunlight.
- Avoid placing this product in a place subject to noise by electric field, magnetic field, etc.
- Avoid placing this product in a place subject to high temperature and high humidity.

6 Installation

Pay attention to the following guidelines for safe, trouble-free operation.

This product is a high-precision device:
- Do not place in direct sunlight
- Do not place under high temperature and high humidity.
- Do not place in an environment with dust, dirt, salt, or corrosive gas.
- Do not place in an area subject to large vibrations.
- Do not place in an area subject to noise by electric field, magnetic field, etc.
- Do not place in an area where the unit is subject to falling objects landing on it.
- Do not place with possible exposure to water

Install the TSL-210 in a level place. It is recommended to install this product on a vibration-proof base. The mainframe of the TSL-210 weighs about 7 kg. Please ensure that the table or shelf upon which it is installed has sufficient strength. Clearance of 5 cm at the rear side of the unit should be allowed for proper ventilation.

• Before connecting the power cord

Set the power voltage.
Open the lid of power input portion of the rear panel, and switch the power voltage to your desired voltage by turning the rotary switch. (Refer to 7.Descriptions of Panel Equipment)

• Power fuse

It is necessary to exchange fuses in accordance with power voltage.
(Refer to 7.Descriptions of Panel Equipment)
In the case of power voltage AC100V/120V T3A/125V
In the case of power voltage AC230V/240V T1.6A/250V
* Use a surge resistant type fuse.

• Power cord connection

This product uses a 3-line power cord and plug with a protective ground line. Power cord may be attached and detached, Connect it to the power source socket at the rear panel. Use the power cord supplied with the unit.

NOTE

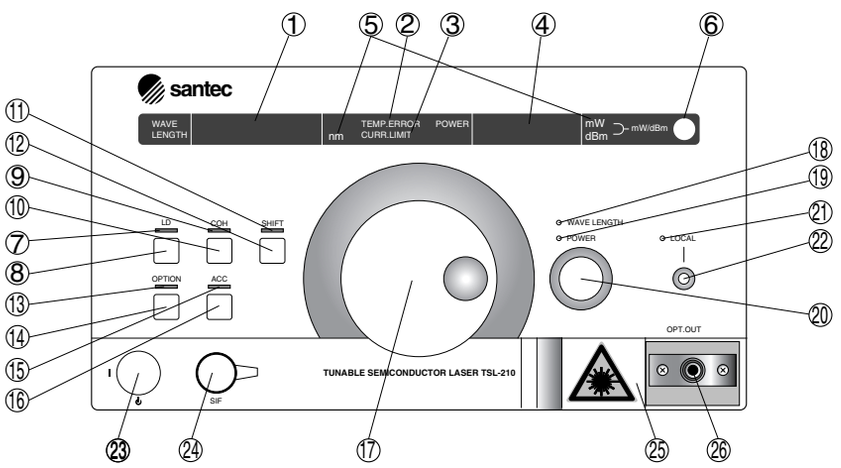
Do not remove the rubber feet from the device as they are used to maintain a heat releasing vent.

CAUTION

This product is grounded by the ground line of the power cord.
Insufficient grounding may cause electric shock, which is very dangerous.
To avoid electric shock, be sure the unit is properly grounded.

7 Descriptions of Panel Equipment

7-1 Front Panel



(1) Wavelength / fine tuning display panel
This displays the currently set wavelength and the wavelength at wavelength calibration. When fine tuning is turned ON, it displays the currently set control amount.

(2) Temperature stabilization (TEMP. ERROR)
This LED indicates that temperature control is not stable. Use the system after "TEMP.ERROR" display goes off. For several minutes after turning the system on, the display is on. The display goes out after about 10 minutes, which varies with external environment. This is same when target temperature is set by communication command.

(3) Current Limit (CURR. LIMIT)
This LED indicates that the injection current reaches its hardware limit owing to the fact that too large a target was set with the Automatic Power Control (APC). It is not possible to have the same optical output across 100% of the tuning range. The gain is tailing off at both ends of the tuning range, especially the short wave side. Refer to the test records.

(4) Optical output power display panel / GP-IB address display panel
1. This displays optical output power. The minimum display value of optical output power is -40.00dB/0mW
2. When changing GP-IB address, it displays GP-IB address.

(5) Unit display
The unit lit shows the unit of data on the current display panel.

(6) Optical output power unit change key / Wavelength calibration key
This toggles the unit of optical output power by dBm or mW.
Pressing this key while the SHIFT LED is lit causes wavelength calibration.

(7) LD drive LED / ATT Mode (Option)

1. This LED indicates that current is injected into LD.
2. When this LED flickers, it shows that LD drive is in the mode not to feed back the fluctuation of optical output power. This is used when to tune low frequency modulation.

   *Note : While this LED is lit, when the unit is operating in the ACC mode (refer to Section 16. ACC mode key / RS-232C Delimiter Adjustment) the ATT mode (option) will be operated in manual mode.

(8) LD drive key

This toggles ON/OFF the current to LD. When the power is supplied, current is not injected to LD. Prior to shutting off the power source, be sure to shut off the injection current to LD. If the power is shut off while current is supplied to LD, the LD may be damaged.

(9) Coherence control LED

This LED indicates that coherence control is carried out.

(10) Coherence control key

This toggles ON/OFF the coherence control to widen spectrum linewidth. When the coherence control is ON, spectrum linewidth is widened.

(11) Shift LED

Pressing other key while this LED is lit changes wavelength calibration or GPIB address, and switches the minimum digit setting and LD drive mode.

(12) Shift key

Pressing an optional key while the SHIFT LED is turned ON executes some other commands as follows:

SHIFT + mW/dBm Key	= wavelength calibration
SHIFT + WAVELENGTH/POWER Key	= minimum digit setting
SHIFT + LOCAL Key	= GP-IB address setting

(13) Fine tuning / Frequency Locking (Option) LED

1. This LED indicates that fine tuning control is being processed.
2. Illumination of the LED indicates that the frequency locking function has been activated.

(14) Fine tuning control key / RS-232C delimiter change

1. This toggles ON/OFF the fine tuning control to finely tune the wavelength. By setting control amount by the rotary encoder, fine tuning of wavelength in the range about ±0.02nm is available.
2. When this key is pressed during power on, the delimiter of RS-232C may be changed. (Refer to 9-2-A. Turning ON./Setting RS-232C Delimiter.)

(15) ACC mode LED

This LED lighting shows that this device is in ACC mode.

(16) ACC Mode Key/RS-232C Delimiter Adjustment/ATT Mode Switching (Option)

1. The TSL-210 can be operated in either Automatic Power Control (APC) or Automatic Current Control (ACC) mode. When the power switch is first turned on, the unit will be in the APC mode. In APC mode, the optical output power can be set; this is maintained through feedback loop that adjusts the injection current. In the ACC mode, the current is preset and the rotary-encoder only allows tuning of the output wavelength. In the APC mode wavelength adjustment will not result in an output power change; however, to facilitate the output power remaining constant, the LD injection current must change, which results in the wavelength and side mode suppression ratio also changing slightly. If it is necessary to avoid such changes, please operate the unit under ACC mode.
2. If this key is pressed when the power is first switched on, The RS-232C delimiter can be varied. (Please see Section 9-2-A. Turning on/Setting RS-232C delimiter)
3. Pressing this key while the SHIFT LED is lit toggles the control mode of ATT (option) between ON and OFF.

(17) Rotary encoder

This is used to set data of wavelength, optical output power, fine tuning and so forth. Setting of optical output power is not available when ACC is ON.

(18) Rotary encoder wavelength / Fine tuning setting LED

This LED lighting indicates that the rotary encoder is set for wavelength tuning.

(19) Rotary encoder optical output power setting LED

This LED lighting indicates that the rotary encoder is set for optical output power tuning.

1. The rotary encoder is set for control amount in fine tuning mode.
2. Pressing this key while the SHIFT LED is lit changes minimum tunable step of wavelength setting. (Refer to 9-4 Setting Wavelength)

(20) Rotary encoder change key/Minimum digit setting

This key switches the rotary encoder to wavelength tuning or optical output power tuning. The currently selected parameters can be confirmed by setting LED of each parameter. Optical output power setting by rotary encoder is not available when ACC mode is ON.
(Please refer to Section 9-3. How to use rotary encoder.)

(21) GP-IB remote LED

This LED lighting indicates the remote status by GPIB. In the remote status, other operation by GPIB local key on the front panel cannot be accepted. The local key releases the remote status, and key operation becomes available.

(22) GP-IB local key/GB-IB address change key

1. When in remote status by GP-IB control, pressing this key brings you back to local status, and enables the control of the front panel.
2. Pressing this key while the SHIFT LED is lit enables changing of the GP-IB address. The GP-IB address is displayed in the place of optical output power display. The address is changed by the rotary encoder and pressing the key again. (Please refer to Section 10-1-D. TSL-210 GP-IB)

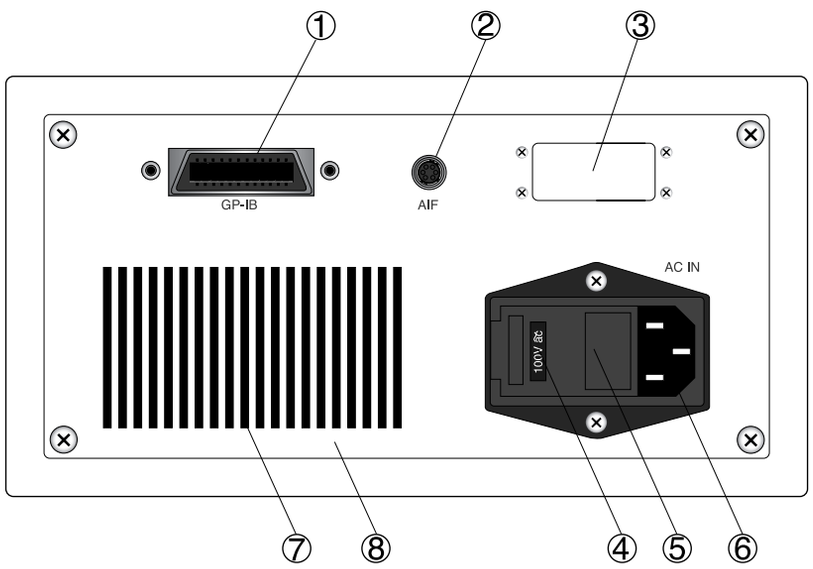
(23) Main switch
This toggles ON/OFF the power source. (I=ON, O=OFF)
Switch this by use of the power key.

(24) SIF (serial interface) connector
This is a connector for RS-232C communication. It is used in numeric key operation or table operation by external devices such as Zaurus or so. (Please refer to Section 10-2. RS-232C)

(25) Protection shutter
This is a protective shutter to avoid direct output light.

(26) Light output connector
This is an FC adapter, and its inside is SPC polished connector, single mode optical fiber. (Output of connector shape and polarization maintaining optical fiber output is available by option.)

7-2 Rear Panel

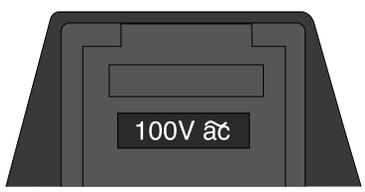


(1) GP-IB connector (Refer to 10-5 GP-IB)

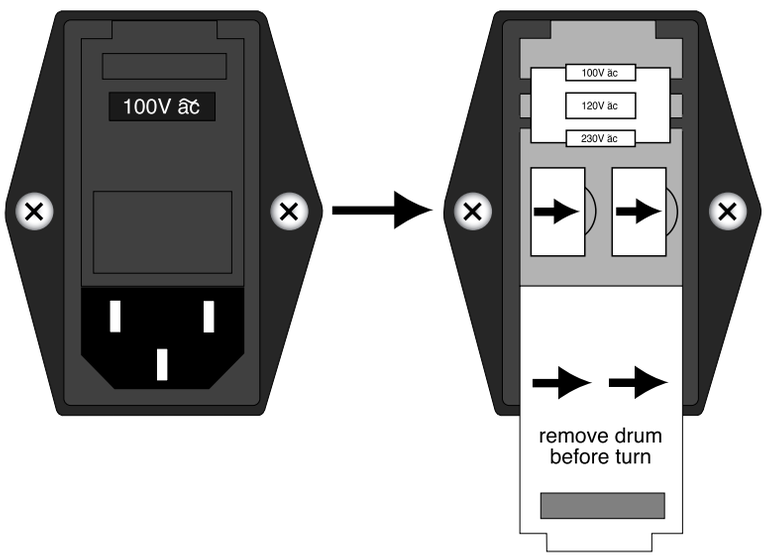
(2) AIF (analog interface) connector
Terminal for fine tuning control and low frequency modulation from external.

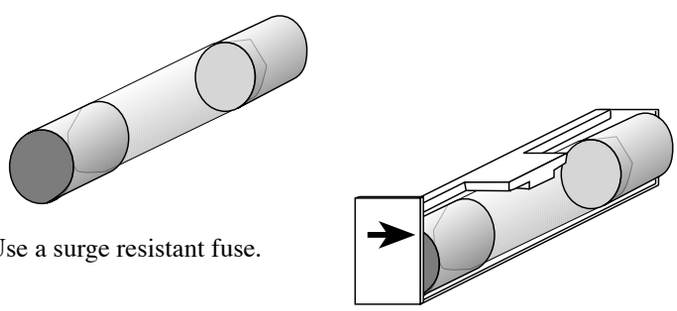
(3) Option Panel
Input terminal for level adjustment knob of variable coherence control and RF modulation of options.

(4) Power voltage display panel
This changes when the inside rotary switch is changed. This displays the power voltage that can be supplied at present. If a different power voltage is used, make sure the rotary switch is set properly and the correct fuse is used.



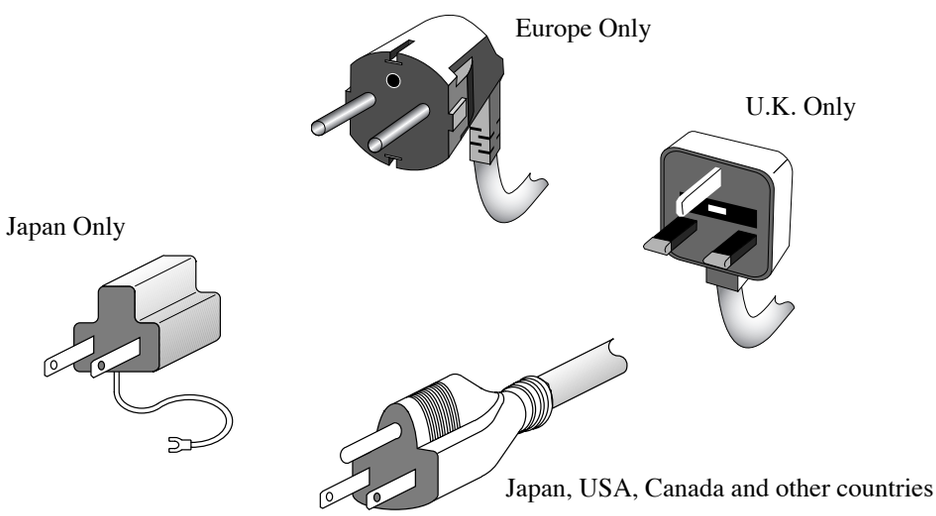
(5) Power voltage change switch and fuse box lid
When it is necessary to change the power voltage setting, open the lid, set the internal rotary switch to the correct voltage and replace the fuses with the correct rating. Replace the lid.





Use a surge resistant fuse.

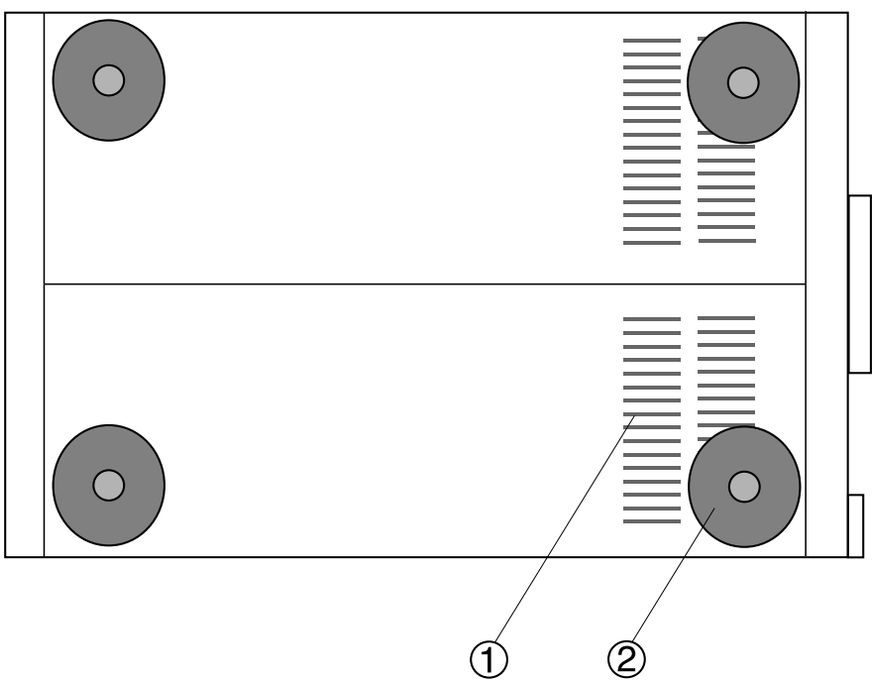
6) Power source socket
Use the attached power source cable.



(7) Slit
Slit for heat dissipation. A fan is arranged inside of the slit. Arrange space of over 5cm to allow for proper ventilation.

(8) Name plate
Product type, option, serial number are described on it.

7-3 Bottom Panel



(1) Vent
This is a heat release vent. The vent intakes air for cooling. Do not cover the vent or place any heat sources near by; the instrument may retain heat or malfunction.

(2) Rubber feet
The rubber feet support the instrument and absorb external vibration. Do not remove them from the instrument.

8 Functions of This Unit

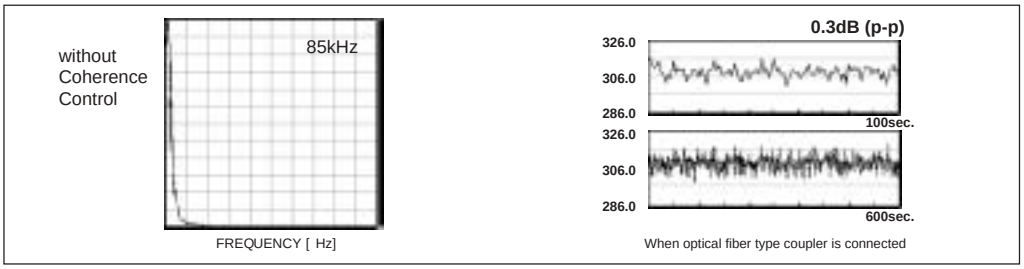
8-1. Wide-band Wavelength Tuning TSL-210

The use of a diffraction grating as external mirror in the design controls the loss to wavelength within the external cavity by controlling the angle of diffraction grating in a high-precision manner, and also allows for the tuning of an oscillated wavelength over a wide range. TSL-210 wavelength setting is not only accomplished by diffraction grating, but also by changing the length of the cavity. The combined manipulation of external cavity length and diffraction grating angle realizes high-precision wavelength tuning. The operating table allows for the diffraction grating to be adjusted for cavity length and for grating angle via microcomputer control.

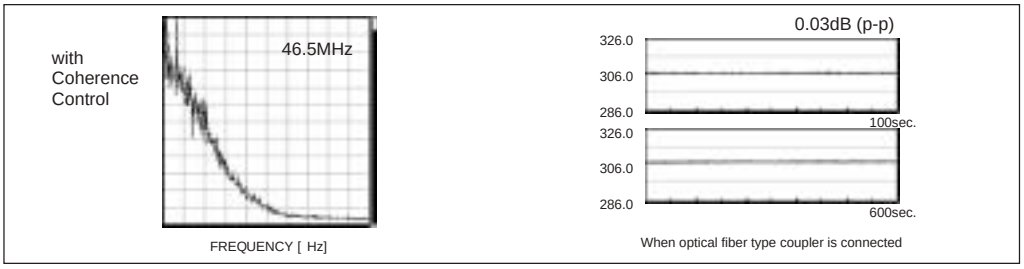
8-2. Coherence Control

The oscillated spectrum linewidth of the TSL-210 is fairly narrow in comparison with normal semiconductor lasers. Spectrum linewidth is one of the factors that determines light coherence, and the narrower the spectrum linewidth, the more improved the coherence. Considering the length of fiber used or the complexity of some test set-ups, there is the possibility that within the length of fiber in the test set-up there is a reflection point in the optical fiber transmission system, optical output power changes within the fiber due to interference. To combat this, the TSL-210 is equipped with a Coherence Control.

The measurement example of optical output power stability and spectrum linewidth in the case where optical fiber type coupler is connected at the output end of the TSL-210 is shown below:



TSL-210 has the spectrum linewidth 2-step control so as to configure a stable measurement system even in such a case.
The optical output power stability at control and the measurement example of spectrum linewidth are shown below :



8-3. LD Injection Current, Ambient Temperature Control Function

To keep a stable oscillating condition of the semiconductor laser, the TSL-210 precisely controls injection current and adjusts for ambient temperature changes. The circuit that supplies the LD injection current provides a stable, constant current and also has a protection circuit so that the LD does not become damaged. The injection current is controlled both by CPU and the APC circuit, which has a built-in photo-detector. The APC circuit by a built-in photo-detector. When the hardware limit of the current driver is reached, the CURR. LIMIT display is lit. For the temperature control, when the chamber temperature has stabilized, the TEMP.ERROR display goes out.

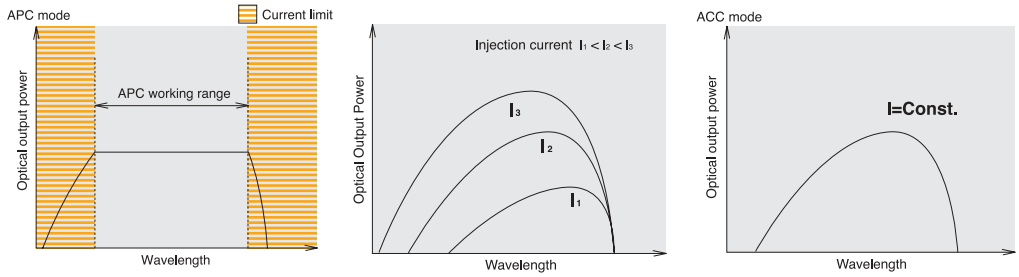
8-4. Optical Output Power Control Function

The TSL-210 has a mechanism to separately monitor part of the optical output power that is split off of the main output signal by an optical fiber type coupler. It also has a function to automatically set the injection current by setting optical output power.

The TSL-210 has two modes: Automatic Current Control (ACC) mode, which holds current constant, and Automatic Power Control (APC) mode, which holds output power constant. In the APC mode, the TSL-210 uses calibrated feedback from a photo detector (PD) to ensure constant optical output power. When wavelength tuning is executed in the APC mode, the TSL-210 keeps almost constant optical output power. It is not possible to have the same optical output across 100% of the tuning range. The gain is tailing off at both ends of the tuning range, especially the short wave side. In ACC mode, the TSL-210 carries out control by set constant current. If using the optional LF modulation, use it in the ACC mode.

Adjusting the injection current to the LD controls the optical output power of the system. In APC mode or when controlling the current using the communication control, please note that if the current becomes low the SSR will deteriorate. (Please refer to Section 13-4 Built-in Attenuator.)

Relationship between injection current, wavelength and optical output power of TSL-210

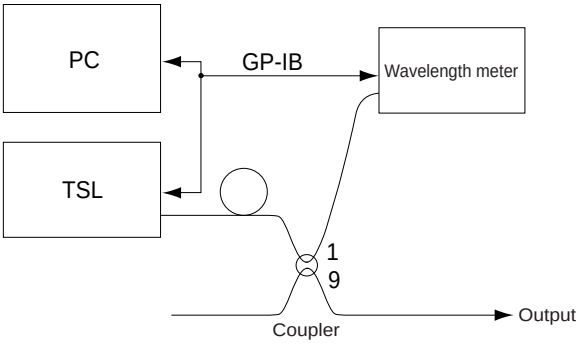


NOTE

Water molecule absorbs light in 1300nm~1500nm and the output power decreases when measuring with optical spectrum analyzer. It is impossible to avoid it because it is a physical phenomemon. We recommend to use TSL-210 in the condition with the extremely low humidity or avoid the water absorption points.

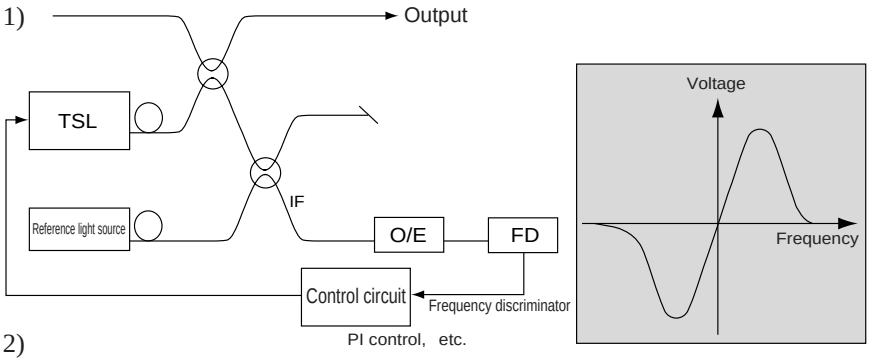
8-5. Fine Tuning Function

The TSL-210 can control wavelength in a wide range by high precision control of the angle of diffraction grating through the use of an electro-mechanical motor. In addition, the TSL-210 is equipped with a piezo (PZT) to control wavelength with higher resolution. This fine-tuning enables wavelength fine-tuning of < 0.001 nm within the coarse tuning range of about +/- 0.02 nm. When used in combination with a wavelength meter, the TSL-210 can be set with precision of 0.001 nm.

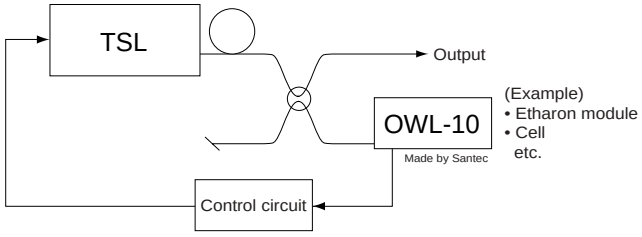


In a model with the frequency locking option, by impressing the appropriate external voltage on the analog interface (AIF) connector at the rear panel, fine tuning control is available. This control may be applied to frequency lock (Example 1, below) to feedback the frequency deviation signal to the reference light source to the fine tuning control thus enabling stabilization by feeding back the deviation signal from the Etalon module to the fine tuning control circuit. (Example 2, below). (Refer to Section 9-6-B, External Control.)

(Example 1)



(Example 2)



9 Fundamental Operation

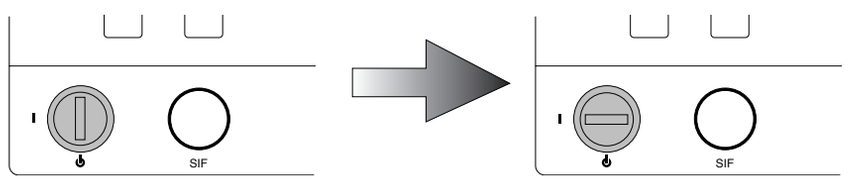
9-1 How to Turn ON

DANGER!!

Before turning ON the unit, make sure that the protective shutter is closed. Laser beam, if it comes into your eye, may cause injury in your sense of sight.

9-1-A Turning ON/Setting RS-232C Delimiter

Make sure the power is supplied by the attached power cord.
Turn the key 90 degrees to the right by the power key to turn the system ON.



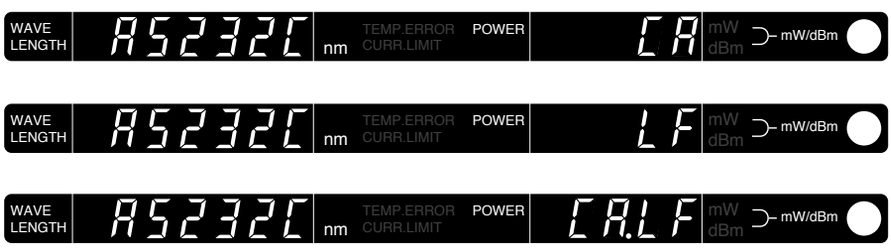
The power key may be inserted or removed.

Turn the key 90 degrees.
The power key cannot be inserted or removed.

When the unit is turned ON, the following actions are carried out until the unit is activated.

1) All the indications and LEDs are lit.
2) Wavelength display panel and LED goes off, and GP-IB address currently set on GP-IB address display plate is displayed.

3) RS-232C delimiter is displayed.



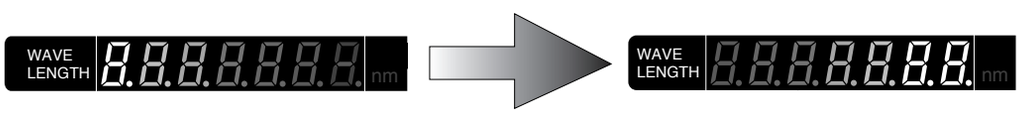
RS-232C delimiter can be changed by turning on power while holding OPTION or APC key. The delimiter setting is kept effective even though unit is OFF.

- OPTION key : CR
- APC key : LF
- OPTION + APC key : CR/LF (Press and hold both keys.)

4) All the indications and LEDs are lit.

5) LEDs go out, and only wavelength plate is lit.

6) Optical system is initialized. During the period, it moves so that “0” runs on the wavelength display plate.



Optical output power, -40.00dB/0.00 mW is displayed. This is the minimum optical output power and means that no current is injected into the LD.

When the chamber temperature falls within +/- 0.1 C of the set temperature and becomes stable, the TEMP.ERROR display indicator on the front panel goes out, and the status value changes. For several minutes after turning the power on, the TEMP.ERRORR display is lit. About 10 minutes afterward, the TEMP.ERROR display goes out. This time interval also occurs when the target temperature is changed by command.

9-1-B Optical Fiber Connection

Open the protective cover and connect the optical fiber.

CAUTION

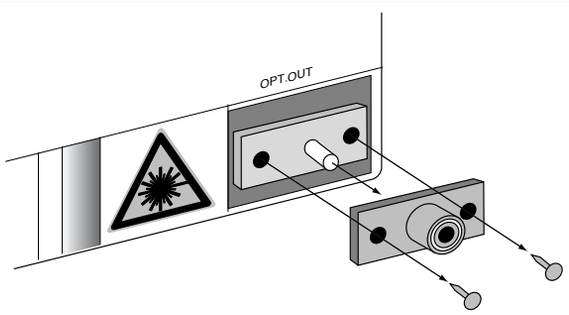
Before connecting optical fiber, clean the end surface of optical fiber.
Dirty surface with dust may cause loss.

9-1-C Cleaning the Optical Connector

Connection of an optical fiber with dust and dirt on the end of the optical connector of the TSL-210 will cause loss of optical input, therefore, clean the connector periodically. The optical adapter may be removed by removing the screws as shown in the figure below.

DANGER!!

This product uses a semiconductor laser. Laser beam may cause visual injury if it gets in eye. Before cleaning of the optical connector, be sure to turn the power off (Refer to 9-10), and make sure there is no optical output power.



Procedures

1) Remove the 2 screws that fix the optical adapter with a plus screw driver.
2) Pull out the optical adapter. To facilitate easy removed phillips attach a connector cap to the optical adapter, and pinch and pull out the connector cap.
3) Clean the end of the optical connector with alcohol.
4) After cleaning, insert the optical adapter into the optical connector and fix it with 2 screws.

NOTE

After cleaning, insert the optical adapter into the optical connector and fix it with 2 screws secure.
If the optical adapter is not attached correctly, optical output power loss results.

9-1-D Changing LD Current/Changing Unit of Optical Output Power

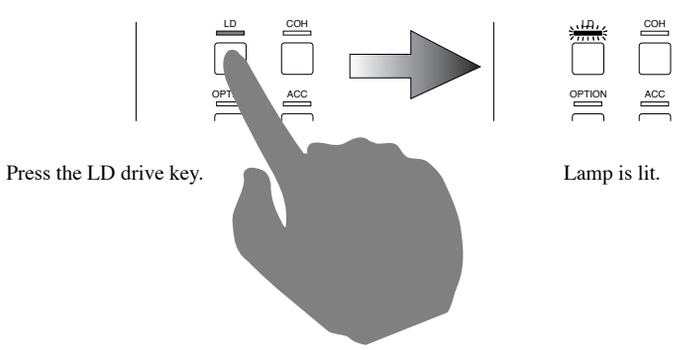
DANGER!!

Before turning ON the unit, make sure that the protective shutter is closed or the optical fiber is connected. Keep the optical output terminal away from your eyes. Laser beam, if it comes into your eye, may cause injury in your sense of sight.

TSL-210 operates in either APC (automatic power control) mode or ACC (automatic current control) mode. In the APC mode, the optical output power can be set and the injection current information is fed back so that the optical output power is kept at the set value. In the ACC mode, control is made using the predetermined amount of injection current.

When the unit is turned ON, current is not supplied to LD. Therefore, to drive the LD, it is necessary to supply current into the LD by key operation from the front panel or by communication control.

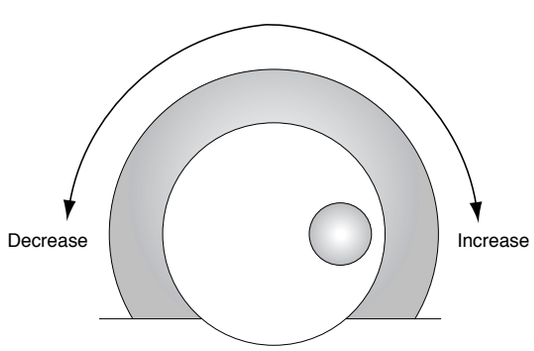
Press the LD drive key.



When the key is pressed, the LD drive LED is lit and current is supplied up to the set current by APC mode. The set optical output power at power start up is -40.00dBm/0.00mW.

9-2 How to Use Rotary Encoder

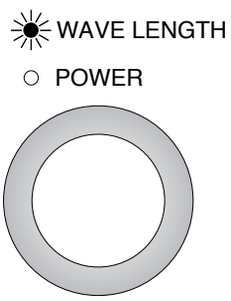
This product does not come equipped with a numeric key to input numeric values. A rotary encoder is used to set wavelength, and to set optical output power (in APC mode only), to fine tune, to calibrate wavelength, to set GP-IB address, and to set the minimum increment/ decrement resolution of the encoder. Turning the encoder to the left decreases numeric value, while turning it to the right increases numeric value. The tunable step of the encoder changes four steps according to rotational speed.



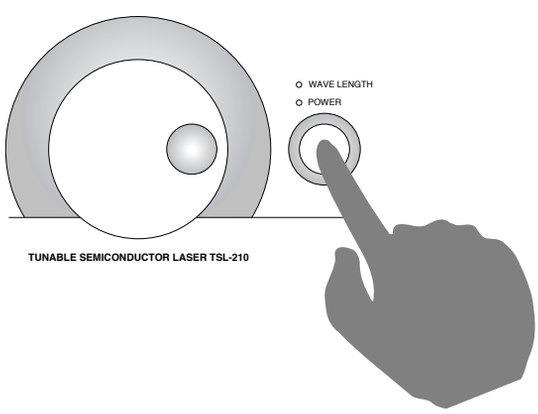
TUNABLE SEMICONDUCTOR LASER TSL-210

9-3 Setting Wavelength

Make sure that the rotary encoder wavelength setting LED is lit.



When the LED is not lit, turn the rotary encoder change key to the wavelength side.



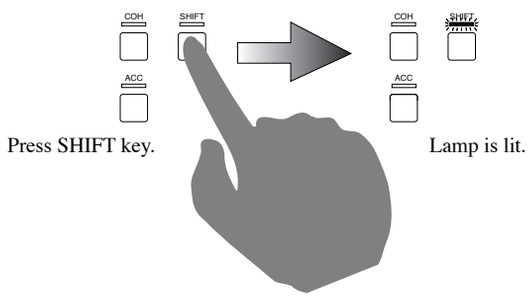
After making sure the wavelength setting LED is lit, set the wavelength by the rotary encoder. The wavelength reading exactly follows the rotations of the encoder dial when the dial is gradually turned, while the reading changes in unit of nm when the dial is turned fast. When the wavelength display stops changing, it means that the wavelength is set in a range of 0 and 1nm. The setting will complete in 170 msec.

NOTE

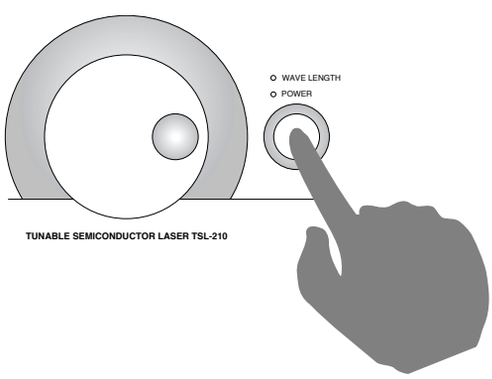
TSL-210 wavelength setting includes slight hysterisis, and there is wavelength displacement between the setting from short wavelength to long wavelength and the setting from long wavelength to short wavelength, therefore, in setting wavelength, be sure to set from short wavelength to long wavelength.

9-3-A. Minimum digit setting

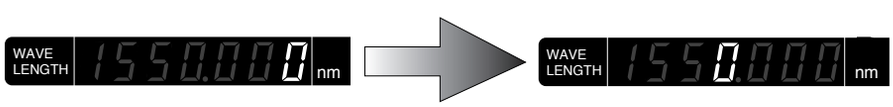
As for wavelength setting, minimum tuning step can be selected by the following operation. Please push shift key. (This key toggles the sift function ON/OFF)
When the key is pressed, SHIFT LED is lit, and the next key entry is ready.



When the SHIFT LED is lit, press the rotary encoder change key.



If the key is pressed, minimum step digit which is currently set on the wavelength display panel is flickering. Select minimum step digit by rotating rotary encoder. (Setting range is 10nm – 1/1000nm)

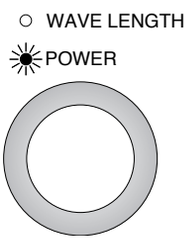


Then set the digit by pressing rotary encoder change key. When the key is pressed SHIFT LED goes off and TSL-210 go back normal mode.
Minimum step digit won't be changed until main power off or resetting.

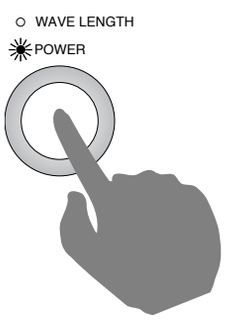
9-4 Setting Optical Output Power (APC function)

9-4-A. Setting Optical Output Power (APC function)

It is necessary to operate the machine in APC mode to set optical output power. Optical output power cannot be set in ACC mode. Be sure that the mode is in APC. (ACC indicator is not lit. If ACC indicator is lit, press ACC again thereby activating APC.)

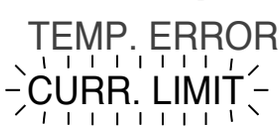


If the LED is not lit, toggle the rotary encoder change key (toggle action) to the optical output power side.

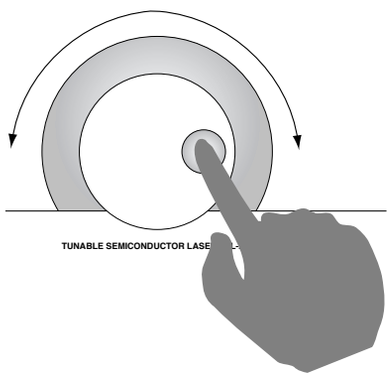


NOTE

When tuning a wavelength in APC mode, for some wavelength and optical output power settings, the target optical output power cannot be obtained even if LD injection current is at the maximum possible value. In such a case, CURR LIMIT LED is lit to show that this is the case. (Refer to Section 8-4 Optical Output Power Control Function)

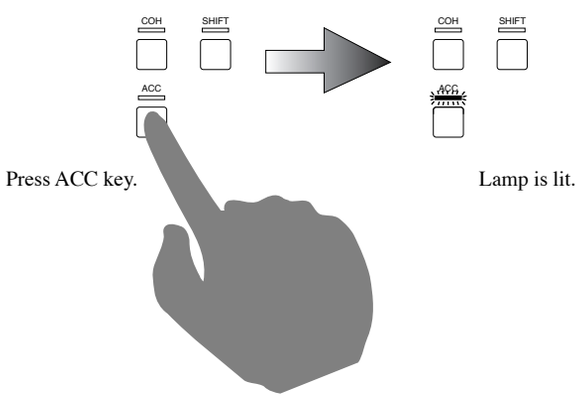


Set the optical output power by the rotary encoder. And as for entry of optical output power, entry is available by either "mW" or "dBm".



9-4-B. ACC Function

This product operates in two modes, APC (automatic power control) mode and ACC (automatic current control) mode. It operates in APC mode when it is turned on.
When optical output power is changed in normal APC mode, wavelength and side mode suppression ratio change slightly owing to the change in injection current to LD, therefore, so as to avoid this, use the TSL-210 in ACC mode. To operate it in ACC mode, press the ACC key; When the key is pressed, the ACC mode LED is lit. In ACC mode, it is not possible to set the optical output power.



Press ACC key. Lamp is lit.

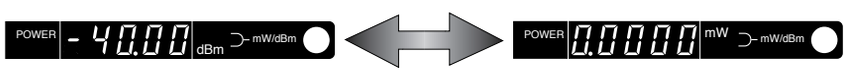
NOTE

Optical output power value and current value are held until power is shut off unless their setting is changed. Therefore, when it is toggled to ACC mode, optical output power is made at the present setting of the injection current value; when it is toggled to APC mode, optical output power is made at the present setting of the optical output power value.

9-4-C. Changeover of Optical Output Power Unit

NOTE

Changeover of optical output power Unit
The display of optical output power unit may be changed between “mW” or “dBm”. Press the optical output power unit change key. When the key is pressed, unit display is changed.



9-5 Fine Tuning Function

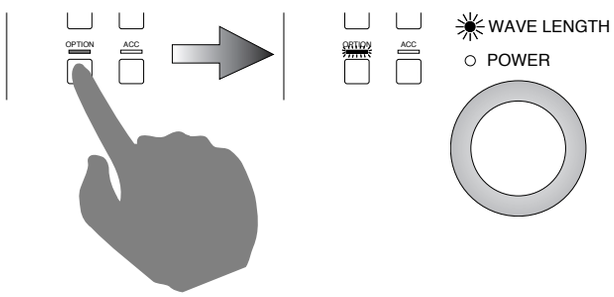
This product is equipped with a fine tuning function that enables the user to precisely tune wavelength by adjustment of cavity length. Resolution appears < 0.001 nm, and tuning with a step of 1/20,000 over a range of 5 GHz. is accomplished. By combination with a wavelength meter via communication, setting at accuracy 1/1000 of a nm is available. The TSL-210 has an external control to impress voltage from the analog interface (AIF) connector at the rear panel. For the optional Frequency Locking unit, in order to stabilize the laser to a constant fixed frequency, a voltage signal can be input into the connector.

NOTE

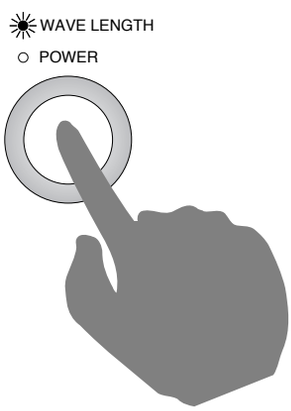
When the optional frequency locking unit is fitted, fine tuning is not possible when frequency locking is activated.

9-5-A. Internal Control

Press the option key. (This key toggles the fine tuning control ON/OFF.) When this key is pressed, the option LED is lit. Wavelength display changes into fine tuning display. The initial value is 0.00. Make sure that the rotary encoder wavelength setting LED is lit.



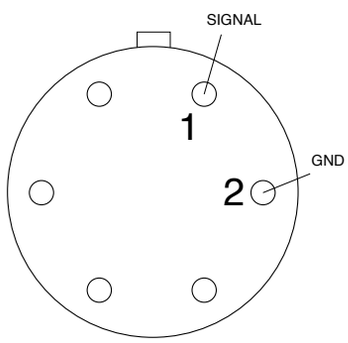
If the LED is not lit, change the rotary encoder change key (toggle action) to the wavelength side.



When the wavelength setting LED is lit, the fine tuning amount may be set within the range –100 to + 100 by the rotary encoder. Almost perfectly continuos tuning of wavelength is available. During fine tuning control, the coarse tuning is not available (rotation of the diffraction grating). To turn OFF the fine tuning control, press the option key once again. When it is turned off, the control amount returns to the initial value of 0.00, and the external cavity changes back to it's original length.

9-5-B. External Control

The external control of fine tuning controls the driver circuit to drive PZT (piezo) by external input voltage. Input ±3V voltage from pin No.1 (SIGNAL) and pin No.2 (GND) of the AIF (analog interface) connector on the rear panel. Impressing voltages other than the above causes voltage limit in the built-in driver circuit to be reached, and control is not available. Wavelength is in reverse proportion to impressed voltage, and when impressed voltage is larger, the wavelength changes to a longer wavelength, and is changed by about 0.04nm to ±3V.
(9-20 AIF (analog interface) connector pin assignment reference)



NOTE

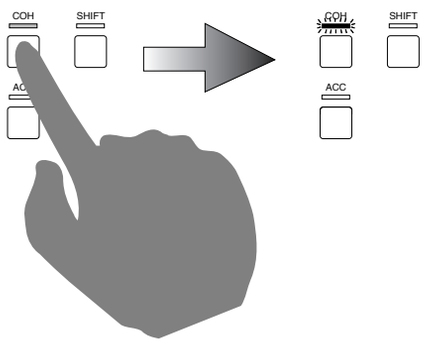
This is an AIF connector on the rear panel looking from the front.

CAUTION

Do not apply a voltage greater than the stated input voltage level. Doing so may cause damage to the equipment.

9-6 Coherence Control

Press the coherence control key.
(This key toggles ON/OFF of the coherence control.)

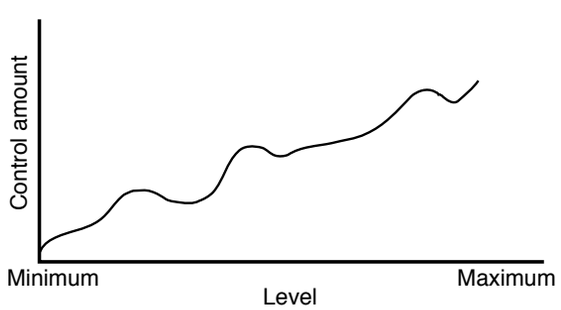


When the key is pressed, the coherence control LED is lit, to show that the coherence control is ON. To turn OFF the coherence control, press the coherence control key once again.

9-6-A Variable Coherence Control

By utilizing an external cavity structure in the design, the TSL-210 makes the most of the characteristics of a semiconductor laser. The greatest of these characteristics is the improvement of spectrum purity. However, when spectrum purity is improved, interference distance becomes longer, and interference by a slight reflection point somewhere in a test set-up may deteriorate the quality of the measurement system. To solve such a problem, the TSL-210 has a spectrum linewidth control function, the Coherence Control. The Coherence Control, in a sense, puts noise on a light source. If its level becomes strengthened too much, it becomes a noise signal. To optimize the effects of the Coherence Control, it is best to be able to control in small increments. The standard model only has a single Coherence Control setting.

In the Variable Coherence Control option, a volume knob is attached to the option panel on the rear panel. Turning the knob clockwise makes the level larger. Adjust the level by turning the adjustment potentiometer. The level and control amount does not necessarily appear linear.



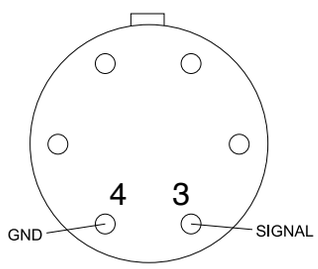
9-7 Low Frequency Modulation

CAUTION

Do not apply voltage in excess of input level amount. When not using Low Frequency modulation, be sure to cap the terminals, so that deterioration of the terminals does not occur.

In the low frequency modulation, the current driver to drive LD is controlled by external input voltage. The current driver to drive the LD is given current limitation by hardware limit circuit, and thereby is protected against excessive injection current.

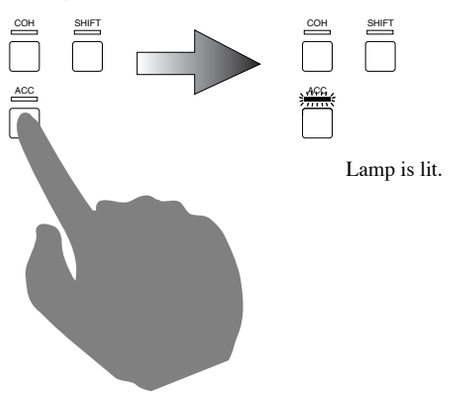
Make sure that the power between TSL-210 and signal source is shut off in advance, and connect the cable to input modulation signal. Turn on power to the mainframe TSL-210 and the frequency generator external modulator.



NOTE

This is an AIF connector on the rear panel looking from the front.

Turn ON the LD key to change current to LD. Activate ACC mode, if it is not already activated. (Press ACC as shown below.)



Lamp is lit.

NOTE

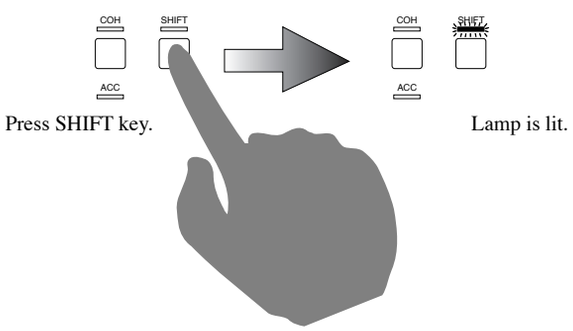
TSL-210 has the current control mode and the power control mode. In either case, feed back loop control to stabilize optical output power inside is conducted. In the case to use low frequency modulation, if feed back loop is not removed, external input voltage is handled as fluctuation, so preferable modulation is not available. Remove the feed back loop in the above procedures before use.

Specifications:

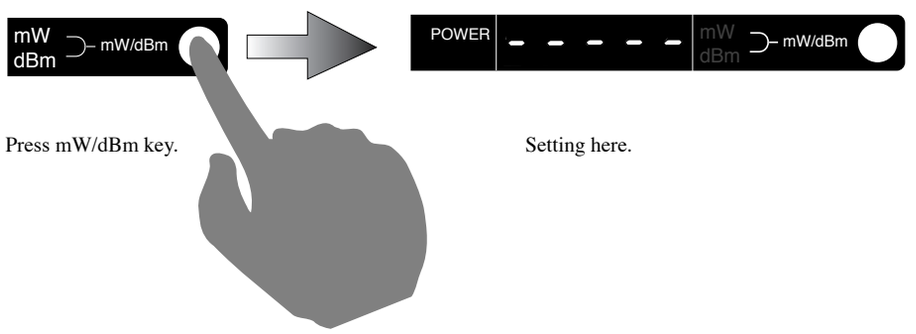
Tuning band range	:0-10KHz
Input level	:±1V
Modulation efficiency	:100mA/V
Input impedance	:4.7kΩ

9-8 Wavelength Calibration

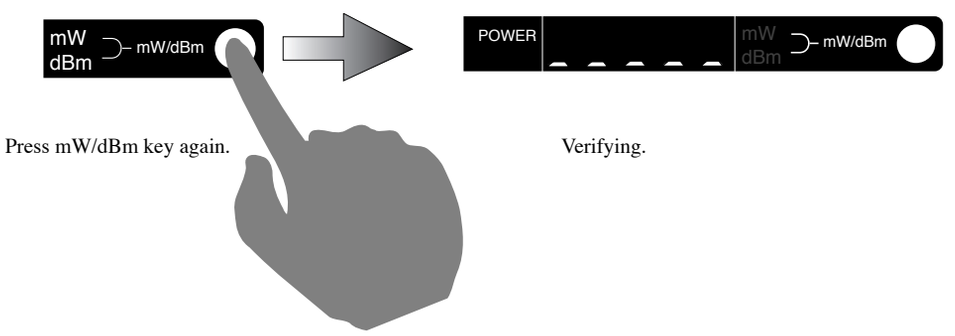
This product is equipped with wavelength calibration function to calibrate difference in wavelength with other measuring device and calibrate the wavelength monitor of the TSL-210.
Press SHIFT key. (This key toggles ON/OFF the SHIFT function.)
When the key is pressed, SHIFT LED is lit, and the next key entry is ready.



When the SHIFT LED is lit, press the wavelength calibration key.
When the key is pressed, all the displays in the optical output power display panels change into "-", to show that the unit is in wavelength calibration condition. Make sure that the rotary encoder change key is set at wavelength selection. Using the rotary encoder, select the wavelength to be calibrated.



After completion of the setting routine, press the wavelength calibration key once again. When the key is pressed, set value internal writing condition starts. The symbol "- (minus)" in the display changes to the symbol "_ (under bar)." Do not press any key during writing. Otherwise, maloperation may result.



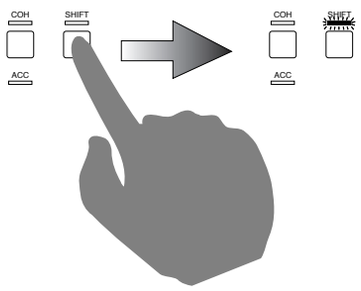
Upon completion of writing, the symbol "_" is replaced with the optical output power value and shift lamp goes OFF.

NOTE

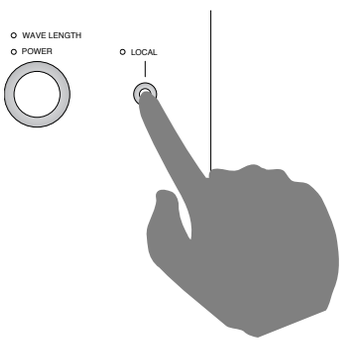
Wavelength calibration value is made effective only after power is turned on so that wrong setting tried during power-up sequence is not recognized. If the unit is turned off and then on, the unit starts with the default setting. If wrong calibration is made after the power is on, enter the correct value or turn the unit off and on again to cancel the wrong setting. Effective calibration range is with in approx. ±3 nm of the current value. If the calibration is outside this range, the unit may be malfunctioning.

9-9 Setting GP-IB Address and Delimiter

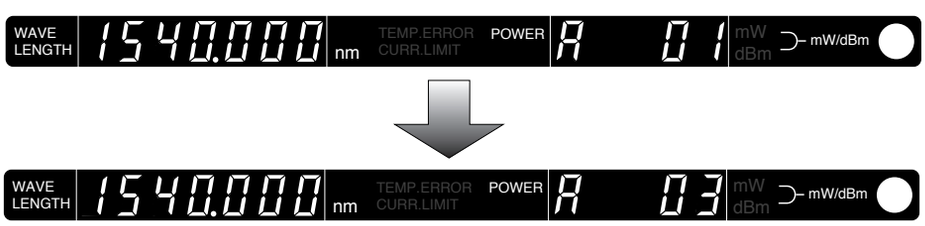
After setting, press GP-IB address delimiter key again.



Move to delimiter setting



Change delimiter
Move in to delimiter setting mode after address setting.
Delimiter has CR, LF, CR+LF and EOI which doesn't have any character.
Change the delimiter using rotary encoder and press GP-IB address and delimiter key to select the delimiter.



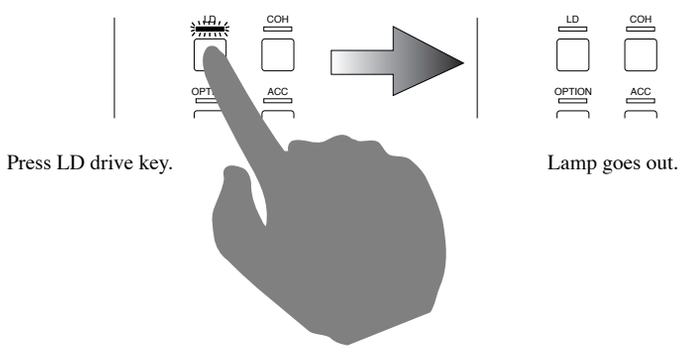
GP-IB address and delimiter is saved to memory after setting. SHIT LED goes off and display shows output power.

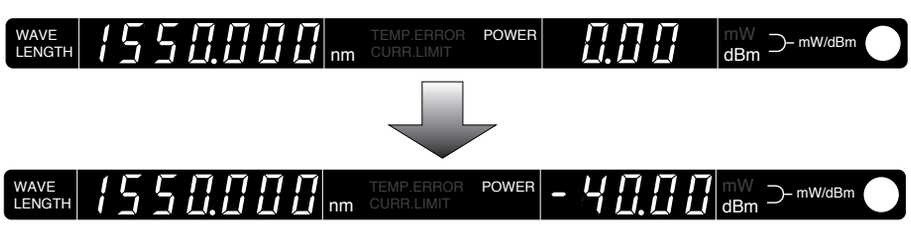
*At this moment, GP-IB address and delimiter is only saved to memory. It will be effected after resetting TSL-210.

9-10 Turning OFF

9-10-A Turning OFF Injection Current (LD drive LED lights or flickers)

Press the LD drive key. When the key is pressed, the injection current value will reduce to zero, and the value of the optical output power display panel changes according to current.





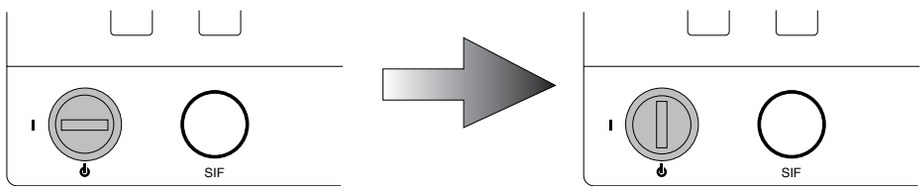
The protection circuit prevents an instantaneous loss of current in the LD; therefore, it will take a moment after pressing the LD drive key for the LD to go out. Injection current is not completely shut off until the LD indicator goes out—please pay special attention to the indicator and wait until it is out before shutting off the power source.

CAUTION

Before shutting off the power, make sure that LD drive LED is off.
Otherwise, LD may be damaged.

9-10-B. Turning the Power OFF

Make sure that the LD drive LED is off, then turn the power key 90 degrees to the left to turn off the power.



Turn the power key 90 degrees to the left.

10 Communication

CAUTION

Before connecting or disconnecting the communication connector, be sure to turn OFF this product. Otherwise, a fault may result.

The TSL-210 supports three different communication protocols, RS-232C and GP-IB, for external communication with the TSL-210. In addition, LabVIEW software drivers are available. The control commands of each communication are the same; however echo back and data retrieval methods are different. Explanations of the features and differences are outlined below.

10-1 GP-IB

10-1-A Outline

GP-IB is an acronym for General Purpose Interface Bus. GP-IB utilizes a standard nearly identical to buses such as HP-IB and IEEE-488. GP-IB is an easy-to-operate parallel interface with excellent expandability to allow test set-ups to have connections to control computer, measuring device, and other equipment. The GP-IB connection consists of 16 signal lines, 8 ground lines, and 8 signal lines—which are used as data lines, 3 for handshaking and 5 for control lines. Each connected device has one or two statuses out of three statuses, e.g. controller, talker (sender), and listener (receiver). Generally the controller is a single system as only one controller is allowed; however, it is possible to transfer the “control rights” to another device. But since most computers today are controllers themselves, each device is designated as talker or listener, and then data are sent and received and controlled on bus.

10-1-B How to Use

In GP-IB, it is necessary to set address per each device to be connected. Addresses are from 0 to 30, and each of all the devices connected should have an identical address.
Connect devices with GP-IB cable and turn the system on.

CAUTION

Note : Do not disconnect or connect a cable from and to devices connected with GP-IB cable, do not short-circuit connector, and do not turn ON/OFF the devices. Otherwise, action may be stopped, error may occur, causing a failure. In the event of trouble owing to these causes, reset all the connected devices, and then activate the system once again. When configuring a system, remove the unused device or unnecessary cable and return to the original setup.

10-1-C GP-IB Function

GP-IB has 10 kinds of interface functions, each of which has its grade that is called it's sub set. A "O" after the symbol of each function shows that support is not made, and each numeric value represents grade.

Symbol	Function	TSL-210 Sub Set
SH	Source	SH:1 all functions
AH	Acceptor handshake	AH:1 all functions
T	Talker	T8: basic talker, listener release by MLA
L	Listener	L4: basic listener, talker release by MTA
TE	Expanded talker	TEO: none
LE	Expanded listener	LEO: none
SR	Service request	SRO: none
RL	Remote/local	RL1: switching of remote/local, local lockout
PP	Parallel port	PPO: none
DT	Device trigger	DTO: none
DC	Device cleaner	DC1: all functions
C	Controller	CO: none

10-1-D GP-IB of TSL-210

1. Address

When the system is turned on, the address is displayed. To confirm or change an address, press the SHIFT key at the front panel, and then press the LOCAL key; the optical output power display will change into the GP-IB address display, which can be changed by the rotary encoder. Press LOCAL after making the change, and the GP-IB address will be stored into TSL-210 EEROM (electrically erasable and programmable read only memory).(Refer to 9-10. Setting GP-IB Address)

2. Remote/Local Function

Remote status occurs when the TSL-210 confirms MLA (My Listener Address) or MTA (My Talker Address) irrespective of true or false of REN (remote enable) of control lines. In remote status, other operation than local key from the front panel cannot be accepted. To return from remote status to local status, press LOCAL key at the front panel or execute the GP-IB command GTL (Go To Local). In the TSL-210, GTL is valid only when REN is true. And even if REN changes from true to false, it will not return to local status. Further, after execution of LLO (Local Lock Out), local key even from the front panel cannot be accepted, and it cannot return to local status even by GTL. To release LLO, execute IFC
(Inter Face Clear) irrespective of true or false of REN.

3. Device Clear Function

When DCL (Device Clear) is executed, TSL-210 is reset.

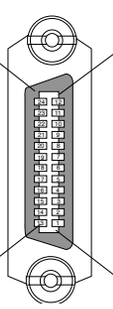
4. Command, Data, Delimiter

Command consists of 2 alphabetical letters, irrespective of upper or lower case.
When inputting data, input numeric value data following command. Command, delimiter of command, and data are CL+LF (0D0A). When a wrong command is received, the TSL-210 outputs "NR" to the next data request; but, when it receives a current command, it stops outputting "NR".

10-1-E GP-IB Connector

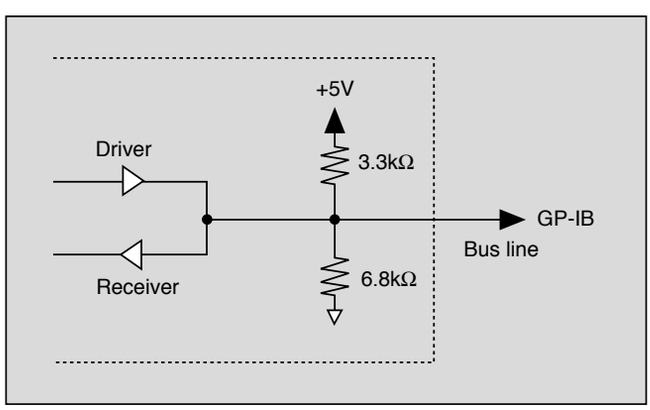
Pin Assignment of GP-IB Connector

Signal name	Pin No.
Gnd, LOGIC	24
Gnd, (ATN)	23
Gnd, (SQR)	22
Gnd, (IFC)	21
Gnd, (NDAC)	20
Gnd, (NRFD)	19
Gnd, (DAV)	18
REN	17
DIO 8	16
DIO 7	15
DIO 6	14
DIO 5	13



Pin No.	Signal name
12	SHIELD
11	ATN
10	SRQ
9	IFC
8	NDAC
7	NRFD
6	DAV
5	EOI
4	DIO 4
3	DIO 3
2	DIO 2
1	DIO 1

End of signal line



10-2 RS-232C

10-2-A Outline

RS-232C was originally designed to connect a data terminal device and a modem; it requires a power source larger than the 5V power source which is used in current personal computers and also a minus power source. However, since most personal computers are now equipped with RS-232C, which requires only 3 lines, a user can easily interface the TSL-210 with a PC.

10-2-B How to Use

The basic lines needed for communication are three lines, namely, data send line, data receive line, and ground line. (The send line goes to the receive port on the other device.) Besides the three basic lines, there are control lines to show whether data communication is available or not and lines to know the operating condition of the devices; but these are connected internally for communication. However, to interrupt communication, to transmit data over long distances, or to transmit data at high speed, appropriate lines for these purposes will be necessary. Note that a mismatch in communication condition will prevent current communication even after correct connection of the devices. Communication conditions include communication method, baud rate, data length, stop bit, parity check, X control, delimiter, etc.

10-2-C RS-232C of TSL-210

RS-232C of TSL-210 employs a simple 3-line communication method. When connecting it to a computer, connect TXD to the receive line of the TSL-210, connect RXD to the send line of the TSL-210, and connect ground line to SG; short-circuit the four terminals RTS, CTS, DSR, and CD at computer side. To make the communication of command and data precise, send back-echo after execution of command.

1. Communication Conditions
Communication conditions of the TSL-210 are fixed and cannot be changed. Communication conditions of TSL-210 are as follows:

Start-stop	Full duplex
Baud rate	9600 bps
Data length	8 bit
Stop bit	1 bit
Parity	None
X control	None

2. Command, Data, Delimiter

Command consists of 2 alphabetical letters, irrespective of upper or lower case. When inputting data, input numeric value data following command. When it receives a correct command, it echoes back 2 letters of command irrespective of data presence or absence. But when a wrong command is received, TSL-210 outputs "NR". It always confirms echo back and makes control adjustments so that communication of commands and data are precise. To take out data from TSL-210, command for take out without data of echo back is prepared. Delimiter can be set for CR, LF, or CL/LF.(See 9-2-A. Turning ON/Setting RS-232C delimiter)

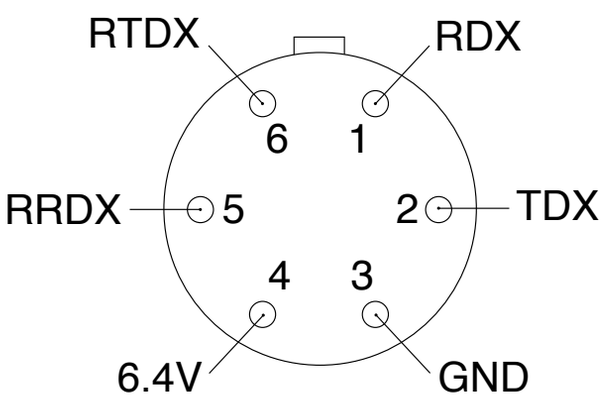
10-2-D. SIF connector (RS-232C)

TSL-210 supports RS-232C level and TTL level serial communication however, these cannot be uses at the same time. (These are connected as wired and) If external equipment supports RS-232C, connect wires as follows:

External equipment TSL-210
Send --- Receive
Receive --- Send
SG --- GND
Shake hand line should be terminated by external equipment.

[SIF pingassingment]

1 RDX : TTL input to TSL-210 (receive)
2 TDX : TTL output from TSL-210 (send)
3 GND : GND
4 6.4V : 6.4V output (power supply for control pad)
5 RRDX : RS-232C level input to TSL-210 (receive)
6 RTDX : RS-232C level output from TSL-210 (send)



NOTE

This is an SIF connector on the front panel looking from the front.

D sub 9 pin connector

No.	Signal	
1	Data Carrier Detect	DCD
2	Receive Data	RXD
3	Transit Data	TXD
4	Data Terminal Ready	DTR
5	Signal Ground	SG(GND)
6	Data Set Ready	DSR
7	Request To Send	RTS
8	Clear To Send	CTS
9	Ring Indicate	RI

SIF Connector

No.	Signal
1	RDX
2	TDX
3	GND
4	6.4V
5	RRDX
6	RTDX

D sub 25 pin connector

No.	Signal	
1	Frame Ground	FG
2	Transit Data	TXD
3	Receive Data	RXD
4	Request To Send	RTS
5	Clear To send	CTS
6	Data Set Ready	DSR
7	Signal Ground	SG
8	Data Carrier Detect	DCD
9		-
:		-
25		-

SIF Connector

No.	Signal
1	RDX
2	TDX
3	GND
4	6.4V
5	RRDX
6	RTDX

CAUTION

Do not connect pin assignment incorrectly. It may cause damage to the equipment.

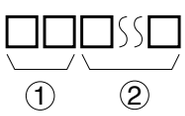
10-2-E. Control pad

TSL-210 is not equipped with numeric keys. The operation panel has only the necessary minimum displays, keys and operation by the rotary encoder.
The control pad enables numeric input, command input, wavelength sweep and table control by connecting via SIF cable. This control pad improve operation.

10-3 Communication Control

10-3-A. Commands

There are commands to change internal conditions and commands to change external conditions. When changing output data, send a command consisting of two alpha characters. When changing control data, send numeric data following a command of two alpha characters. In this case, the output data is changed at the same instant as the control data.
After sending command, GP-IB does not echo back, but RS-232C echoes back two alpha characters after sending command irrespective of data presence or absence. (DI command is an exception.) The format of command and data is shown below:



1. Command of 2 alpha characters to TSL
2. Data in the case when data is added to the command or expanded portion of command

In actual communication, the delimiter should follow the command and data.

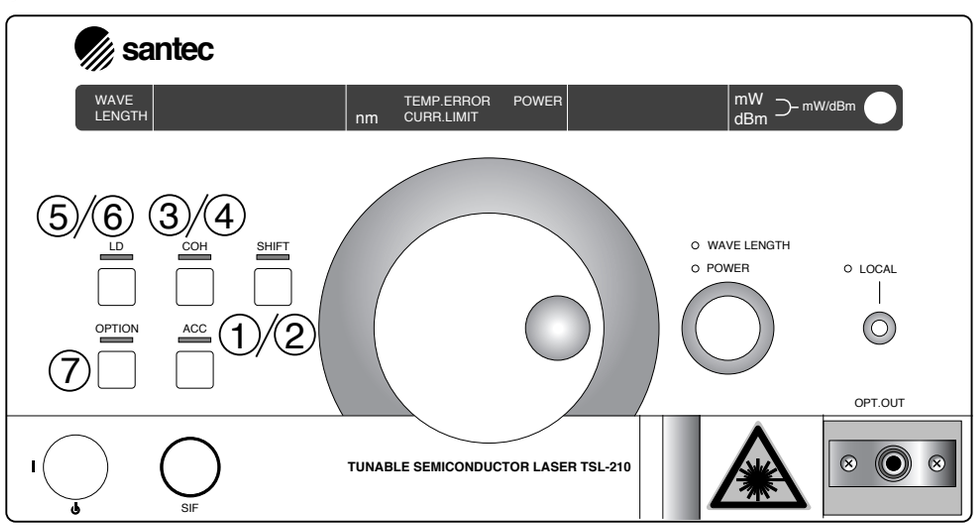
List of Commands

Command Parameter	Contents	Message Type	Key	
CU	1. Sets output variable to current.	1. CU	-	
	2. Sets injection current to numeric data added to command. Unit is mA.	2. CU X X X . X X		
TL	1. Sets output variable to LD temperature.	1. TL	-	
	2. Sets LD temperature to numeric data added to command. Unit is °C.	2. TL X X . X X		
WA	1. Sets output variable to wavelength.	1. WA	-	
	2. Sets oscillation wavelength to numeric data added to command. Unit is nm.	2. WA X X X X . X X		
AO	Changes over control mode to ACC mode.	AO	1	
AF	Changes over control mode to APC mode.	AF	2	
SU	Sets output variable to status. RS-232C does not echo back.	SU	-	
OP	1. Sets output variable to optical output power.	1. OP		
	2. Sets optical output power to numeric data added to command and controls injection current. Unit is dBm.	2. OP X X X . X X		
LP	1. Sets output variable to optical output power.	1. LP		
	2. Sets optical output power to numeric data added to command and controls injection current. Unit is mW.	2. LP X X X . X X		
CO	Turns ON the coherence control.	CO	3	
CF	Turns OFF the coherence control.	CF	4	
CV	1. Sets output variable to coherence control value.	1. CV	-	
	2. Sets output value of the integrated wavelength monitor. Value range is 0~10.00.	2. CV X X . X X		
LO	Supplies current to LD.	LO	5	*2
LF	Shuts off injection current of LD.	LF	6	*2
DI	Exclusive for RS-232C. Command without echo to receive data, and the currently set data can be taken out by the next input of "DI".	DI	-	
FT	1. Sets the output variable to fine tuning.	1. FT	7	*1
	2. Sets fine tuning to the numeric data added to command. Sets it in the range ±100.00.	2. FT X X X . X X		

AT	1. Sets output variable of ATT.	1. AT	-	*3
	2. Sets ATT number to numeric data appended to command. Value range is 0~20.	2. AT X X . X X		
	3. Sets ATT mode to manual control mode.	3. ATD		
	4. Sets ATT mode to automatic control mode.	4. ATE		

*1 When wavelength is set by WA command, fine tuning is turned off and FT value ise set back to 0.
*2 When supplying or intercepting current to LD, it takes time to set the internal processing. The status changes when the processing finishes.
*3 This command can be set only when in ACC or ATT manual mode.

Key Index



10-3-B. Taking Out Data

In the TSL-210, the method to retrieve data differs between GP-IB and RS-232C. Explanations on how to take data out per each communication protocol are outlined below:

1. GP-IB

When a command is executed, the output data changes. At the next data request, data is automatically selected and output. For example, when retrieving wavelength data, send the wavelength tuning command, or send the command with the addition of data. Until the next output data change command is sent, the TSL-210 sends the current wavelength data to data request. When an incorrect command is received, the TSL-210 outputs "NR" to the next data request; when the correct command is received, the TSL-210 stops outputting "NR", and begins responding to the new command.

2. RS-232C

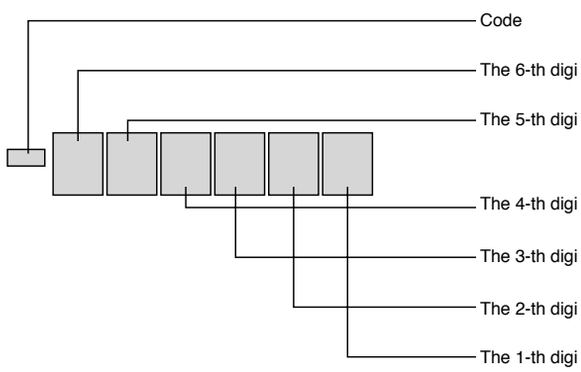
When a command is executed, output data changes. At the next data request, data is automatically selected and output. For example, when retrieving wavelength data, send the wavelength tuning command, or send the command with the addition of data. Until the next output data change command is sent, the TSL-210 sends the current wavelength data to data request. When an incorrect command is received, the TSL-210 outputs "NR" as an echo back, but when a correct command is received, it echoes back two letter characters. Different from GP-IB, RS-232C uses a command (DI) without echo back for data request. The data input after transmission of the DI command is the current output available.

NOTE

Command (DI) and (SU) do not return echo back.

10-3-C. Status

The status of TSL is represented by minus sign and 6-digit 0 ~ 7 numbers. Status can be taken out by communication SU command, and each status may be confirmed by the display panel and LED on the front panel. The contents of each digit and code are shown below.



Code [-/none] -(Minus) indicates that current is being injected into LD.

6th digit [1/0] 1 indicated that coherence control is now on.

5th digit [1/0] 1 indicates that fine tuning control is now on. 2 indicates that frequency locking is on.

4th digit [7~0] 1 indicates that ACC mode is now on. 2 indicates that automatic ATT mode is now on. 3 indicates that both ACC and ATT are operating.

3rd digit [1/0] 1 indicates that the actual temperature of the LD block and/or the optical unit is greater than ±0.1°C from the target temperature. 2 indicates that the actual etalon temperature of the frequency locking unit is greater than ±0.1 °C from the target temperature. 3 indicated that both LD block and/or optical unit and etalon temperature are out of target range.

2nd digit [1/0] 1 indicates that the LD current driver has reached its hard limit.

1st digit [7~0] 1 indicates that wavelength tuning is on. 2 indicated that set current value for current driver tuning is now on. 4 indicates that ATT tuning is on. The displayed value is a summed combination of the above conditions.

Example-1) " – 0 0 2 0 0 4 "

1. Attenuation tuning is on.
2. Injection current is within the control range.
3. Temperature is stable.
4. APC mode is set automatic ATT control is operating.
5. Normal wavelength control status.
6. Coherence control is OFF.
7. Current is being injected into LD.

Example-2) " – 1 0 1 0 0 5 "

1. Attenuation tuning and wavelength tuning are on.
2. Injection current is within the control range.
3. Temperature is stable.
4. ACC mode
5. Normal wavelength control.
6. Coherence control is now ON.
7. Current is being injected into LD.

10-4 Sample Program

This sample program is written in N88BASIC on NEC-9800 series. This program steps wavelength from 1500 nm up to 1580 nm, in unit of 0.1 nm, and reads the optical output power at each wavelength. This program assumes that all the required communication conditions such as delimiter are set.

10-4-A. RS-232C Sample Program

```
                                        [ Description ]
1000    OPEN"COM1:N81N"AS #1            RS232-C line file open, communication type setting
1010    PRINT #1, "WA1500"              Sets wavelength to "1500nm".
1020    INPUT #1, ANS$                  Waits for echo back.
1030    GOSUB *MOTOR.CHK                Checks whether wavelength tuning is ON or not.
1040    FOR SW=1500 TO 1580 STEP .1     Varies from 1500nm to 1580nm by 0.1nm, and reads optical
                                        output power.
1050        PRINT #1, "WA"+STR$(SW)     Sets wavelength.
1060        INPUT #1, ANS$              Waits for echo back.
1070        GOSUB *MOTOR.CHK            Checks whether wavelength tuning is ON or not.
1080        PRINT #1, "LP"              Sets output variable to optical output power (mW).
1090        INPUT #1, ANS$              Waits for echo back.
1100        PRINT #1, "DI"              Sets reading output variable without echo back.
1110        INPUT #1, POW$              Reads data of optical output power (mW).
1120    NEXT
1130    *MOTOR.CHK                      < Routine to check whether wavelength tuning is ON or not >
1140        PRINT #1, "SU"              Sets output variable to status.
1150        PRINT #1, "DI"              Sets reading output variable without echo back.
1160        INPUT #1, ANS$              Reads status.
1170        IF(RIGHT$(ANS$,1)="0") THEN RETURN  Sees 1st digit to check whether it is busy or not.
1180    GOTO *MOTOR.CHK
1190    CLOSE #1                        Closes line of RS-232C.
1200    STOP
```

10-4-B. GP-IB Sample Program

```
                                                    [ Description ]
1000    ISET IFC                                    Sends out "IFC" signal.
1010    ISET REN                                    Sets "REN" signal to TRUE.
1020    PRINT @1; "WA1500"                          Sets wavelength to "1500nm".
1030    GOSUB *MOTOR.CHK                            Checks whether wavelength tuning is ON or not.
1040    FOR SW=1500 TO 1580 STEP .1                 Varies from 1500nm to 1580nm by 0.1nm, and
                                                    reads optical output power.
1050        PRINT @1, "WA"+STR$(SW)                 Sets wavelength.
1060        GOSUB *MOTOR.CHK                        Checks whether wavelength tuning is ON or not.
1070        PRINT @1, "LP"                          Sets output variable to optical output power (mW).
1080        INPUT @1, POW$                          Sets reading output variable without echo back.
1090    NEXT                                        Reads data of optical output power (mW).
1100    *MOTOR.CHK                                  < Routine to check whether wavelength tuning is
                                                    ON or not >
1110        PRINT @1, "SU"                          Sets output variable to status.
1120        INPUT @1, ANS$                          Reads status.
1130        IF(RIGHT$(ANS$,1)="0")  THEN RETURN     Sees 1st digit to check whether it is busy or not.
1140    GOTO *MOTOR.CHK
1150    STOP
```

11 Maintenance

11-1. Daily Maintenance

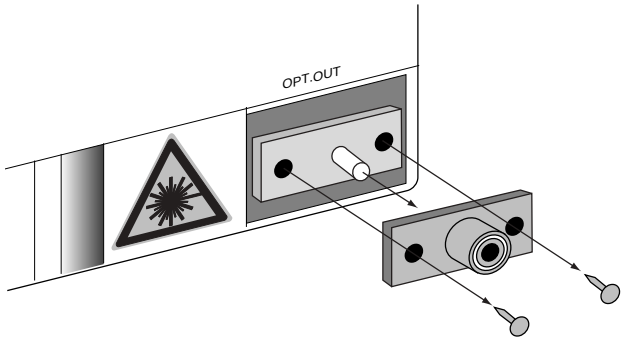
Connection of an optical fiber with dust and dirt on the end of the optical connector of the TSL-210 will cause loss of optical input, therefore, clean the connector periodically. The optical adapter may be removed by removing the screws as shown in the figure below.

11-2. Cleaning the Optical Connector

Connection of the optical fiber with dust and dirt on the end of the optical connector of TSL-210 cause loss of optical output, therefore, clean the connector periodically. The optical adapter arranged at the optical connector may be pulled out by removing fixation screws, therefore, remove it and clean the end of the optical connector.

DANGER!!

This product uses a semiconductor laser. Laser beam may cause visual injury if it gets in eye. Before cleaning of the optical connector, be sure to turn the power off (Refer to 9-11.), and make sure there is no optical output power.



Procedures

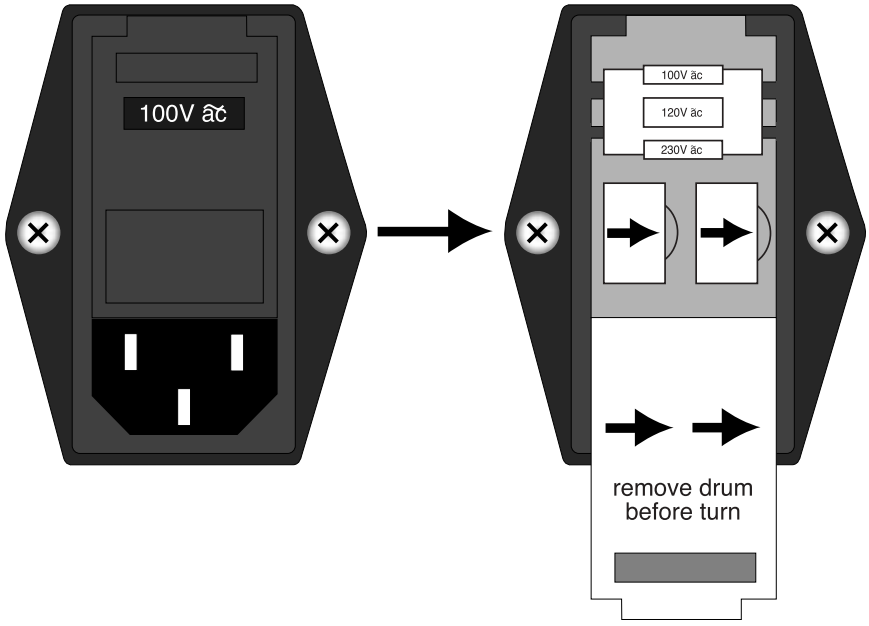
1) Remove the 2 screws that fix the optical adapter with a phillips screw driver.
2) Pull out the optical adapter. To facilitare removal, attach a connector cap to the optical adapter, and
   pinch and pull out the connector cap.
3) Clean the end of the optical connector with alcohol.
4) After cleaning, insert the optical adapter into the optical connector and fix it with 2 screws.

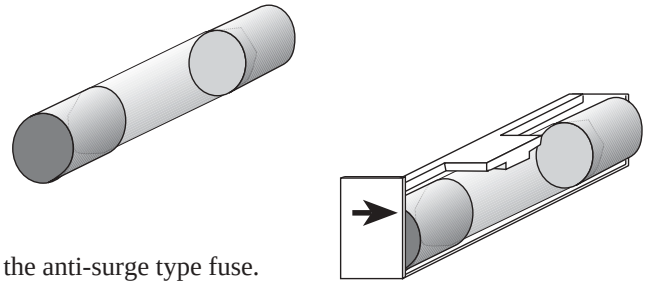
NOTE

After cleaning, insert the optical adapter into the optical connector and fix it securely with 2 screws. If the optical adapter is not attached correctly, optical output power loss will result.

11-3. Replacing the Fuse

Use the suitable fuse for power source voltage.





* Use the anti-surge type fuse.

11-4. Inspection and calibration

The warranty for TSL-210 is one year.
We recommend to have TSL-210 inspected and calibrated regularly (1 year).
For inspection or calibration, please contact our sales team.

12 Long-term Storage

Here are some instructions on long-term storage of this product.

NOTE

Recycling the packing materials will help repacakge this product, so keep the packing materials.

Notes before Storage

1) Wipe away dust, dirt, finger print, other stain on this product.
2) Use the packing materials for packing.
3) Avoid storing this product in the following places:
   - Do not subject to direct sunlight
   - Do not place under high temperature and humidity
   - Do not place in an area full of dust, dirt, salt, corrosive gas
   - Do not place in an area under vibration
   - Do not place in an area subject to noise from electric field, magnetic field, etc.

Note on Transportation

This product is a high-precision device, so avoid any shock or impact, and observe the above notes before storage prior to transportation.

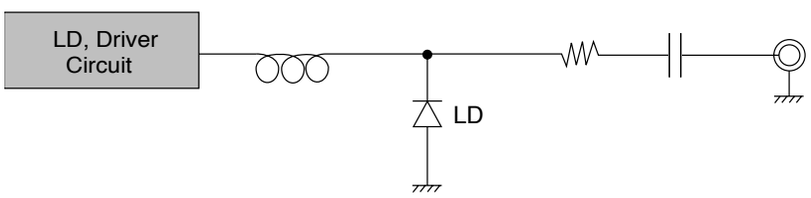
13 Option

13-1 High Frequency Modulation

CAUTION

Do not apply voltage which is outside the input level. When not using high frequency modulation, terminate the high frequency modulation port. Otherwise optical output power may become unstable.
Input the high modulation signal only while the current is being injected into the LD. Otherwise, damage to the LD will occur.

The high frequency modulation terminal is connected to the LD through the matching resistor and condenser and has no protection. The input level must be kept low enough not to cause damage to the LD. The bias current is injected into the LD from the current driver through the coil.



Before inputting the signal, turn on power to the unit and turn on LD key.

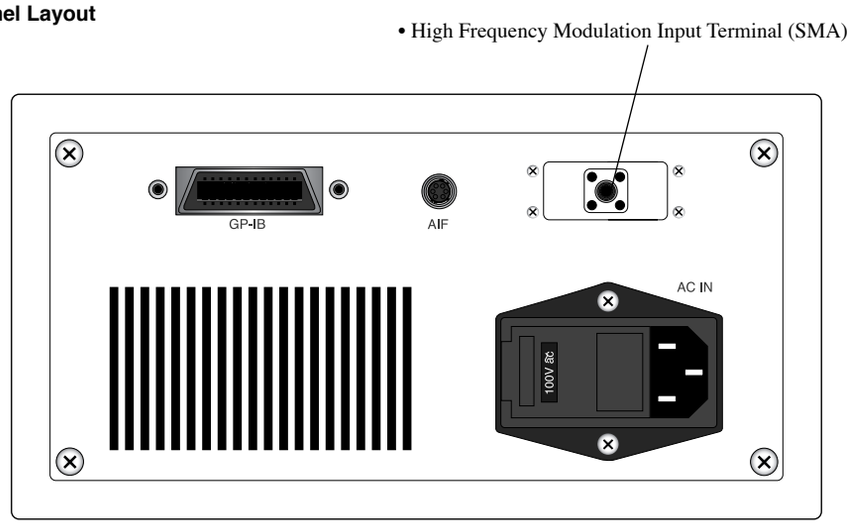
When using high frequency modulation, follow the following procedure.

(1) Make sure that both TSL-210 and signal source are off. Connect the signal source to the TSL-210 through the connection cable.
(2) Turn on TSL-210 and the signal source.
(3) Press LD key to inject the current to the LD.
(4) Feed the external signal to the LD.
(5) To shut off the current being injected into the LD, first turn off the external signal.

High frequency modulation characteristics

Modulation band	: 10-100MHz
Input level	: <0dBm
Input impedance	: 50Ω

Rear Panel Layout



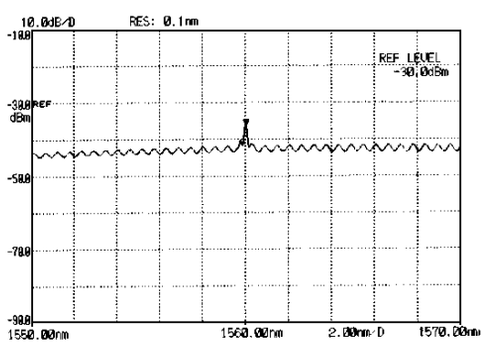
13-2 Control Pad (CP-10)

TSL-210 is designed with a simple and easy to use front panel interface. It has minimal function keys and does not have a numeric keypad for direct wavelength and power setting input. The CP-10 control pad addresses both of these issues, and provides full support of all functions in a compact, handheld design. The unit is programmable enabling up to 128 combinations of wavelength and power settings to be stored and wavelegnth sweeps to be performed.
The CP-10 unit connects to the TSL-210 unit through the front panel SIF connector and communicates through the RS-232C interface.

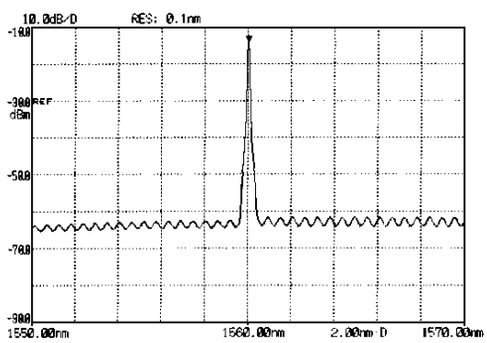
13-3 Built-in Attenuator

13-3-A Introduction

By adopting an external cavity structure the product has maintained various semiconductor laser features. In particular this structure make it possible to tune the wavelength of the laser light. However, the optical output power is controlled by tuning the LD injection current. This causes a change in the optical path length in the LD that can consequently cause an optical wavelength shift or cause difficulty in maintaining adequate SSR (side-mode suppression ratio). To counter these problems, a tunable attenuator (ATT) can be fitted on the output side of the external cavity. This is available as an option. The data below shows a comparison of the spectrum of the output signal with the output power set to -15dB with and without the attenuator.



Without ATT



With ATT

13-3-B Features and Principle Structure

An optional feature is the ability to reduce the optical output power loss from installing a variable attenuator in the optical test set-up. By including an internal ATT, variable attenuation is realized with a minimum of optical power loss when compared with an external attenuator set-up. An attenuator is made of a mechanically tunable graded ND filter. It can be tuned continuously with the resolution of 0.1dB within 0 to 20dB attenuation range.

13-3-C Control Method

ATT option is not designed to frequently control the attenuation level. Both manual control and automatic control are available and these modes can be set using the external communication port.

1) Manual Control
Manual control allows the ATT number to be set using the external communication port.

NOTE

When the unit is operated in APC mode, manual control of ATT can be set only through communication commands.

2) Automatic Control
Automatic control of ATT is initially active when the unit is operated in APC mode. When APC is in operation and the APC target value changes, if the current reaches its upper limit, the lower attenuation level is selected. If the current becomes less than 80mA, the larger attenuation level is selected. However, if for some reason the APC target value setting is not achievable, the previous attenuation setting is used.

13-3-D Control Method of Use

Several setting methods are available for this option: control mode switching from front panel, external initialization and mode switching using external control, and ATT number switching using manual mode.

After turning the power on, initialization is performed and automatic control is set in active.

* For information on the commands for the external communication control, please refer to the section given in parentheses.
(10-3. Communication control, List of Commands)

1) Control Mode Switching (ATE, ATD)
Toggling between manual control and automatic control is achieved using the external communication port. The LED above of LD key flashes to indicate that automatic control has been set (LED ON = Automatic control)

* In ACC mode (LED above ACC key is lit), irrespective of indication by the flashing LED manual control mode will always be operative.

2) Manual Control Mode (ATD, AT xx.xx, AO)
Manual control is possible using the external communication interface. Switch to manual control mode when the unit is operated in ACC mode or with external low frequency modulation. ATT is set to 0dB if APC mode is switched to ACC mode while automatic control mode of ATT is active. Manual control is effective only in ATT manual mode or in ACC mode.

3) Automatic control (ATE, AF)

Automatic control is available via key operation from the front panel or via mode switching through the external communication port. In APC mode, ATT can be automatically set depending on the change of optical output power. When it is in Automatic Control mode the LED above the LD key is lit and in the case of control by external communication a 2 is added to the 4th digit of the status display. Details of reading the status display are given in section 6.

> * In this case, re-initialization is repeated when either the APC target value is reset or when the wavelength is tuned. Also, when ATT is selected, if ATT reaches its maximum limit, no further attenuation is possible and retry operation cannot be performed. In the case when the minimum is reached, the current limit will be reached and the limit status indicator will be lit. No further attenuation will be possible.

4) Confirmation of set value (AT)

Set value of ATT changes by automatic control. And this value can be confirmed (read-out) via external communication command (AT). Set value is fixed in manual control mode.

14 Troubleshooting

Table of Troubleshooting

Fault condition	Cause	Action
No power	Cord is unconnected.	Connect cord properly.
	No fuse or fuse is blown out	Open the fuse box lid and replace fuse (see section 7)
	Power voltage is incorrect	Open the fuse box lid and rotate power voltage change switch to proper voltage (see section 7)
No light output	LD drive key is not turned on	Press LD drive key to turn LD ON(see section 9-2-D)
	Target output power is not set or too is low	Set target out put power (see section 9-5)
	surface of connector is dirty	Clean the surface of connector (see section 11-2)
Wavelength tuning is not possible	Rotary encoder is not set to wavelength tuning	Press rotary encoder mode key to the switch mode to wavelength tuning
Optical output power adj ustment is not possible	APC mode is off	Turn APC mode on and press rotary encoder mode
	Rotary encoder is not set to output power setting	key to switch the mode to output power adj ustment
RS-232C communication is not possible	communication condition is incorrect	Check the communication condition (see section 10-2)
	Delimiter setting is incorrect	Check the delimiter setting (see section 9-2-A)
	Cable has a problem	check the cable (see section 10-2-D)
GP-IB communication is not possible	GP-IB address is not set correctly	Set GPIB address correctly (see section 9-10)
	Delimiter setting is incorrect	Check the delimiter setting (see section 10-1-D)
	Cable is not connected properly	Check the connection of the cable
CP-10 communication is not possible	Cable has a problem	Check the connection of the cable
Optical output power is low	Attenuator setting is not set correctly	Check the attenuator setting is set correctly.

If after checking the above, the unit is still not operating correctly please contact our technical support staff.

WARNING!

In the event of any trouble with this product, turn the unit off in accordance with the procedures to shut off the power described in this operation manual, disconnect the power source cord, make sure the product name and serial number described on the name plate of the product, and then contact our dealer at your place or directly contact us at Santec Photonics Laboratories. Our telephone number and facsimile number are shown below. However, we are not responsible for any trouble arising from your own repair or modification on this product.

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