



Quantum Cascade Laser

Quantum Cascade Lasers are semiconductor laser that offer peak emission in the mid-IR range (4 μm to 10 μm). They have gained considerable attention as a new light source for mid-IR applications such as molecular gas analysis.

- **Features**
 - Mid-IR laser (4 μm to 10 μm)
 - Compact, lightweight
- **Applications**
 - Trace gas analysis Environmental measurement, Combustion gas measurement, Plasma measurement, In vivo gas analysis
 - IR molecular spectroscopy Chemical sensing, Molecular oscillation

Wavelength swept pulsed quantum cascade laser L14890-09



It is a pulsed quantum cascade laser that realized broadly wavelength sweeping by external cavity configuration. It can carry out the measurement of mid-infrared spectrum remotely, contactless and with high throughput. This product offers new value to the mid-infrared spectroscopy, which was traditionally carried out with FT-IR, by utilizing features of laser; high output and high wavelength resolution.

Characteristics

Unless otherwise specified, the repetition rate of the MEMS operation signals $F_{(mems)}=1.8$ kHz, the repetition frequency $F_{(qcl)}$ of the QCL operation signal is 180 kHz, and the QCL operation temperature $T_{op(qcl)}$ is 20 °C.

Characteristic	Condition	Min.	Typ.	Max.	Unit
Wavenumber sweep frequency	External control *1 (MEMS operation signal)	—	1.8 *2	—	kHz
Pulsed output power	MEMS stop	200	600	900	mW
Optical pulse width	Fixed before shipment	80	100	120	ns
Optical pulse repetition frequency	External control *1 (QCL operation signal)	—	180 *3	—	kHz
Spectrum linewidth *4	MEMS stop	—	2.0	3.0	cm ⁻¹
Beam diameter *5	Distance *6 800 mm ± 20 mm MEMS stop	3	5	7	mm
Beam divergency *7	Distance *6 800 mm ± 20 mm MEMS stop	—	—	5	mrاد
Beam directional stability	Distance *6 800 mm ± 20 mm	—	—	2	mrاد
Polarization	Vertical to the bottom				
Center wavenumber	Calculated from wavenumber sweep width	1020	1075	1140	cm ⁻¹
Wavenumber sweep width	Pulsed output power > 10 mW	180	200	—	cm ⁻¹

*1 Controlled by a signal source such as a separate function generator.

*2 $F_{(mems)}$: Repetition frequency of the MEMS operation signal.

*3 $F_{(qcl)}$: Repetition frequency and rise edge of the QCL operation signal.

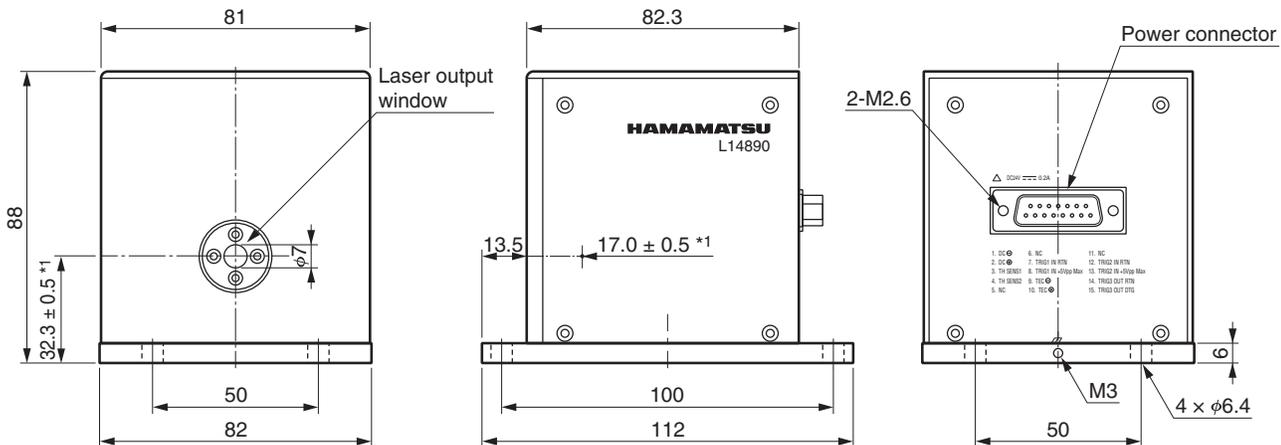
*4 Full width at half maximum of the spectrum.

*5 $1/e^2$

*6 Distance from the outgoing window

*7 Half angle

Dimensional outline (unit: mm)



*1: Emitter

* Tolerance: ±0.3 mm unless specified

LHJ3F0043-27_A

CLASS 3B LASER

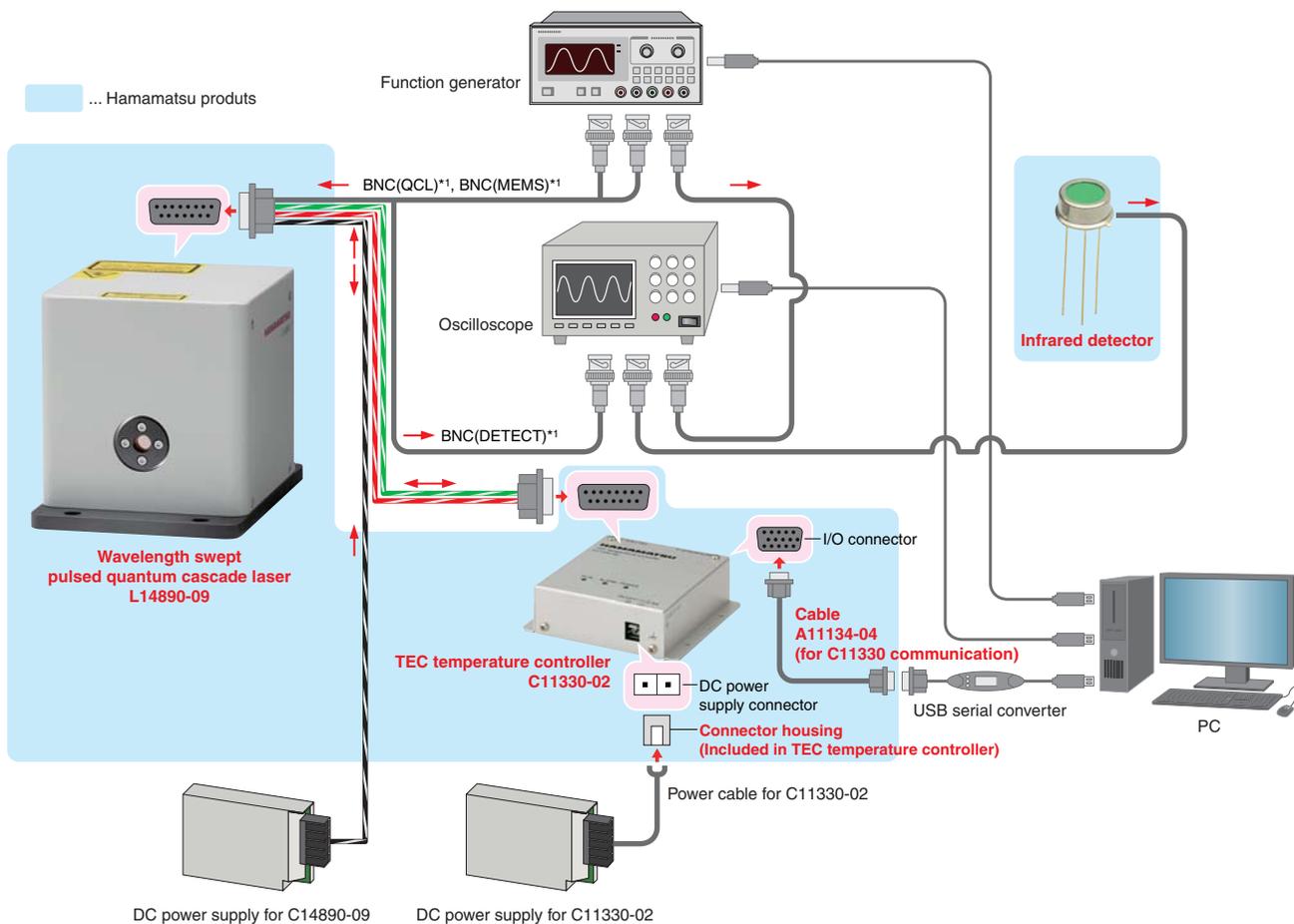
Invisible Laser Radiation: Avoid Exposure to Beam

●The Laser emits invisible laser radiation. The instrument which used the LASER, operated under ordinary conditions, is classified as Class 3B according to the laser product classification code IEC 60825-1. See IEC 60825-1 for more details and safety operation concerning the above countermeasures.



CONNECTION EXAMPLE

Connection example of wavelength swept pulsed quantum cascade laser



*1: The name printed on the power cable attached to the product.

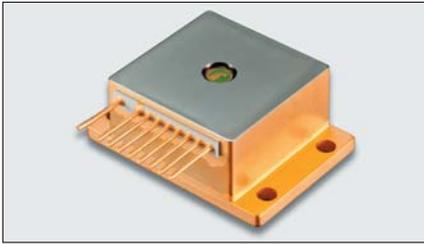
* The cable connected to the power connector is attached with the product. The cables connected to the DC power supply and the TEC temperature controller have to be manipulated by the user.

* This configuration is recommended for working the sample software properly. Contact Hamamatsu sales about the model number of recommended equipment.

The Products must not be brought into the United States of America.
 Hamamatsu will not assume any responsibility in the unlikely event that it is incorporated into your products and brought into the United States of America.

QCL LINEUP

■ CW quantum cascade lasers



HHL package

Quantum cascade lasers, which emit single mode mid-IR laser beam under the room temperature by employing single phonon resonance-continuum depopulation (SPC) and distributed feedback (DFB) structures.

By controlling the chip's operating temperature through the peltier element installed in the HHL package, it is possible to tune the emission wavelength without mode hopping while keeping longitudinal single mode operation.

Common specifications

Operating temperature (QCL) ^{*1}		Line width ^{*2}	Tunable range ^{*3}	Output power	Threshold current	Side-mode suppression ratio (SMSR)
Min.	Max.	Max.	Min.	Min.	Max.	Min.
+10 °C	+50 °C	0.2 cm ⁻¹ ^{*4}	±1.0 cm ⁻¹	20 mW	1.0 A	25 dB
Condition: Emission wavenumber (cm ⁻¹) ^{*5}					Condition: T _{op(qcl)} =20 °C	

^{*1} This specifies the temperature range within which the target emission wavenumber (K) can be realized.

^{*2} Full-width half maximum

^{*3} This specifies the continuous tunable range (without mode hopping). The center wavenumber of the tuning range is the emission wavenumber (K).

^{*4} The figures are limited by the resolution and signal/noise ratio of the measuring instruments used.

^{*5} Refer to the line-up table

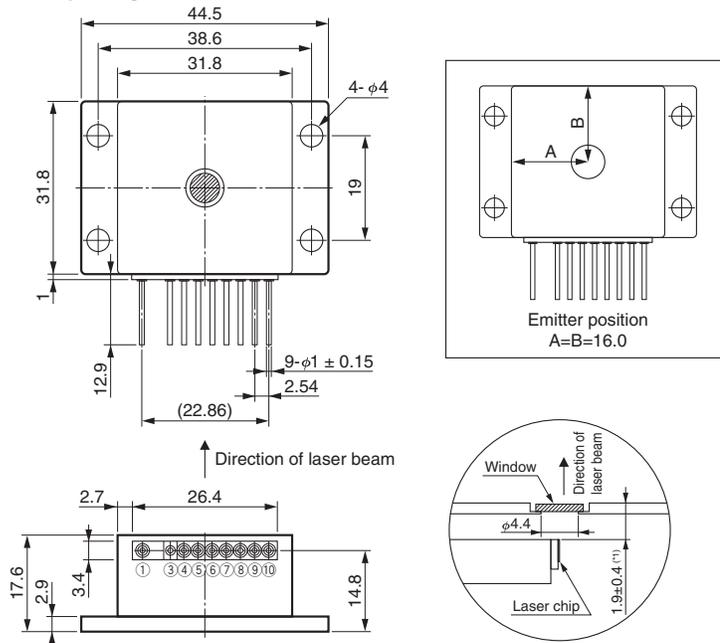
Line-up

Type No.	Wavelength	Wavenumber	Target gas
L12004-2310H-C	4.33 μm	2310 cm ⁻¹	CO ₂ , CO ₂ isotope
L12004-2209H-C	4.53 μm	2209 cm ⁻¹	N ₂ O
L12004-2190H-C	4.57 μm	2190 cm ⁻¹	N ₂ O, CO
L12005-1900H-C	5.26 μm	1900 cm ⁻¹	NO
L12006-1631H-C	6.13 μm	1631 cm ⁻¹	NO ₂
L12007-1392H-C	7.18 μm	1392 cm ⁻¹	SO ₃
L12007-1354H-C	7.39 μm	1354 cm ⁻¹	SO ₂
L12007-1294H-C	7.73 μm	1294 cm ⁻¹	CH ₄

* Please make contact with the Hamamatsu sales office about QCLs with emission wavelengths not listed above.

Dimensional outline (unit: mm)

HHL package



Pin No. ^{*2}	Function	Pin No. ^{*2}	Function
①	TEC cathode (-)	⑦	QCL cathode (-)
③	N.C.	⑧	Thermistor (Top(c))
④	QCL anode (+)	⑨	Thermistor (Top(c))
⑤	Thermistor (Top(qcl))	⑩	TEC anode (+)
⑥	Thermistor (Top(qcl))	—	—

^{*1} Edge of QCL chip and outside of the package

^{*2} ③ is electrically connected to the package. The other pins are electrically isolated from the package.

^{*} Tolerance is +/- 0.3 mm unless specified.

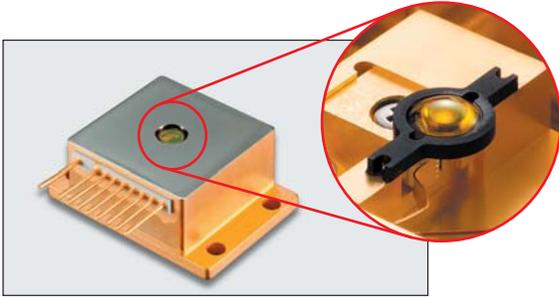
CLASS 3B LASER

Invisible Laser Radiation: Avoid Exposure to Beam

● The Laser emits invisible laser radiation. The instrument which used the LASER, operated under ordinary conditions, is classified as Class 3B according to the laser product classification code IEC 60825-1. See IEC 60825-1 for more details and safety operation concerning the above countermeasures.



■ CW quantum cascade laser (built-in lens)



HHL package

The lens integrated package for DFB-CW type QCL is sealed and collimated housing. Internal lens provides collimated output beam radiation. TEC (peltier) and thermistor for temperature stabilization of QCL-laser chip are inside the housing.

The lens integrated package allows to use under good usability without beam alignment of invisible mid-infrared laser.

Common specifications

Operating temperature (QCL) ^{*1}		Line width ^{*2}	Tunable range ^{*3}	Output power	Threshold current	Side-mode suppression ratio (SMSR)	Beam spread angle ^{*4,5}	Beam waist position ^{*4,6}		Beam waist width ^{*4,7}
Min.	Max.	Max.	Min.	Min.	Max.	Min.	Typ.	Min.	Max.	Typ.
+10 °C	+50 °C	0.2 cm ⁻¹ ^{*8}	±1.0 cm ⁻¹	20 mW	1.0 A	25 dB	3 mrad	50 mm	1000 mm	1.5 mm
Condition: Emission wavenumber (cm ⁻¹) ^{*9}						Condition: T _{op(qcl)} =20 °C				

*1 This specifies the temperature range within which the target emission wavenumber (K) can be realized.

*2 Full-width half maximum

*3 This specifies the continuous tunable range (without mode hopping). The center wavenumber of the tuning range is the emission wavenumber (K).

*4 This product has individual difference. Confirm date sheet attached to a product.

*5 Half angle. Larger spread angle either vertical direction (vertical to pins of package) or horizontal direction (horizontal to pins of package).

*6 From package top surface

*7 1/e² beam diameter

*8 The figures are limited by the resolution and signal/noise ratio of the measuring instruments used.

*9 Refer to the line-up table

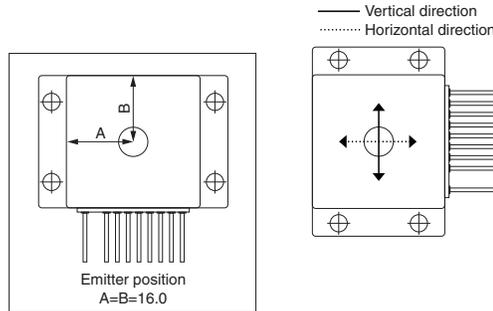
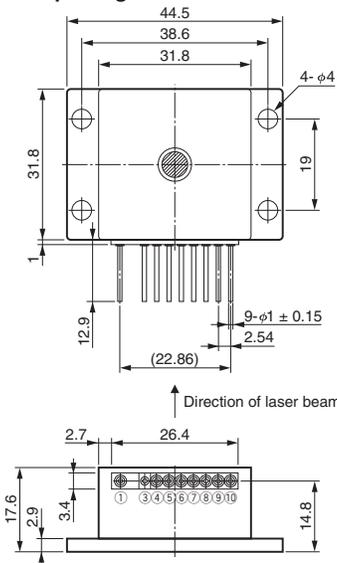
Line-up

Type No.	Wavelength	Wavenumber	Target gas
L12004-2310H-E	4.33 μm	2310 cm ⁻¹	CO ₂ , CO ₂ isotope
L12004-2190H-E	4.57 μm	2190 cm ⁻¹	N ₂ O, CO
L12005-1900H-E	5.26 μm	1900 cm ⁻¹	NO
L12006-1631H-E	6.13 μm	1631 cm ⁻¹	N ₂ O

* Please make contact with the Hamamatsu sales office about QCLs with emission wavelengths not listed above.

Dimensional outline (unit: mm)

HHL package



Pin No. ^{*1}	Function	Pin No. ^{*1}	Function
①	TEC cathode (-)	⑦	QCL cathode (-)
③	N.C.	⑧	Thermistor (Top(c))
④	QCL anode (+)	⑨	Thermistor (Top(c))
⑤	Thermistor (Top(qcl))	⑩	TEC anode (+)
⑥	Thermistor (Top(qcl))	—	—

*1 ③ is electrically connected to the package. The other pins are electrically isolated from the package.

* Tolerance is +/- 0.3 mm unless specified.

CLASS 3B LASER

Invisible Laser Radiation: Avoid Exposure to Beam

● The Laser emits invisible laser radiation. The instrument which used the LASER, operated under ordinary conditions, is classified as Class 3B according to the laser product classification code IEC 60825-1. See IEC 60825-1 for more details and safety operation concerning the above countermeasures.



CONNECTION EXAMPLE

CW quantum cascade lasers

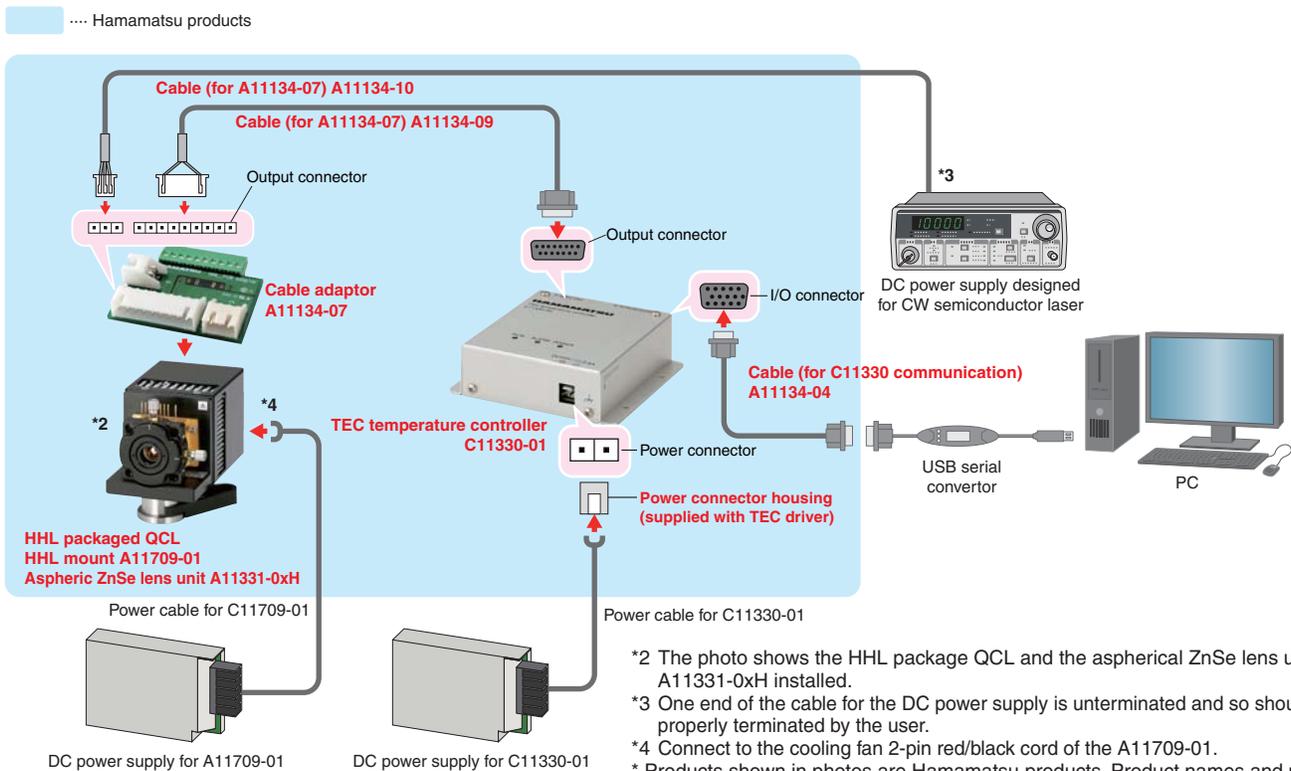
- ① CW QCL (L12004, L12005, L12006, L12007 series)
- ② TEC temperature controller C11330-01
- ③ Forced air cooling HHL mount A11709-01 or water cooling HHL mount A11709-02
- ④ Aspheric ZnSe lens A11331-0x *1 and/or lens unit A11331-0xH *1
- ⑤ Cable A11134-04
- ⑥ Laser power supply
(Use DC power supply designed for CW semiconductor laser available in market.)
- ⑦ Cable adaptor A11134-07
- ⑧ Cable A11134-09
- ⑨ Cable A11134-10
- ⑩ Heatseeker A10767

*1 Select suitable lens based on the emission wavelength of the QCL to use.

CW quantum cascade laser (built-in lens)

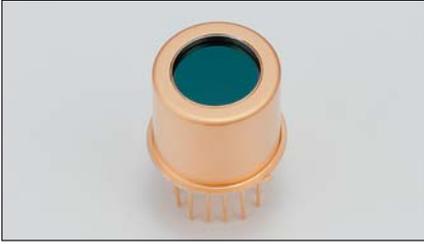
- ① CW QCL (L12004-2310H-E, L12004-2190H-E, L12005-1900H-E, L12006-1631H-E)
- ② TEC temperature controller C11330-01
- ③ Forced air cooling HHL mount A11709-01 or water cooling HHL mount A11709-02
- ④ Cable A11134-04
- ⑤ Laser power supply
(Use DC power supply designed for CW semiconductor laser available in market.)
- ⑥ Cable adaptor A11134-07
- ⑦ Cable A11134-09
- ⑧ Cable A11134-10
- ⑨ Heatseeker A10767

Connection example of CW Quantum Cascade Lasers



QCL LINEUP

Pulsed quantum cascade lasers



TO-8 package

Quantum cascade lasers, which emit single mode mid-IR laser beam under the room temperature by employing single phonon resonance-continuum depopulation (SPC) and distributed feedback (DFB) structures.

By controlling the chip's operating temperature through the peltier element installed in the TO-8 package, it is possible to tune the emission wavelength without mode hopping while keeping longitudinal single mode operation.

Common specifications

Operating temperature (QCL) ^{*1}		Line width ^{*2}	Tunable range ^{*3}	Output power	Threshold current	Side-mode suppression ratio (SMSR)
Min.	Max.	Max.	Min.	Min.	Max.	Min.
-10 °C	+50 °C	0.2 cm ⁻¹ ^{*4}	±1.0 cm ⁻¹	50 mW	1.5 A	25 dB
Condition: Emission wavenumber (cm ⁻¹) ^{*5}						

Standard driving conditions: $t_w=50$ ns, $f_r=200$ kHz, $T_{op(qcl)}=20$ °C

*1 This specifies the temperature range within which the target emission wavenumber (K) can be realized.

*2 Full-width half maximum

*3 This specifies the continuous tunable range (without mode hopping). The center wavenumber of the tuning range is the emission wavenumber (K).

*4 The figures are limited by the resolution and signal/noise ratio of the measuring instruments used.

*5 Refer to the line-up table

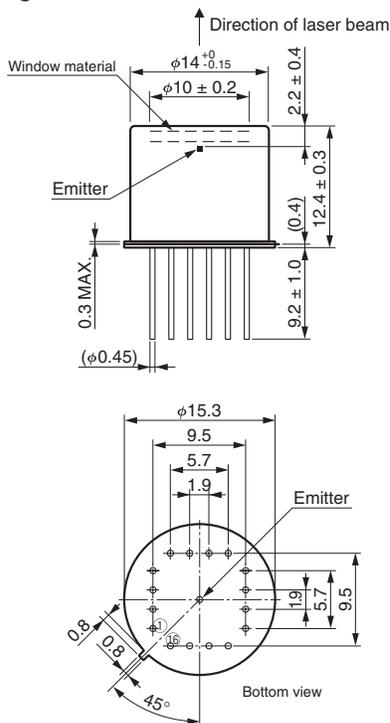
Line-up

Type No.	Wavelength	Wavenumber	Target gas
L12014-2231T-C	4.48 μm	2231 cm ⁻¹	N ₂ O, CO, CO ₂
L12015-1901T-C	5.26 μm	1901 cm ⁻¹	NO
L12016-1630T-C	6.13 μm	1630 cm ⁻¹	NO ₂
L12017-1278T-C	7.82 μm	1278 cm ⁻¹	CH ₄ , N ₂ O
L12020-0993T-C	10.07 μm	993 cm ⁻¹	NH ₃

* Please make contact with the Hamamatsu sales office about QCLs with emission wavelengths not listed above.

Dimensional outline (unit: mm)

TO-8 package



Pin No.	Function	PIN No.	FUNCTION	Pin No.	Function
①	TEC cathode (-)	⑦	QCL anode (+)	⑬	QCL cathode (-)
②	N.C.	⑧	QCL anode (+)	⑭	QCL cathode (-)
③	N.C.	⑨	Thermistor (Top(qcl))	⑮	QCL cathode (-)
④	TEC anode (+)	⑩	Thermistor (Top(qcl))	⑯	QCL cathode (-)
⑤	QCL anode (+)	⑪	N.C.	—	—
⑥	QCL anode (+)	⑫	N.C.	—	—

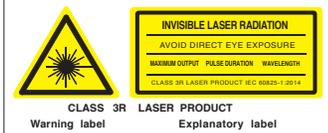
* Tolerance is ±0.3 mm unless specified.

* All the pins are electrically isolated from the package.

CLASS 3R LASER

Invisible Laser Radiation: Avoid Direct Eye Exposure

● The Laser emits invisible laser radiation. The instrument which used the LASER, operated under ordinary conditions, is classified as Class 3B according to the laser product classification code IEC 60825-1. See IEC 60825-1 for more details and safety operation concerning the above countermeasures.



CONNECTION EXAMPLE

DFB-pulsed QCL (1)

- ① DFB-pulsed QCL (L12014, L12015, L12016, L12017 series)
- ② TEC temperature controller C11330-02
- ③ TO-8 pulsed driver C14277 series
- ④ Aspheric ZnSe lens A11331-02 and/or lens unit A11331-02H *1
- ⑤ Cable A11134-04
- ⑥ Cable A11134-06
- ⑦ Heatseeker A10767 *2

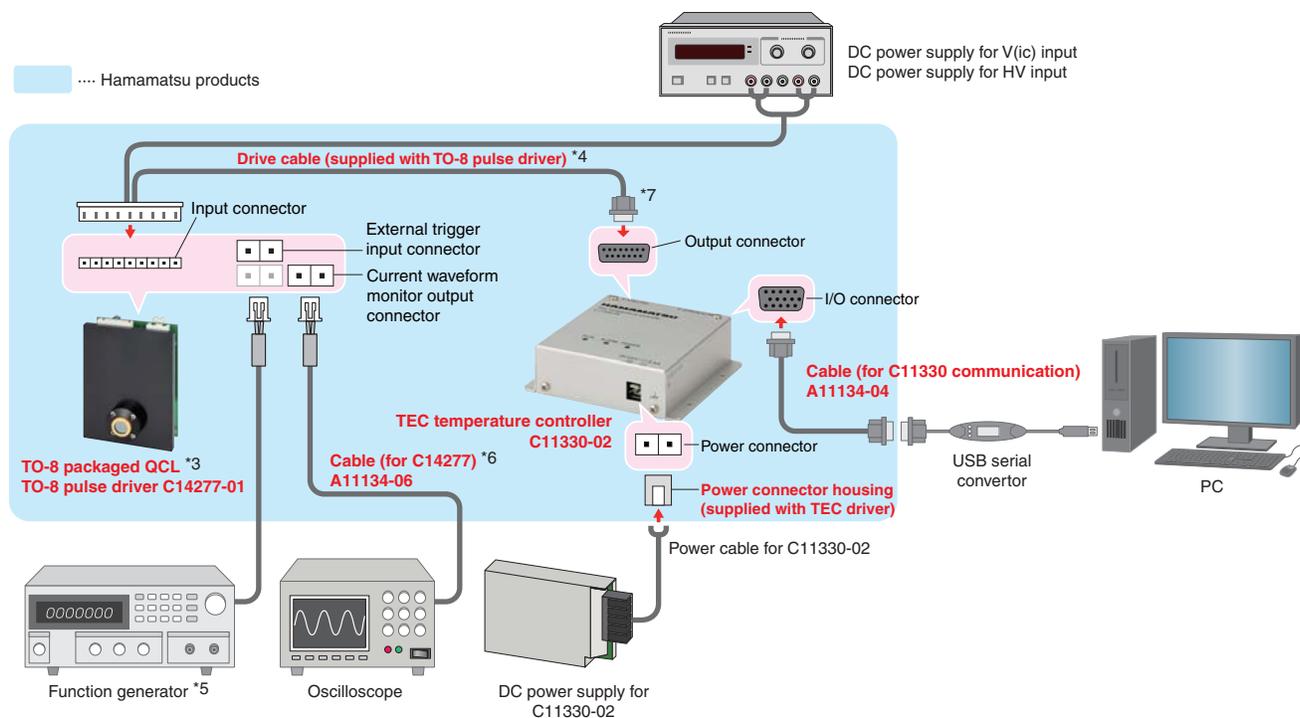
DFB-pulsed QCL (2)

- ① DFB-pulsed QCL (L12020 series)
- ② TEC temperature controller C11330-02
- ③ TO-8 pulsed driver C11635 and/or C14277 series
- ④ Aspheric ZnSe lens A11331-01 and/or lens unit A11331-01H *1
- ⑤ Cable A11134-04
- ⑥ Heatseeker A10767 *2

*1 Select suitable lens based on the emission wavelength of the QCL to use.

*2 Might not be used depending on the drive conditions.

Connection example of DFB-Pulsed QCL



*3 The photo shows the TO-8 package QCL and the aspherical ZnSe lens unit A11331-0xH installed.

*4 The drive cable should be properly terminated for connecting TEC temperature controller and power supply.

*5 This connection example is for C14277-01. Function generator is not required for C14277-02 operation.

*6 A couple of A11134-06 is needed each for C14277-01/02 operation.

*7 One end of the cable for TEC temperature controller is unterminated and so should be properly terminated by the user.

* Products shown in photos are Hamamatsu products. Product names and part numbers are written in red.

* Prepare additional devices and cables separately. Contact with Hamamatsu sales as for recommended items.

QCL LINEUP

Pulsed QCL module



Pulsed QCL module

The pulsed QCL module is a compact module containing a TO-8 can packaged pulsed DFB quantum cascade laser, pulse driver and TEC temperature controller. Uses DC 24 V input only.

The module can be easily put to use and controlled remotely via Ethernet connection.

Common specifications

Operating temperature (QCL) ^{*1}		Line width ^{*2}	Tunable range ^{*3}	Output power	Side-mode suppression ratio (SMSR)
Min.	Max.	Max.	Min.	Min.	Min.
-10 °C	+60 °C	1.0 cm ⁻¹	±1.0 cm ⁻¹	100 mW	25 dB
Condition: Emission wavenumber (cm ⁻¹) ^{*4}					

Standard driving conditions: $t_w=500$ ns, $f_r=100$ kHz, $T_{op(qcl)}=20$ °C

*1 This specifies the temperature range within which the target emission wavenumber (K) can be realized.

*2 Full-width half maximum

*3 This specifies the continuous tunable range (without mode hopping). The center wavenumber of the tuning range is the emission wavenumber (K).

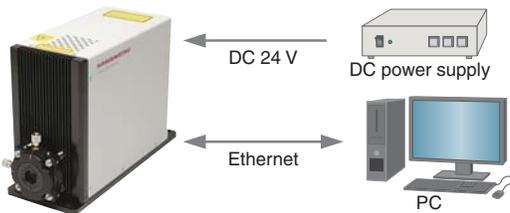
*4 Refer to the line-up table

Line-up

Type No.	Wavelength	Wavenumber	Target gas	Collimation lens	Beam spread angle	Beam waist width ^{*1}
					Typ.	Typ.
L14147-1278-01	7.82 μm	1278 cm ⁻¹	CH ₄ , N ₂ O	Not included	3 mrad	5 mm
L14147-1278-02				Included		

*1 1/e² beam radius

* Please make contact with the Hamamatsu sales office about QCLs with emission wavelengths not listed above.



CLASS 3R LASER

Invisible Laser Radiation: Avoid Direct Eye Exposure

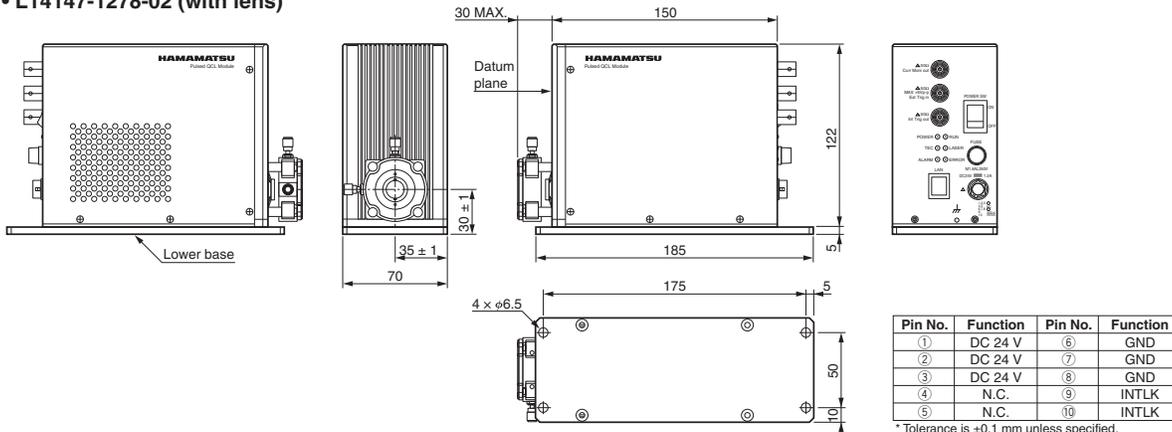
● The Laser emits invisible laser radiation. The instrument which used the LASER, operated under ordinary conditions, is classified as Class 3B according to the laser product classification code IEC 60825-1. See IEC 60825-1 for more details and safety operation concerning the above countermeasures.



CLASS 3R LASER PRODUCT
Warning label Explanatory label

Dimensional outline (unit: mm)

• L14147-1278-02 (with lens)



PERIPHERAL INSTRUMENTS AND ACCESSORIES

TEC temperature controller C11330 series



Peltier TEC (thermoelectric cooler) driver is used to control QCL temperature with high accuracy and high stability.
Designed to be built into an instrument.

HHL mount A11709 series



A11709-01 forced air cooling



A11709-02 water cooling

* Mounts shown in photos have HHL package QCL.

Cooling Unit for HHL packaged QCL. Two types of cooling, forced air and water, are available.
An aspheric ZnSe lens unit A11331-0xH can be mounted.

TO-8 pulse driver C14277 series



C14277-01 external trigger type



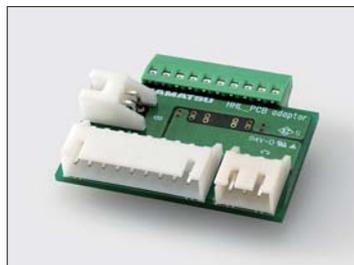
C14277-02 internal trigger type

This TO-8 pulsed driver is exclusive use for pulsed QCL (TO-8 can package). This product is designed to be built into equipment and does not work solely. Two type of external and internal trigger are available.

Cable / Cable adaptor



Cable A11134 series



Cable adaptor (for HHL) A11134-07

These are cables and cable adaptors for quantum cascade laser. Connect the HHL package to the peripherals or accessories to the peripherals.

■ Lens / Lens unit



●Aspheric ZnSe lens A11331-0x



●Aspheric ZnSe lens unit A11331-0xH

A11331-0xH can be mounted on HHL mount A11709 series and TO-8 pulse driver C14277.

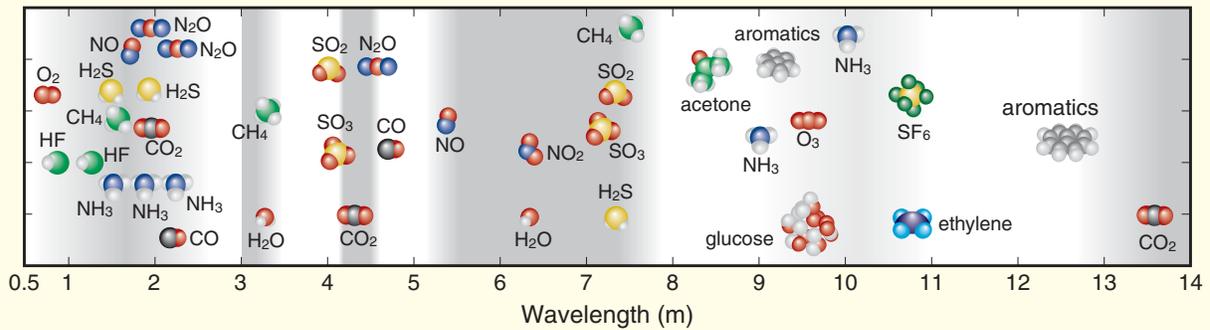
■ Heatseeker A10767



Heatseeker A10767 consists of 2 types of thermal viewing card and an alignment target. It can be used for visualization and alignment of the QCL laser beam.

Reference

Absorption Spectra of Gases



Wavelength	Gases	Suitable QCLs	
		DFB-CW type	DFB-pulsed type
4.3 μm	¹² CO ₂ / ¹³ CO ₂	L12004-2310H-C	—
4.5 μm	N ₂ O, CO, CO ₂	—	L12014-2231T-C
4.5 μm	N ₂ O, CO	L12004-2190H-C	—
4.5 μm	N ₂ O	L12004-2209H-C	—
5.2 μm	NO	L12005-1900H-C	L12015-1901T-C
6.1 μm	NO ₂	L12006-1631H-C	L12016-1630T-C
7.2 μm	SO ₃	L12007-1392H-C	—
7.4 μm	SO ₂	L12007-1354H-C	—
7.8 μm	¹² CH ₄ / ¹³ CH ₄	L12007-1294H-C	—
7.8 μm	CH ₄ , N ₂ O	—	L12017-1278T-C
9.0 μm	NH ₃	—	—
9.6 μm	O ₃	—	—
10 μm	NH ₃	—	L12020-0993T-C

* This table does not guarantee the detection of each gas.

Read carefully before using QCL

For safe and effective use, carefully read the documents that come with your QCL and accessories. Read all manuals and instructions thoroughly and also be aware of local laser rules and regulations.

Warning

This catalog is not a guarantee of product perfection. When the products are used in an instrument which may cause bodily harm or damage property, it is dangerous to operate the instrument unless proper safety measures are taken against possible product defects.

Caution

● Absolute maximum ratings

Absolute maximum ratings listed in the specification sheet and/or test sheet are limiting values that must not be exceeded even momentarily. Using this product under conditions where any one of the maximum ratings is exceeded may cause serious and irreparable damage to the products.

Values in absolute maximum ratings for forward current and forward voltage differ in each product, so always check the values listed in the test sheet that comes with each product and make sure that these values are not exceeded.

● Laser driver power supply

Current surges and current fluctuations may impair performance of the laser device. Do not apply reverse current and reverse voltage to the QCL.

● Heat dissipation

This product uses a Peltier element to control temperature of the laser device, so the Joule heat generated in this product must be dissipated. If operated with poor heat dissipation, the device temperature may soon exceed the absolute maximum rating for the operating case temperature listed in specification sheet. Make sure that a proper heatsink is installed on the product. Poor heat dissipation may lead to excessive heating during operation and cause device deterioration or open-circuit faults even if the Peltier current is within the maximum rating. Heat dissipation on the laser side may not be sufficient when supplying electrical current to the Peltier element in heating mode, and cause failures or affect reliability. Carefully check these points before actual operation.

HAMAMATSU PHOTONICS K.K. www.hamamatsu.com

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