Boston Electronics

HAMAMATSU

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Quantum Cascade Photodetector
P16309-01

■ Features

- Ultrafast MIR photodetector with over 20 GHz response
- Response frequency range (-3 dB): DC to 20 GHz
- Peak sensitive wavelength: 4.65 μm
- Photosensitivity: 1 mA/W (Typ.)
- No cooling, and no operation bias are required

■ Applications

- Heterodyne detection
- High frequency/high time resolved measurement

■ Outline

This is a ultrafast mid-infrared photodetector with a response bandwidth of 20 GHz (-3 dB). It operates bias free with no cooling required, so no external power supplies are needed. Setup happens in two simple steps: connecting the SMA fitting to measuring instruments (oscilloscope etc.), and directing light incidence to the internal focusing lens.

■ General ratings

Parameter	Description	Unit
Connector type	SMA	—
Cooling	Non-cooled	—
Lens	Focusing lens *1	—
Aperture	ϕ4.5	mm
Polarizing direction	Marked in the body *2	—

*1 Incident light have to be colimated.
*2 See "Figure 4"

■ Absolute maximum ratings

Parameter	Symbol	Value	Unit
Opearting temperature *1	T_{opr}	-10 to +50	°C
Storage temperature *1	T_{stg}	-10 to +50	°C
Incident light level	P_{max}	1	W/cm²

*1 No condensation
* No bias is required for the operation.
* Ambient temperature: T_a=25 °C

■ Electrical and optical characteristics

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Peak sensitive wavelength	λ_p	—	4.60	4.65	4.70	μm
Photosensitivity	S	$\lambda=\lambda_p$, f_0=800 Hz, Δf=1 Hz	0.5	1.0	—	mA/W
Detectivity	D*	$\lambda=\lambda_p$, f_0=800 Hz, Δf=1 Hz	8.0×10^8	1.5×10^9	—	$cm \cdot Hz^{1/2}/W$
Noise equivalent power	NEP	$\lambda=\lambda_p$, f_0=800 Hz	—	3.0×10^{-10}	1.0×10^{-9}	$W/Hz^{1/2}$
Cut-off frequency	f_c	-3 dB down, Zi=50 Ω	18	20	—	GHz
Terminal capacitance	C_t	f=1 MHz	—	1.1	1.5	pF
Shunt resistance	R_{sh}	V_{meas}=10 mV	70	90	110	kΩ

* Ambient temperature: T_a=25 °C

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Figure 1: Spectral response (example)

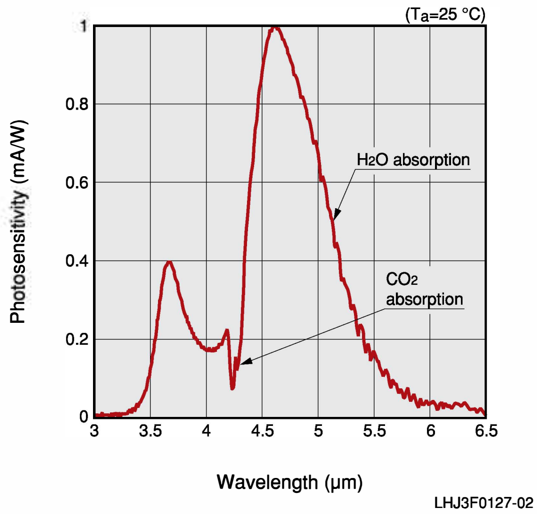


Figure 2: Response frequency (example)

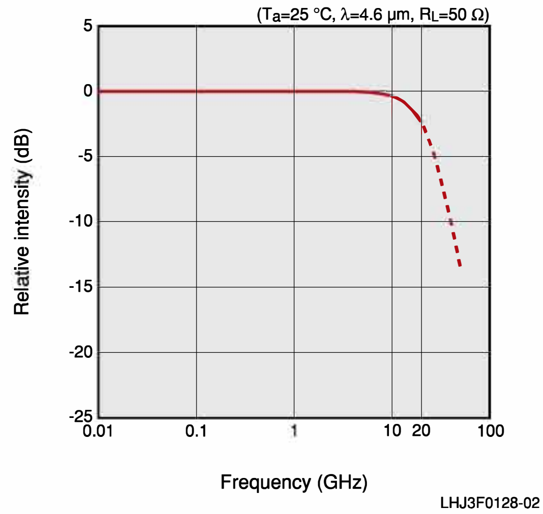
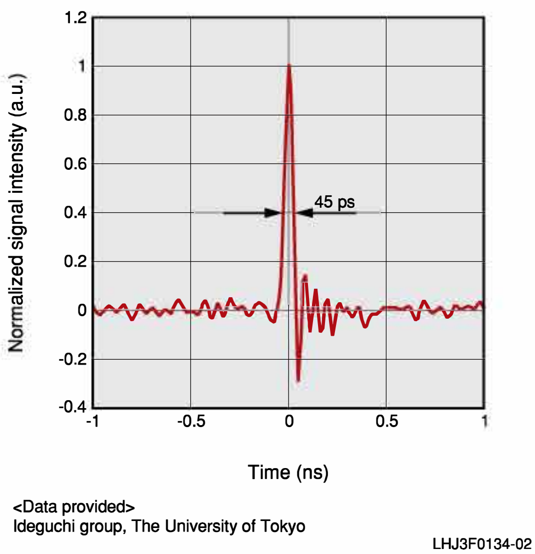
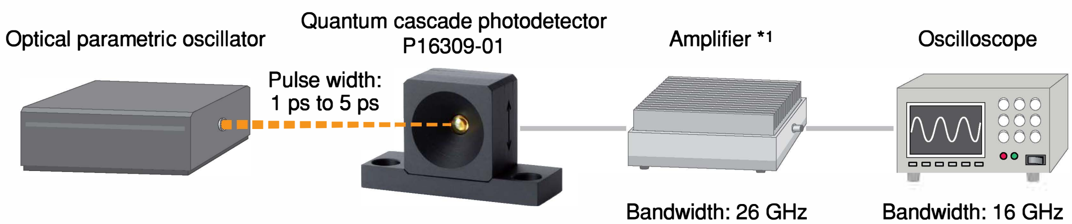


Figure 3: Ultrashort pulse waveform measurement

●**Measurement example**

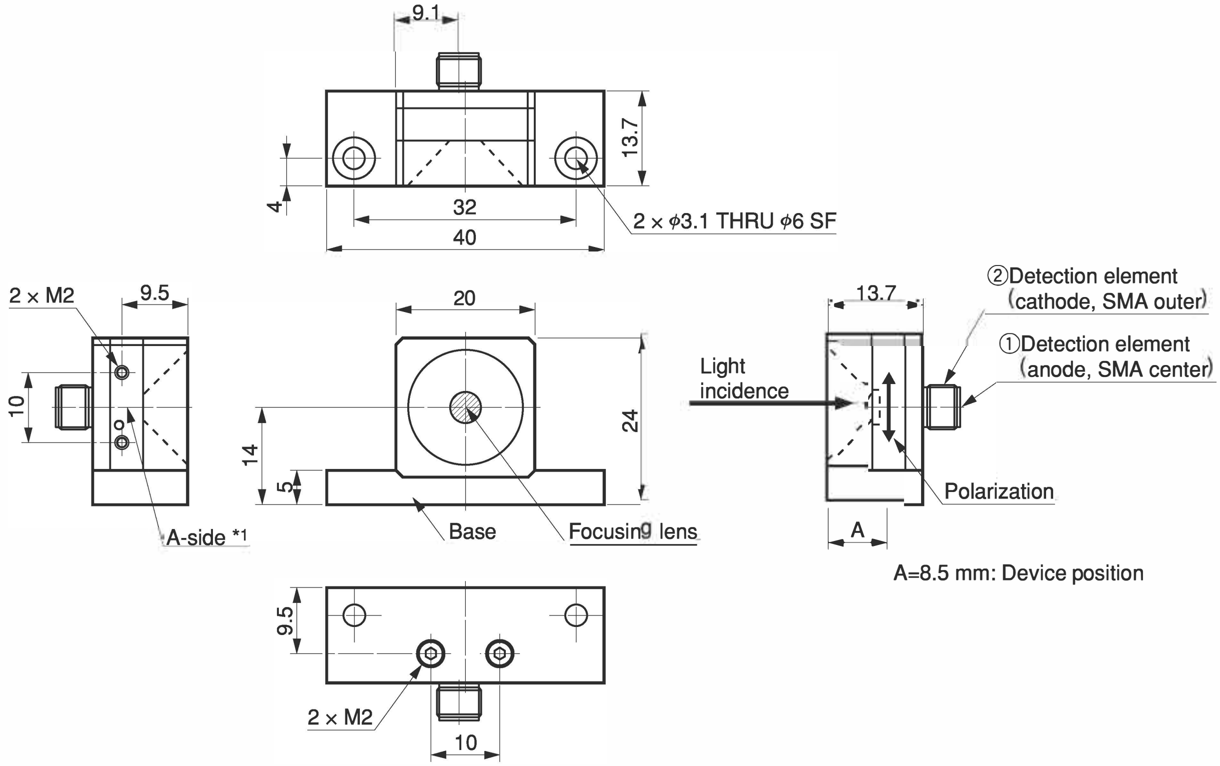


●**Measurement configuration**



*1 An example: Keysight technologies, 83006A

Figure 4: Dimensions (unit: mm)



*1 A-side can be fixed on the base as the bottom aspect.
* Tolerances: ±0.3 mm (dimension without an indication)
* Both of ① and ② are electrically insulated from the package.

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●Information described in this material current as of February 2022. Specifications are subject to change without notice.

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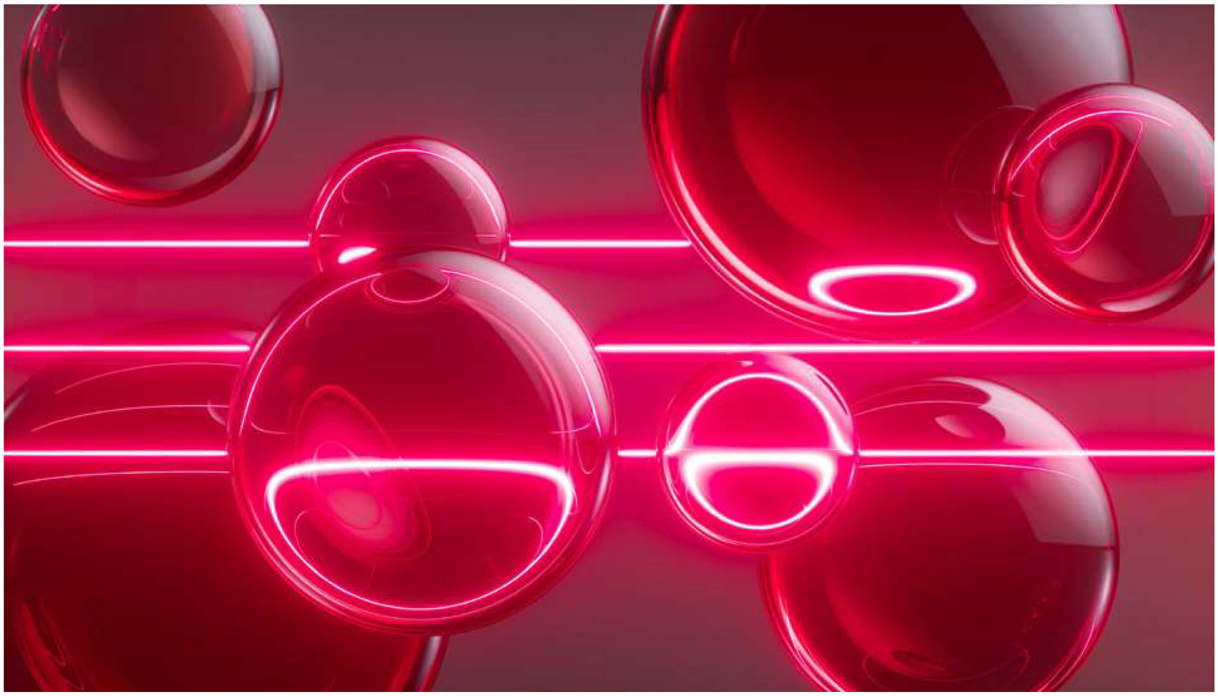
Advancing High Speed MIR Detection with Quantum Cascade Detectors

The mid-infrared (MIR) region of the electromagnetic spectrum stands out for its vast potential across numerous applications. It boasts rich rotovibrational spectra of various light molecules (small organic molecules, gases, etc.), making **MIR absorption spectroscopy** an invaluable tool for **label-free detection in diverse fields**. Additionally, MIR wavelengths exhibit low scattering by aerosols, rendering them highly promising for research in free-space communication. Notably, specific regions within the MIR spectrum (around 4 µm and 10 µm) offer low absorption by atmospheric gases, facilitating long-distance free-space communication.

The success of MIR applications is rooted in the availability of the required MIR photonic technologies. As such, quantum cascade detectors (QCDs) emerge as a key technology. These photovoltaic detectors are designed to operate over different spectral regions of the MIR. What sets them apart is their ability to **function at room temperature without a bias voltage**. Furthermore, they are characterized by their **low noise**, which compensates for their relatively lower photoresponse compared to alternative MIR detectors. This characteristic pushes their **specific detectivity above 1 x 10^9 cm·Hz1/2/W**. However, the most interesting feature of QCDs is their **exceptional speed**, theoretically exceeding 100 GHz and often exceeding 20 Ghz at a -3 dB threshold.

Hamamatsu Photonics is proud to have released **the world's first commercially available QCD**[1,2,3], marking a significant milestone in MIR technology.

Hamamatsu Photonics' quantum cascade photodetector (QCD) P16309-01.



Remarkably, this groundbreaking device is **one of the only commercial QCDs operating at room temperature without necessitating any cooling mechanism.** Its applications include high-speed detection of gases[4] and high-speed spectroscopy[5] in the MIR region. For example, QCDs can potentially play a critical role in enabling kinetic studies of chemical reactions, which often occur at sub-nanosecond time scales. This capability enables the development of new chemical processes, impacting various facets of life, from **improving energy yield to reducing emissions and promoting the adoption of eco-friendly chemicals.**

Moreover, the high speed of QCDs paves the way for realizing **free-space communication in the MIR region**. Their small size and hassle-free operation bring them closer to widespread adoption in large-scale applications such as communication. Beyond these applications, many more MIR applications stand to benefit from the impressive performance parameters and simplified packaging of QCDs.

References

[1] https://www.hamamatsu.com/jp/en/news/products-and-technologies/2021/20210928000000.html

[2] https://www.hamamatsu.com/jp/en/product/optical-sensors/infrared-detector/qcd/P16309-01.html

[3] https://doi.org/10.1063/5.0038147

[4] https://doi.org/10.3390/s21175706

[5] https://doi.org/10.1038/s42005-020-00420-3