RB-Series SiPM Sensors

Advance Information

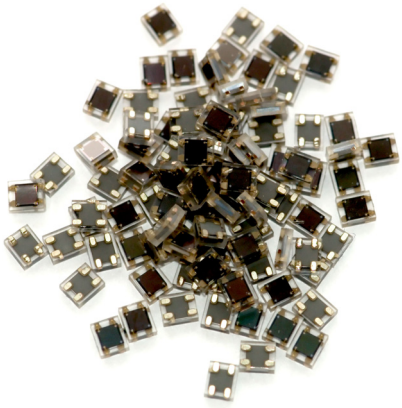
Silicon Photomultipliers (SiPM), Red-Enhanced Second Generation

ON Semiconductor®

www.onsemi.com

RB−Series sensors are the second release of Silicon Photo−multipliers (SiPM) from ON Semiconductor's R-Series range. These sensors provide further sensitivity improvements in the red and NIR region of the electromagnetic spectrum. All R-Series SiPM sensors feature high responsivity, fast signal response and a low temperature coefficient of operating voltage, all achieved at a low bias voltage. The sensor is packaged in a compact and robust MLP (molded lead frame) package that is suitable for reflow solder processes. Both the sensor and the package are designed for volume production with the product delivered on tape and reel.

SiPM sensors are an improvement over avalanche photodiodes (APD) and PIN diodes due to their high gain and single photon sensitivity. This enables the detection of low reflectivity targets at very long distance in LiDAR applications. Unlike the similarly-operated SPAD that can only detect single photons, the SiPM overcomes this limitation by incorporating a 'microcell' structure that allows for multi-photon detection with a high dynamic range. It is strongly recommended that those new to SiPM sensors consult the Introduction to Silicon Photomultipliers application note.



ORDERING INFORMATION

See detailed ordering and shipping information on page 10 of this data sheet.

Table 1. GENERAL PARAMETERS

Parameter (Note 1)	**Microcell Size**	**Minimum**	**Typical**	**Maximum**	**Unit**
Breakdown Voltage (Vbr) (Notes 2, 3, 4)	10 μm		27		V
	20 μm		23		
	35 μm		25		
Overvoltage (Vov) (Notes 2, 4)	10 μm		20	20	V
	20 μm		10	15	
	35 μm		7	10	
Spectral Range (Note 5)		300		1050	nm

1. All measurements made at 21°C unless otherwise stated.
2. Operating bias (Vbias) = Vbr + Vov
3. The breakdown voltage (Vbr) is defined as the value of the voltage intercept of a straight line fit to a plot of √I vs V, where I is the current and V is the bias voltage.
4. Specific Vbr and Vov information for a given lot is available in the lot release note. The lot number is given on the product packaging.
5. Range at which the maximum PDE is > 1%.

Table 2. PHYSICAL PARAMETERS

Parameter	**10010**	**10020**	**10035**
Active Area	1 mm × 1 mm		
Microcell Size	10 μm × 10 μm	20 μm × 20 μm	35 μm × 35 μm
Number of Microcells	4296	1590	620
Microcell Fill Factor	43%	63%	76%

This document contains information on a new product. Specifications and information herein are subject to change without notice.

Table 3. PERFORMANCE PARAMETERS

Parameter (Note 6)	**10010**	**10020**	**10035**	**Unit**
PDE @ 905 nm @ Maximum Overvoltage (Notes 7, 8)	4.0	7.3	10.3	%
PDE @ 905 nm @ Typical Overvoltage (Notes 6, 7)	4.0	5.6	9.1	%
Responsivity @ 905 nm @ Maximum Overvoltage (Note 8)	52	270	420	kA/W
Responsivity @ 905 nm @ Typical Overvoltage (Note 6)	52	61	240	kA/W
Gain − Cathode-anode Output (Note 6)	0.7×10^6	0.9×10^6	1.7×10^6	
Dark Count Rate (Notes 6, 9)	2.5	2.7	2.6	MHz
Dark Current (Note 6)	0.52	0.54	1.5	μA
Rise Time − Standard Output (Notes 6, 10)	1.5	1.0	0.9	ns
Microcell Recharge Time Constant (Notes 6, 10, 11)	12	21	73	ns
Rise Time − Fast Output (Notes 6, 10)	490	490	490	ps
Fast Output Pulse Width (FWHM) (Notes 6, 10)	2.3	2.0	3.7	ns
Crosstalk (Note 6, 12)	30	22	43	%
Afterpulsing (Note 6)	13	6	1	%
Excess Noise Factor (Note 6)	1.34	1.19	1.22	
Temperature Coefficient of Vbr		See page 5		

6. All measurements made at 21°C and 'Typical' overvoltage (see page 1) unless otherwise specified.
7. PDE (Photon Detection Efficiency) is the product of the QE * AIP * FF, where QE is quantum efficiency, AIP is the avalanche initiation probability and FF is the fill factor of the microcells.
8. Measured at maximum overvoltage.
9. Each thermally generated 'noise' carrier in the active volume of the sensor will generate a signal equal to that of a single photon. The rate of these spurious counts is referred to as the dark count rate.
10. All timing measurements acquired using a ON Semiconductor SMA board, see page 6.
11. RC charging time constant of the microcell (τ).
12. A lower overvoltage can be used to achieve lower crosstalk.

Table 4. PACKAGE PARAMETERS

Parameter	**10010**	**10020**	**10035**
Package Dimensions	1.5 mm × 1.8 mm		
Soldering Conditions	Lead-free, reflow soldering process compatible. See the SMT Handling application note for more details		
Encapsulant Type	Clear transfer molding compound		
Encapsulant Refractive Index	1.57 @ 589 nm		
Moisture Sensitivity Level (MSL)	MSL 3 for tape & reel (TR) MSL 4 for tape only (TR1)		

Table 5. ABSOLUTE MAXIMUM RATINGS

Rating	**10010**	**10020**	**10035**
Maximum Average Current	3 mA		
Recommended Operating Temperature Range	−40°C to +85°C		
Maximum Storage Temperature	105°C		

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

PERFORMANCE PLOTS

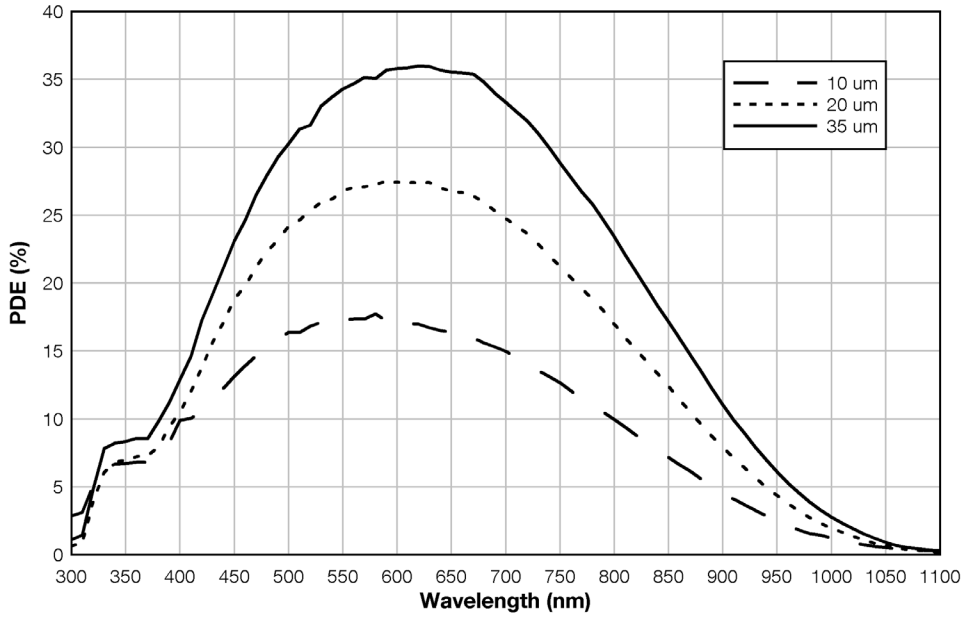


Figure 1. PDE vs. Wavelength
(MICRORB−10010, MICRORB−10020, MICRORB−10035 @ Maximum Overvoltage)

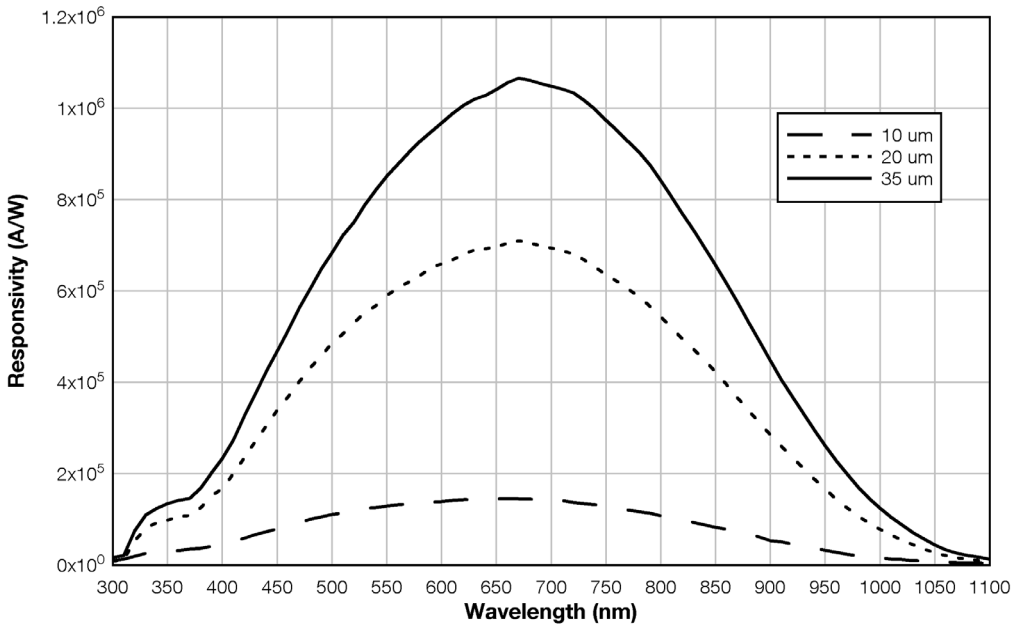


Figure 2. Responsivity vs. Wavelength
(MICRORB−10010, MICRORB−10020, MICRORB−10035 @ Maximum Overvoltage)

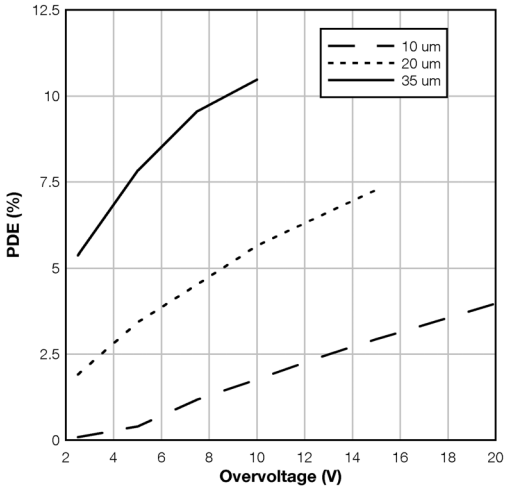


Figure 3. PDE vs. Overvoltage
(MICRORB−10010, MICRORB−10020, MICRORB−10035 @ 905 nm)

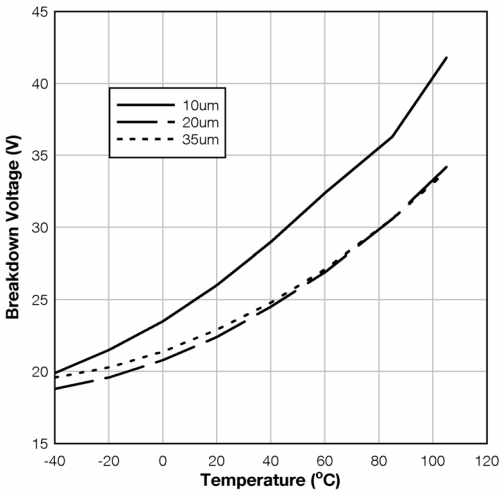


Figure 5. Breakdown Voltage vs. Temperature
(MICRORB−10010, MICRORB−10020, MICRORB−10035)

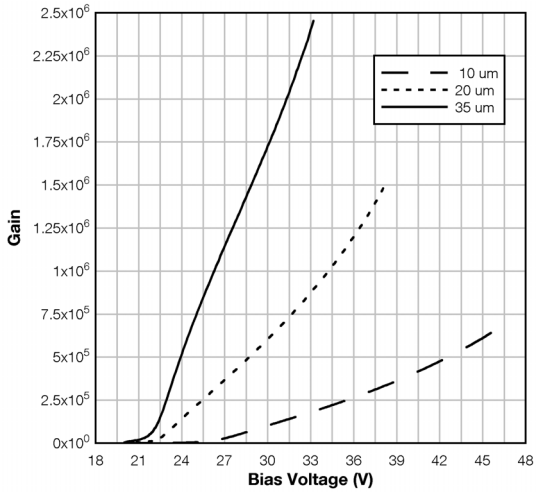


Figure 4. Gain vs. Bias Voltage
(MICRORB−10010, MICRORB−10020, MICRORB−10035)

Temperature Coefficient of Breakdown Voltage

The RB-Series breakdown voltage has a non-linear relationship with temperature. The plots below show typical behavior for each microcell size. Please contact ON Semiconductor Sales for more infromation.

Pulse Shape

The measurement of the pulse shapes below were acquired using a ON Semiconductor SMA board (see page 6) with a 50 ps pulse from a 420 nm laser. The laser is set to a level that illuminates 10−15% of the microcells to ensure that the SiPM is in the linear range of operation.

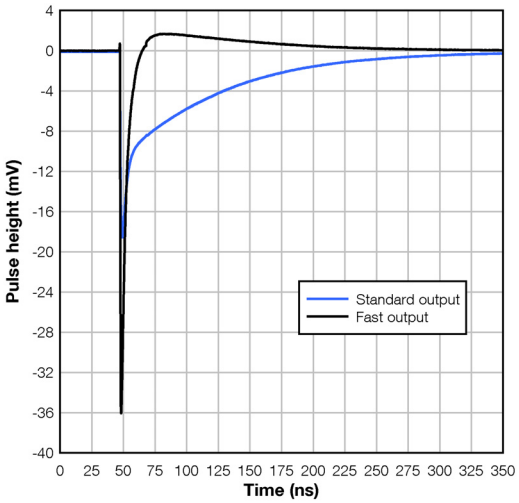


Figure 6. Pulse Shape
(MICRORB−10035)

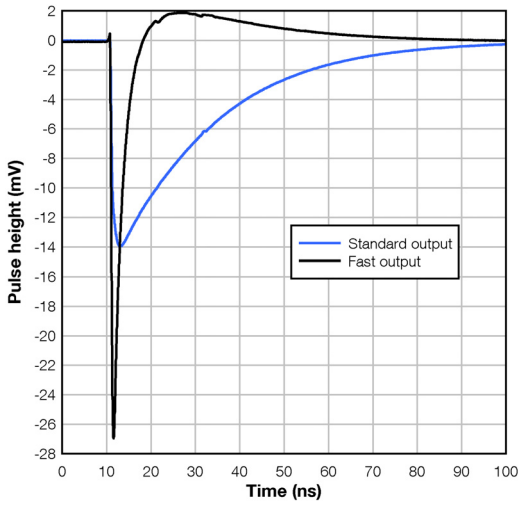


Figure 7. Pulse Shape
(MICRORB−10020)

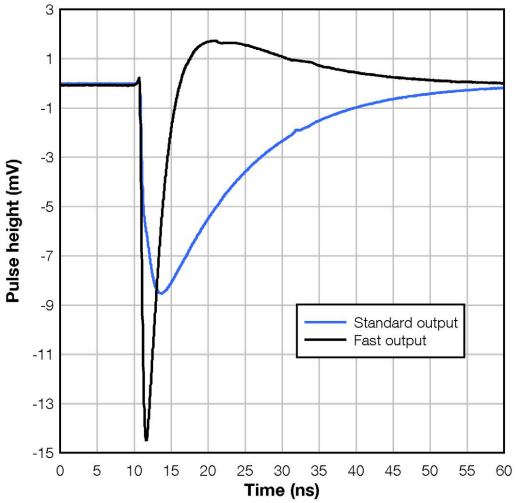
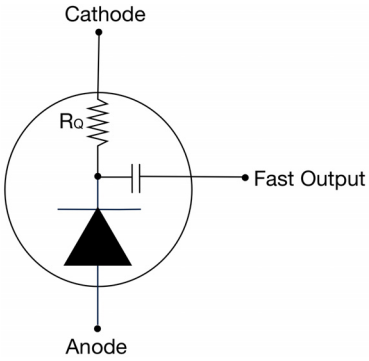


Figure 8. Pulse Shape
(MICRORB−10010)

NOTE: MICRORB sensors use an N-on-P diode and therefore have a different fast pulse polarity compared to ON Semiconductor P-on-N sensors i.e. C-Series, although the pin-out is the same.

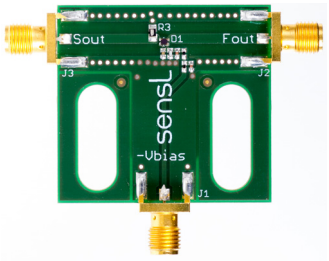


EVALUATION BOARDS

SMA BIASING BOARD (MICRORB−SMA−100XX)

The MICRORB−SMA is a printed circuit board (PCB) that can facilitate the evaluation of the MICRORB MLP sensors. The board has three female SMA connectors for connecting the bias voltage, the standard output from the cathode and the fast output signal. The output signals can be connected directly to a 50 Ω-terminated oscilloscope for viewing. The biasing and output signal tracks are laid out in such a way as to preserve the fast timing characteristics of the sensor.

The MICRORB−SMA is recommended for users who require a plug-and-play set-up to quickly evaluate MICRORB sensors with optimum timing performance. The board also allows the signal from the cathode-anode readout to be observed at the same time as the fast output. The outputs can be connected directly to the oscilloscope or measurement device, but external preamplification may be required to boost the signal. The table below lists the SMA board connections. The SMA board electrical schematics are available to download in the Board Reference Design document.



MICRORB−SMA−100XX	
Output	**Function**
Vbias	Negative bias input (anode)
Fout	Fast output
Sout	Standard output (cathode)

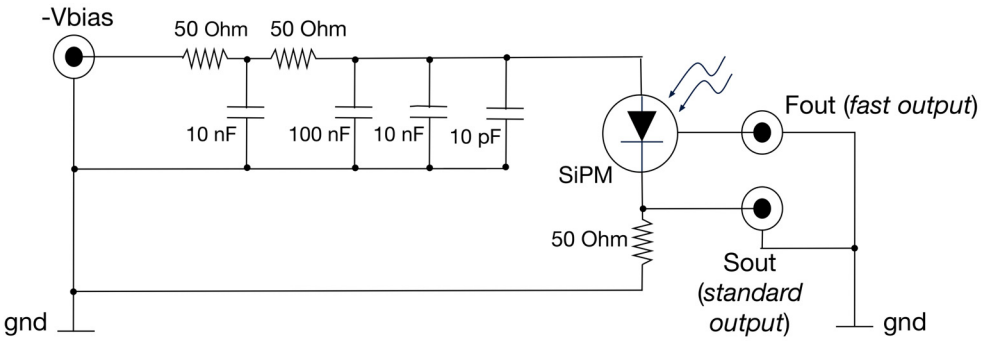


Figure 9. SMA Board Circuit Schematic

PIN ADAPTER BOARD (MICRORB−SMTPA−100XX)

The Pin Adapter board (SMTPA) is a small PCB board that houses the SIPM sensor and has through-hole pins to allow its use with standard sockets or probe clips. This product is useful for those needing a quick way to evaluate the MLP-packaged sensor without the need for specialist surface-mount soldering. While this is a ‘quick fix’ suitable for many evaluations, it should be noted that the timing performance from this board will not be optimized and if the best possible timing performance is required, the MICRORB−SMA−100XX is recommended. The SMTPA circuit schematic is shown below. Please consult the Biasing and Readout Application Note for further information on biasing. The SMTPA board electrical schematics are available to download in the Board Reference Design document.

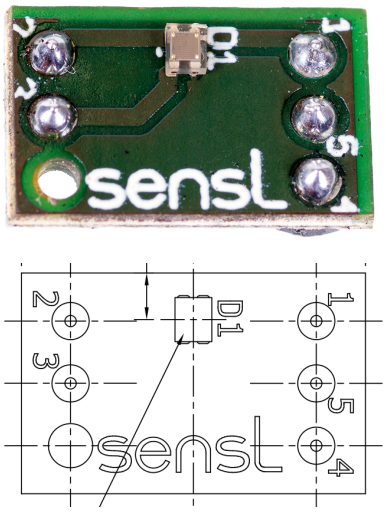


Figure 10. Top View of the SMTPA Board Showing the Pin Numbering

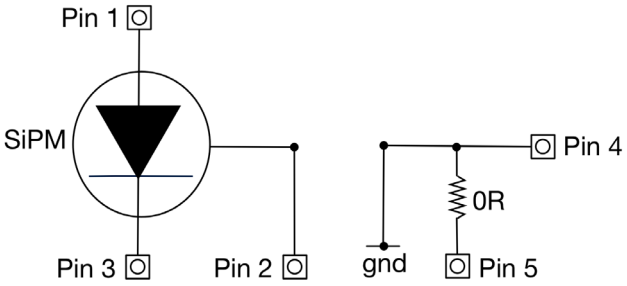


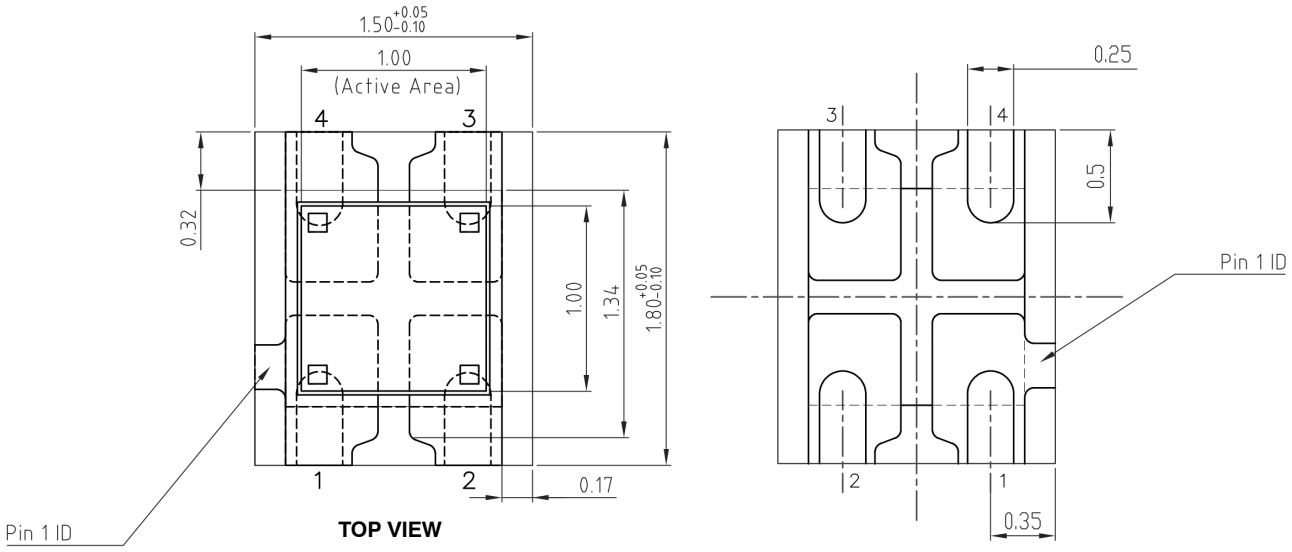
Figure 11. SMTPA Board Circuit Schematic

MICRORB−SMTPA−100XX	
Pin No.	**Connection**
1	Anode
2	Fast output
3	Cathode
4	Ground
5	Ground

PACKAGE DIMENSIONS

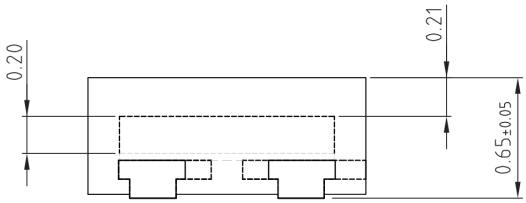
(All Dimensions in mm)

MICRORB−100XX−MLP



TOP VIEW

BOTTOM VIEW



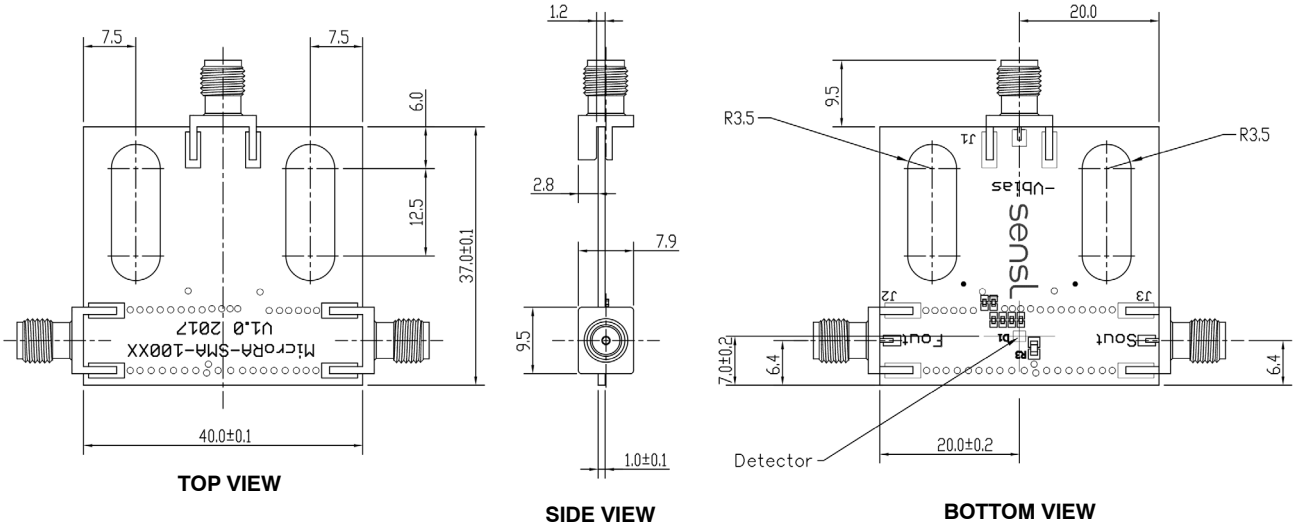
SIDE VIEW

Pin Number	Assignment
1	Anode
2	Fast output
3	Cathode
4	No Connect*

*The ‘No Connect’ pins are electrically isolated and should be soldered to a ground (or bias) plane to help with heat dissipation.

The CAD file for the MICRORB−100XX−MLP package and tape and reel, and the solder footprint is available to download here.

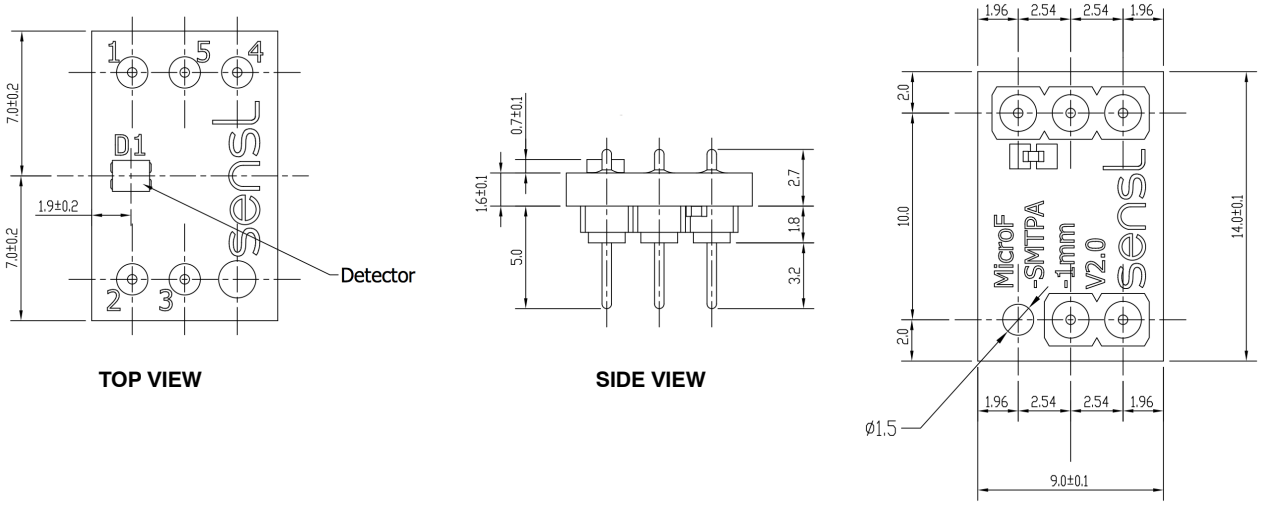
MICRORB−SMA−100XX



TOP VIEW **SIDE VIEW** **BOTTOM VIEW**

The complete MICRORB−SMA−100XX CAD file is available to download here.

MICRORB−SMTPA−100XX



TOP VIEW **SIDE VIEW** **BOTTOM VIEW**

The complete MICRORB−SMTPA−100XX CAD file is available to download here.

USEFUL LINKS

- Introduction to Silicon Photomultipliers Application Note − If you are new to SiPM, this document explains their operation and main performance parameters.
- Biasing and Readout Application Note − This document gives detailed information on how to bias the sensor for both standard and fast configurations, and amplifying and reading out the signal.
- How to Evaluate and Compare Silicon Photomultipliers Application Note − Information on what to consider when selecting an SiPM.
- Handling and Soldering Guide − This document gives information on safe handling of the sensors and soldering to PCB.
- ON Semiconductor Website − for more information on all of ON Semiconductor's products as well as application information.
- CAD file library − ON Semiconductor CAD files.

ORDERING INFORMATION

Table 6. ORDERING INFORMATION

Product Code	Microcell Size	Sensor Active Area	Package Description	Delivery Option (Note 13)
MICRORB−10010−MLP	10 μm	1 × 1 mm^2	4-side tileable, surface mount, molded leadframe package (MLP)	TR1, TR
MICRORB−SMA−10010−GEVB			MLP sensor mounted onto a PCB with SMA connectors for bias and output.	PK
MICRORB−SMTPA−10010−GEVB			MLP packaged sensor mounted onto a pin adapter board.	PK
MICRORB−10020−MLP	20 μm		4-side tileable, surface mount, molded leadframe package (MLP)	TR1, TR
MICRORB−SMA−10020−GEVB			MLP sensor mounted onto a PCB with SMA connectors for bias and output.	PK
MICRORB−SMTPA−10020−GEVB			MLP packaged sensor mounted onto a pin adapter board.	PK
MICRORB−10035−MLP	35 μm		4-side tileable, surface mount, molded leadframe package (MLP)	TR1, TR
MICRORB−SMA−10035−GEVB			MLP sensor mounted onto a PCB with SMA connectors for bias and output.	PK
MICRORB−SMTPA−10035−GEVB			MLP packaged sensor mounted onto a pin adapter board.	PK

13. The two-letter delivery option code should be appended to the order number, e.g.) to receive a MICRORB−10035−MLP on cut tape, use MICRORB−10035−MLP−TA. The codes are as follows:
    PK = ESD Package
    TR1 = Tape
    TR = Tape and Reel

    There is a minimum order quantity (MOQ) of 3000 for the tape and reel (TR) option. Quantities less than this are available on tape (−TR1). The TR option is only available in multiples of the MOQ.

For information on the availability of automotive qualified versions of these parts, please contact sales@onsemi.com

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PUBLICATION ORDERING INFORMATION

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Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative

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