High Gain, Low Noise Silicon Photomultiplier (SC-6-Si-S3-S)

Egismos' low-light sensors feature an industry-leading low dark-count rate, combined with high photon detection efficiency (PDE) that extends much further into the blue part of the spectrum using a high-volume, P-on-N silicon process. For ultrafast timing applications select Egismos sensors have a fast output. These fast signals can have rising time of 300ps and pulse width of 600ps. The sensor is available in 3mm sensor size and packaged in a 4-side tileable surface mount (SMT) package that is compatible with industry standard, lead-free, reflow soldering processes.

The Silicon Photomultipliers (SiPM) form a range of high gain, single-photon sensitive, UV to visible light sensors. They have performance characteristics similar to a conventional
PMT, while benefiting from the practical advantages of solid-state technology: low operating voltage, excellent temperature stability, robustness, compactness, output uniformity, and low cost.

PERFORMANCE PARAMETERS

Sensor Size	Microcell Size	Parameter[1]	Overvoltage	Min.	Typ.	Max.	Units
3mm	35µm	Breakdown Voltage (Vbr)[3]		24.2		24.7	V
		Recommended overvoltage Range (Voltage above Vbr)[2]		1.0		5.0	V
		Spectral Range		300		800	nm
		Peak Wavelength (λp)			420		nm
		Current level				15	mA

[1] *All measurements made at 2.5V overvoltage and 21°C unless otherwise stated.*

[2] *Please consult the maximum current levels when selecting the overvoltage to apply.*

[3] *The breakdown voltage (Vbr) is defined as the value of the voltage intercept of a parabolic line fit to the current vs. voltage characteristic curve.*

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Sensor Size	Microcell Size	Parameter	Overvoltage	Min.	Typ.	Max.	Units
3mm	35µm	PDE [4] at λp	Vbr + 2.5V		31		%
			Vbr + 5.0V		41		%
		Gain (anode to cathode readout)	Vbr + 2.5V		$3x10^6$		
		Gain (fast terminal readout)	Vbr + 2.5V		$4.3x10^4$		
		Dark Current [5]	Vbr + 2.5V		154	443	nA

[4] *Note this is true "sensor PDE" which does not contain afterpulsing or crosstalk.*

[5] *Dark current derived from dark count data as DC*M*q*(1+CT)*(1+AP), where DC is dark count, M is gain, q is the charge of an electron, CT is cross talk and AP is afterpulsing.*

Sensor Size	Microcell Size	Parameter	Overvoltage	Min.	Typ.	Max.	Units
3mm	35µm	Dark Count Rate	Vbr + 2.5V		300	860	kHz
		Rise Time - Fast Output [6]			0.6		ns
		Signal Pulse Width - Fast Output (FWHM)			1.5		ns
		Microcell recovery time [7]			180		ns
		Capacitance [8] (anode-cathode)	Vbr + 2.5V		850		pF
		Capacitance [8] (fast terminal to cathode)	Vbr + 2.5V		12		pF

[6] *Measured as time to go from 10% to 90% of the peak amplitude.*

[7] *Time for microcell to recharge (90% to 10% of pulse peak amplitude).*

[8] *Internal capacitance of the sensor. Typically add 2-3pF for sensor in package. Listed by unique microcell size for each part version*

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Sensor Size	Microcell Size	Parameter	Overvoltage	Min.	Typ.	Max.	Units
3mm	35µm	Temperature dependence of Vbr [9]			21.5		mV/°C
		Temperature dependence of Gain [10]			-0.8		%/°C
		Crosstalk	Vbr + 2.5V		7		%
		After pulsing	Vbr + 2.5V		0.2		%

[9] Calculated as the change in Vbr extracted from pulsed laser gain measurements.

[10] Quoted as the percentage change per degree C from the measured value at 21°C.

GENERAL PARAMETERS

GENERAL PARAMETERS	
Active area	3 x 3 mm^2
No. of microcells	4774
Microcell fill factor	64%

SMT Package Specifics	
Package dimensions	4 x 4 mm^2
Recommended operating temperature range	-40°C to +85°C
Recommended storage temperature range	-40°C to +85°C
Soldering conditions	Lead-free, reflow soldering process compatible
Encapsulant type	Clear transfer molding compound
Encapsulant refractive Index	1.54 @ 589nm

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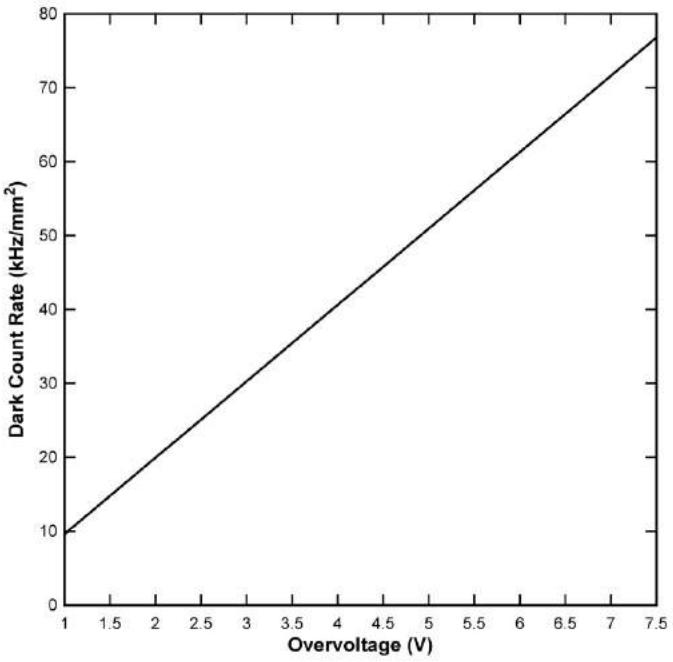
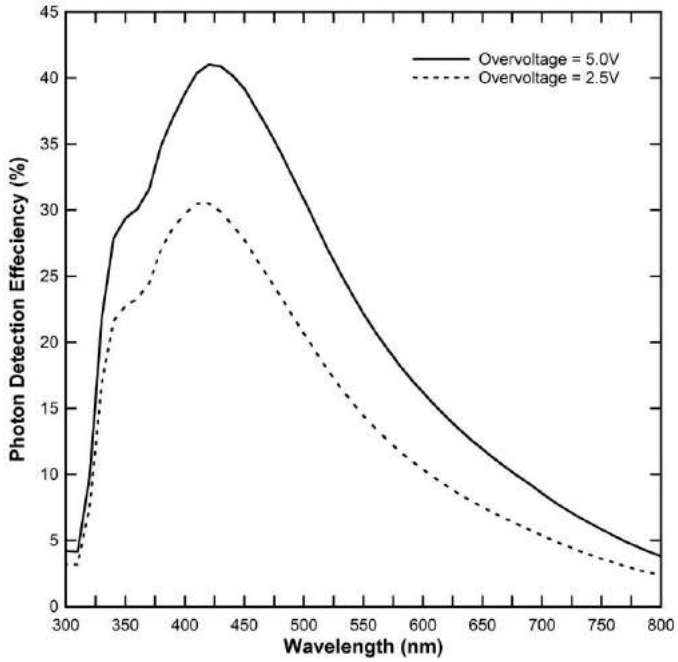
PERFORMANCE

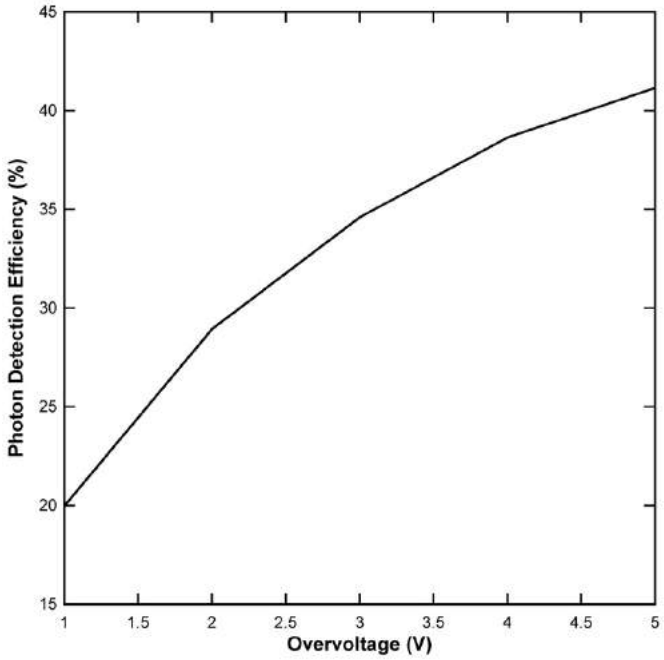
Dark Count Rate versus Overvoltage



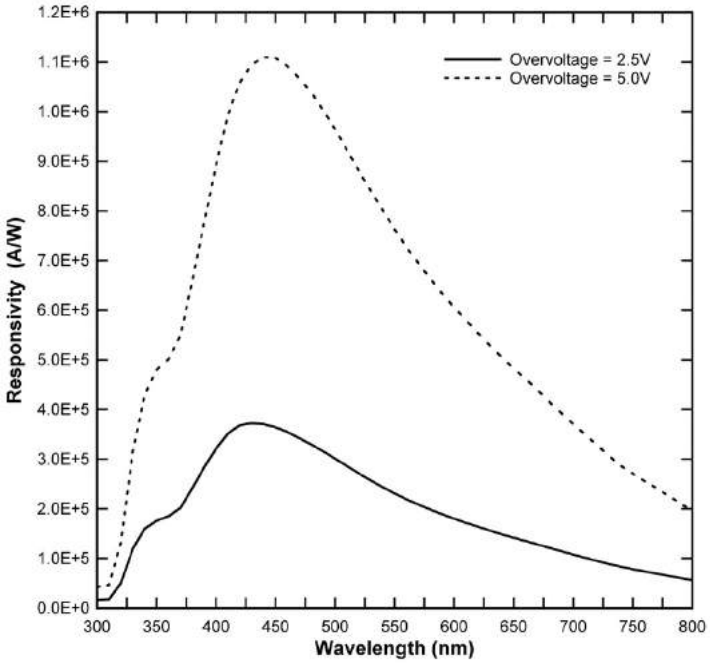
PDE versus Wavelength



PDE at 420nm versus Voltage

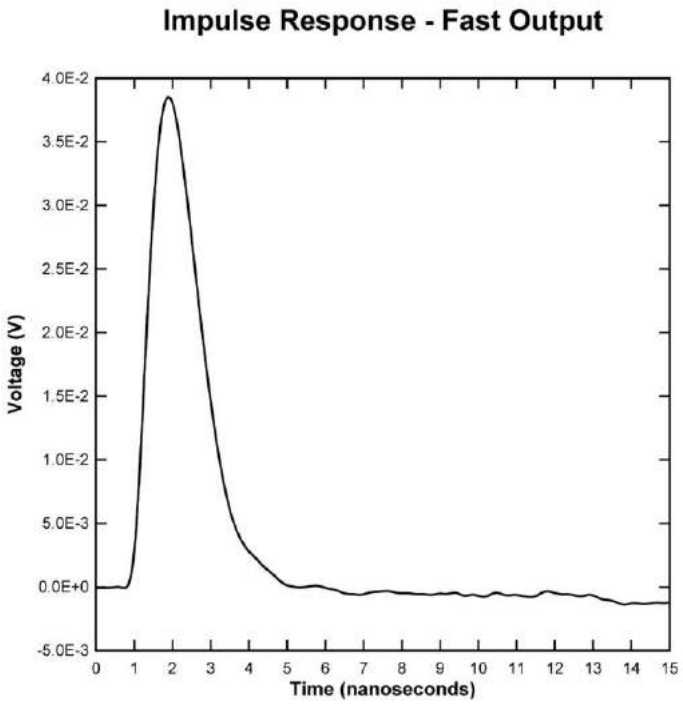


Responsivity versus Wavelength



FAST OUTPUT SIGNALS

The oscilloscope graph below shows an example of measured waveform from the fast output of 3mm sensor mounted on the Egismos SMA product board; the SMA product board measurement is obtained using a 2.5GHz bandwidth oscilloscope and 45ps pulses from a 405nm laser at 100KHz. No amplifier was used, and the output of the SMA product board was directly connected to the oscilloscope using a 1m long, 50Ω coaxial cable.



EVALUATION BOARD OPTION (SC-6-Si-S3-E)

SMA CONNECTER BIASING BOARD

The SubMiniature version A (SMA) biasing board is a simple board designed to allow evaluation of the range of SiPM sensor. The board has three female SMA connectors for connecting the bias voltage, standard output from the anode and the fast output signal. The biasing and output line is laid out in such a way as to preserve the fast timing characteristics of the sensor.

The SMA biasing board is recommended for users who require a plug-and-play set-up to quickly evaluate SMT sensors with optimum timing performance. The board also allows the standard output from the anode to be observed at the same time as the fast output. The outputs can be connected directly to the oscilloscope or measurement device. The table below lists the SMA board connections.

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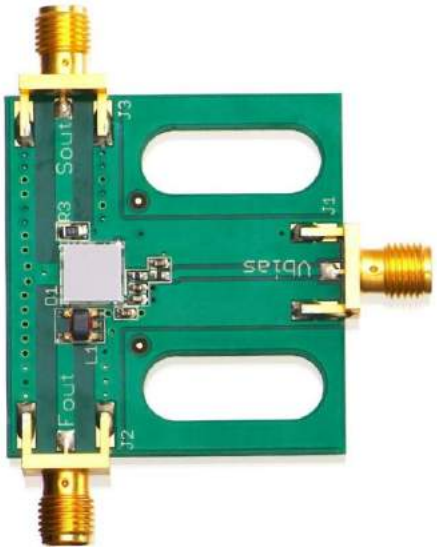
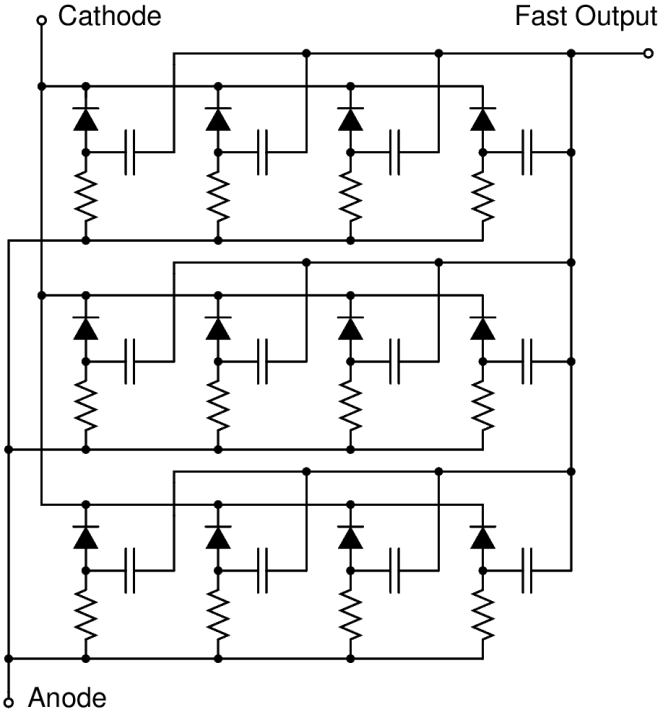
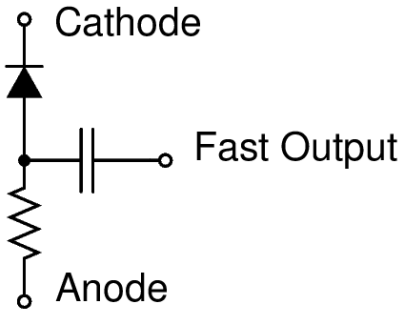
Output	Function
Vbias	positive bias input (cathode)
Fout	fast output
Sout	standard output (anode)



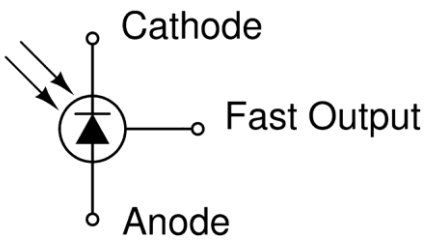
CIRCUIT SCHEMATICS



Simplified circuit schematic of the Egismos SiPM showing only a 12 microcell example.



Circuit schematic of the Egismos SiPM microcell, showing details of the Fast Output.



Egismos SiPM component symbol.

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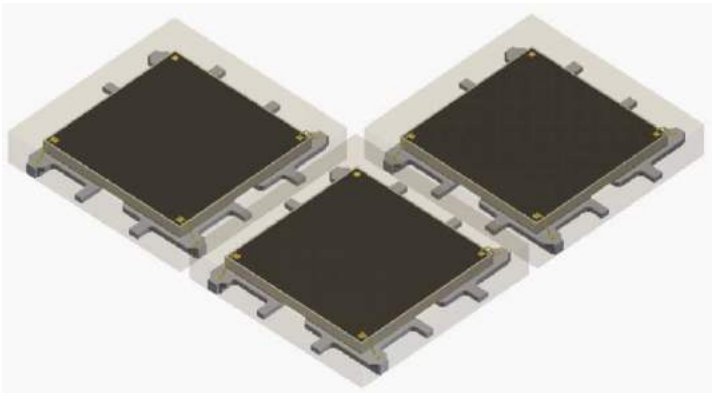
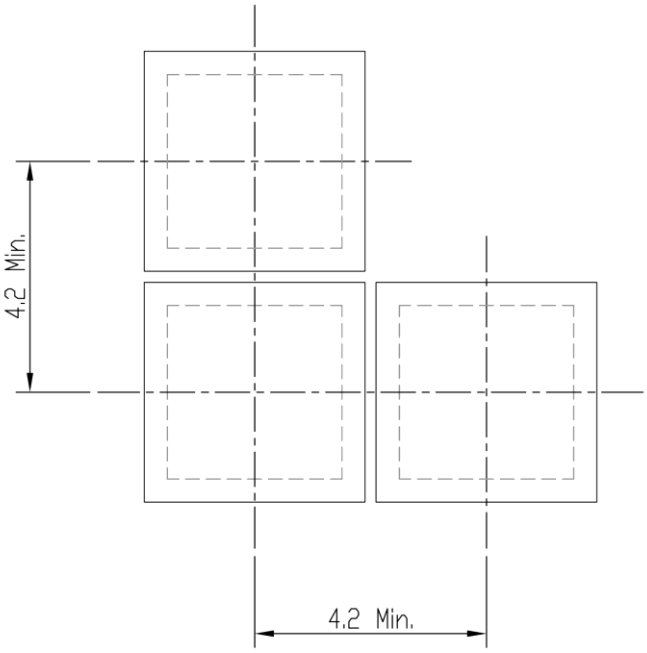
TILING OF THE SMT PACKAGE

Egismos has developed a market-leading, custom SMT package for the SiPM sensor. It is a compact, leadless, chip-scale package that is compatible with lead-free, reflow soldering processes. A clear encapsulant is used for optimal coupling to scintillators or fiber optic elements.

The dead-space between the sensor chip and the edge of the package has been minimized resulting in a package that can be tiled on 4 sides. This allows multiple devices to be configured into unique layouts for a wide range of custom applications. Two-dimensional tiling examples are illustrated for the 3mm package. The distance between active areas is typically 1.2mm when tiled, but actual alignment and placement tolerances will depend on the accuracy of the user's assembly process.



3mm SMTtiling.



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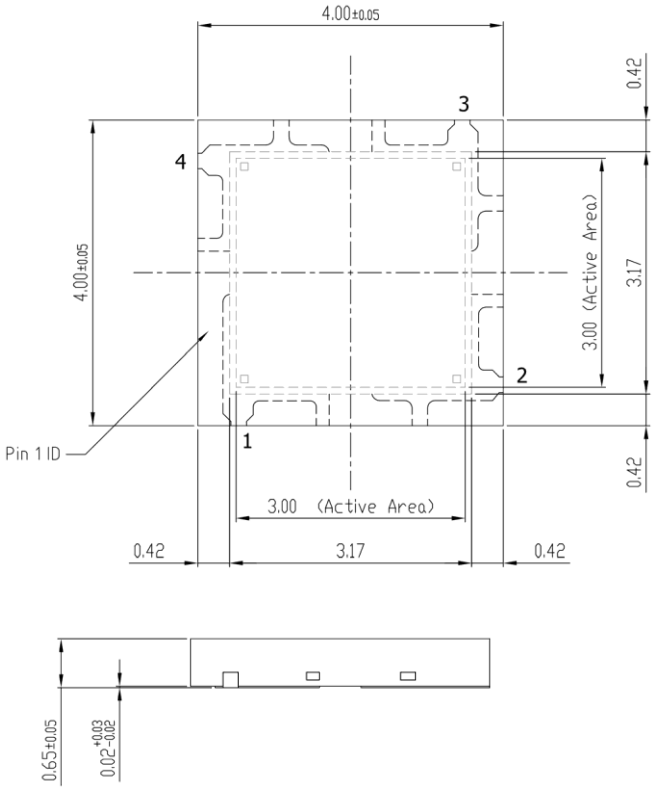
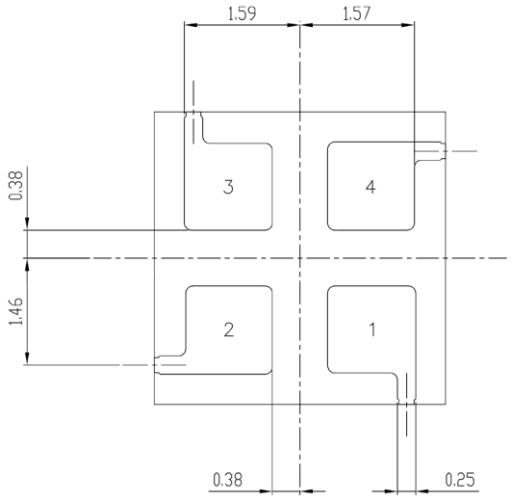
SCHEMATICS (All Dimensions in mm)

SMT Package





Pin Assignments	
Pin #	Function
1	Anode
2	Fast Output
3	Cathode
4	No Connect

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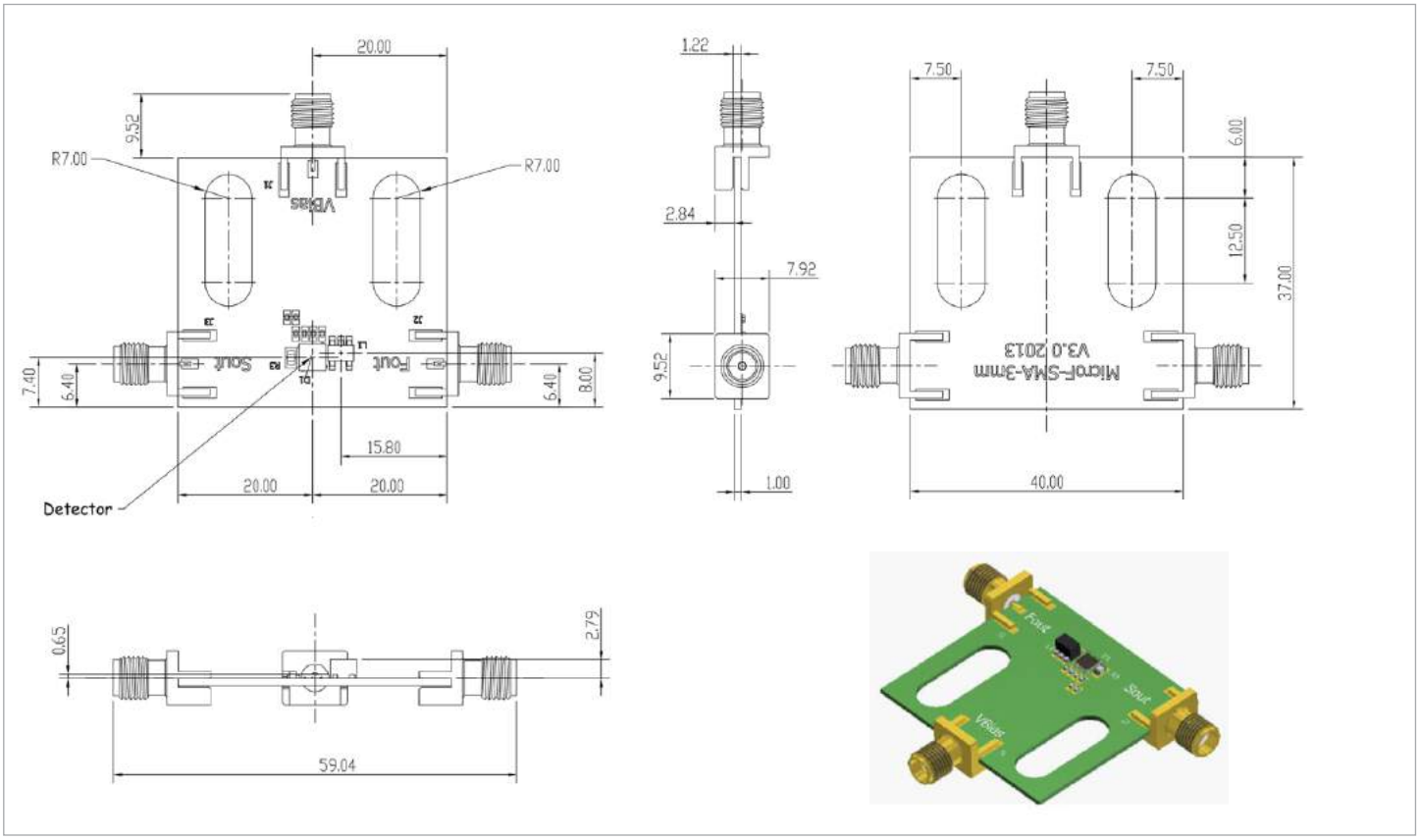
SMA Board



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