High Sensitivity Transimpedance Amplifier with Precision Photo Current Monitor for 10Gb/s Optical Receiver

MG2952 is a 10Gb/s high sensitivity transimpedance amplifier (TIA) with wide input dynamic range. With an appropriate PIN/APD detector, its optical sensitivity can be as high as -21/-28dBm and its overload tolerance can be greater than $2mA_{pp}$. A novel gain control (AGC) circuit is implemented to achieve wide dynamic range and excellent transimpedance linearity over frequency. A precision average current monitor is provided for receiving power reporting in both IMON sourcing and sinking applications through bonding option.

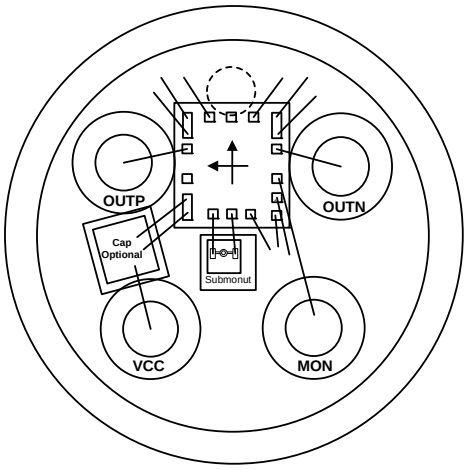
Features

- Bandwidth: >10GHz
- Sensitivity: -21/-28dBm (PIN/APD)
- Input current overload : $2mA_{pp}$
- Typical differential trans-impedance: 6kΩ
- Small signal lower cut-off frequency: <0.5kHz
- Selectable precision I-source or I-sink monitor
- Single +3.3V supply, typical current 32mA

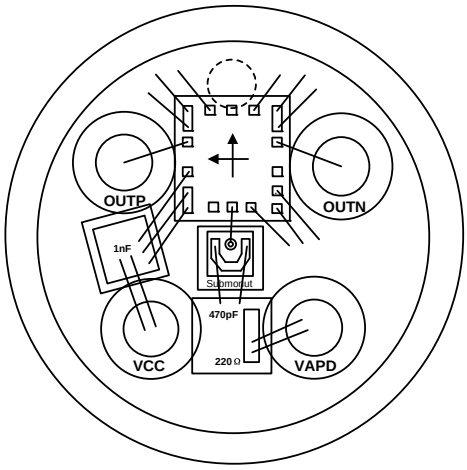
Applications

- 10G Ethernet
- OC-192 Receiver
- XGPON ONU
- XFP/SFP Modules
- 10Gbps ROSA
- 8X Fiber Channel

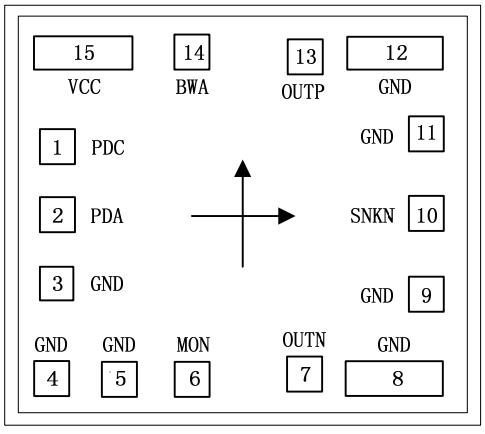
TO-CAN Bonding Diagrams：



(a) 5 pin TO-CAN for PIN with I-source monitor



(b) 5 pin TO bonding for APD



Pad Diagram

1.0 Product Specification

1.1 Absolute Maximum Ratings

Absolute maximum ratings are the values of voltage, current, temperature, power dissipation etc., which should not be exceeded at any time, otherwise deterioration or destruction of the IC may take place.

Parameter	Min	Max	Units
Power supply (VCC - GND)	-0.5	4	V
Storage temperature	-55	150	°C
Input current (peak to peak)	0	8	mA

1.2 Recommended Operating Conditions

Parameter	Min	Max	Units
Power supply (VCC - GND)	2.97	3.63	V
PD capacitance for 10 Gbps		0.2	pF
Operating ambient temperature	-40	85	°C

1.3 DC Characteristics

Symbol	Parameter	Min	Typ	Max	Units
VB	Photodiode bias voltage (PDC - PDA)		2.8		V
VCM	Common mode output voltage		3.15		V
ICC	Supply current (no loads)	30	32	37	mA
RLOAD	Recommended differential output load		50		Ω
NOTES:					

1.4 AC Characteristics (T = 25 °C, VCC = 3.3V, Cpd = 0.2 pF, L = 0.7 nH)

Parameter	Conditions	Min	Typical	Max	Units
Small Signal Bandwidth	Input below AGC on		11		GHz
Small Signal Low Frequency Cut-off	Input below AGC on		0.5		kHz
Small Signal Transimpedance	Input below AGC on		6		kΩ
Input Referred Noise (RMS)	10Gbps application		900		nA
Optical Input Sensitivity（PIN detector）	SNR=14,ρ=0.9,er=10		-21		dBm
Overload Input Current			2		mA
Differential Output Swing	$30\mu A_{pp}$ to $2mA_{pp}$		200		mV_{PP}
Output Resistance			50		Ω
Photo Current Monitor Offset			0	0.1	μA
Photo Current Monitor Ratio	VMON=0 to 1.5V		1		
Photo Current Monitor Ratio Accuracy	Input: 10μA to 2mA	0.9	1	1.1	dB
Power Supply Rejection Ratio	DC to 4MHz		25		dB

2.0 Functional Description

2.1 Overview

MG2952 is a continuous mode transimpedance amplifier. Its main function is to convert high speed input light pulse streams into output voltage pulse streams over various environment conditions (supply voltages, temperature etc) and across wide input range.

MG2952 has wide input dynamic range, high optical sensitivity (typical -21dBm) and high overload tolerance (greater than $2mA_{pp}$). Automatic gain control (AGC) circuit is implemented in order to achieve such wide dynamic range. In addition to automatically reducing TIA gain, this AGC circuit also helps to maintain integrity of input signal with excellent transimpedance linearity over frequency.

A precision current sourcing monitor of average photodiode current is available at the MON pad for PIN photodiodes.

2.2 TIA Front Stage

The transimpedance amplifier consists of a high gain single-ended amplifier (TIA) with a feedback resistor. Advanced design techniques are employed to maintain the stability of the amplifier across all input conditions. An on-chip low dropout linear regulator has been incorporated into the design to give excellent noise rejection up to several MHz. Higher frequency power supply noise is removed by a decoupling capacitor connected to PDC. The circuit is designed for photodiodes in common cathode configuration, with the anode connected to the input of TIA and the cathode connected to AC ground (PDC terminal). Reverse DC bias is applied to reduce the photodiode capacitance. Avalanche photodiode cathode can be connected externally to a higher voltage.

2.3 AGC

The MG2952 is designed to operate over the input range of +3dBm to -21dBm. An advanced circuit design technique (AGC) is developed here to extend the amplifier's dynamic range by automatically limiting the transimpedance gain. Another function of AGC is that it drastically improve linearity and reduce distortion of the transimpedance amplifier when input optical signal is greater than approximately –15dBm (@ 0.9 A/W), or ~$50\mu A_{pp}$.

2.4 Output Stage

The output stage is designed to drive a differential (100Ω) load. CML type of output stage, i.e. differential pair circuit is used in MG2952 design. It is suitable for driving capacitive loads such as inter-stage filters.

2.5 Monitor Output Configuration

Through different bonding options of pad SNKN， MON pin in MG2952 can be configured to source or sink current to ground accurately in two mode compatible with the DDMI Receive Power Specification (SFP-8472).

SNKN Pad Option	MON Output
Floating	Sourcing current to ground equal to PD current
Tied to GND	Sinking current to ground equal to PD current

3.0 Applications Information

3.1 TO-CAN Bonding Diagrams：

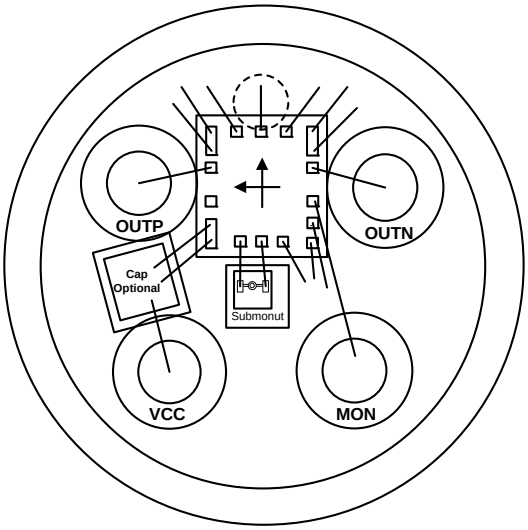


Figure 3-1 5 pin TO-CAN for PIN with I-sink monitor

Typical TO-CAN bonding configurations are shown in the first page (I-source monitor) and Figure 3 above (I-sink monitor) for different applications. Great care must be taking in TO bonding to ensure appropriate bandwidth performance. VCC bond wire de-coupling capacitor is required not optional for 10G TO-CAN. The capacitor should be placed close to TIA die to make the double bond-wire as short as possible to maximize signal quality. The number and length of bond-wires between TIA and PD will greatly affect the bandwidth. PD capacitance is also a significant factor for bandwidth. In general, PD should be placed as close to TIA die as possible.

3.2 TO Assembly

Typical recommended assembly of TIA in optical TO header is shown in Figure 3-2. The MG2952 is designed to work with bond wire inductance of ~1nH. Metal Shim is often required to raise TIA die so that bonding pads are horizontally in the same level as photo diode which is typically mounted on a ceramic sub-mount for appropriate focal length.

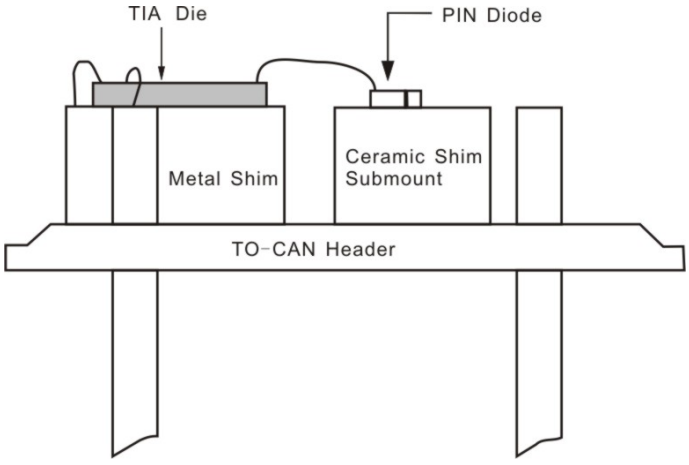


Figure 3-2 Suggested PIN Diode Connection Methods

4.0 Die Specification

4.1 Pad Descriptions:

Die Pad	Name	Function
1	PDC	Common PIN input. Connect to photo diode cathode (and optional cap).
2	PDA	Active PIN input. Connect to photo diode anode.
3,4,5,8,9,11, 12	GND	Ground pin. Connect to the most negative supply.
15	VCC	Power pin. Connect to most positive supply (only one VCC pad needs to be connected).
6	MON	Analog PD current monitor output. When SNKN not connected, MON is sourcing current out; when SNKN tied to ground, MON is sinking current in.
7	OUTN	Differential data output negative (goes low as light increases).
10	SNKN	MON mode select pin. When SNKN not connected, MON is sourcing current out; when SNKN tied to ground, MON is sinking current in.
13	OUTP	Differential data output (goes high as light increases).
14	BWA	Bandwidth Adjust: default floating, lower bandwidth when tied to GND or VCC.
NA	Backside	Backside. Connect to the lowest potential, usually ground.
NOTES: Alternatively the photodiode cathode may be connected to a decoupled positive supply, e.g. VCC.		

4.2 Pad Coordinates:

Pad Number	Pad	X	Y	Pad Number	Pad	X	Y
1	PDC	-392	170	9	VSS	391	-170
2	PDA	-384	0	10	SNKN	391	0
3	GND	-392	-170	11	VSS	391	170
4	GND	-392	-341	12a	VSS	391	341
5	GND	-254	-341	12b	VSS	224	341
6	MON	-104	-341	13	OUTP	56	332
7	OUTN	56	-332	14	BWA	-104	341
8a	GND	224	-341	15a	VCC	-234	341
8b	GND	391	-341	15b	VCC	-392	341

4.3 Other Notes：

Die Thickness：250μm

Die Size：900μm x 800 μm

Pad Materials：Aluminum