M02006

CMOS Pre-amplifier with AGC for Long-reach 155 Mbps Fiber-optics Based Transmitter

Rev V4

Features

- Low-cost IC, fabricated in sub-micron CMOS
- Receiver sensitivity typically -40 dBm at 155 Mbps, when integrated into a module with suitable photodiode and post-amplifier
- 115 MHz bandwidth allows wide range of operation; suitable for 100, 125 and 155 Mbps
- Typical differential gain of 200 kΩ at low signal levels
- AGC gives continuous operation to >0 dBm
- 165 mW power consumption at +5 V supply
- > 35 dB Power-supply noise rejection
- Available as die

Applications

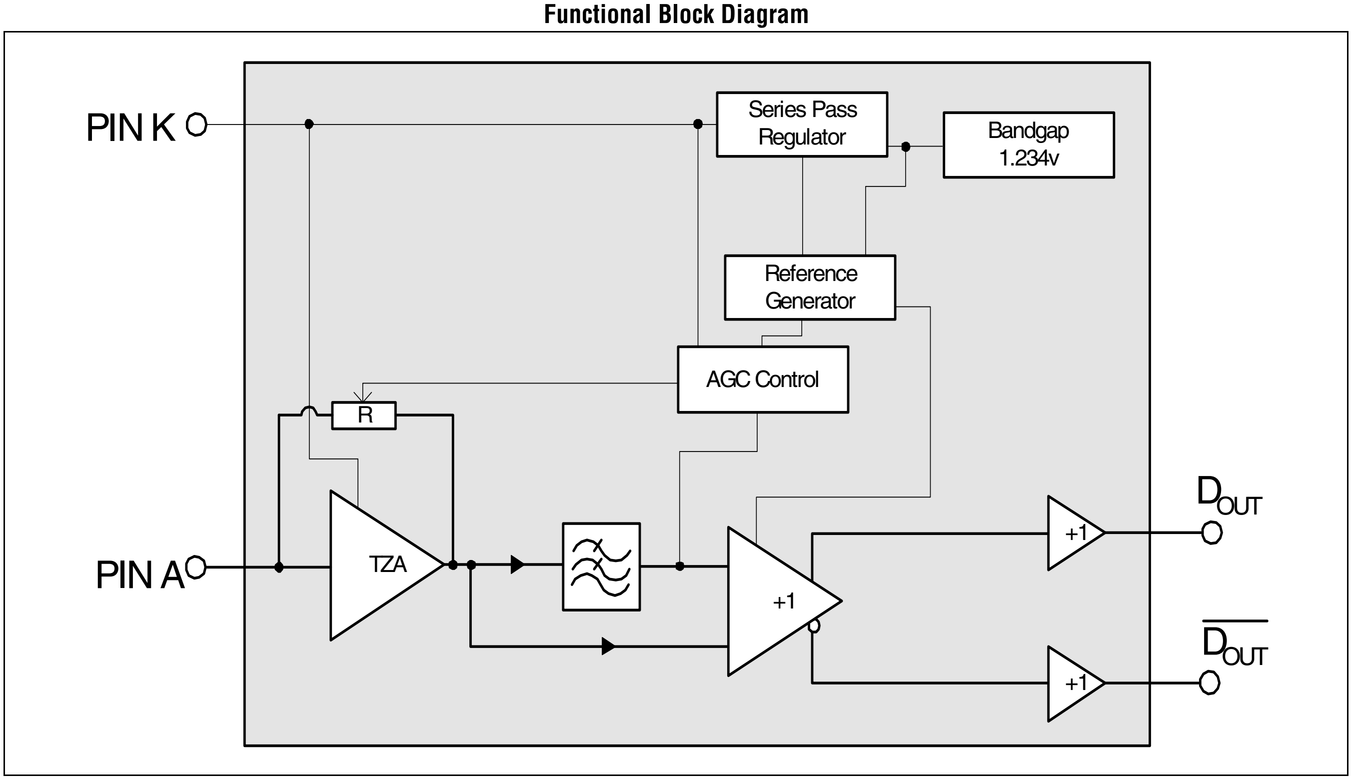
- SDH / SONET / ATM
- Fast Ethernet

The M02006 is a low-noise, transimpedance amplifier with AGC, manufactured in sub-micron CMOS. Its wide dynamic range, differential output and high PIN bias make it well suited for telecommunications, especially OC-3/STM-1. However, the M02006 is intended to meet the needs of both Telecom and Datacom users.

The M02006 is available only in die form. For optimum system performance, die should be mounted in close proximity with the photodetector.

The M02006 is designed to be used with the MC2045 postamplifier IC. When combined with a photodiode, the chip set forms a high performance, low cost 5 V receiver.

Functional Block Diagram



CMOS Pre-amplifier with AGC for Long-reach 155 Mbps Fiber-optics Based Transmitter

Rev V4

Ordering Information

Part	Pin-package
M02006E-DIE [1]	Available in waffle pack, whole wafer on a grip ring and one-quarter wafer
M02006F-DIE [2]	Available in waffle pack, whole wafer on a grip ring and one-quarter wafer

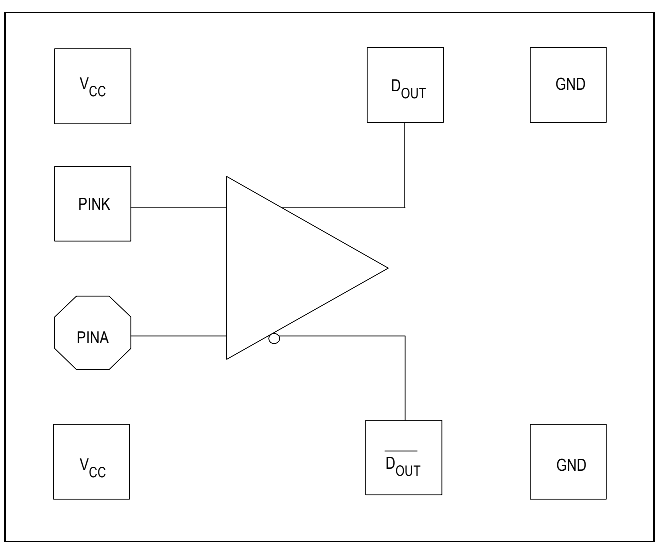
NOTES:

1. M02006E transimpedance limits are 60kΩ to 88kΩ
2. M02006F transimpedance limits are 88kΩ to 110kΩ

Revision History

Revision	Level	Date	Description
V4	Release	May 2015	Updated logos and page layout. No content changes.
C (V3)	Release	August 2010	Changed the max Icc from 35 mA to 38 mA (Table 1-2). Corrected the Max/Min columns on Table 1-3. Added new ordering information. Remove package information since device is die sales only.
B (V2)	Release	June 2006	Updated format. Updated Absolute Maximum Ratings. Added TIA Use with Externally Biased Detectors section.
A (V1)	Release	February 2002	Initial Release.

Top Level Diagram



1.0 Product Specification

1.1 Absolute Maximum Ratings

Table 1-1. Absolute Maximum Ratings

Symbol	Parameter	Rating	Units
T_A	Operating ambient	-40 to +85	°C
T_{STG}	Storage temperature	-65 to +150	°C
V_PINA, V_PINK, V_Dout, V_DoutB,	Input voltage at PINA, PINK, Dout, DoutB	-0.4 to V_{CC} +0.4	V
I_PINK	Maximum Current sourced out of PINK	10	mA
V_{CC}	Power Supply (V_{CC} – GND)	-0.4 to 6	V

1.2 DC Characteristics

Table 1-2. DC Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units
V_B	PIN bias voltage (PINK - PINA)	2	2.3	2.6	V
V_{CM}	Common mode output voltage	-	$V_{CC}/2$	-	V
I_{CC}	Supply current (no loads)	-	-	38	mA

1.3 AC Characteristics

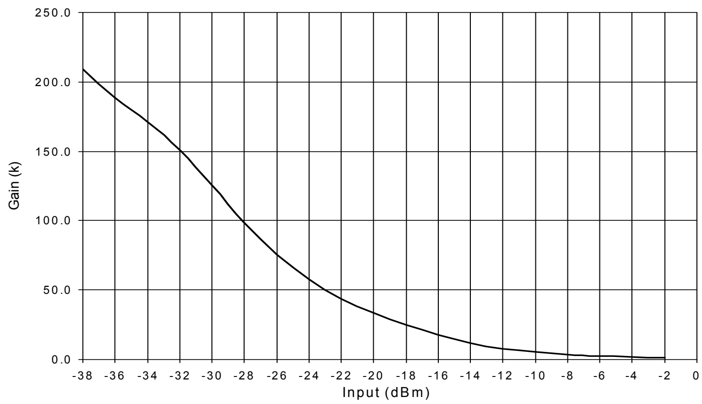
Table 1-3. AC Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units
R_{OUT}	Output impedance (single ended)	-	50	-	Ω
I_{NOISE}	Input noise current (1), (2)	-	7.5	12	nA_{rms}
PIN(mean), Min.	Optical sensitivity (1), (2)	-40	-	-37	dBm
I_{MAX}	Input overload current	2.2	4.5	-	mA_{PP}
PIN(mean), Max.	Optical saturation (2)	-	+3	-	dBm
G	Small signal transimpedance (3), (4), (5) Single ended: Differential:	 - -	 - -	 130 260	kΩ
V_D	Differential output voltage (3)	-	-	800	mV
BW	Bandwidth to -3 dB point (electrical)	100	-	-	MHz
$T_r T_f$	Data out rise/fall times (20% - 80% points)	-	-	2	ns
T_{PWD}	Pulse width distortion	-	-	1	%
OS_{PULSE}	Pulse overshoot	-	-	3	%
T_{AGC}	AGC setting time	-	-	100	µs
OS_{AGC}	AGC overshoot	-	-	12	%
PSRR	Power supply rejection ratio (<4 MHz)	40	-	-	dB

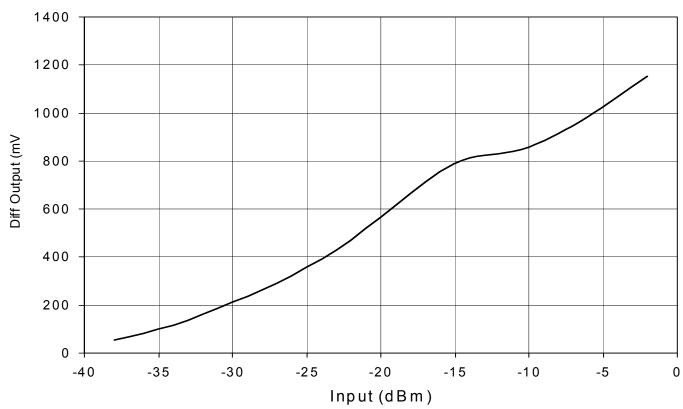
NOTES:

1. Measured with input capacitance, C_{IN} = 0.7 pF to 1.0 pF
2. Assuming photodiode response of 0.9 A/W, extinction ratio of 10 dB and BER of 10^{-10}
3. The 2006 is designed to drive a load >500 Ω. Measurements are taken into high Z
4. Measured at 10 MHz
5. Measured at input current = 2µA_{PP}

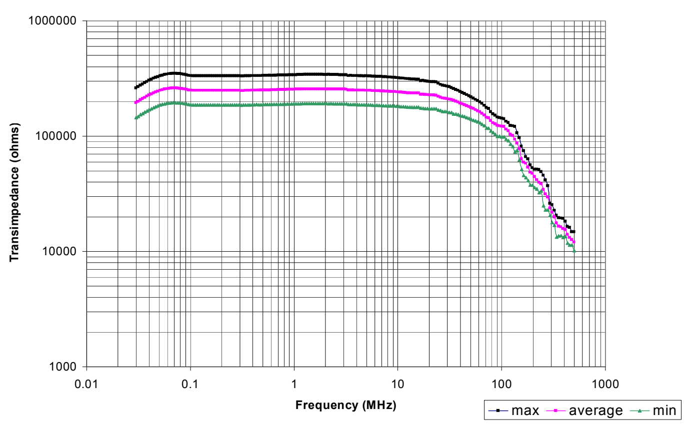
Figure 1-1. Typical Performance Curves



Typical gain vs input level



Differential output vs input



Transimpedance vs frequency
(@ -40 dBm optical input power)
(VCC = 5.0V, +21 °C)

2.0 Pin Description

2.1 Pin Descriptions

Table 2-1. Pin Descriptions

Die Pad No	Name	Function
1, 8	GND	Ground pin. Connect to the most negative supply, Both pins should be used
2	D_{OUT}	Non-inverted data output. Differential output with D_{OUT} (goes high as light increases)
3, 6	V_{CC}	Power pin. Connect to most positive supply. Either or both pins may be used
4	PINK	PIN cathode connection. Connect between this pin and PINA. Connect a decoupling capacitor to ground
5	PINA	PIN anode connection. Connect between this pin and PINK
7	D_{OUT}	Inverted data output. Differential output with D_{OUT}

3.0 Functional Description

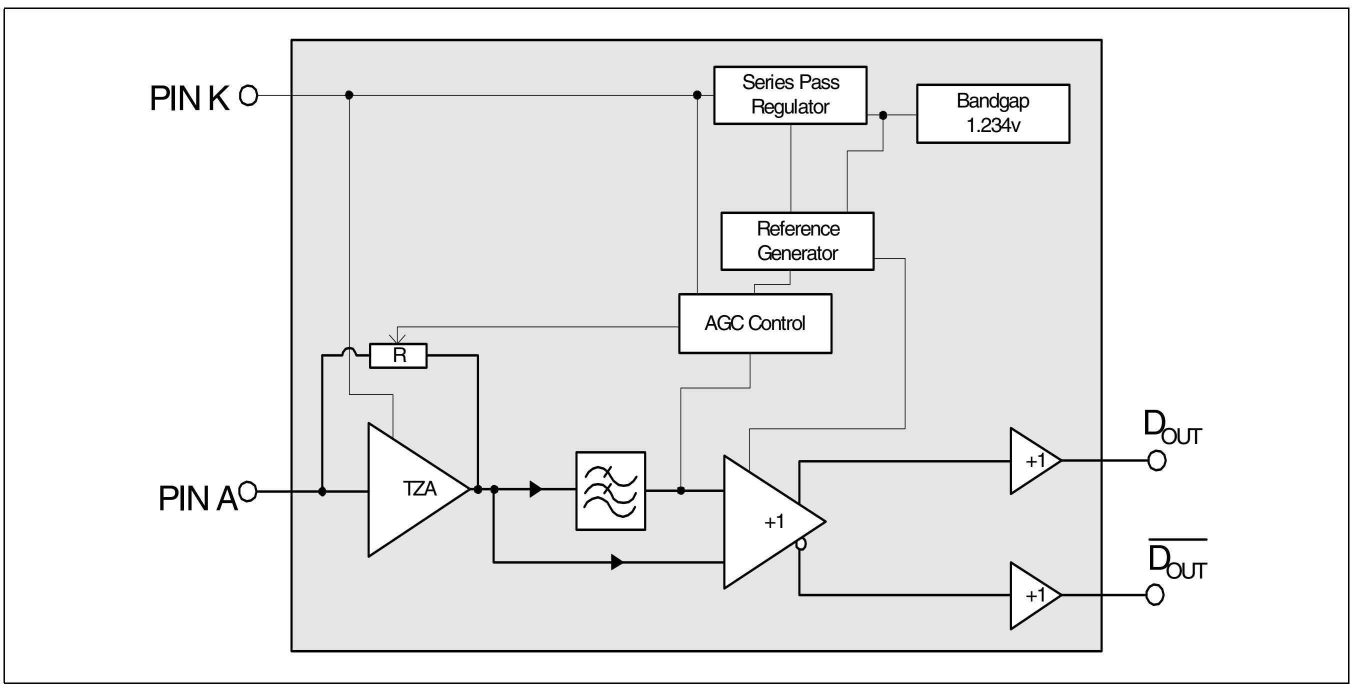
3.1 Overview

The M02006 is a low-noise, transimpedance amplifier with AGC, manufactured in sub-micron CMOS. Its wide dynamic range, differential output and high PIN bias make it well suited for telecommunications, especially OC-3/ STM-1. However, the M02006 is intended to meet the needs of both Telecom and Datacom users.

The M02006 is available only in die form. For optimum system performance, die should be mounted in close proximity with the photodetector.

The M02006 is designed to be used with the MC2045 postamplifier IC. When combined with a photodiode, the chip set forms a high performance, low cost 5 V receiver.

Figure 3-1. Functional Block Diagram



3.2 TZA

The transimpedance amplifier consists of a high gain single-ended CMOS amplifier, with a feedback resistor. The feedback creates a virtual low impedance at the input and nearly all of the input current passes through the feedback resistor, defining the voltage at the output. Advanced CMOS design techniques are employed to maintain the stability of this stage across all input conditions.

Single-ended amplifiers have inherently poor power supply noise rejection. For this reason, 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 external decoupling.

The circuit is designed for PIN photodiodes in the grounded cathode configuration, with the anode connected to the input of the TZA and the cathode connected to AC ground. Reverse dc bias is applied via PINK to reduce the photodiode capacitance.

3.3 AGC

The M02006 has been designed to operate over the input range of +3 dBm to –39 dBm at long wavelengths.

This represents a ratio of 1:12500, whereas the acceptable dynamic range of the output is only 1:250 which implies a compression of 50:1 in the transimpedance.

The design uses a MOS transistor configured as a voltage controlled resistor to achieve transimpedance variation, which allows the device to maintain a relatively constant output amplitude over more than 30db of optical input power.

3.4 Output Stage

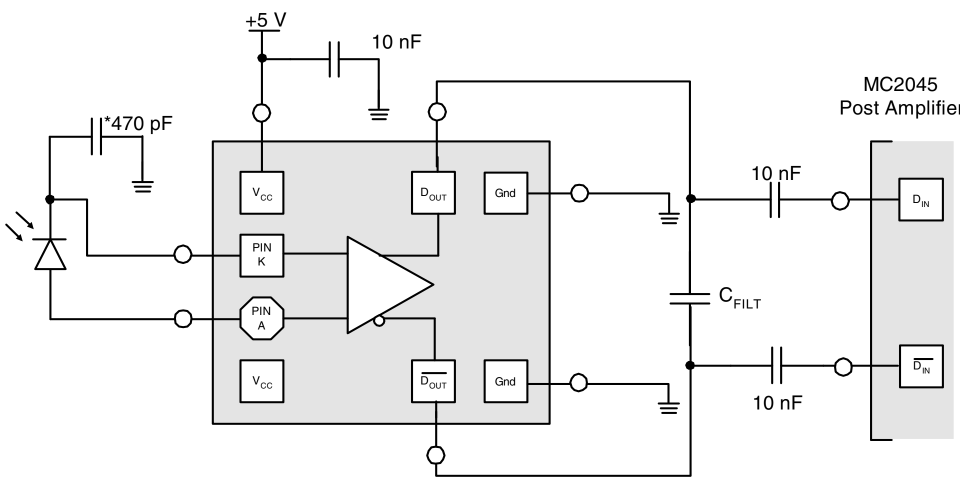
The signal from the TZA enters a phase splitter and a pair of voltage follower outputs. These are designed to drive a high impedance (>500 Ω) load. They are stable for driving capacitive loads, such as interstage filters.

4.0 Applications

4.1 Filter Design

The achievable sensitivity of the M02006 is dependant on the noise bandwidth of the amplifier, which varies with temperature and process. The bandwidth should therefore be limited by an interstage filter. This will typically employ a one pole filter, using a capacitor across the outputs. For maximum sensitivity, a filter with steeper roll-off and better transient response can be implemented with inductors and capacitors. If the module is intended to be used at several rates, interstage filtering should not be employed. A typical application circuit is shown in Figure 4-1.

Figure 4-1. Typical Applications Circuit

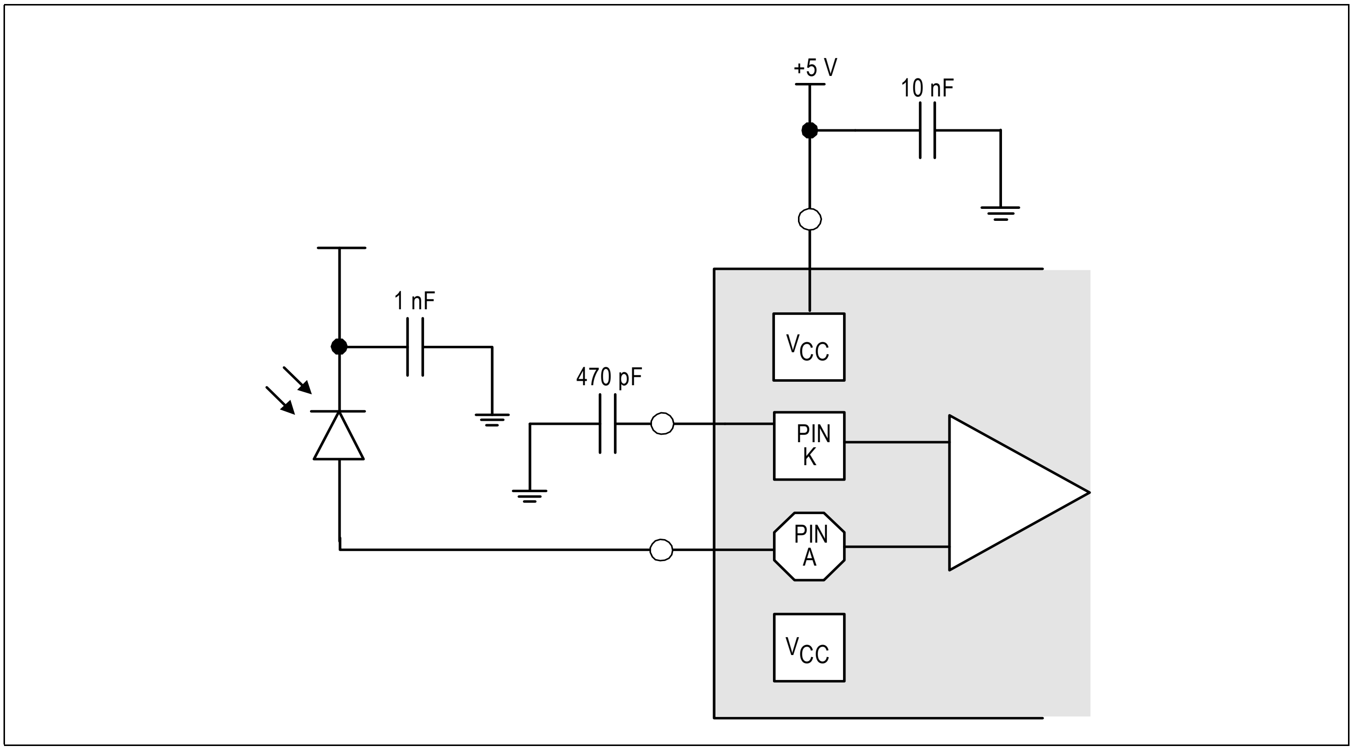


* The 470pF capacitor should be mounted inside the TOcan/optical sub assembly with the photodiode

4.2 Alternative Input Arrangement

An alternative arrangement can be used to connect the photodiode, with the photodiode cathode being connected directly to V_{CC} see Figure 4-2. This requires two decoupling capacitors, one connecting V_{CC} to ground and the other from PIN K to ground. This arrangement gives slightly more reverse bias on the photodiode, but will have worse low frequency noise performance.

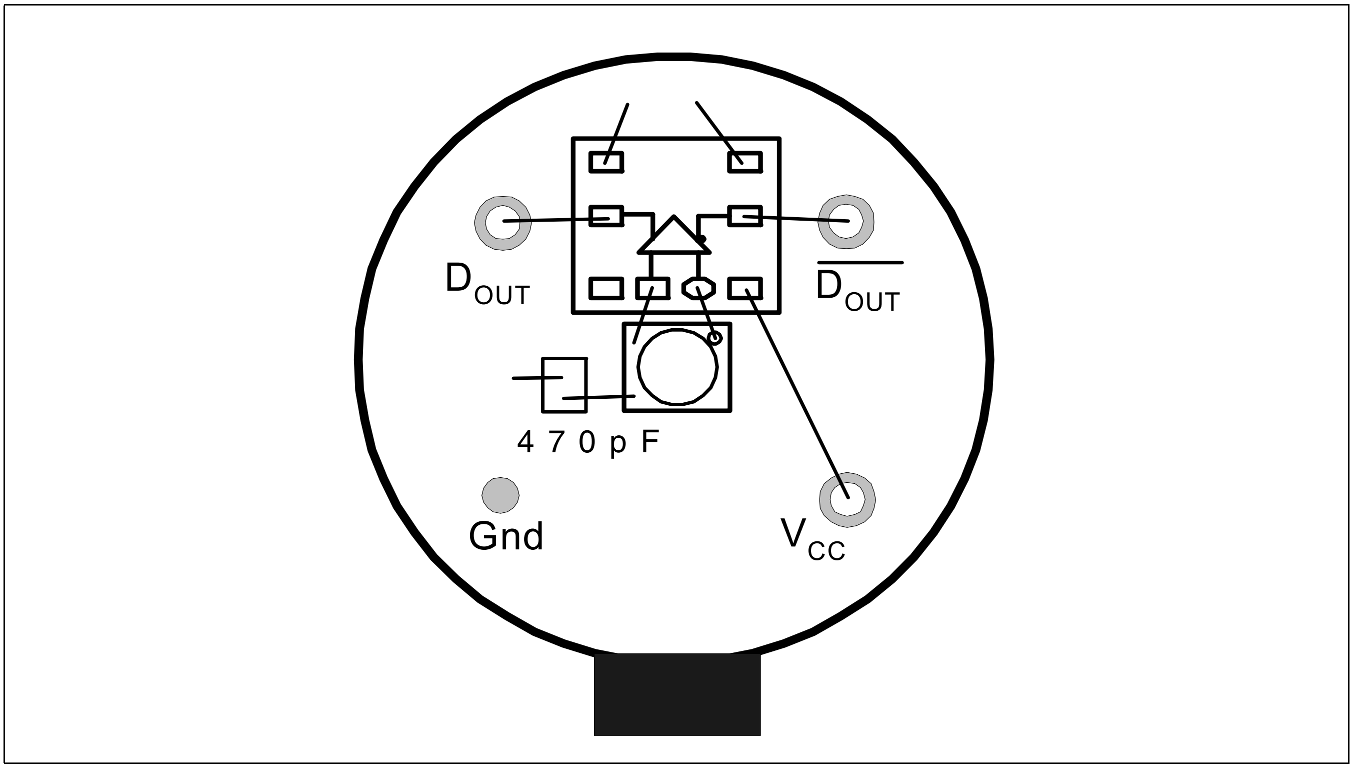
Figure 4-2. Alternative Application Arrangement



4.3 Layout Considerations

Use good high-frequency design and layout techniques, taking care to bypass V_{CC} over the frequencies to several hundred MHz. When using die, take care to minimise bond-wire length, especially for the PIN A and Gnd pads. A typical TO-can assembly is shown in Figure 4-3.

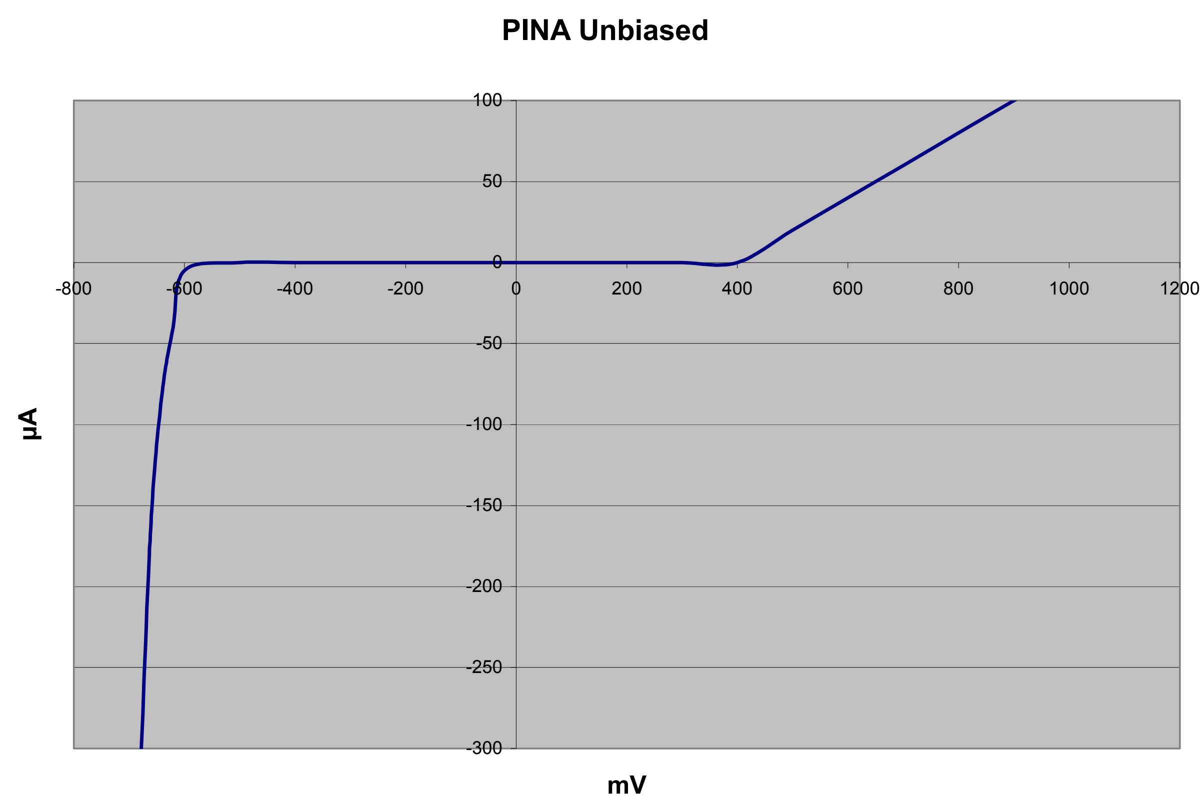
Figure 4-3. Typical TO-can Assembly



4.4 TIA Use with Externally Biased Detectors

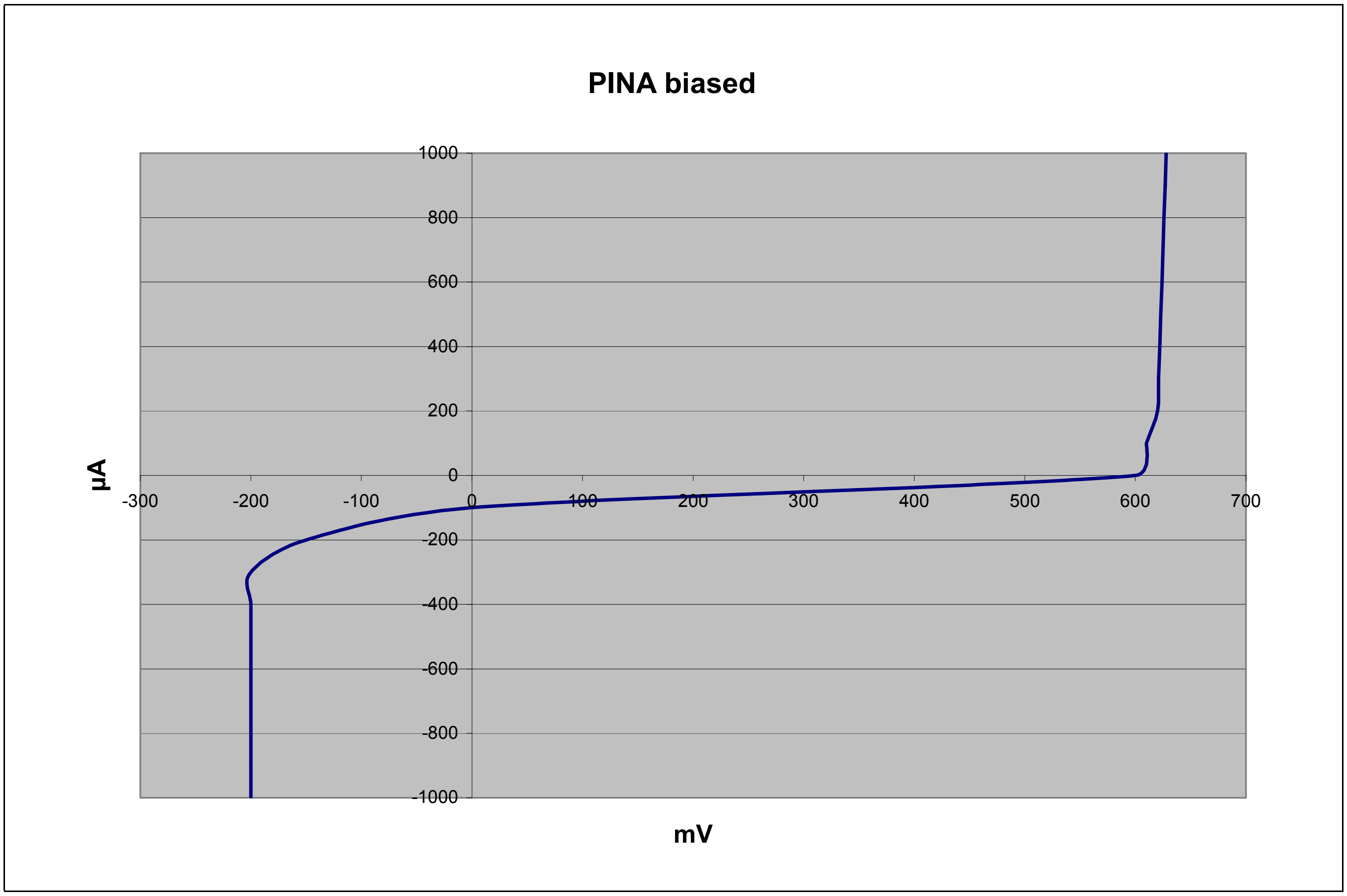
In some applications, MACOM TIAs are used with detectors biased at a voltage greater than available from TIA PIN cathode supply. This works well if some basic cautions are observed. When turned off, the input to the TIA exhibits the following I/V characteristic as shown in Figure 4-4.

Figure 4-4. TIA Use with Externally Biased Detectors, Powered Off



In the positive direction after about 700 mV, the impedance of the input is relatively high. After the TIA is turned on, the DC servo and AGC circuits attempt to null any input currents (up to the absolute maximum stated in the device table) as shown by the I/V curve in Figure 4-5.

Figure 4-5. TIA Use with Externally Biased Detectors, Powered On



It can be seen that any negative voltage below 200 mV is nulled and that any positive going voltage above the PINA standing voltage is nulled by the DC servo. The DC servo upper bandwidth varies from part to part, but is generally at least 10 kHz.

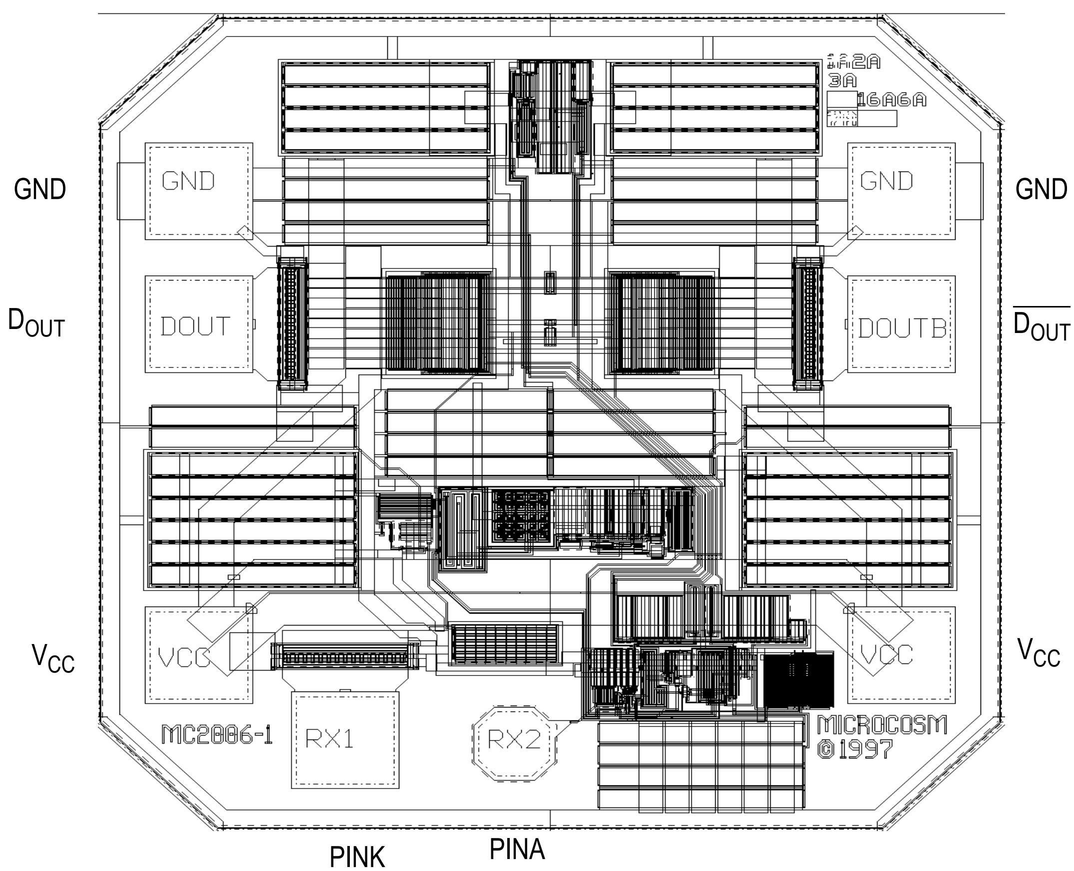
When externally biasing a detector such as an APD with a voltage in the 30-80V range, care should be taken to power up the TIA first and to keep the TIA powered up until after the power supply voltage on the APD is removed. Failure to do this with the TIA unpowered may result in damage to the input FET gate at PINA. In some cases the damage may be very subtle, in that nearly normal operation may be experienced with the damage causing slight reductions in bandwidth, and corresponding reductions in input sensitivity.

4.4.1 Treatment of PINK

PINK still requires bypassing to ground with a high quality 220-1000 pf (470 pf recommended) capacitor, even with no other connection to it. The capacitor stabilizes the internal voltage regulator of the TIA.

5.0 Packaging Specification

Figure 5-1. Bare Die Information



Die size : 1.01 x 0.96 mm
Die Thickness : 300 µm ±10%

Table 5-1. Pad Coordinates

Pad No	Description	X (µm)	Y (µm)
1	GND	-347	255
2	D_{OUT}	-347	109
3	V_{CC}	-347	-255
4	PINK	-202.6	-348.45
5	PINA	-35.45	-352.3
6	V_{CC}	347	-255
7	D_{OUT}	347	109
8	GAN	347	255