

## MC2009

### **Pin Pre-amplifier with AGC for 3.3V Fiber Optic Applications to 622 Mbps**

The MC2009 is a low-noise, transimpedance amplifier with AGC, manufactured in low-cost CMOS. Its wide dynamic range, differential output and high PIN bias make it well suited for telecommunications, especially OC-12/STM-4. However, the MC2009 is intended to meet the needs of both Telecom and Datacom users.

The MC2009 is available in die form. For optimum system performance die should be mounted in close proximity with the photodetector.

The MC2009 is designed to be used with the Mindspeed MC2044C Postamplifier IC. When combined with a photodiode, the chip set forms a high performance, low cost 3.3V receiver.

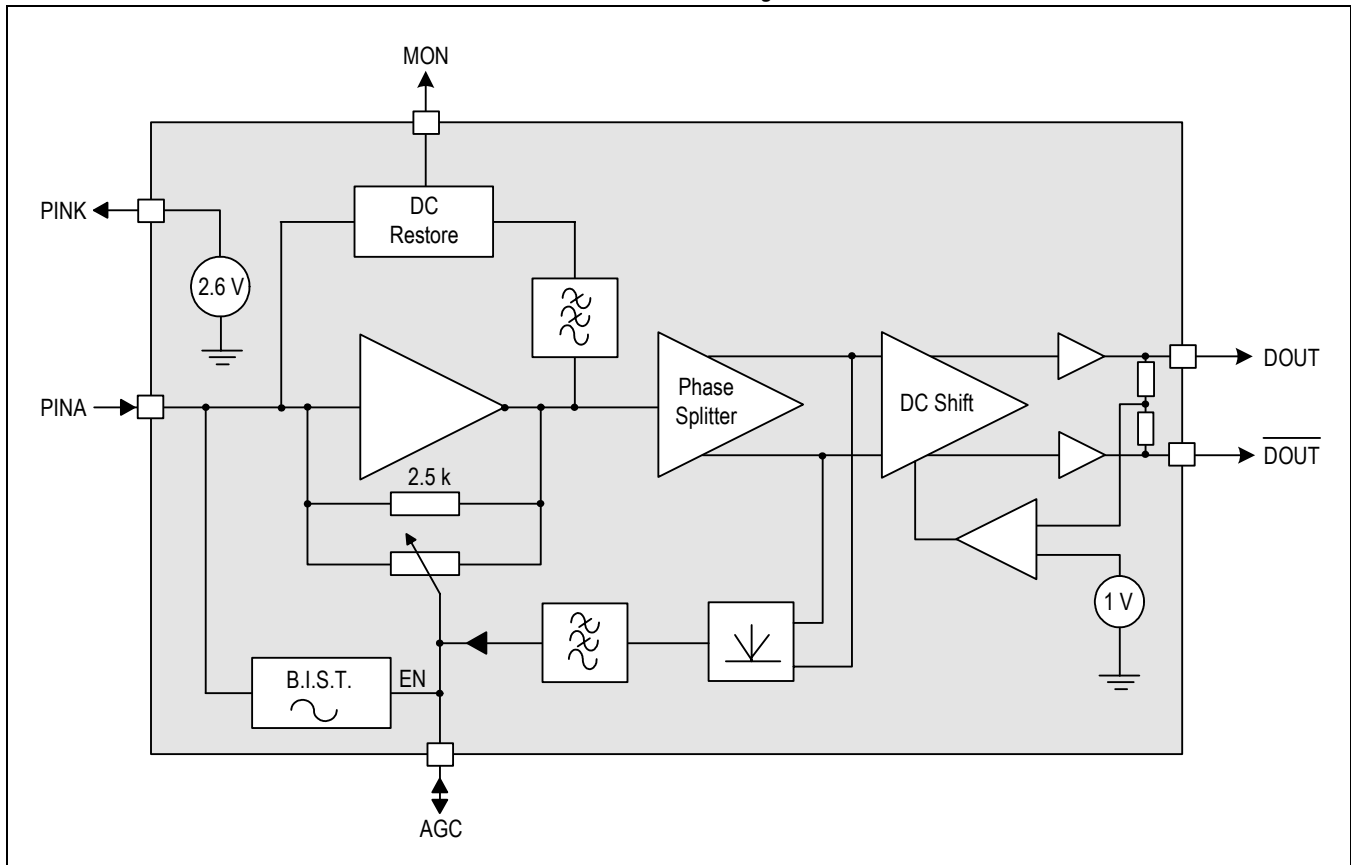
#### Applications

- ATM/SDH/SONET
- PON/FTTH

#### Features

- Low cost IC fabricated in CMOS.
- Receiver sensitivity better than -32 dBm @ 622 Mbps.
- Minimum 340 MHz bandwidth and multi-pole roll off allows a wide range of operation up to 622 Mbps.
- Typical differential transimpedance at low signal levels of 40Ω.
- AGC gives continuous operation to +3 dBm
- > 33 dB power-supply noise rejection.
- Typical 130 mW power consumption at 3.3V supply.
- Monitor output gives linear indication of received optical power.
- Differential output.

Functional Block Diagram



## Ordering Information

Part Number	Package	Operating Temperature
MC2009-XX*	Waffle Pack	-40 °C to 85 °C
MC2009-XX*	Expanded whole wafer on a ring	-40 °C to 85 °C

\* Consult price list for exact part number when ordering.

## Revision History

Revision	Level	Date	ASIC Revision	Description
D	Preliminary	July 2004		Updated Block Diagram and Top Level Diagram Updated Absolute Maximum Ratings Updated AC Characteristics



# Table of Contents

---

Ordering Information	ii
Revision History	ii
Table of Contents	iii
List of Figures	iv
List of Tables	v
1.0 Functional Description	1
1.1 Overview	1
1.2 Features	2
1.3 General Description	2
1.3.1 TIA (Transimpedance Amplifier)	2
1.3.2 AGC	3
1.3.3 Output Stage	3
1.3.4 Monitor Output	3
1.3.5 Assembly	7
1.4 Applications	9
1.5 Pin Definitions	9
2.0 Product Specification	10
2.1 Absolute Maximum Ratings	10
2.2 Recommended Operating Conditions	10
2.3 DC Characteristics	10
2.4 AC Characteristics	11
2.5 Bare Die Layout and X Y Coordinates	12



# List of Figures

---

Figure 1-1.	M02009 Block Diagram .....	1
Figure 1-2.	Top level diagram .....	2
Figure 1-3.	Typical Performance (1 of 3) .....	4
Figure 1-4.	Typical Performance (2 of 3) .....	5
Figure 1-5.	Typical Performance (3 of 3) .....	6
Figure 1-6.	TO-Can Assembly Diagram .....	8



# List of Tables

---

Table 1-1.	Pad Description .....	9
Table 2-1.	Absolute Maximum Ratings .....	10
Table 2-2.	Recommended Operating System .....	10
Table 2-3.	DC Characteristics .....	10
Table 2-4.	AC Characteristics .....	11
Table 2-5.	Bare Die Layout Example .....	12



# 1.0 Functional Description

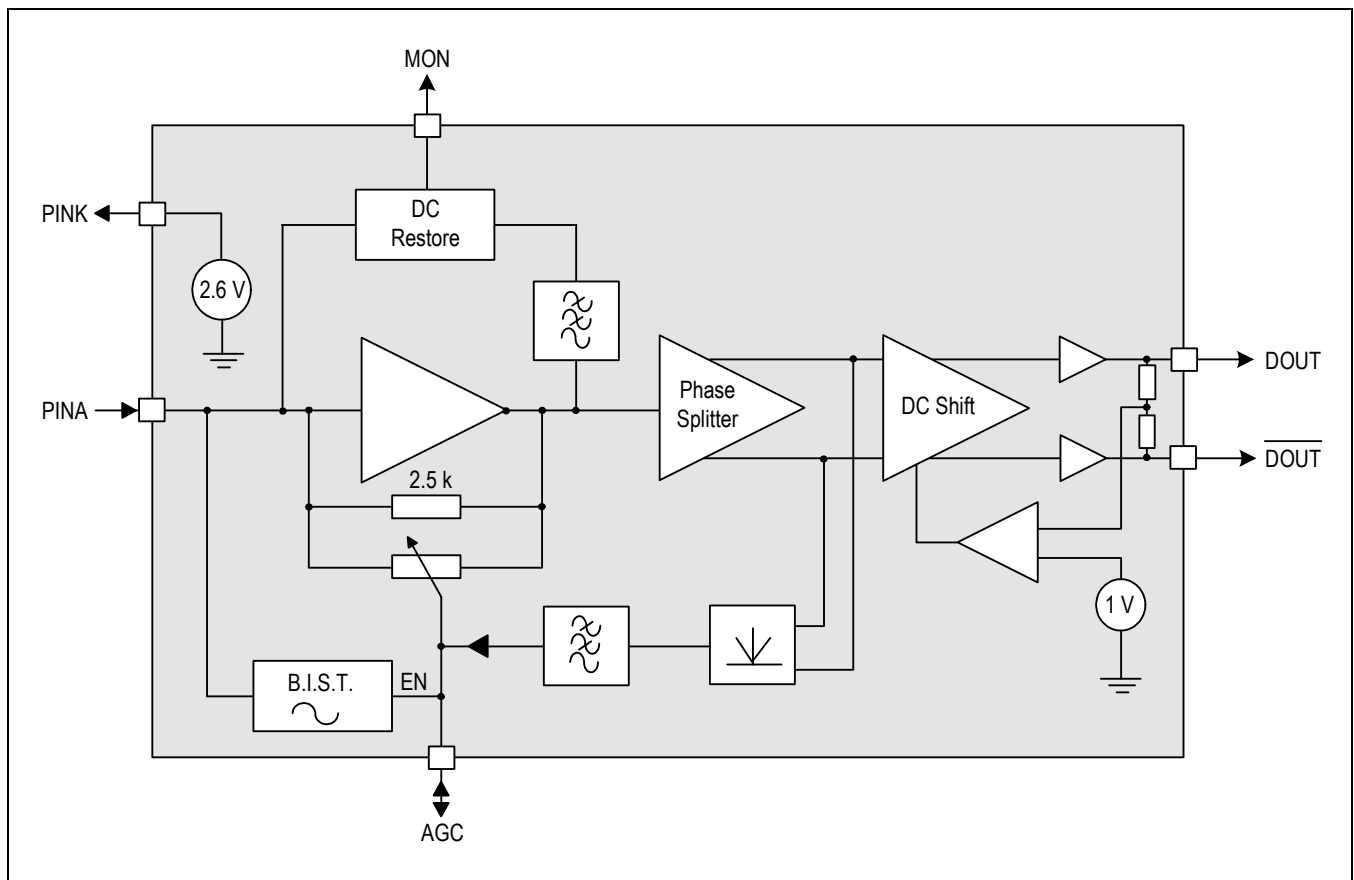
## 1.1 Overview

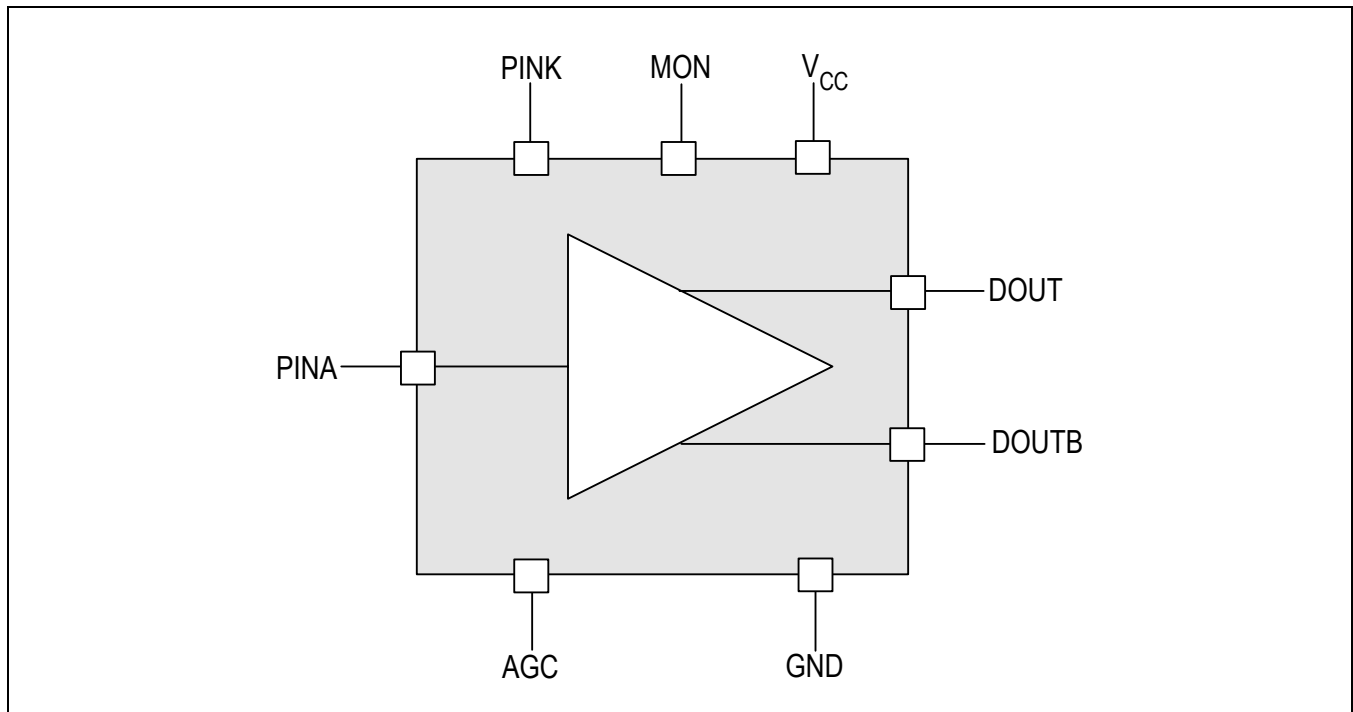
The MC2009 is a low-noise, transimpedance amplifier with AGC, manufactured in low-cost CMOS. Its wide dynamic range, differential output and high PIN bias make it well suited for telecommunications, especially OC-12/STM-4. However, the MC2009 is intended to meet the needs of both Telecom and Datacom users.

The MC2009 is available in die form. For optimum system performance die should be mounted in close proximity with the photodetector.

The MC2009 is designed to be used with the Mindspeed MC2044C Postamplifier IC. When combined with a photodiode, the chip set forms a high performance, low cost 3.3V receiver.

Figure 1-1. M02009 Block Diagram



**Figure 1-2. Top level diagram**

## 1.2 Features

- Low cost IC fabricated in CMOS.
- Receiver sensitivity better than -32 dBm @ 622 Mbps.
- Minimum 340 MHz bandwidth and multi-pole roll off allows a wide range of operation up to 622 Mbps.
- Typical differential transimpedance at low signal levels of 40Ω.
- AGC gives continuous operation to +3 dBm
- > 33 dB power-supply noise rejection.
- Typical 130 mW power consumption at 3.3V supply.
- Monitor output gives linear indication of received optical power.
- Differential output.

## 1.3 General Description

### 1.3.1 TIA (Transimpedance Amplifier)

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 virtually 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 these stages 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 TIA and the cathode connected to AC ground. Reverse DC bias is applied to reduce the photodiode capacitance.

### 1.3.2 AGC

The MC2009 has been designed to operate over the input range of +3 dBm to –32 dBm at long wavelengths. This represents a ratio of 1:3000, whereas the acceptable dynamic range of the output is only 1:100 which implies a compression of 30:1 in the transimpedance. The design uses a MOS transistor to achieve the transimpedance variation.

Another feature of the AGC is that it is only operates on signals greater than –20 dBm (@ 0.9A/W). This knee in the gain response is important when setting “signal detect” functions in the following postamplifier. It also aids in active photodiode alignment.

The AGC pad allows the AGC to be disabled during photodiode alignment by grounding the pad through a low impedance. The AGC control voltage can be monitored during normal operation at this pad by a high impedance (>10 MΩ) circuit. In addition, taking this pad to  $V_{CC} + 1.2V$  enables an internal test oscillator which supplies a 1 MHz 10 uA pk(approximate) square wave current internally between the PIN K and PIN A pads to emulate a photodiode for test purposes.

### 1.3.3 Output Stage

The signal from the TIA enters a phase splitter and a pair of voltage follower outputs. These are designed to drive a high impedance (>500Ω) load. They are stable for driving capacitive loads such as interstage filters. Each output has its own GND pad, all four GND pads on the chip should be connected for proper operation.

Since the MC2009 exhibits rapid rolloff, external filtering is not required.

### 1.3.4 Monitor Output

High impedance output sinks a 1:1 replica of average photodiode current for monitoring purposes.

Note that this output is provided because in this device it is not possible to connect the photodiode cathode to  $V_{CC}$ . For the correct operation of the AGC and DC restore, the photodiode cathode must be connected to the PINK pin. The MC2009 measures the photodiode current and uses this information to set the transimpedance and reduce the DCoffset of the outputs. To convert this output to a voltage, a resistor to  $V_{CC}$  should be used. Note that for linearity, ensure that  $V_{mon}$  is always > 1V.



Figure 1-3. Typical Performance (1 of 3)

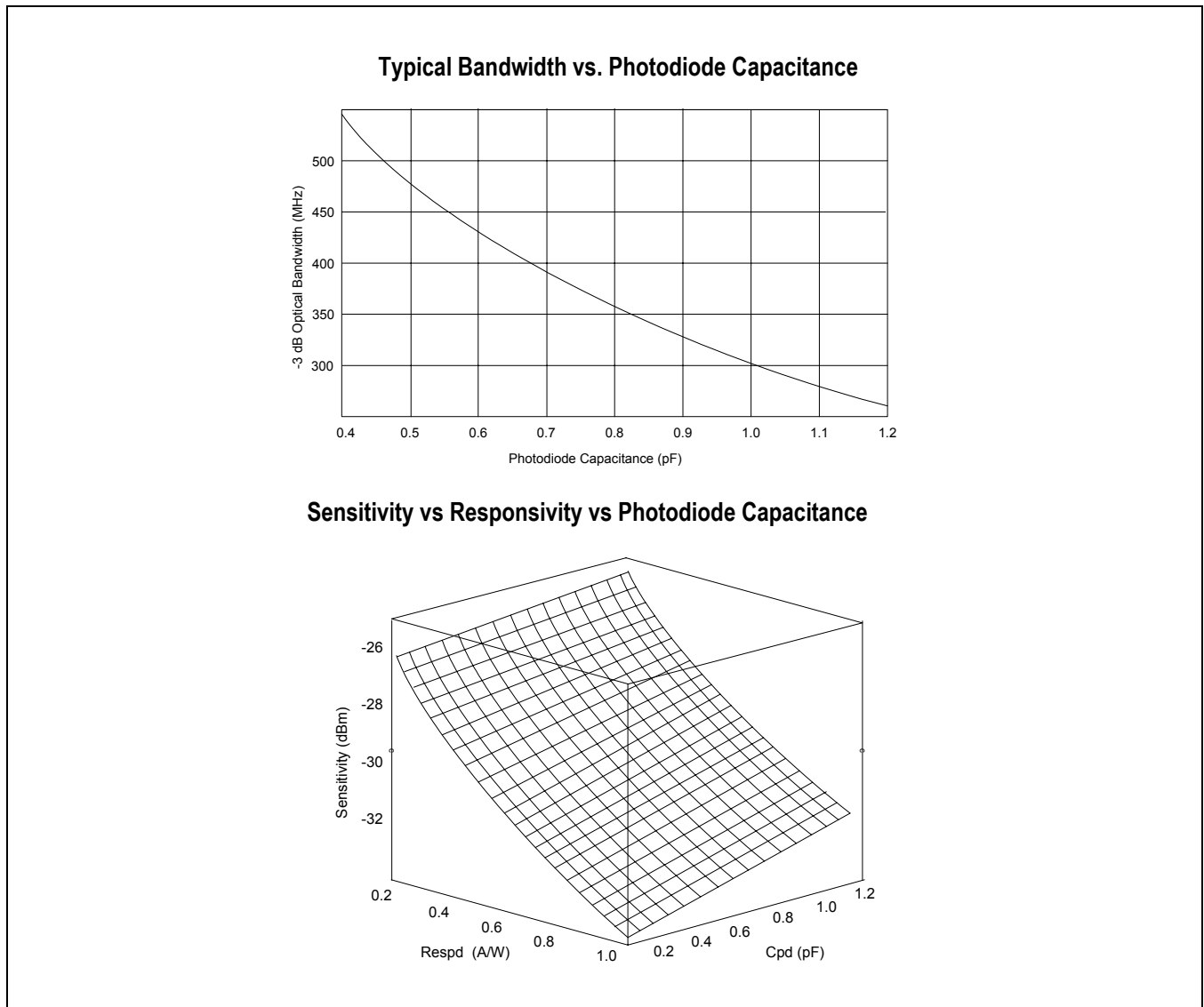


Figure 1-4. Typical Performance (2 of 3)

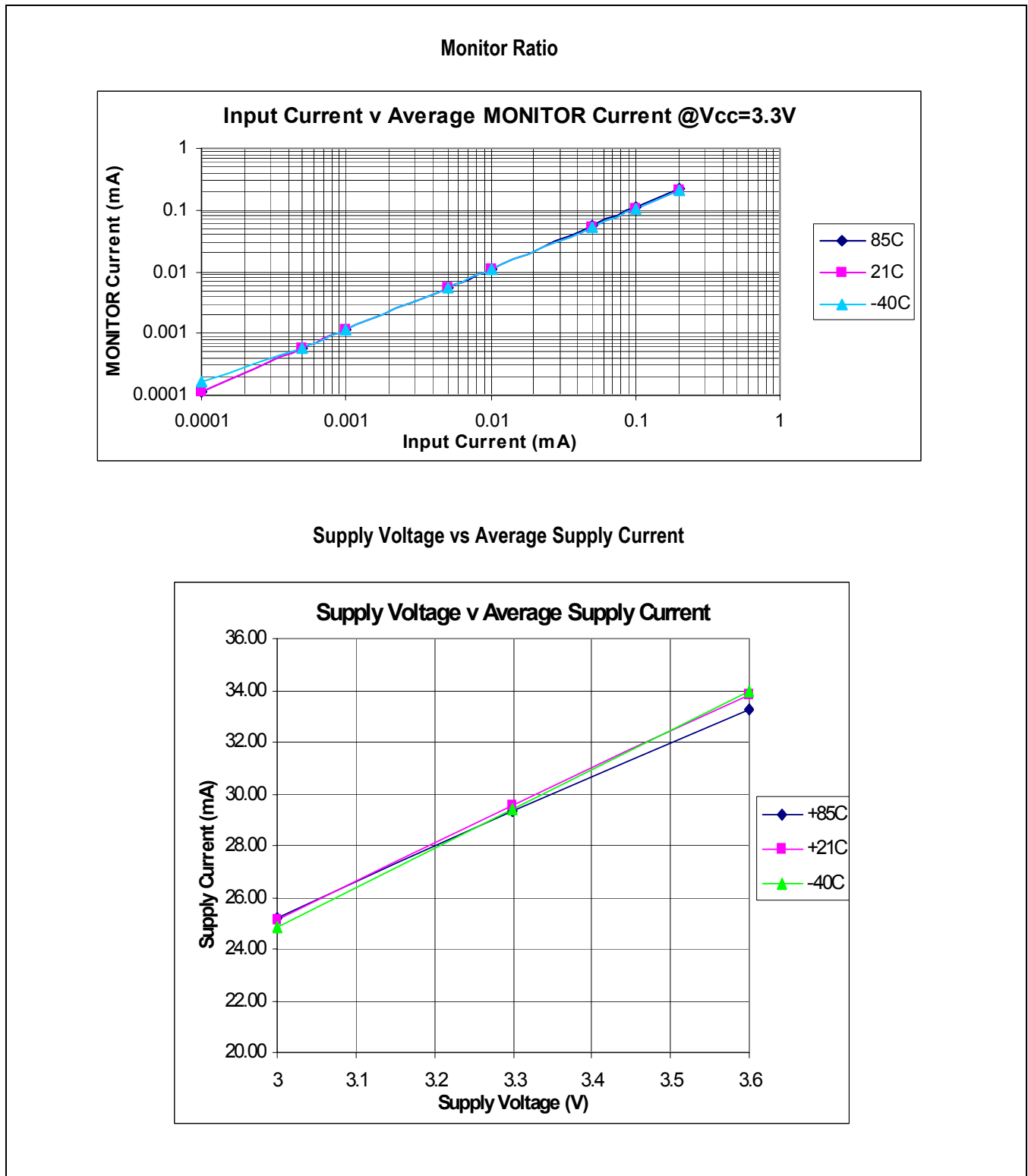
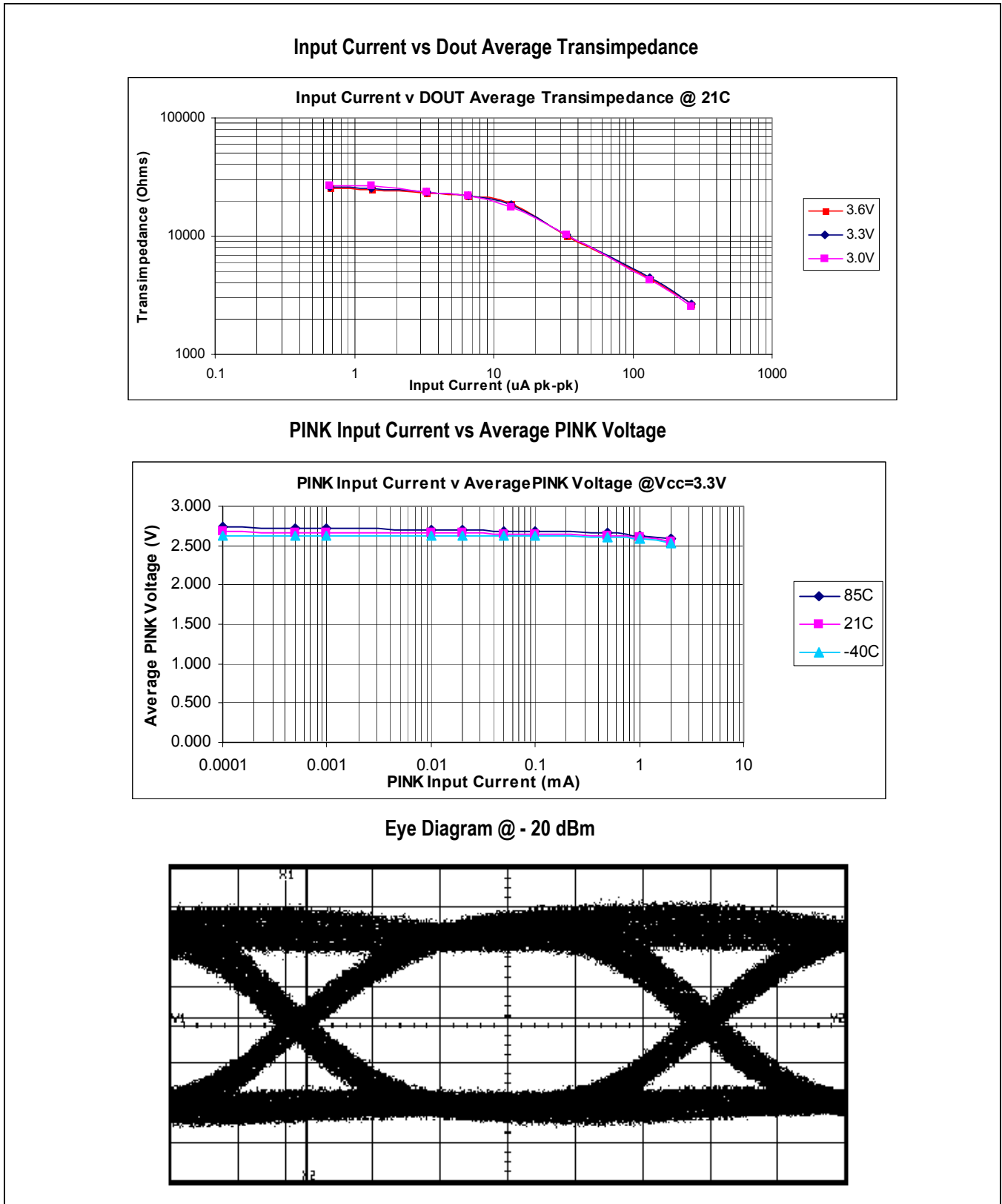


Figure 1-5. Typical Performance (3 of 3)



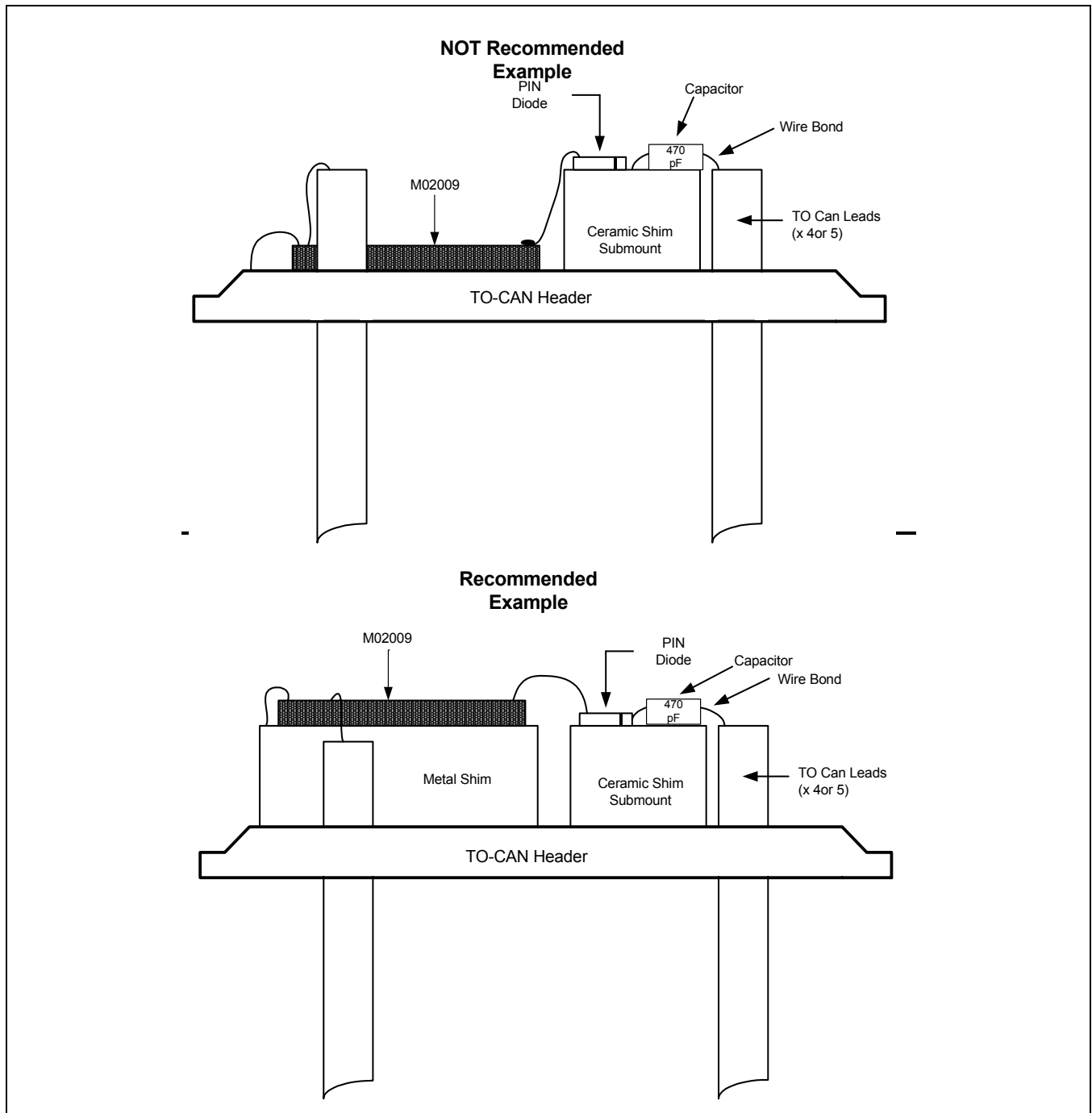
### 1.3.5 Assembly

The M02009 is designed to work with a wirebond inductance of 1 nh +/- 0.25 nh. Many existing TO-Can configurations will not allow wirebond lengths that short, since the PIN diode submount and the TIA die are more than 1 mm away in the vertical direction, due to the need to have the PIN diode in the correct focal plane. This can be remediated by raising up the TIA die with a conductive metal shim. This will effectively reduce the bond wire length. Refer to Figure 5 on the following page for details. Mindspeed recommends ball bonding with a 1 mil (25µm) gold wire.

In addition, please refer to the Mindspeed Product Bulletin (document number 0201X-PBD-001). Care must be taken when selecting chip capacitors, since they must have good low ESR characteristics up to 1 Ghz. It is also important that the termination materials of the capacitor be compatible with the attach method used.

Tin/Lead (Pb/Sn) or Tin (Sn) solder finish capacitors are incompatible with silver-filled epoxies. Palladium/Silver (Pd/Ag) terminations are compatible with silver filled epoxies. Solder can be used only if the substrate thick-film inks are compatible with Tin-bearing solders.

Figure 1-6. TO-Can Assembly Diagram



## 1.4 Applications

- ATM/SDH/SONET
- PON/FTTH

## 1.5 Pin Definitions

**Table 1-1. Pad Description**

Name	Function
GND	Ground. Connect to the most negative supply. All pads should be connected
D <sub>OUT</sub>	Non-Inverted Data Output. Differential output with D <sub>OUT</sub>
V <sub>CC</sub>	Power. Connect to most positive supply. Either or both pads may be used.
PINK	Photodiode Cathode connection. Connect photodiode between PINK and PINA. Connect de-coupling cap between PINK and GND (470pF typ).
PINA	Photodiode Anode connection. Connect photodiode between PINA and PINK.
D <sub>OUT</sub>	Inverted Data Output. Differential output with D <sub>OUT</sub>
MON	Optical input power monitor. Current sink output, current flow into pin.
AGC	AGC disable/monitor (test mode enable)



## 2.0 Product Specification

---

### 2.1 Absolute Maximum Ratings

Table 2-1. Absolute Maximum Ratings

Symbol	Parameter	Rating	Units
$V_{CC}$	Power supply ( $V_{CC}$ -GND)	4.5	V
$T_A$	Operating ambient	-40 to +85	°C
$T_J$	Junction temperature (die)	+150	°C
$T_{STG}$	Storage temperature	-65 to +150	°C
$I_{MAX}$	Input Overload Current	4.5	MA <sub>PP</sub>

### 2.2 Recommended Operating Conditions

Table 2-2. Recommended Operating System

Symbol	Parameter	Rating	Units
$V_{CC}$	Power supply ( $V_{CC}$ -GND)	$3.3 \pm 10\%$	V
$T_J$	Junction temperature (die)	-40 to +100	°C
$T_A$	Operating ambient temperature	-40 to +85 <sup>1</sup>	°C

### 2.3 DC Characteristics

Table 2-3. DC Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units
$V_B$	PIN Photodiode bias voltage (PINK - PINA)	1.5	1.6	1.8	V
$V_{OH}$ & $V_{OL}$	Output High and Low Voltages	1.1	1.6	2.4	V
$V_{CM}$	Common mode output voltage	1.4	1.6	1.9	V
$I_{CC}$	Supply current (no loads)	--	30	45	mA

**NOTE:**

1. Die are tested and guaranteed at 25 °C, and are designed and characterized to operate over the whole temperature range.

## 2.4 AC Characteristics

**Table 2-4. AC Characteristics**

Symbol	Parameter	Min.	Typ.	Max.	Units
R <sub>OUT</sub>	Output impedance (single ended) <sup>3</sup>	30	45	60	Ω
I <sub>NOISE</sub>	Total integrated input referred RMS noise <sup>1,2,8</sup>	50	70	91	nA
G	Small signal Transimpedance <sup>3, 4</sup> Single ended Differential	14 28	18 36	23 46	KΩ
BW	Bandwidth (-3dB point optical) <sup>1, 5, 8</sup>	340	400	460	MHz
PSSR	Power Supply Rejection Ratio (<4 MHz) <sup>8</sup>	27	30	31	dB
V <sub>D</sub>	Differential output voltage <sup>3, 8</sup>	600	800	1000	mV
LF cutoff	Lower frequency cutoff (-3 dB corner) <sup>8</sup>	-	40	50	KHz
OS <sub>PULSE</sub>	Pulse overshoot <sup>1, 8, 9</sup>	-	13	20	%
T <sub>PWD</sub>	Pulse width distortion <sup>1, 8</sup>	-	3	8	%
T <sub>AGC</sub>	AGC Time constant <sup>6, 8, 11</sup>	-	32	1800	us
Jitter	Jitter <sup>1, 8, 9</sup>	-	145	200	ps, p-p
PIN(mean), min	Optical Sensitivity <sup>1,2,8</sup>	-	-32	-	dBm
I <sub>max</sub>	Input Overload Current	-	-	4.5	mA <sub>pp</sub>

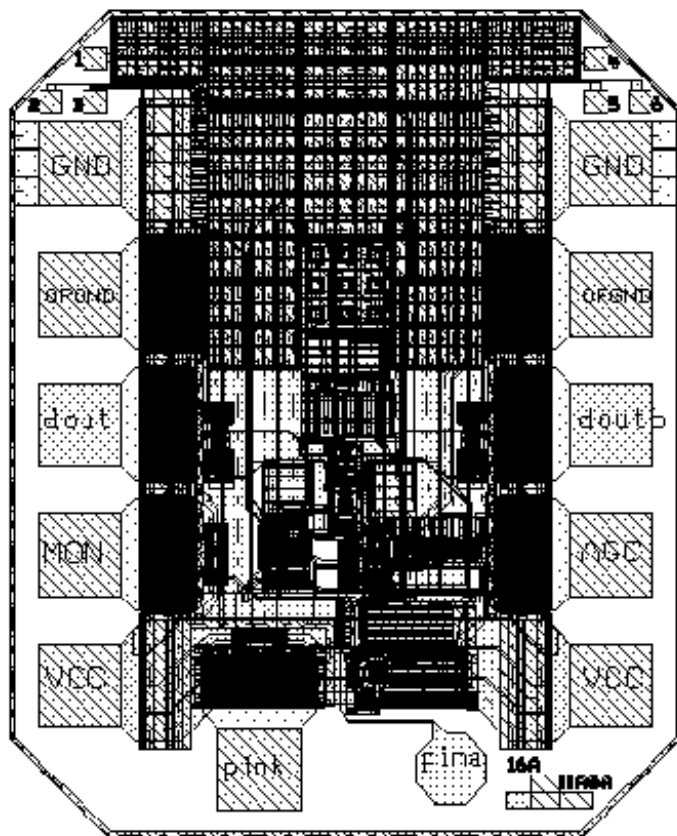
**NOTES:**

1. Measured with input capacitance, C<sub>IN</sub> = 0.7 pF
2. Assuming a photodiode responsivity of 0.9 A/W, at an extinction ratio of 10 dB and BER of 10<sup>-10</sup> BW=415 MHz
3. The MC2009 is designed to drive a load >500Ω.
4. Measured at 1 MHz, 1 uA
5. Measured at -30 dBm
6. AGC time constant can be increased by adding a capacitor from AGC pad to ground
7. Worst case occurs at the AGC knee point. This corresponds to approximate optical power levels in the range of -20 dBm to -25 dBm.
8. Guaranteed by design and characterization.
9. Optical input >= -20 dBm.
10. Die are tested and guaranteed at 25 °C, however are characterized to operate over the whole temperature range.
11. For a 30 db input signal change.



## 2.5 Bare Die Layout and X Y Coordinates

Table 2-5. Bare Die Layout Example



Pad	X	Y
GND	-307	300
GNDD <sub>OUT</sub>	-307	150
D <sub>OUT</sub>	-307	0
MON	-307	-150
V <sub>CC</sub>	-307	-300
PINK	-99.25	-397
PINA	124.8	-397
V <sub>CC</sub>	307	-300
AGC	307	-150
D <sub>OUT</sub>	307	0
GNDD <sub>OUT</sub>	307	150
GND	307	300

**Notes:**

- Process technology: CMOS, Silicon Nitride passivation
- Die thickness: 300 μm
- Pad metallization: Aluminum
- Die size: 890 μm x 1020 μm
- Pad opening: 86 μmsq
- Octagonal pad: 70 μm across flat
- Pad Centers in μm referenced to center of device.

© 2004, Mindspeed Technologies™, Inc. All rights reserved.

Information in this document is provided in connection with Mindspeed Technologies™ ("Mindspeed™") products. These materials are provided by Mindspeed as a service to its customers and may be used for informational purposes only. Except as provided in Mindspeed's Terms and Conditions of Sale for such products or in any separate agreement related to this document, Mindspeed assumes no liability whatsoever. Mindspeed assumes no responsibility for errors or omissions in these materials. Mindspeed may make changes to specifications and product descriptions at any time, without notice. Mindspeed makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MINDSPEED PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MINDSPEED FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MINDSPEED SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

Mindspeed products are not intended for use in medical, lifesaving or life sustaining applications. Mindspeed customers using or selling Mindspeed products for use in such applications do so at their own risk and agree to fully indemnify Mindspeed for any damages resulting from such improper use or sale.

[www.mindspeed.com](http://www.mindspeed.com)

General Information:  
U.S. and Canada: (800) 854-8099  
International: (949) 483-6996  
Headquarters - Newport Beach  
4000 MacArthur Blvd., East Tower  
Newport Beach, CA. 92660