M02009

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.

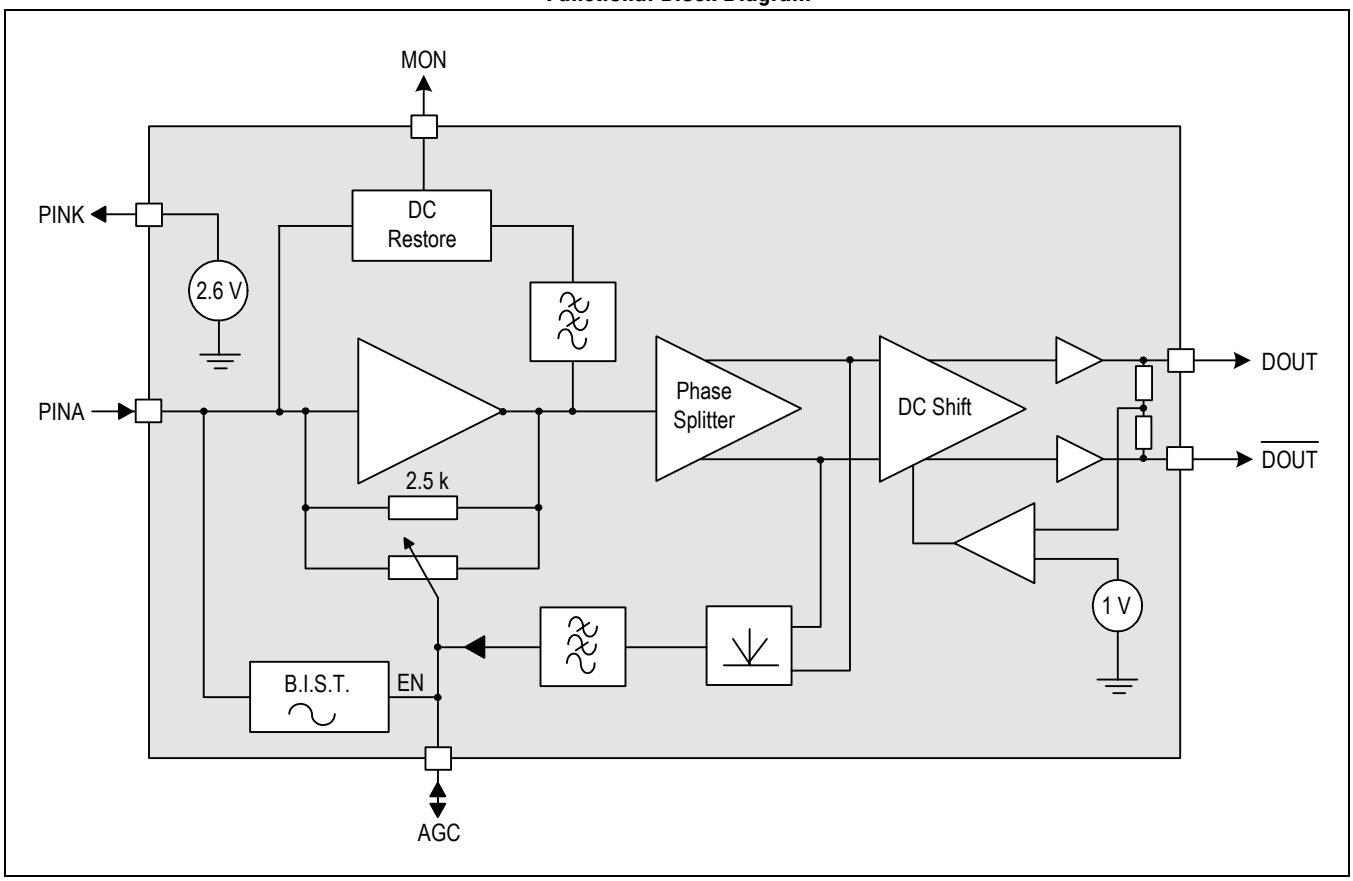
Applications

- 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 comsumption 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

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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.

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Figure 1-1. M02009 Block Diagram

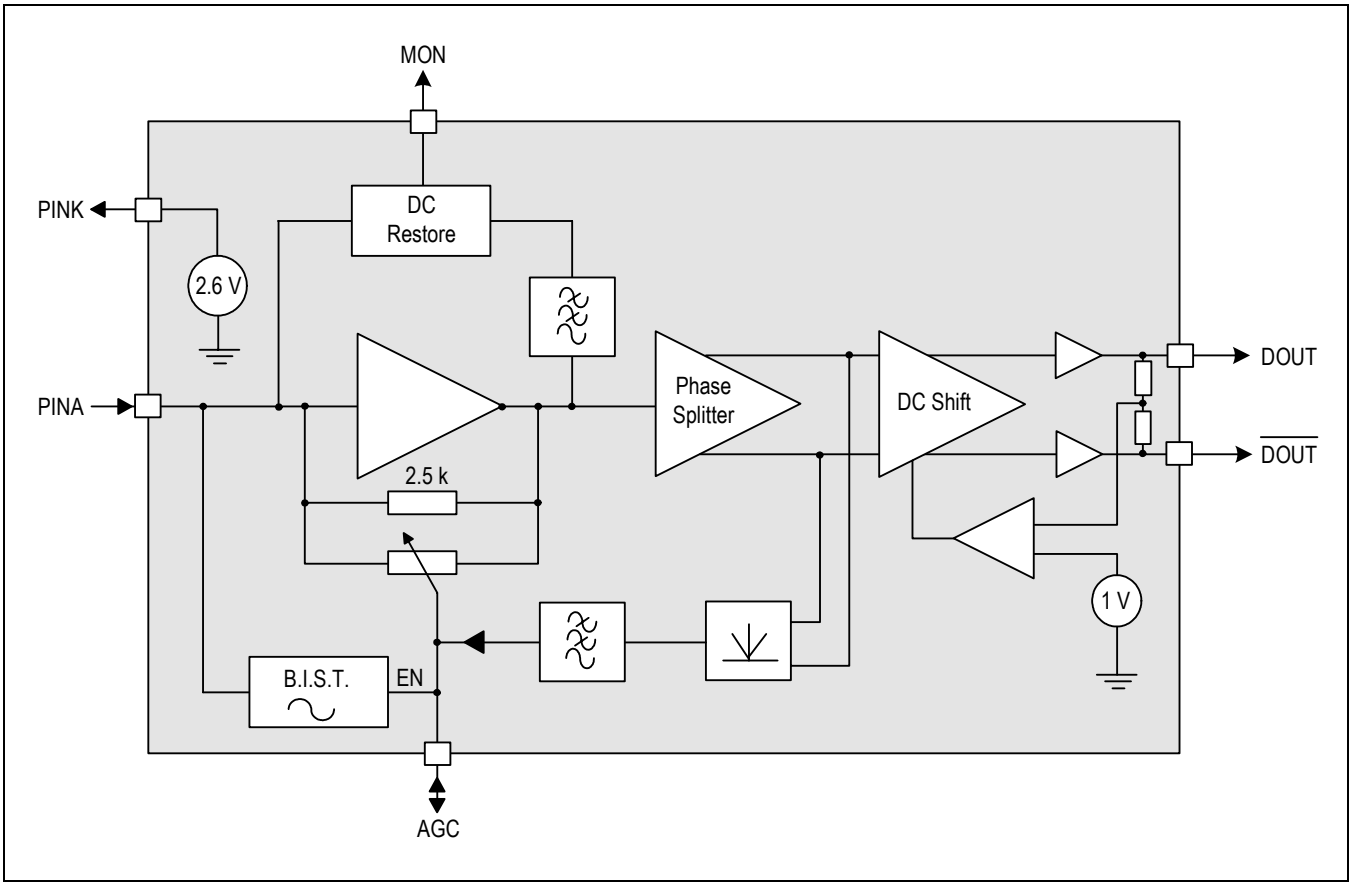
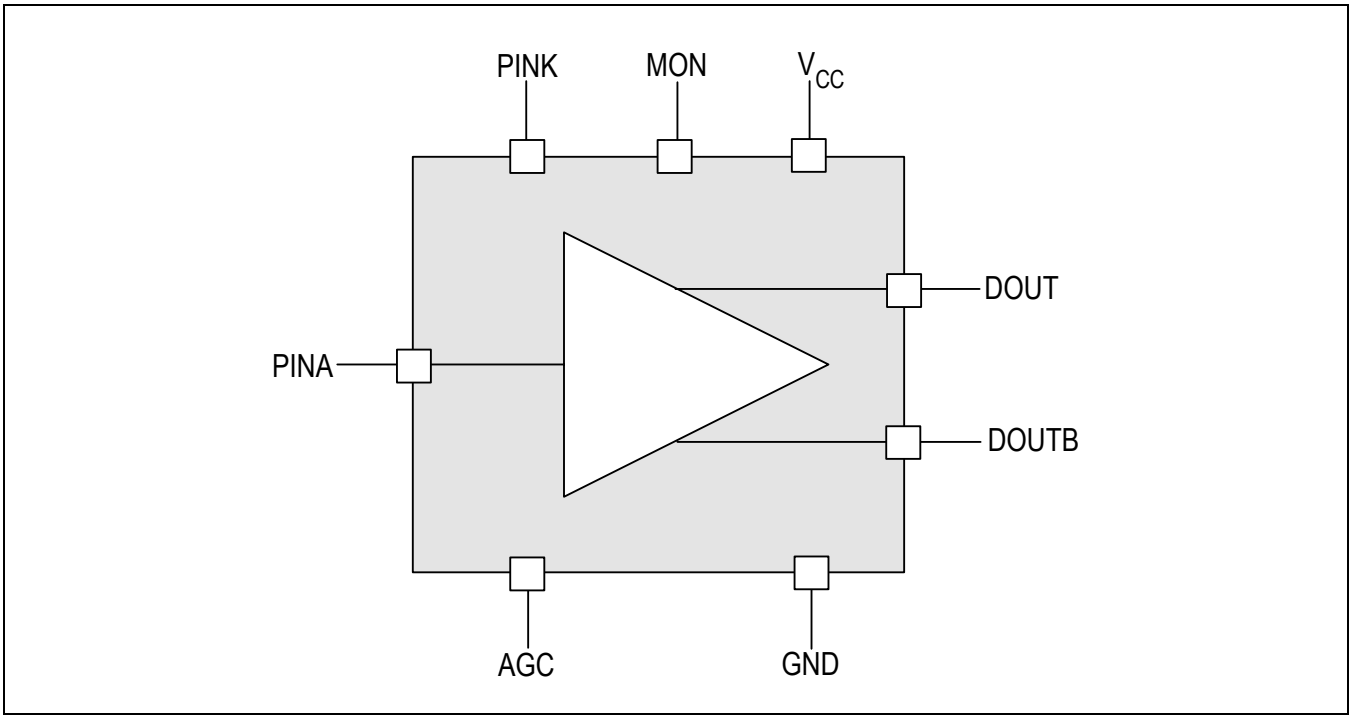


Figure 1-2. Top level diagram



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 comsumption 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.

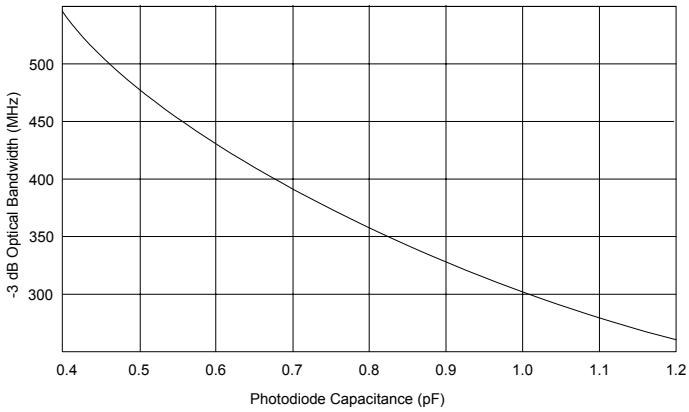
1.3.4 Monitor Output

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 Vcc. 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 Vcc should be used. Note that for linearity, ensure that Vmon is always > 1V.

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

Typical Bandwidth vs. Photodiode Capacitance



Sensitivity vs Responsivity vs Photodiode Capacitance

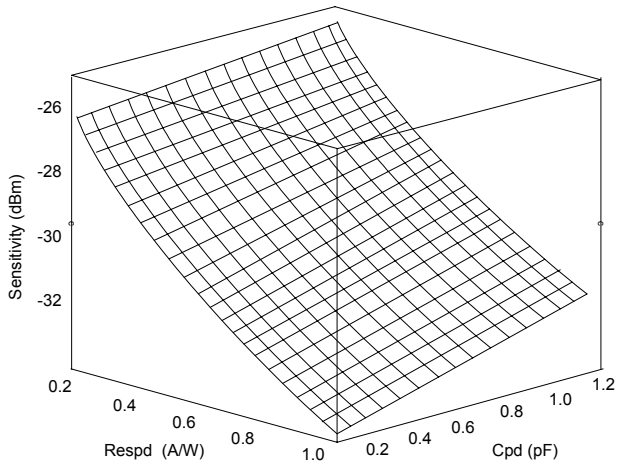


Figure 1-4. Typical Performance (2 of 3)

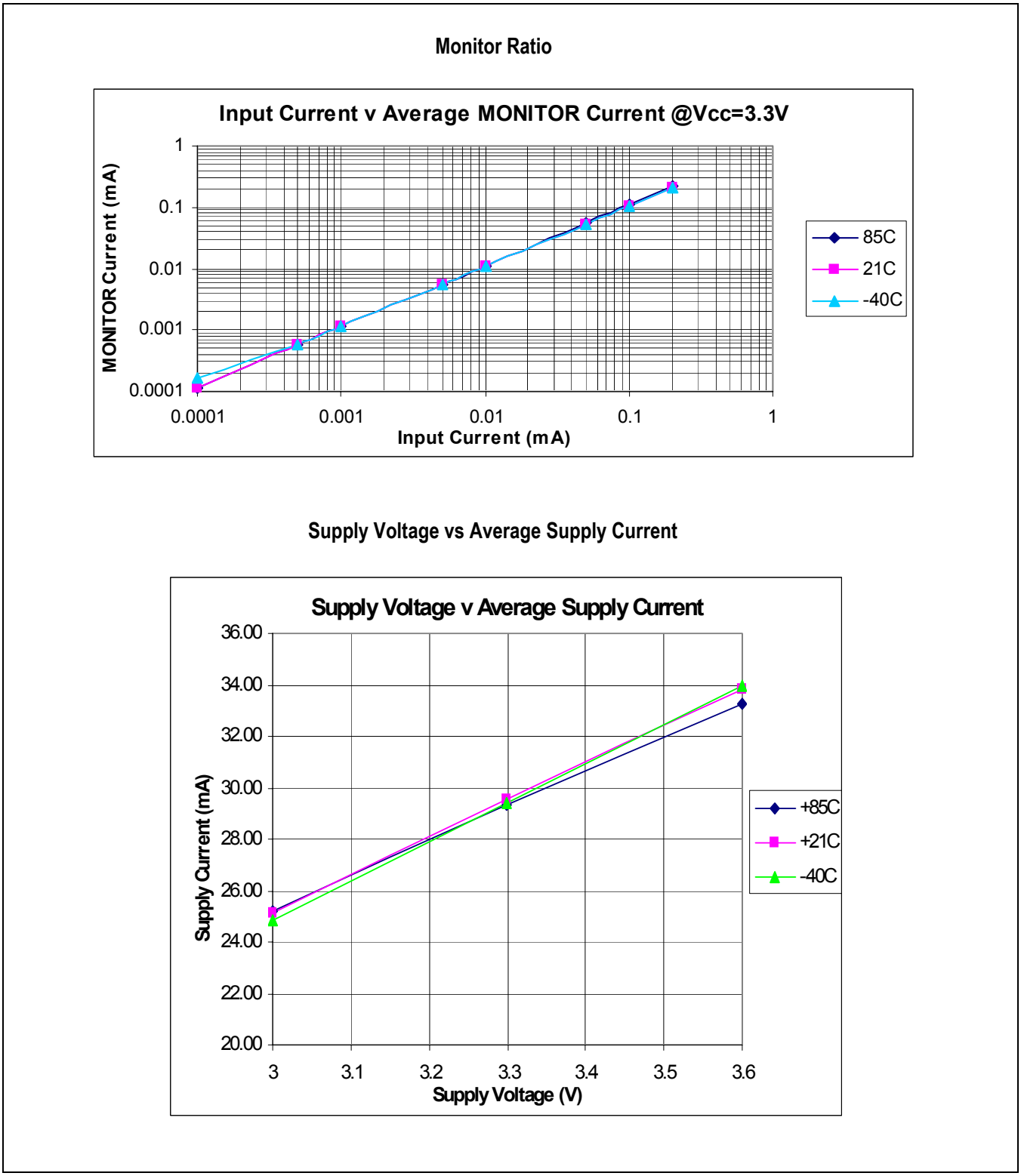
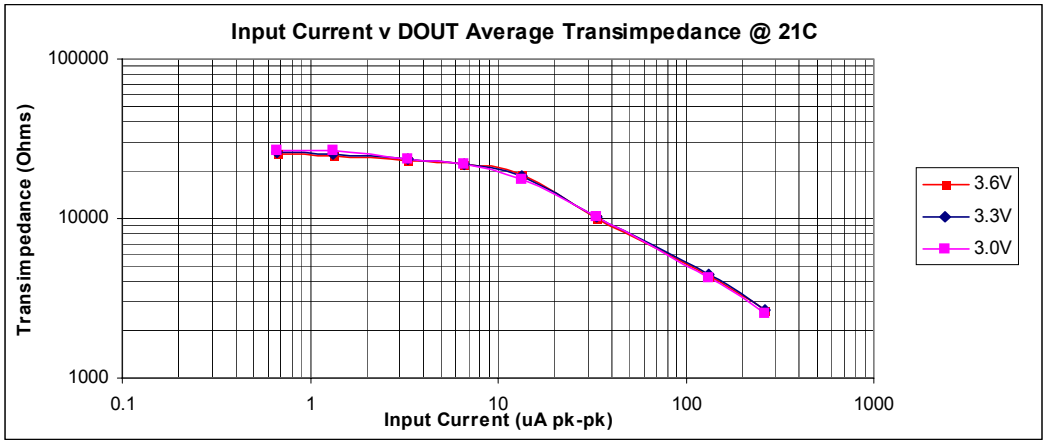
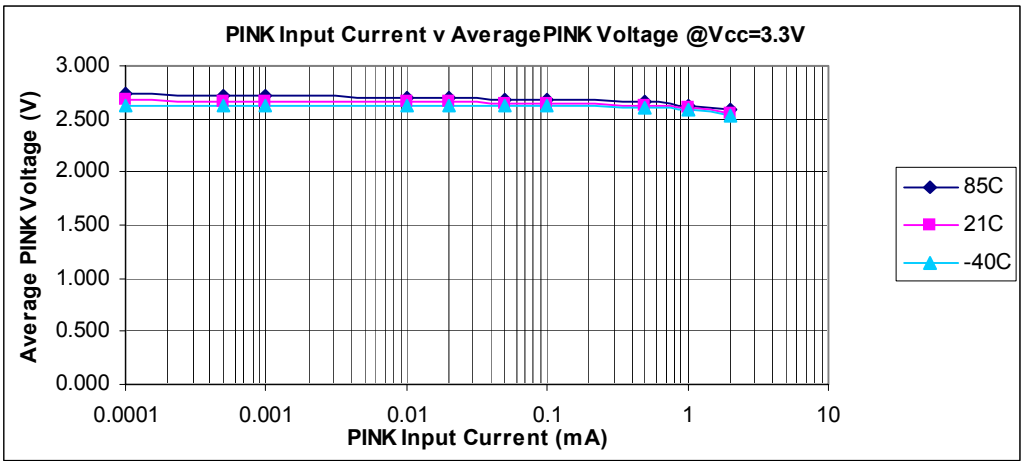


Figure 1-5. Typical Performance (3 of 3)

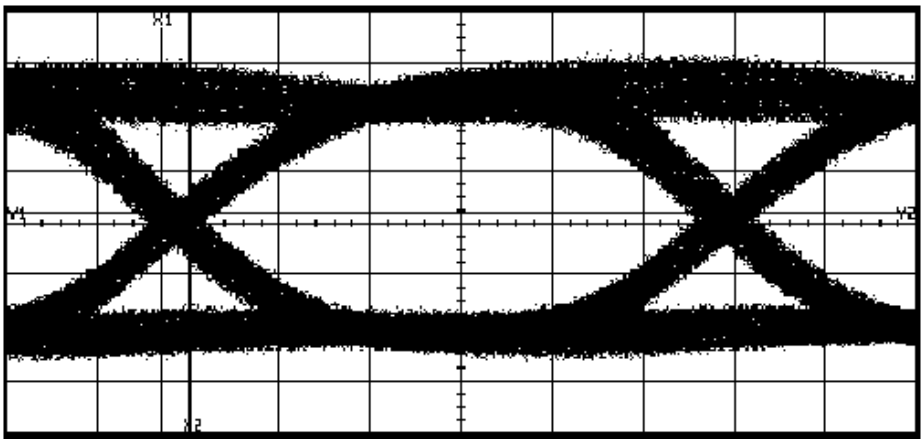
Input Current vs Dout Average Transimpedance



PINK Input Current vs Average PINK Voltage



Eye Diagram @ - 20 dBm



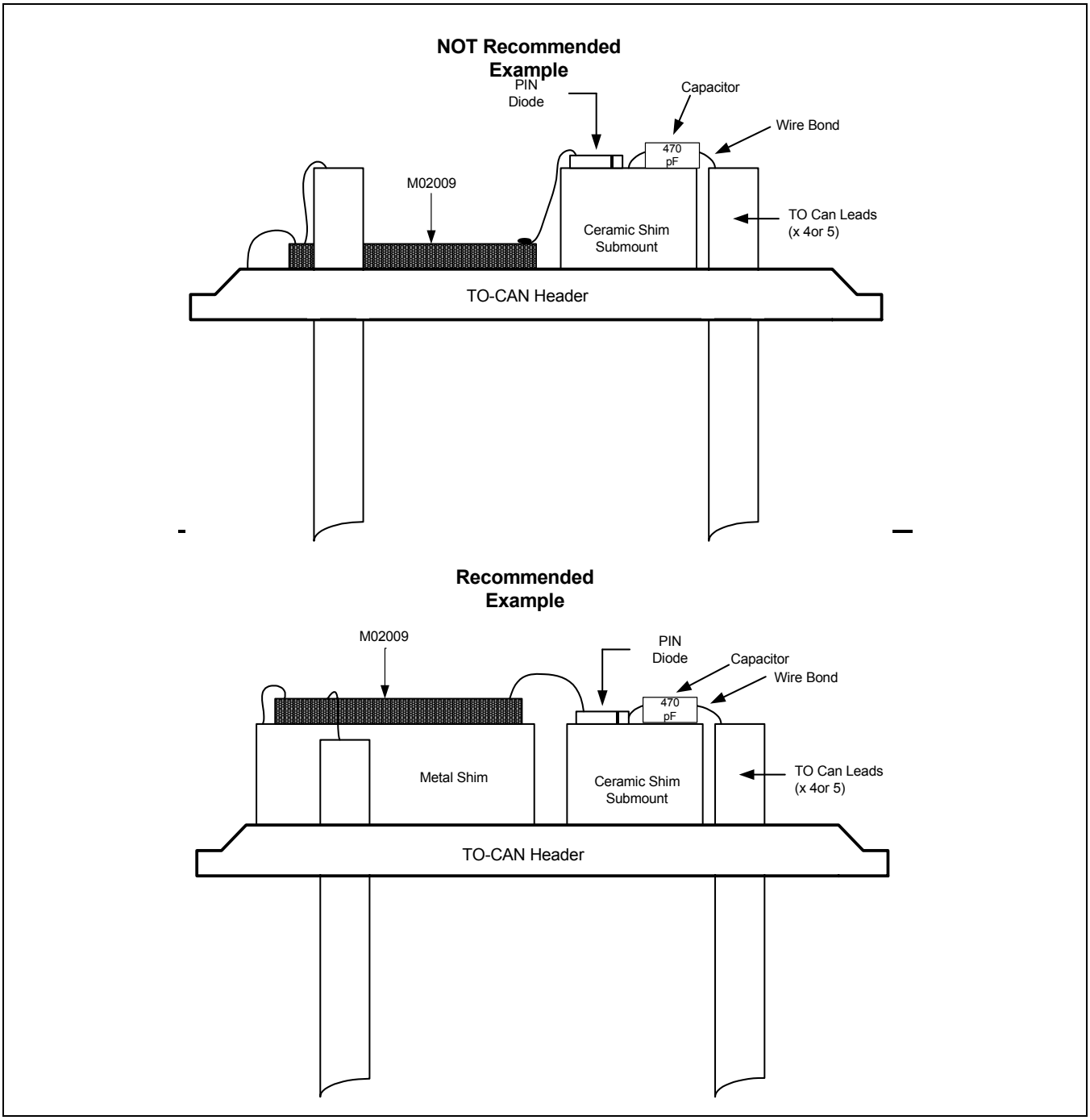
1.3.5 Assembly

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_{OUT}	Non-Inverted Data Output. Differential output with D_{OUT}
V_{CC}	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_{OUT}	Inverted Data Output. Differential output with D_{OUT}
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_{PP}

2.2 Recommended Operating Conditions

Table 2-2. Recommended Operating System

Symbol	Parameter	Rating	Units
V_{CC}	Power supply (V_{CC}-GND)	3.3 ± 10%	V
T_J	Junction temperature (die)	-40 to +100	°C
T_A	Operating ambient temperature	-40 to +85 [1]	°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

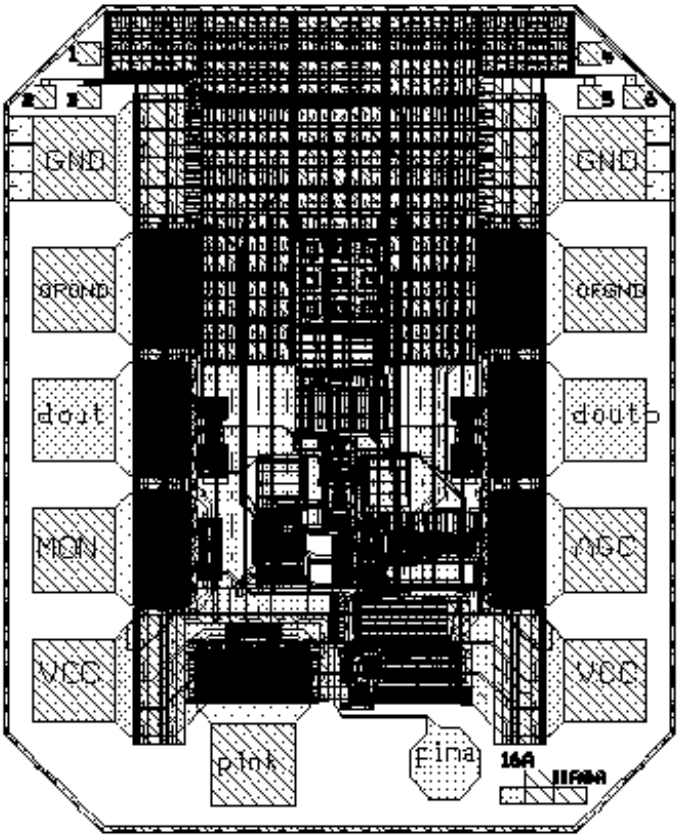
Symbol	Parameter	Min.	Typ.	Max.	Units
R_{OUT}	Output impedance (single ended) [3]	30	45	60	Ω
I_{NOISE}	Total integrated input referred RMS noise[1,2,8]	50	70	91	nA
G	Small signal Transimpedance [3, 4] Single ended Diffferential	 14 28	 18 36	 23 46	KΩ
BW	Bandwidth (-3dB point optical) [1, 5, 8]	340	400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

NOTES:

1. Measured with input capacitance, C_{IN} = 0.7 pF
2. Assuming a photodiode responsivity of 0.9 A/W, at an extinction ratio of 10 dB and BER of 10^{-10} 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 appoximate 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
$GNDD_{OUT}$	-307	150
D_{OUT}	-307	0
MON	-307	-150
V_{CC}	-307	-300
PINK	-99.25	-397
PINA	124.8	-397
V_{CC}	307	-300
AGC	307	-150
D_{OUT}	307	0
$GNDD_{OUT}$	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.

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