

### FEATURES

Integrated SiGe PIN photodiode, transimpedance amplifier (TIA), and limiting amplifier (LA)

Power monitor output: 1.0 A/W at O band wavelengths

50  $\mu\text{m}$  diameter germanium photodiode

Input sensitivity

$P_{\text{OMA}} = -16.5 \text{ dBm}$

$P_{\text{AVE}} = -17.3 \text{ dBm}$  (ER = 6 dB)

PRBS31 at 10.52 Gbps, BER =  $10^{-12}$ ,  $\lambda = 1270 \text{ nm}$ , 1290 nm, 1300 nm, 1310 nm, and 1330 nm

Antireflective coating (ARC) optimized to 1310 nm

Single 3.3 V supply

Power dissipation: 102 mW

Differential output swing: 460 mV p-p

On-chip power monitor function

Die size: 0.835 mm  $\times$  0.675 mm

### APPLICATIONS

Optical module receivers up to 11.3 Gbps

Short range 10 Gb SONET, FC, Ethernet, CPRI, OBSAI, and LTE optical receivers

Capable to be in ROSA, BOSA, or MCM packages

### GENERAL DESCRIPTION

The ADN3010-11 is a high speed optical receiver featuring a proprietary large area germanium photodiode monolithically integrated with a silicon TIA and LA. The integration of the photodiode eliminates bond wires between the diode and the TIA that provides guaranteed performance and improved manufacturing reliability. The 50  $\mu\text{m}$  diameter photodetector enables an easy optical coupling design when aligned with a single mode fiber (SMF). With a 1310 nm optimized ARC, the ADN3010-11 supports 10GBASE-LR and other applications with extended data rates of up to 11.3 Gbps.

Although the ADN3010-11 can operate in the wavelength range from 850 nm to 1565 nm, it has an antireflective coating (ARC) centered at 1310 nm and is characterized only at original band

### FUNCTIONAL BLOCK DIAGRAM

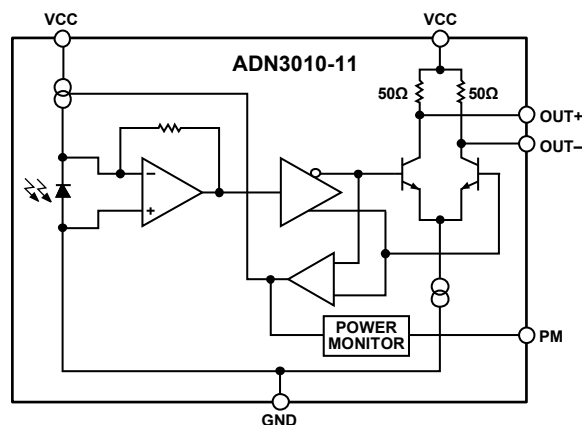


Figure 1.

(O band) wavelengths (1270 nm, 1290 nm, 1300 nm, 1310 nm, and 1330 nm) in this data sheet.

The power monitor pin provides either an output voltage or current that is proportional to the sensed average photocurrent.

Typical power consumption of the ADN3010-11 is 102 mW from a single 3.3 V supply. When the output is saturated, it has a typical differential amplitude of 460 mV p-p at 10.52 Gbps.

The ADN3010-11 is available in die form, and it is operational over the extended industrial temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

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REVISION HISTORY

1/15—Revision 0: Initial Version

## SPECIFICATIONS

$T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = 3.0\text{ V}$  to  $3.6\text{ V}$ ,  $R_L = 100\ \Omega$  differential (ac-coupled),  $\lambda = 1310\text{ nm}$ , unless otherwise noted.

Table 1.

| Parameter                                           | Test Conditions/Comments                                                                                                      | Min   | Typ              | Max  | Unit                      |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------|------------------|------|---------------------------|
| <b>OPTICAL INPUT CHARACTERISTICS</b>                |                                                                                                                               |       |                  |      |                           |
| Data Rate                                           |                                                                                                                               |       | 10.52            | 11.3 | Gbps                      |
| Photodiode Diameter                                 |                                                                                                                               |       | 50               |      | $\mu\text{m}$             |
| Input Sensitivity                                   | PRBS31 at 10.52 Gbps, bit error rate (BER) = $10^{-12}$ , $\lambda = 1270\text{ nm}$ , 1290 nm, 1300 nm, 1310 nm, and 1330 nm |       |                  |      |                           |
| Optical Modulation Amplitude (OMA) Power, $P_{OMA}$ | $T_A = 25^{\circ}\text{C}$ , $V_{CC} = 3.3\text{ V}$                                                                          |       | -16.5            |      | dBm                       |
|                                                     | $T_A = 85^{\circ}\text{C}$ , $V_{CC} = 3.0\text{ V}$                                                                          | -15.0 |                  |      | dBm                       |
| Optical Average Power, $P_{AVE}^1$                  | Extinction ratio (ER) = 6 dB, $T_A = 25^{\circ}\text{C}$ , $V_{CC} = 3.3\text{ V}$                                            |       | -17.3            |      | dBm                       |
| <b>OUTPUT CHARACTERISTICS</b>                       |                                                                                                                               |       |                  |      |                           |
| Output Impedance                                    | Differential                                                                                                                  |       | 100              |      | $\Omega$                  |
|                                                     | Each output, single-ended                                                                                                     |       | 50               |      | $\Omega$                  |
| Differential Output Voltage Swing (Limited)         | Data rate = 10.52 Gbps                                                                                                        |       | 460              |      | mV p-p                    |
|                                                     | Data rate = 1.0 Gbps                                                                                                          |       | 520              |      | mV p-p                    |
| Rise/Fall Time                                      | 20% to 80%                                                                                                                    |       | 30.5             |      | ps                        |
| Duty Cycle Distortion                               | PRBS15 at 10.52 Gbps                                                                                                          |       | 0.82             |      | ps                        |
| Deterministic Jitter (Peak-to-Peak)                 | PRBS15 at 10.52 Gbps                                                                                                          |       | 22.8             |      | ps                        |
| Random Jitter (RMS)                                 | PRBS15 at 10.52 Gbps                                                                                                          |       | 1.74             |      | ps                        |
| Power Monitor Output (PMO) in O Band <sup>2</sup>   | $\lambda = 1270\text{ nm}$ , 1290 nm, 1300 nm, 1310 nm, and 1330 nm                                                           |       | 1.0              |      | A/W                       |
| Differential Common-Mode Voltage                    | OUT+ and OUT- each dc-coupled $50\ \Omega$ to $V_{CC}$                                                                        |       | $V_{CC} - 0.113$ |      | V                         |
| <b>DC CHARACTERISTICS</b>                           |                                                                                                                               |       |                  |      |                           |
| Supply Voltage, $V_{CC}$                            |                                                                                                                               | 3.0   | 3.3              | 3.6  | V                         |
| Supply Current, $I_{CC}$                            |                                                                                                                               |       | 31               | 49   | mA                        |
| PMO Slope                                           | Voltage mode, open circuit voltage output ( $V_{OC}$ )                                                                        |       | 730              |      | $\mu\text{V}/\mu\text{W}$ |
|                                                     | Current mode, short-circuit current output ( $I_{SC}$ )                                                                       |       | 0.73             |      | $\mu\text{A}/\mu\text{W}$ |
| PMO Offset                                          | No optical input, voltage mode                                                                                                |       | 32               |      | mV                        |
| Interception                                        | No optical input, current mode                                                                                                |       | 32               |      | $\mu\text{A}$             |
| OPERATING TEMPERATURE RANGE                         |                                                                                                                               | -40   |                  | +85  | $^{\circ}\text{C}$        |

<sup>1</sup> From a known OMA sensitivity and optical ER,  $P_{AVE}$  sensitivity can be calculated with

$$P_{AVE}(\text{dBm}) = P_{OMA}(\text{dBm}) + 10\log((10^{(ER/10)} + 1)/(2 \times (10^{(ER/10)} - 1)))$$

where  $P_{OMA} = -16.5\text{ dBm}$  and  $ER = 6\text{ dB}$ .

<sup>2</sup> O band wavelength range is 1260 nm to 1360 nm.

## ABSOLUTE MAXIMUM RATINGS

Table 2.

| Parameter                                           | Rating                                          |
|-----------------------------------------------------|-------------------------------------------------|
| Supply Voltage                                      | 4.5 V                                           |
| Optical Input Peak Power                            | 10 dBm                                          |
| Maximum Voltage to All Input and Output Signal Pins | $V_{CC} + 0.4\text{ V}$                         |
| Minimum Voltage to All Input and Output Pins        | $\text{GND} - 0.4\text{ V}$                     |
| Storage Temperature Range                           | $-65^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ |
| Die Attach Temperature (<30 sec)                    | $410^{\circ}\text{C}$                           |
| Junction Temperature                                | $150^{\circ}\text{C}$                           |

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

### ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

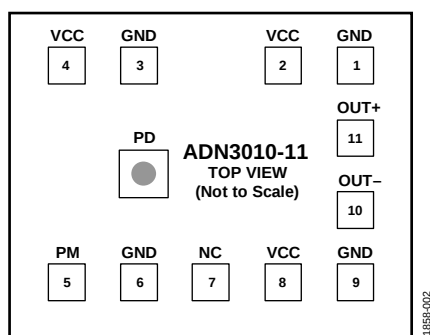


Figure 2. Pad Configuration

Table 3. Pad Function Descriptions

| Pad No. | Mnemonic | X (mm) <sup>1</sup> | Y (mm) <sup>1</sup> | Description                                       |
|---------|----------|---------------------|---------------------|---------------------------------------------------|
| 1       | GND      | 0.300               | 0.225               | Amplifier Ground.                                 |
| 2       | VCC      | 0.150               | 0.225               | Output Stage 3.3 V Supply.                        |
| 3       | GND      | -0.150              | 0.225               | Amplifier Ground.                                 |
| 4       | VCC      | -0.300              | 0.225               | Input Amplifier 3.3 V Supply.                     |
| 5       | PM       | -0.300              | -0.225              | Power Monitor Output.                             |
| 6       | GND      | -0.150              | -0.225              | Amplifier Ground.                                 |
| 7       | NC       | 0                   | -0.225              | No Connection. Do not bond to this pad.           |
| 8       | VCC      | 0.150               | -0.225              | Output Stage 3.3 V Supply.                        |
| 9       | GND      | 0.300               | -0.225              | Amplifier Ground.                                 |
| 10      | OUT-     | 0.300               | -0.075              | CML, Negative Output. AC coupling is recommended. |
| 11      | OUT+     | 0.300               | 0.075               | CML, Positive Output. AC coupling is recommended. |
|         | PD       | -0.140              | 0                   | Photodiode.                                       |

<sup>1</sup> Referenced to die center.

## TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{ V}$ ,  $R_{LOAD} = 100\ \Omega$  differential (ac-coupled),  $\lambda = 1310\text{ nm}$ , unless otherwise noted.

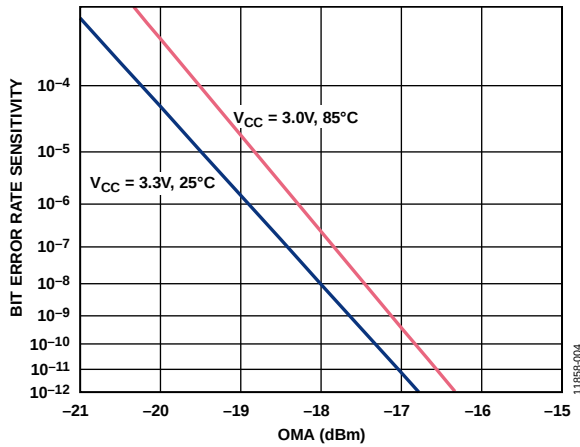


Figure 3. BER Sensitivity at 10.52 Gbps vs. OMA at Various Temperatures and Supplies

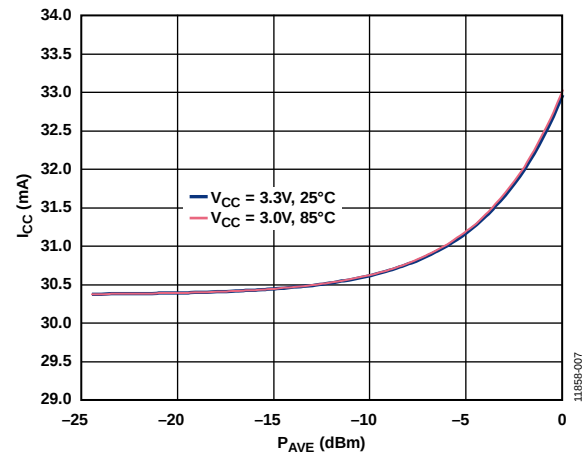


Figure 6.  $I_{CC}$  vs.  $P_{AVE}$  at Various Temperatures and Supplies

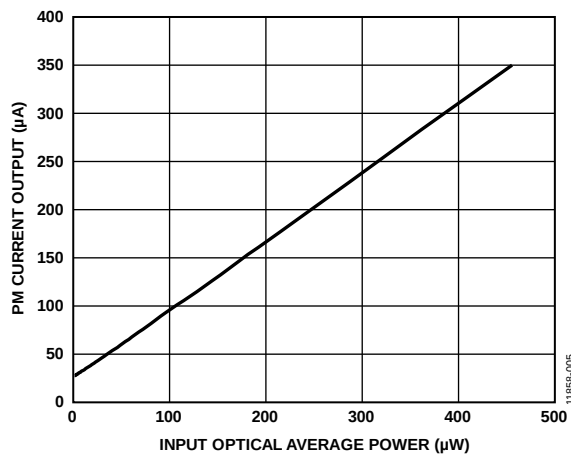


Figure 4. PM Current Output vs. Input Optical Average Power

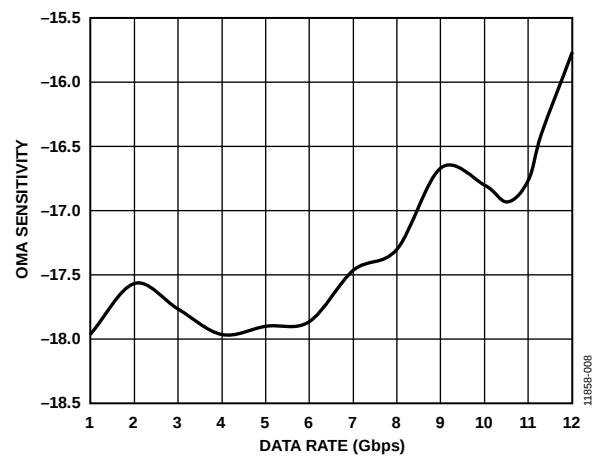


Figure 7. OMA Sensitivity vs. Data Rate

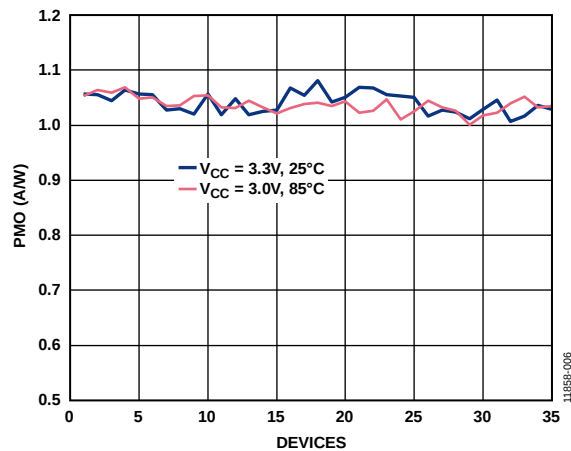


Figure 5. Power Monitor Output at Various Temperatures and Supplies

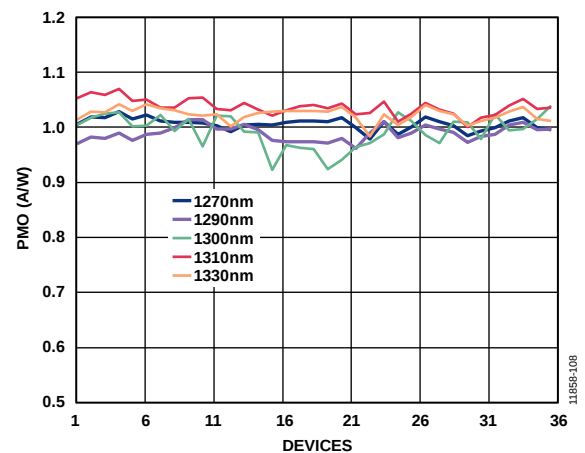


Figure 8. Power Monitor Output at Various Wavelengths,  $T_A = 85^\circ\text{C}$ ,  $V_{CC} = 3.0\text{ V}$

## THEORY OF OPERATION

The power monitor pin, PM, provides either a voltage or a current output that is proportional to the sensed average photocurrent. This feature allows the user to check how well a fiber or an optical coupling system is aligned to the [ADN3010-11](#) photodetector (PD), which is typically useful during receiver optical subassembly (ROSA) manufacturing.

To receive a PM pin signal from a transistor outline (TO) packaged ROSA, the TO header must support at least five pins.

Figure 3 shows BER at 10.52 Gbps vs. input OMA at various temperatures and supplies. In Figure 3, fitting the curve to a

best fit straight line allows extrapolation of the OMA sensitivities at either  $\text{BER} = 10^{-10}$  or  $10^{-12}$  from the measured OMA input data at a wider range of BER. The extrapolated  $\text{BER} = 10^{-10}$  sensitivity spans from  $-16.8$  dBm to  $-17.4$  dBm OMA and the  $\text{BER} = 10^{-12}$  sensitivity spans from  $-16.4$  dBm to  $-16.8$  dBm OMA at various temperature and supply voltages.

Figure 6 shows the [ADN3010-11](#) supply current,  $I_{\text{CC}}$ , vs. optical average power,  $P_{\text{AVE}}$ , at various temperatures and supply voltages.

## APPLICATIONS INFORMATION

### BONDING

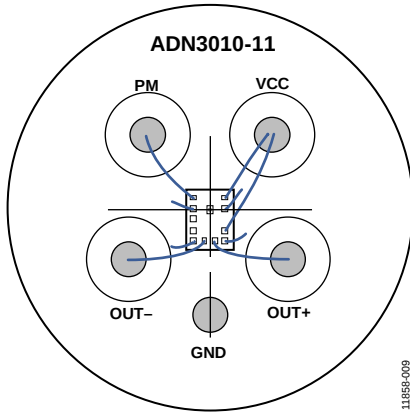


Figure 9. Typical Bonding Diagram for 5-Pin Metal Header Package [TO-46]

By using the recommended sequence in Table 4, the ESD or electronics stress introduced by a bonding tip can be reduced.

Table 4. Recommended Bonding Sequence

| Bonding Order | Pad No.        | Mnemonic |
|---------------|----------------|----------|
| 1             | 9              | GND      |
| 2             | 8 <sup>1</sup> | VCC      |
| 3             | 6              | GND      |
| 4             | 5              | PM       |
| 5             | 4              | VCC      |
| 6             | 3              | GND      |
| 7             | 2              | VCC      |
| 8             | 1              | GND      |
| 9             | 11             | OUT+     |
| 10            | 10             | OUT-     |

<sup>1</sup> Bonding this pad is not necessary in a metal header package [TO].

### POWER MONITOR (PM) OUTPUT APPLICATIONS

The PM output can be set in either voltage output mode or current output mode for a mirrored photodiode current,  $I_{PD}$ , which includes sensed photocurrent plus a preset offset current. Therefore,  $I_{PD}$  is proportional to the sensed photodiode current.

The setup of the  $V_{OC}$  (open circuit voltage output) and  $I_{SC}$  (short circuit current output) measurement is shown in Figure 10.

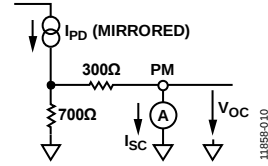


Figure 10. Typical PM Circuit and Test Setup

$V_{OC}$  and  $I_{SC}$  are determined depending on the detection accuracy of  $I_{PD}$ , as follows:

$$V_{OC} = 0.7 \text{ V at } I_{PD} = 1.0 \text{ mA} \pm 10\%$$

$$I_{SC} = 700 \text{ } \mu\text{A at } I_{PD} = 1.0 \text{ mA} \pm 5\%$$

where  $I_{PD}$  is proportional to the PD dark current and process tolerance.

The PMO offset is composed of the ADN3010-11 photodiode dark current (mirrored) and a preset offset current (see Table 1 for details).

### POWER MONITOR OUTPUT ESTIMATION

The PMO can be used to achieve optimal optical coupling. To use the PM pin properly, calibrate the integrated PD dark current out because the dark current is temperature and reversed bias dependent.

In voltage mode,

$$PMO = (V_{OC} - V_{DK})/0.7/P_{AVE} \text{ (optical power)}$$

In current mode,

$$PMO = (I_{SC} - I_{DK})/0.7/P_{AVE} \text{ (optical power)}$$

where:

$PMO$  is the power monitor output (A/W) in voltage and current modes.

$V_{OC}$  is the voltage output (mV) produced by an input light with an optical average power,  $P_{AVE}$ .

$V_{DK}$  is the voltage output (mV) at no light input,  $P_{AVE} = 0 \text{ mW}$ .

$P_{AVE}$  is the average optical power of an input light to the receiver PD.

$I_{SC}$  is the current output at an input light with  $P_{AVE} = 100 \text{ mW}$ .

$I_{DK}$  is the current output ( $\mu\text{A}$ ) at no light input,  $P_{AVE} = 0 \text{ mW}$ .

## OUTLINE DIMENSIONS

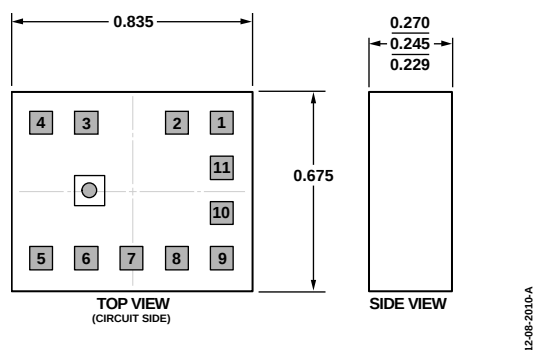


Figure 11. 11-Pad Bare Die [CHIP]  
(C-11-1)

Dimensions shown in millimeters

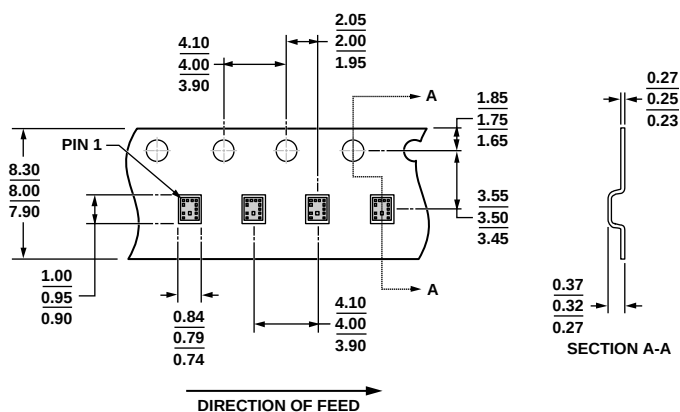


Figure 12. Tape and Reel Outline Dimensions  
Dimensions shown in millimeters

## DIE SPECIFICATIONS AND ASSEMBLY RECOMMENDATIONS

Table 5. Die Specifications

| Parameter            | Value                                                            | Unit           |
|----------------------|------------------------------------------------------------------|----------------|
| Die Size             | 0.835 (−0.04) × 0.675 (−0.04)                                    | mm             |
| Saw Blade Size       | 0.04                                                             | mm             |
| Die Grind Thickness  | 0.25 ± 0.0127 (10.0 ± 0.5 mils), 675 μm before backside grinding | mm             |
| Bond Pad             | 0.076 × 0.076                                                    | mm             |
| Backside Contact     | Ground                                                           | Not applicable |
| Passivation Openings | 0.076 × 0.076                                                    | mm             |
| Photodiode Diameter  | 0.05                                                             | mm             |

Table 6. Assembly Recommendations

| Assembly Component | Recommendation |
|--------------------|----------------|
| Die Attach         | Ground         |
| Bonding Method     | Ball or wedge  |
| Bonding Sequence   | See Table 4    |

**ORDERING GUIDE**

| Model <sup>1, 2</sup> | Temperature Range | Package Description         | Ordering Quantity | Package Option |
|-----------------------|-------------------|-----------------------------|-------------------|----------------|
| ADN3010-11-50A-R2     | –40°C to +85°C    | 11-Pad Bare Die [CHIP] Reel | 250 per reel      | C-11-1         |
| ADN3010-11-50A-RL7    | –40°C to +85°C    | 11-Pad Bare Die [CHIP] Reel | 5,000 per reel    | C-11-1         |
| ADN3010-11-50A-DF     | –40°C to +85°C    | 6-Inch Film Frame           |                   | C-11-1         |

<sup>1</sup> The ordering guide model is composed of the following fields: -11: data rate option, -50: the integrated photodiode diameter, A: the release version, Rxx: the reel package options, and -DF: film frame package option.

<sup>2</sup> Contact Analog Devices, Inc., for more information about the 6-inch film frame ordering quantity.