**General Description**

The MAX3806 is a high-gain linear preamplifier for distance measurement applications using a laser beam. The device operates from a single +5.0V supply and converts current from an AC-coupled photodiode into a single-ended voltage signal. The input accepts single pulses or bursts of pulses with widths down to 30ns. The amplifier remains linear with input amplitudes from 42nA (SNR = 3) to 40µA. It can also withstand overload signals as large as 2mA. The output stage is designed to drive a high-impedance load to deliver the output-voltage swing at the lowest possible power dissipation. The gain of the preamplifier stage is selected using the GAIN pin to be 60kΩ or 30kΩ. There is also an internal 14dB attenuator that is selected using the ATT pin. The output stage can be disabled (high impedance).

The device is available in a 3mm x 3mm, 12-pin TQFN package and operates over the -40°C to +105°C temperature range.

**Applications**

- LIDAR Sensors for Automotive Applications (ACC, Stop&Go)
- Laser Sensors for Portable Distance Measurement
- Laser Sensors for Industrial Applications

**Features**

- +5V Supply Voltage
- Linearity Range Up to 40µA
- Overload Current Up to 2mA
- 50mW Power Dissipation at +5.0V
- 1.5pA/√Hz Noise Density at 60kΩ Gain
- 14nARMS Input-Referred Noise at 60kΩ Gain
- Selectable Gains (60kΩ, 30kΩ)
- Selectable 14dB Attenuation

**Ordering Information**

<table>
<thead>
<tr>
<th>PART</th>
<th>TEMP RANGE</th>
<th>PIN-PACKAGE</th>
<th>TOP MARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX3806GTC+</td>
<td>-40°C to +105°C</td>
<td>12 TQFN-EP*</td>
<td>ABN</td>
</tr>
</tbody>
</table>

+ Denotes a lead(Pb)-free/RoHS-compliant package.
*EP = Exposed pad.

```
PIN Configuration appears at end of data sheet.
```

**Typical Application Circuits**

```
Typical Application Circuits continued at end of data sheet.
```
Receiver for Optical Distance Measurement

ABSOLUTE MAXIMUM RATINGS
Supply Voltage Range, \( V_{CC} \) .................. -0.5V to +6.0V
Voltage Range at ATT, DIS, GAIN.............. -0.5V to (\( V_{CC} + 0.5V \))
Current Range at IN, OUT.......................... -4mA to +4mA
Continuous Power Dissipation (\( T_A = +70°C \)) 12-Pin TQFN-EP (derate 16.7mW/°C above +70°C) ...1333mW
Storage Temperature Range.......................... -55°C to +150°C
Lead Temperature (soldering, 10s)...................... +300°C

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS
\( (V_{CC} = +4.5V \) to +5.5V, AC-coupled (\( C = 0.01\mu F \)) output load \( \geq 2k\Omega \), \( T_A = -40°C \) to +105°C. Typical values are at \( V_{CC} = +5V \), \( T_A = +25°C \), unless otherwise noted.) (Note 1)

<table>
<thead>
<tr>
<th>PARAMETER SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power-Supply Current</td>
<td>( I_{CC} ) (Note 2)</td>
<td>10</td>
<td>15</td>
<td>mA</td>
<td></td>
</tr>
</tbody>
</table>

INPUT SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input-Referred Noise</td>
<td>Output noise up to 100MHz((gain at 5MHz)) ( C_{IN} = 5pF ), GAIN = 1</td>
<td>14</td>
<td>20</td>
<td></td>
<td>n(\mu{A}\ RMS)</td>
</tr>
<tr>
<td></td>
<td>Output noise up to 100MHz((gain at 5MHz)) ( C_{IN} = 5pF ), GAIN = 0</td>
<td>21</td>
<td>27</td>
<td></td>
<td>n(\mu{A}\ RMS)</td>
</tr>
<tr>
<td>Input-Referred Noise Density</td>
<td>Output noise centered at 5MHz over 100Hz ( C_{IN} = 5pF ), GAIN = 1</td>
<td>1.5</td>
<td>1.8</td>
<td></td>
<td>p(\mu{A}/\sqrt{Hz})</td>
</tr>
<tr>
<td></td>
<td>Output noise centered at 5MHz over 100Hz ( C_{IN} = 5pF ), GAIN = 0</td>
<td>1.7</td>
<td>2.3</td>
<td></td>
<td>p(\mu{A}/\sqrt{Hz})</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>At 1MHz, GAIN = 1</td>
<td>800</td>
<td></td>
<td></td>
<td>(\Omega)</td>
</tr>
<tr>
<td></td>
<td>At 1MHz, GAIN = 0</td>
<td>300</td>
<td></td>
<td></td>
<td>(\Omega)</td>
</tr>
</tbody>
</table>

CMOS/TTL INPUT SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input High Voltage</td>
<td>( V_{IH} )</td>
<td>2</td>
<td>( V_{CC} )</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Input Low Voltage</td>
<td>( V_{IL} )</td>
<td>0</td>
<td>0.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Input Current</td>
<td>( I_{IH}, I_{IL} ) DIS input</td>
<td>±150</td>
<td></td>
<td></td>
<td>(\mu{A})</td>
</tr>
<tr>
<td></td>
<td>( I_{IH} ) GAIN and ATT inputs</td>
<td>-180</td>
<td></td>
<td></td>
<td>(\mu{A})</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>( R_{PULLUP} ) DIS input</td>
<td>60</td>
<td></td>
<td></td>
<td>(k\Omega)</td>
</tr>
<tr>
<td></td>
<td>( R_{PULLDOWN} ) GAIN and ATT inputs</td>
<td>40</td>
<td></td>
<td></td>
<td>(k\Omega)</td>
</tr>
</tbody>
</table>

GENERAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-Signal Transimpedance</td>
<td>( I_{IN} \leq 15\mu{A} ), GAIN = 1</td>
<td>44</td>
<td>60</td>
<td>77</td>
<td>(k\Omega)</td>
</tr>
<tr>
<td></td>
<td>( I_{IN} \leq 50\mu{A} ), GAIN = 0</td>
<td>23</td>
<td>30</td>
<td>37</td>
<td>(k\Omega)</td>
</tr>
<tr>
<td>Small-Signal Bandwidth</td>
<td>( f_{3dB} )</td>
<td>25</td>
<td>49</td>
<td>55</td>
<td>MHz</td>
</tr>
<tr>
<td></td>
<td>( C_{IN} = 5pF ) GAIN = 1, ATT = 0</td>
<td>25</td>
<td>49</td>
<td>55</td>
<td>MHz</td>
</tr>
<tr>
<td></td>
<td>( C_{IN} = 5pF ) GAIN = 0, ATT = 0</td>
<td>55</td>
<td>98</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Gain Peaking</td>
<td>( 5pF \leq C_{IN} \leq 15pF )</td>
<td>1</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Attenuation Stability</td>
<td>ATT = 1; 20log((V_{OUT_ATT_ON}/V_{OUT_ATT_OFF}))</td>
<td>-13</td>
<td>-14</td>
<td>-15</td>
<td>dB</td>
</tr>
</tbody>
</table>

OUTPUT SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Harmonic Distortion</td>
<td>( V_{OUT} = 0.5V ) GAIN = 1</td>
<td>-54</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>( V_{OUT} = 0.5V ) GAIN = 0</td>
<td>-53</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>( V_{OUT} = 10MHz ) GAIN = 1</td>
<td>-38</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>( V_{OUT} = 10MHz ) GAIN = 0</td>
<td>-47</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Power-Supply Noise Rejection (Note 3)</td>
<td>Noise frequency &lt; 1MHz</td>
<td>( GAIN = 1 )</td>
<td>-16</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>( GAIN = 0 )</td>
<td>-23</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
</tbody>
</table>
Receiver for Optical Distance Measurement

ELECTRICAL CHARACTERISTICS (continued)

(VCC = +4.5V to +5.5V, AC-coupled (C = 0.01µF) output load ≥ 2kΩ, TA = -40°C to +105°C. Typical values are at VCC = +5V, TA = +25°C, unless otherwise noted.) (Note 1)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attenuation in Disable Mode</td>
<td></td>
<td>Frequency &lt; 5MHz, 20log(VOUT_DISABLED/VOUT_ENABLED)</td>
<td>ATT = 0</td>
<td>-71</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ATT = 1</td>
<td></td>
<td>-57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Impedance</td>
<td></td>
<td>At 1MHz, DIS = 0, ATT = 0, GAIN = 0 or 1</td>
<td></td>
<td>51</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At 1MHz, DIS = 0, ATT = 1, GAIN = 0 or 1</td>
<td></td>
<td>114</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>At 1MHz, DIS = 1, ATT = 0 or 1, GAIN = 0 or 1</td>
<td></td>
<td>9</td>
<td></td>
<td>kΩ</td>
</tr>
</tbody>
</table>

Note 1: AC specifications are guaranteed by design and characterization.
Note 2: Supply current is measured with OUT unterminated or AC-coupled.
Note 3: Measured by applying 100mVp-p sinusoidal noise to the supply voltage. PSNR is defined as 20log(VOUT_NOISE/VCC_NOISE).

Typical Operating Characteristics

(Typical values are at VCC = +5V, TA = +25°C, CIN = 5pF, ATT = 0, unless otherwise noted.)


Receiver for Optical Distance Measurement

Typical Operating Characteristics (continued)

(Typical values are at \( V_{CC} = +5V, \; T_A = +25^\circ C, \; C_{IN} = 5pF, \; ATT = 0 \), unless otherwise noted.)

**BANDWIDTH vs. INPUT CAPACITANCE (GAIN = 1)**

- \( T_A = -40^\circ C \)
- \( T_A = +25^\circ C \)
- \( T_A = +105^\circ C \)

**BANDWIDTH vs. INPUT CAPACITANCE (GAIN = 0)**

- \( T_A = -40^\circ C \)
- \( T_A = +25^\circ C \)
- \( T_A = +105^\circ C \)

**GAIN PEAKING vs. INPUT CAPACITANCE**

- \( V_{CC} = +5.0V \)
- \( V_{CC} = +5.5V \)
- \( V_{CC} = +4.5V \)

**POWER-SUPPLY NOISE REJECTION (SUPPLY NOISE = 100mVp-p)**

- \( V_{CC} = +5.5V \)
- \( V_{CC} = +5.0V \)
- \( V_{CC} = +4.5V \)

**INPUT-REFERRED NOISE vs. INPUT CAPACITANCE**

- \( V_{CC} = +5V \)
- \( BW = 100MHz \)

**OUTPUT-REFERRED NOISE vs. INPUT CAPACITANCE**

- \( T_A = +25^\circ C \)
- \( BW = 100MHz \)
Receiver for Optical Distance Measurement

Typical Operating Characteristics (continued)

(Typical values are at \( V_{CC} = +5V, TA = +25^\circ C, C_{IN} = 5pF, ATT = 0 \), unless otherwise noted.)

**INPUT-REFERRED NOISE vs. INPUT CAPACITANCE**

- \( V_{CC} = +6V \)
- \( T_A = +105^\circ C \)
- \( GAIN = 0 \)
- \( BW = 100MHz \)

- \( T_A = +25^\circ C \)
- \( VCC = +5.5V \)
- \( VCC = +5.0V \)
- \( VCC = +4.5V \)

**OUTPUT-REFERRED NOISE vs. INPUT CAPACITANCE**

- \( TA = +25^\circ C \)
- \( GAIN = 0 \)
- \( BW = 100MHz \)

**TOTAL HARMONIC DISTORTION vs. FREQUENCY**

- \( VOUT = 0.5VP \)
- \( GAIN = 1 \)
- \( GAIN = 0 \)

**DISABLE SWITCH**

- \( DC-BLOCK = 0.01\mu F, LOAD = 2k\Omega \)
- \( 100m/div \)

**GAIN SWITCH**

- \( DC-BLOCK = 0.01\mu F, LOAD = 2k\Omega \)
- \( 40\mu s/div \)

**ATT SWITCH**

- \( DC-BLOCK = 0.01\mu F, LOAD = 2k\Omega \)
- \( 40\mu s/div \)
Receiver for Optical Distance Measurement

Typical Operating Characteristics (continued)
(Typical values are at \(V_{CC} = +5V, T_A = +25^\circ C, C_{IN} = 5pF, ATT = 0\), unless otherwise noted.)

**Graphs:**
- **Transient Response (Linear Region, Gain = 1):**
  - IN: 20MHz BW LIMIT
  - OUT: 20ns/div
  - Zoom In: 1µA
  - Zoom Out: 60mV

- **Transient Response (Overload Region, Gain = 1):**
  - IN: 20MHz BW LIMIT
  - OUT: 100ns/div
  - Zoom In: 2mV
  - Zoom Out: 1.4V

- **Transient Response (Overload Region, Gain = 1):**
  - IN: 0.01µF DC-Block
  - OUT: 20µs Settling Time
  - Zoom In: 2mV
  - Zoom Out: 1.4V

**Functional Diagram:**
- MAX3806
- IN
- ATTENUATOR
- OUT
- SWITCHABLE IMPEDANCE: 60kΩ OR 30kΩ
- 40kΩ
- VCC
- 60kΩ
- GAIN
- ATT
- DIS
Receiver for Optical Distance Measurement

**Detailed Description**

The MAX3806 preamplifier consists of a selectable-gain transimpedance amplifier, a selectable 14dB attenuator, and an output-driver block. The selectable-gain transimpedance amplifier linearly boosts the signal from the photodiode. This block is followed by an attenuator block that allows the user to attenuate the signal by 14dB selected by the ATT pin. The final block is the output driver that can be disabled by asserting the DIS pin.

**Transimpedance Amplifier**

The selectable-gain transimpedance amplifier is controlled by the GAIN pin. See Table 1 for gain settings.

**Attenuator**

The attenuator block can be set to pass the signal through to the output stage with 0dB of attenuation (ATT forced low) or with 14dB of attenuation (ATT forced high).

**Output Driver**

The output driver is designed to drive an AC-coupled load with an impedance of 2kΩ or greater. The output can be disabled by asserting the DIS pin high. When the output is disabled, the OUT pin goes to a high-impedance state. See Figure 1 for the equivalent output circuit.

**Applications Information**

**Settling Time**

Settling time is the required time for the output to achieve the final steady-state or AC amplitude swing after a setting has been changed on the MAX3806. The output common-mode voltage shifts when a change is

**Table 1. Transimpedance Gain Settings**

<table>
<thead>
<tr>
<th>GAIN</th>
<th>TRANSIMPEDANCE (kΩ)</th>
<th>LINEAR RANGE (µA)</th>
<th>BANDWIDTH (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30</td>
<td>I_{IN} ≤ 40</td>
<td>98</td>
</tr>
<tr>
<td>1</td>
<td>60</td>
<td>I_{IN} ≤ 20</td>
<td>49</td>
</tr>
</tbody>
</table>
Receiver for Optical Distance Measurement

made to either the GAIN or ATT setting. Table 2 provides typical output common-mode voltages for the combination of settings. Settling time is proportional to the RC time constant set by the output DC-blocking capacitor, load, and MAX3806 output impedance. For example, a 0.01µF DC-blocking capacitor, 2kΩ load, and 51Ω output impedance provide an RC time constant of approximately 20µs. After changing the GAIN or ATT setting, the system should wait at least three to four time constants before analyzing received signals.

Settling time is also required when changing the DIS setting. When DIS is asserted high, the output disables to high impedance and typically settles to steady state within 200ns. When DIS is deasserted, the output enables and typically settles to steady state within 50ns.

Overload Recovery Time

Transistors saturate when the amplifier is overloaded, resulting in output distortion. Overload typically occurs with signals greater than 20µA (GAIN = 1) or 40µA (GAIN = 0). It can withstand overload signals as large as 2mA. Recovery time depends on the amplitude and duration of the overload pulse.

Table 2. Output Common-Mode Voltages

<table>
<thead>
<tr>
<th>GAIN</th>
<th>ATT</th>
<th>OUTPUT COMMON-MODE VOLTAGE (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1.65</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.82</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Layout Considerations

Noise performance and bandwidth are adversely affected by capacitance at the IN pad. Minimize capacitance on this pad and select a low-capacitance photodiode. Reducing PCB capacitance can be accomplished by removing the ground plane underneath the connection from the photodiode to the IN pin and by keeping the photodiode as close as possible to the MAX3806.

Use broadband power-supply filtering techniques to achieve the best sensitivity and noise performance.

Exposed-Pad Package and Thermal Considerations

The exposed pad on the 12-pin TQFN provides a very low thermal resistance path for heat removal from the IC. The pad is also electrical ground on the MAX3806 and must be soldered to the circuit board ground for proper thermal and electrical performance. Refer to Application Note 862: HFAN-08.1: Thermal Considerations of QFN and Other Exposed-Paddle Packages for additional information.

Pin Configuration

Package Information

For the latest package outline information and land patterns, go to www.maxim-ic.com/packages.

<table>
<thead>
<tr>
<th>PACKAGE TYPE</th>
<th>PACKAGE CODE</th>
<th>DOCUMENT NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 TQFN-EP</td>
<td>T1233+1</td>
<td>21-0136</td>
</tr>
</tbody>
</table>
Receiver for Optical Distance Measurement

Typical Application Circuits (continued)

* L & C SET THE LOW-FREQUENCY CUTOFF REQUIRED FOR THE APPLICATION.