

EVALUATION KIT AVAILABLE**MAXIM**

Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

General Description

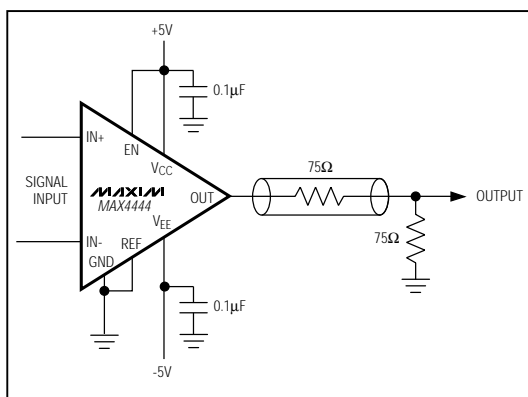
The MAX4444/MAX4445 differential line receivers offer unparalleled high-speed, low-distortion performance. Using a three op amp instrumentation amplifier architecture, these ICs have symmetrical differential inputs and a single-ended output. They operate from $\pm 5V$ supplies and are capable of driving a 100Ω load to $\pm 3.7V$. The MAX4444 has an internally set closed-loop gain of $+2V/V$, while the MAX4445 is compensated for gains of $+2V/V$ or greater, set by an external resistor. A low-power enable mode reduces current consumption to $3.5mA$.

Using current-feedback techniques, the MAX4444/MAX4445 achieve a $550MHz$ bandwidth while maintaining up to a $5000V/\mu s$ slew rate. Excellent differential gain/phase and noise specifications make these amplifiers ideal for a wide variety of video and RF signal-processing applications. An evaluation kit is available to speed design.

Applications

Differential-to-Single-Ended Conversion
Twisted-Pair to Coaxial Converter
High-Speed Instrumentation Amplifier
Data Acquisition
Medical Instrumentation
High-Speed Differential Line Receiver

Typical Operating Circuit



Features

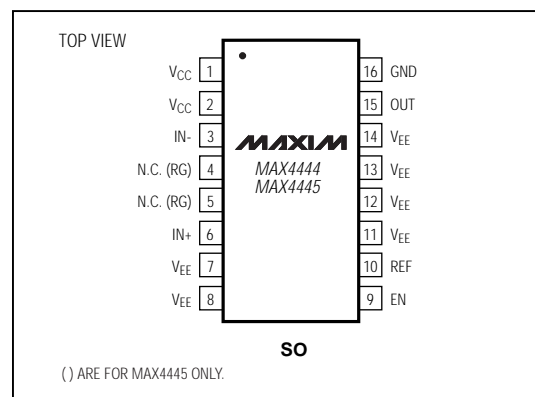
- ♦ **5000V/ μs Slew Rate (MAX4444)**
- ♦ **$+2V/V$ Internally Fixed Gain (MAX4444)**
- ♦ **External Gain Selection (MAX4445, $A_{VCL} \geq +2V/V$)**
- ♦ **550MHz -3dB Bandwidth**
- ♦ **-60dB SFDR at 5MHz**
- ♦ **Low Differential Gain/Phase: 0.07%/0.05°**
- ♦ **Low Noise: $25nV/\sqrt{Hz}$ at $f_{IN} = 100kHz$**
- ♦ **Low-Power Disable Mode Reduces Quiescent Current to 3.5mA**

MAX4444/MAX4445

Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE |
|------------|----------------|--------------|
| MAX4444ESE | -40°C to +85°C | 16 Narrow SO |
| MAX4445ESE | -40°C to +85°C | 16 Narrow SO |

Pin Configuration

**MAXIM**

Maxim Integrated Products 1

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For small orders, phone 1-800-835-8769.

Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

MAX4444/MAX4445

ABSOLUTE MAXIMUM RATINGS

| | | |
|---|--|---|
| V _{CC} to V _{EE} | +12V | Continuous Power Dissipation (T _A = +70°C) |
| Voltage on IN+, IN-, EN, OUT+, OUT-, RG, REF | (V _{EE} - 0.3V) to (V _{CC} + 0.3V) | 16-Pin Narrow SO (derate 20mW/°C above +70°C) ...1600mW |
| Current Into IN+, IN-, RG, EN | 20mA | Operating Temperature Range |
| Output Short-Circuit Duration | Indefinite to GND | -40°C to +85°C |
| | | Storage Temperature Range |
| | | -65°C to +150°C |
| | | Lead Temperature (soldering, 10sec) |
| | | +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.

DC ELECTRICAL CHARACTERISTICS

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} = ≥2V, V_{CM} = 0, R_L = ∞, REF = GND, AVCL = +2V/V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|-----------------------|--|---------|---------------------------|------|-------|
| Operating Supply Voltage Range | | Guaranteed by PSRR test | ±4.5 | | ±5.5 | V |
| Input Common-Mode Voltage Range | V _{CM} | Guaranteed by CMRR test | -2.9 | | 2.9 | V |
| Differential Input Voltage Range | V _{DIFF} | Guaranteed by output swing test | -1.7 | | 1.7 | V |
| Input Offset Voltage | V _{OS} | | | 15 | 65 | mV |
| Input Offset-Voltage Temperature Coefficient | TC _{VOS} | | | 12 | | μV/°C |
| Input Bias Current | I _B | | | 10 | 55 | μA |
| Input Offset Current | I _{OS} | | | 0.25 | 45 | μA |
| Differential Input Resistance | R _{IN} | -2.9V ≤ V _{IN} ≤ +2.9V | | 82 | | kΩ |
| | | -2.9V ≤ V _{CM} ≤ +2.9V | | 170 | | |
| Gain | A _V | -3V ≤ V _{OUT} ≤ +3V | MAX4444 | 2 | | V/V |
| | | | MAX4445 | (1 + 600/R _G) | | |
| Gain Error | | -3V ≤ V _{OUT} ≤ +3V, R _L = 100Ω | MAX4444 | 0.5 | 2 | % |
| | | | MAX4445 | 2.6 | 8 | |
| Gain-Error Drift | | R _L = 100Ω | | 0.003 | | %/°C |
| Output Voltage Swing | V _{OUT} | R _L = 100Ω | ±3.4 | ±3.7 | | V |
| | | R _L = 50Ω | ±3.3 | ±3.6 | | |
| Output Current Drive | I _{OUT} | R _L = 30Ω | 90 | 120 | | mA |
| Power-Supply Rejection Ratio | PSRR | V _S = ±4.5V to ±5.5V | 53 | 70 | | dB |
| Common-Mode Rejection Ratio | CMRR | -2.9V ≤ V _{CM} ≤ +2.9V | 40 | 55 | | dB |
| Disable Output Resistance | R _{OUT(OFF)} | V _{EN} = 0, -3.5V ≤ V _{OUT} ≤ +3.5V, MAX4444 | | 1.8 | | kΩ |
| EN Logic Low Threshold | V _{IL} | | | | 0.8 | V |
| EN Logic High Threshold | V _{IH} | | 2 | | | V |
| EN Logic Input Low Current | I _{IL} | V _{EN} = 0 | | 2.2 | 10 | μA |
| EN Logic Input High Current | I _{IH} | V _{EN} = 5V | | 2.6 | 10 | μA |
| Quiescent Current | I _Q | V _{IN} = 0, V _{EN} = 5V | | 41 | 55 | mA |
| | | V _{IN} = 0, V _{EN} = 0 | | 3.5 | 5.5 | |

Ultra-High Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

MAX4444/MAX4445

AC ELECTRICAL CHARACTERISTICS

($V_{CC} = +5V$, $V_{EE} = -5V$, $V_{EN} = 5V$, $R_L = 100\Omega$, $REF = GND$, $A_{VCL} = +2V/V$, $T_A = +25^\circ C$, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITION | MIN | TYP | MAX | UNITS |
|-----------------------------|-----------------|--|----------------|------|-----|----------------|
| Small-Signal -3dB Bandwidth | BW_{SS} | $V_{OUT} = 100mVp-p$ | | 550 | | MHz |
| Large-Signal -3dB Bandwidth | BW_{LS} | $V_{OUT} = 2Vp-p$ | | 500 | | MHz |
| 0.1dB Gain Flatness | | $V_{OUT} = 100mVp-p$ | | 80 | | MHz |
| Slew Rate (Note 1) | SR | $V_{OUT} = 4V$ step | MAX4444 | 5000 | | V/ μs |
| | | | MAX4445 | 3800 | | |
| | | $V_{OUT} = 2V$ step | MAX4444 | 2400 | | |
| | | | MAX4445 | 2000 | | |
| | | $V_{OUT} = 1V$ step | | 1200 | | |
| $V_{OUT} = 0.5V$ step | | 600 | | | | |
| Rise Time (Note 1) | t_{RISE} | | | 650 | | ps |
| Fall Time (Note 1) | t_{FALL} | $V_{OUT} = 4V$ step | | 825 | | ps |
| | | $V_{OUT} = 2V$ step | | 700 | | |
| | | $V_{OUT} = 1V$ step | | 700 | | |
| | | $V_{OUT} = 0.5V$ step | | 700 | | |
| Settling Time | | Settle to 0.1% , $V_{OUT} = 2V$ step | | 12 | | ns |
| SFDR | | $V_{OUT} = 2Vp-p$ | $f_C = 100kHz$ | -65 | | dBc |
| | | | $f_C = 5MHz$ | -60 | | |
| | | | $f_C = 20MHz$ | -55 | | |
| | | | $f_C = 100MHz$ | -35 | | |
| 2nd-Harmonic Distortion | | $V_{OUT} = 2Vp-p$ | $f_C = 100kHz$ | -65 | | dBc |
| | | | $f_C = 5MHz$ | -62 | | |
| | | | $f_C = 20MHz$ | -50 | | |
| | | | $f_C = 100MHz$ | -35 | | |
| 3rd-Harmonic Distortion | | $V_{OUT} = 2Vp-p$ | $f_C = 100kHz$ | -90 | | dBc |
| | | | $f_C = 5MHz$ | -72 | | |
| | | | $f_C = 20MHz$ | -62 | | |
| | | | $f_C = 100MHz$ | -55 | | |
| Differential Phase Error | DP | NTSC, $R_L = 150\Omega$ | | 0.05 | | degrees |
| Differential Gain Error | DG | NTSC, $R_L = 150\Omega$ | | 0.07 | | % |
| Input Noise Voltage Density | e_N | $f = 100kHz$ (Note 2) | | 25 | | nV/\sqrt{Hz} |
| Input Noise Current Density | i_N | $f = 100kHz$ | | 1.8 | | pA/\sqrt{Hz} |
| Output Impedance | Z_{OUT} | $f = 10MHz$ | | 0.7 | | Ω |
| Enable Time | $t_{SHDN(ON)}$ | $V_{IN} = 1V$, V_{OUT} settle to within 10% | | 80 | | ns |
| Disable Time | $t_{SHDN(OFF)}$ | $V_{IN} = 1V$, V_{OUT} settle to within 10% | | 200 | | ns |
| Power-Up Time | t_{ON} | $V_{IN} = 1V$, V_{OUT} settle to within 10% | | 0.5 | | μs |
| Power-Down Time | t_{OFF} | $V_{IN} = 1V$, V_{OUT} settle to within 10% | | 0.3 | | μs |

Note 1: Input step voltage has <100ps rise (fall) time. Measured at the output from 10% to 90% (90% to 10%) level.

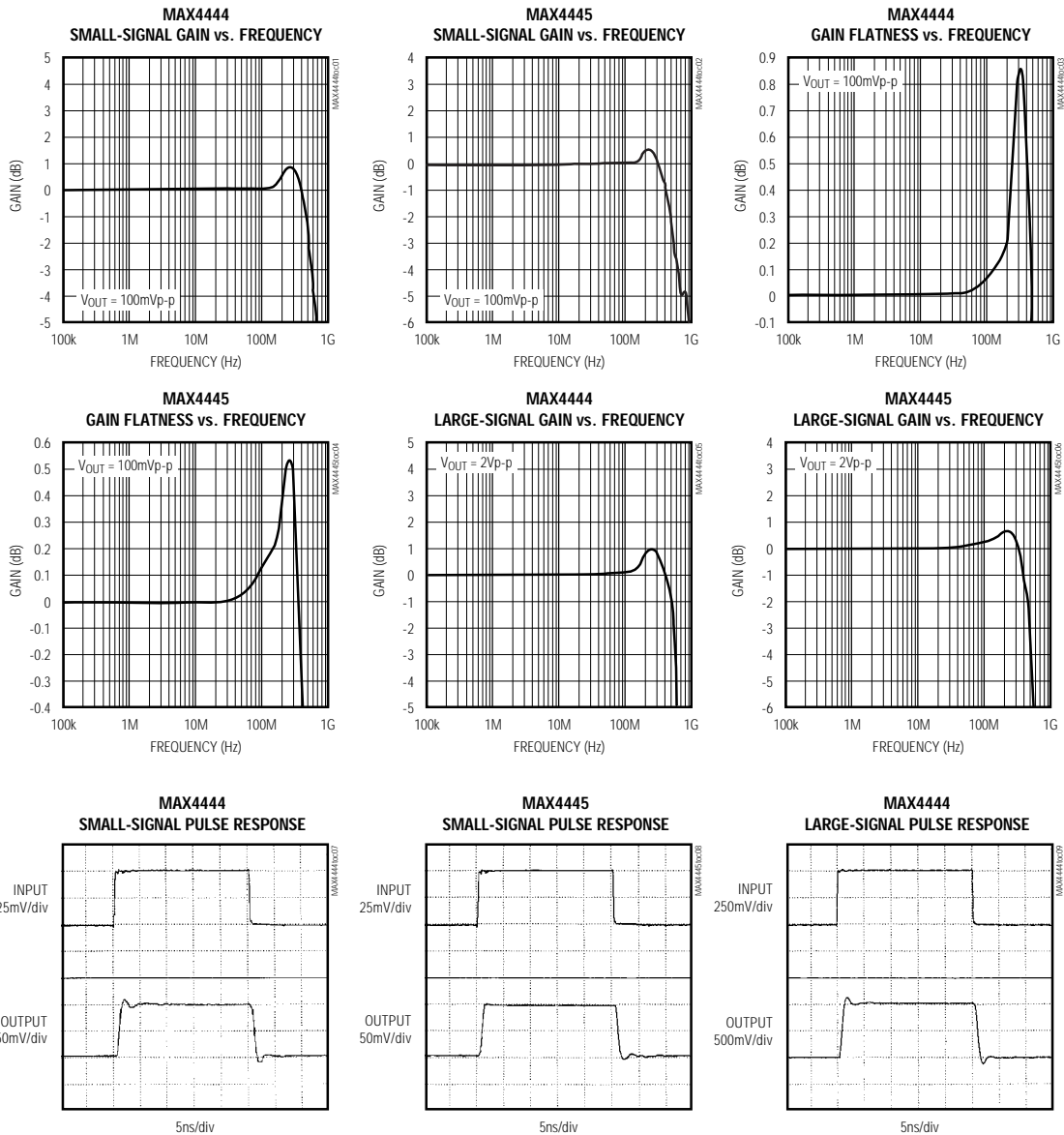
Note 2: Includes the current noise contribution through the on-die feedback resistor.

Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

MAX4444/MAX4445

Typical Operating Characteristics

($V_{CC} = +5V$, $V_{EE} = -5V$, $V_{EN} = 5V$, $V_{IN} = V_{IN+} - V_{IN-}$, $R_L = 100\Omega$, $REF = GND$, $A_V = +2V/V$, $T_A = +25^\circ C$, unless otherwise noted.)

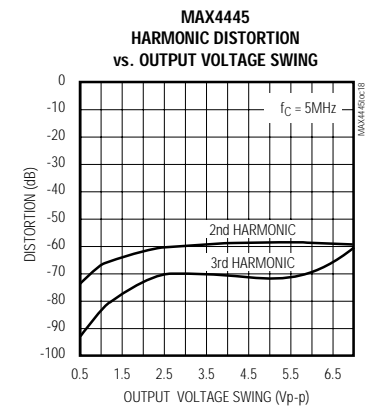
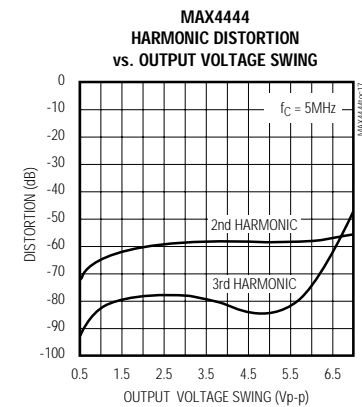
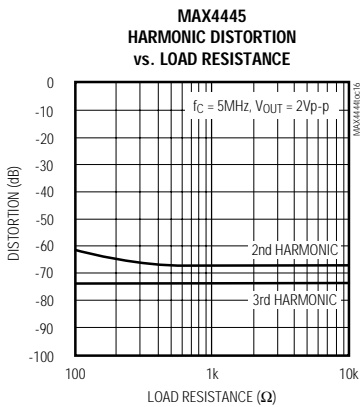
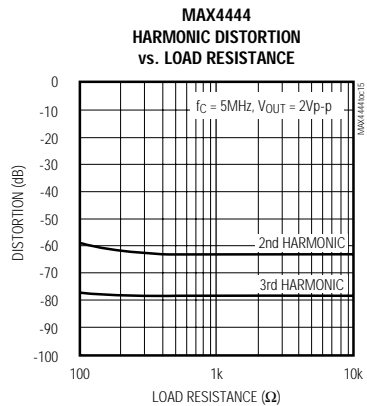
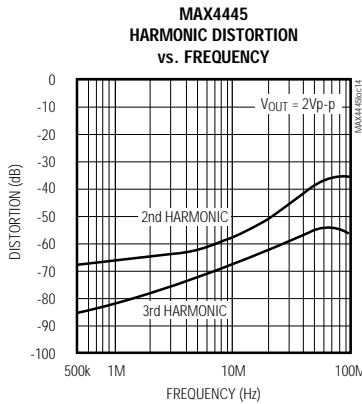
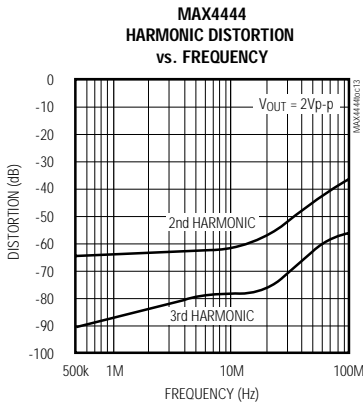
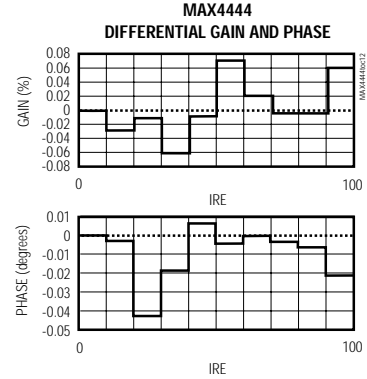
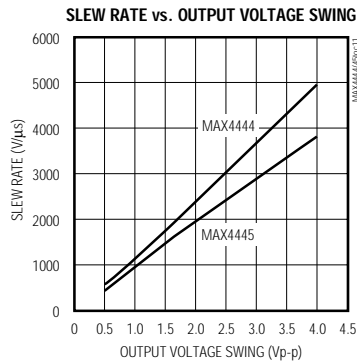
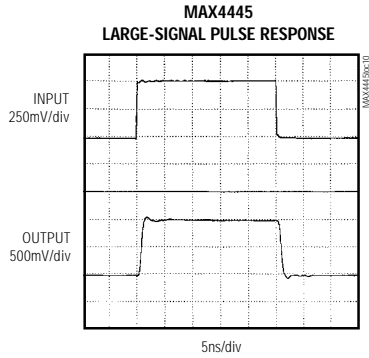


Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

Typical Operating Characteristics (continued)

($V_{CC} = +5V$, $V_{EE} = -5V$, $V_{EN} = 5V$, $V_{IN} = V_{IN+} - V_{IN-}$, $R_L = 100\Omega$, $REF = GND$, $A_V = +2V/V$, $T_A = +25^\circ C$, unless otherwise noted.)

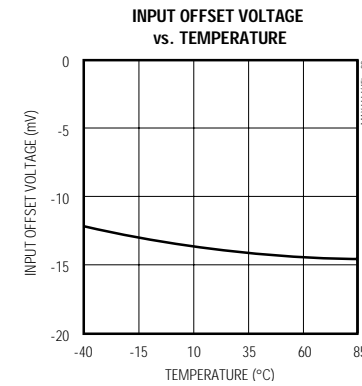
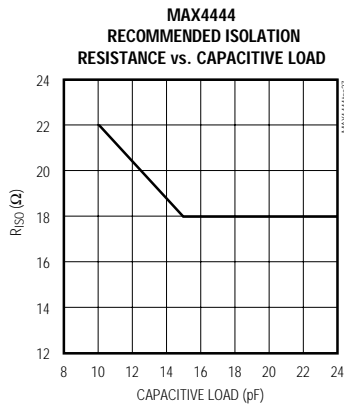
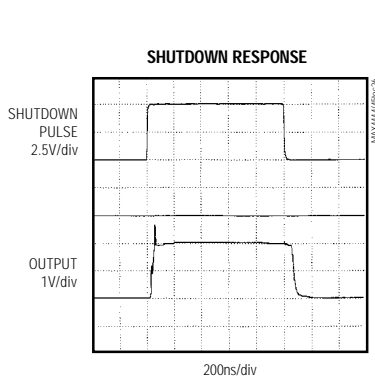
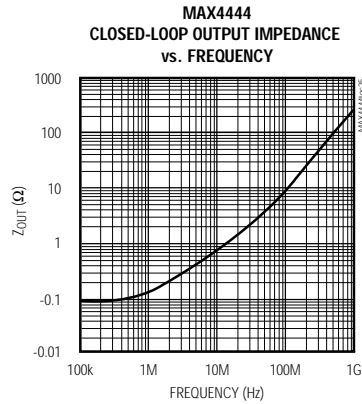
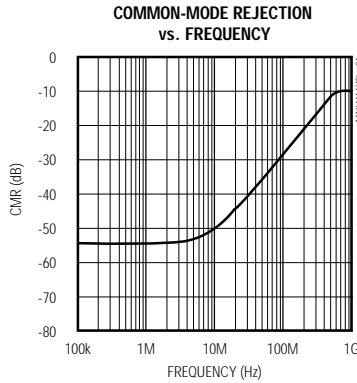
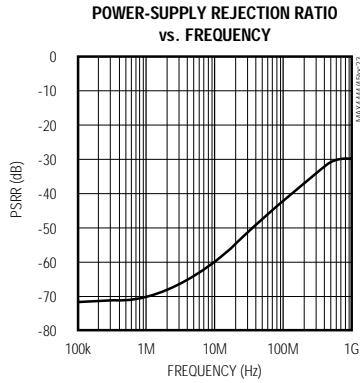
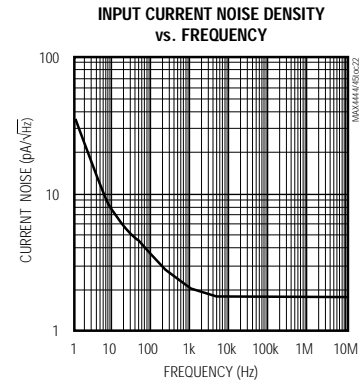
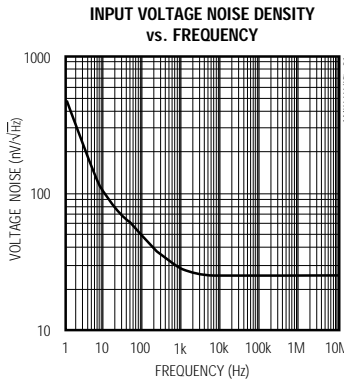
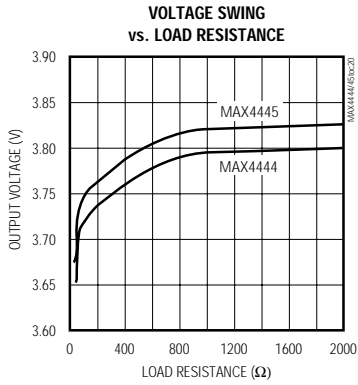
MAX4444/MAX4445



Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

Typical Operating Characteristics (continued)

($V_{CC} = +5V$, $V_{EE} = -5V$, $V_{EN} = 5V$, $V_{IN} = V_{IN+} - V_{IN-}$, $R_L = 100\Omega$, $REF = GND$, $A_V = +2V/V$, $T_A = +25^\circ C$, unless otherwise noted.)

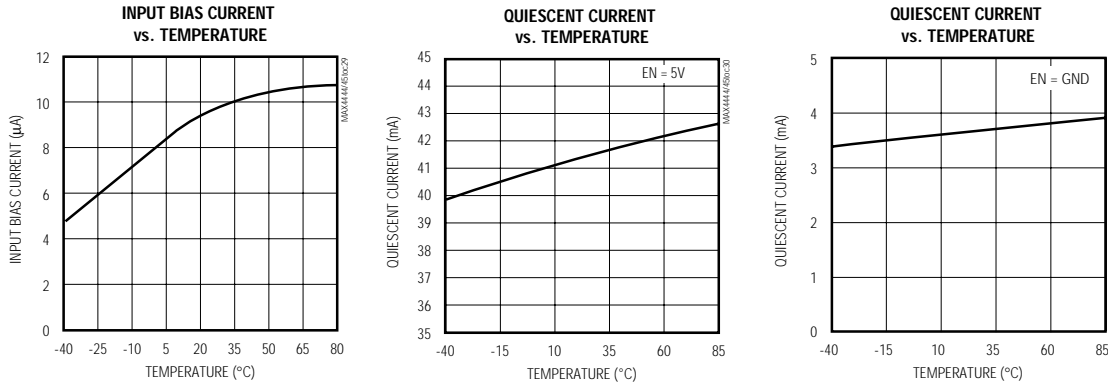


Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

MAX4444/MAX4445

Typical Operating Characteristics (continued)

($V_{CC} = +5V$, $V_{EE} = -5V$, $V_{EN} = 5V$, $V_{IN} = V_{IN+} - V_{IN-}$, $R_L = 100\Omega$, $REF = GND$, $A_V = +2V/V$, $T_A = +25^\circ C$, unless otherwise noted.)



Pin Description

| PIN | | NAME | FUNCTION |
|-------------|-------------|----------|--|
| MAX4444 | MAX4445 | | |
| 1, 2 | 1, 2 | V_{CC} | Positive Power-Supply Input. Bypass with a $0.1\mu F$ capacitor to GND. |
| 3 | 3 | IN- | Inverting Amplifier Input |
| 4, 5 | — | N.C. | No Connection. Not internally connected. Connect to GND for best AC performance. |
| — | 4, 5 | RG | Resistor Gain Input. Connect a resistor between these pins to set closed-loop gain (Figure 1). |
| 6 | 6 | IN+ | Noninverting Amplifier Input |
| 7, 8, 11–14 | 7, 8, 11–14 | V_{EE} | Negative Supply Input. Bypass with a $0.1\mu F$ capacitor. |
| 9 | 9 | EN | Active-High Enable Input. Connect to V_{CC} for normal operation. Connect to GND for disable mode. |
| 10 | 10 | REF | Reference Input. Connect to midpoint of the two power supplies. |
| 15 | 15 | OUT | Amplifier Output |
| 16 | 16 | GND | Ground |

Ultra-High-Speed, Low-Distortion, Differential-to-Single-Ended Line Receivers with Enable

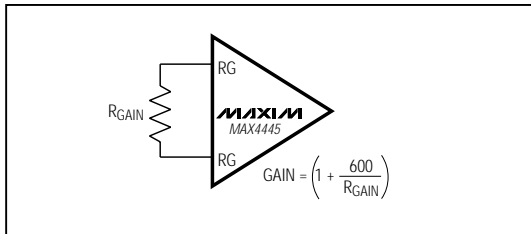


Figure 1. Setting the Amplifier Gain

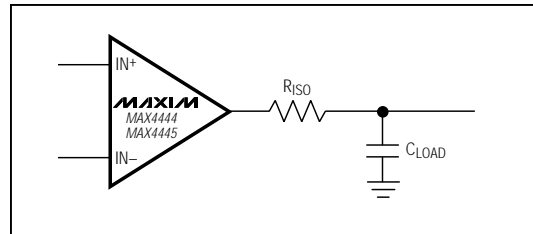


Figure 2. Using an Isolation Resistor for High Capacitive Loads

Detailed Description

The MAX4444/MAX4445 differential-to-single-ended line receivers offer high-speed and low-distortion performance, and are ideally suited for video and RF signal-processing applications. These receivers offer a small-signal bandwidth of 550MHz and have a high slew rate of up to 5000V/μs. Their 120mA output capability allows them to be directly coupled to data acquisition systems.

Applications Information

Grounding Bypassing

Use the following high-frequency design techniques when designing the PC board for the MAX4444/MAX4445.

- Use a multilayer board with one layer dedicated as the ground plane.
- Do not use wire wrap or breadboards due to high inductance.
- Avoid IC sockets due to high parasitic capacitance and inductance.
- Bypass supplies with a 0.1μF capacitor. Use surface-mount capacitors to minimize lead inductance.
- Keep signal lines as short and straight as possible. Do not make 90° turns. Use rounded corners. Do not cross signal paths if possible.
- Ensure that the ground plane is free from voids.

Low-Power Enable Mode

The MAX4444/MAX4445 are disabled when EN goes low. This reduces supply current to only 3.5mA. As the output becomes higher impedance, the effective impedance at the output for the MAX4444 is 1.8kΩ. The effective output impedance for the MAX4445 is 1.8kΩ plus RGAIN.

Setting Gain (MAX4445)

The MAX4445 is stable with a minimum gain configuration of +2V/V. RGAIN, connected between the RG pins, sets the gain of this device as shown in Figure 1. Calculate the expected gain as follows:

$$\text{Gain} = (1 + 600 / \text{RGAIN})$$

Driving Capacitive Loads

The MAX4444/MAX4445 are designed to drive capacitive loads. However, excessive capacitive loads may cause ringing or instability at the output as the phase margin of the device reduces. Adding a small series isolation resistor at the output helps reduce the ringing but slightly increases gain error (Figure 2). For recommended values, see *Typical Operating Characteristics*.

Coaxial Line Driver

The MAX4444/MAX4445 are well suited to drive coaxial cables. Their high output current capability can easily drive the 75Ω characteristic impedance of common coaxial cables. Adjust the gain of the MAX4445 to compensate for cable losses to maintain the required levels at the input of the next stage.

Chip Information

TRANSISTOR COUNT: 254

SUBSTRATE CONNECTED TO V_{EE}

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