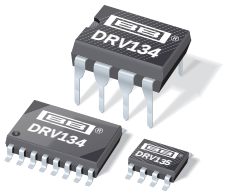
BURR-BROWN®




# DRV134
# DRV135

# AUDIO BALANCED LINE DRIVERS

## FEATURES

- BALANCED OUTPUT
- LOW DISTORTION: 0.0005% at f = 1kHz
- WIDE OUTPUT SWING: 17Vrms into 600Ω
- HIGH CAPACITIVE LOAD DRIVE
- HIGH SLEW RATE: 15V/μs
- WIDE SUPPLY RANGE: ±4.5V to ±18V
- LOW QUIESCENT CURRENT: ±5.2mA
- 8-PIN DIP, SO-8, AND SOL-16 PACKAGES
- COMPANION TO AUDIO DIFFERENTIAL LINE RECEIVERS: INA134 and INA137
- IMPROVED REPLACEMENT FOR SSM2142

## APPLICATIONS

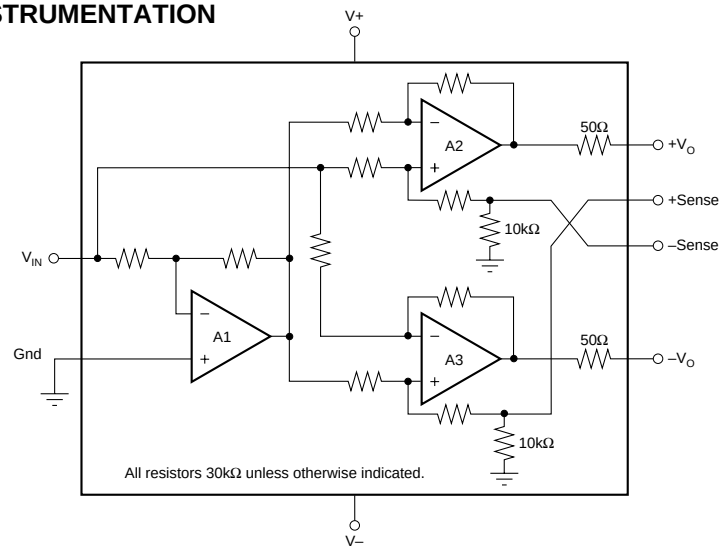
- AUDIO DIFFERENTIAL LINE DRIVER
- AUDIO MIX CONSOLES
- DISTRIBUTION AMPLIFIER
- GRAPHIC/PARAMETRIC EQUALIZERS
- DYNAMIC RANGE PROCESSORS
- DIGITAL EFFECTS PROCESSORS
- TELECOM SYSTEMS
- HI-FI EQUIPMENT
- INDUSTRIAL INSTRUMENTATION

## DESCRIPTION

The DRV134 and DRV135 are differential output amplifiers that convert a single-ended input to a balanced output pair. These balanced audio drivers consist of high performance op amps with on-chip precision resistors. They are fully specified for high performance audio applications and have excellent ac specifications, including low distortion (0.0005% at 1kHz) and high slew rate (15V/μs).

The on-chip resistors are laser-trimmed for accurate gain and optimum output common-mode rejection. Wide output voltage swing and high output drive capability allow use in a wide variety of demanding applications. They easily drive the large capacitive loads associated with long audio cables. Used in combination with the INA134 or INA137 differential receivers, they offer a complete solution for transmitting analog audio signals without degradation.

The DRV134 is available in 8-pin DIP and SOL-16 surface-mount packages. The DRV135 comes in a space-saving SO-8 surface-mount package. Both are specified for operation over the extended industrial temperature range, –40°C to +85°C and operate from –55°C to +125°C.

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PDS-1451A
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# SPECIFICATIONS: $V_S = \pm 18V$

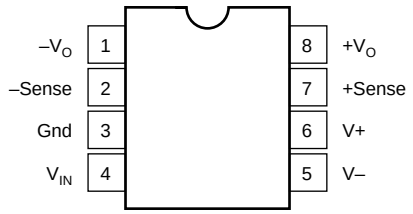
At $T_A$ = +25°C, $V_S$ = ±18V, $R_L$ = 600Ω differential connected between $+V_O$ and $-V_O$, unless otherwise noted.

| PARAMETER | | CONDITIONS | DRV134PA, UA DRV135UA MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **AUDIO PERFORMANCE** | | | | | | |
| Total Harmonic Distortion + Noise | THD+N | f = 20Hz to 20kHz, $V_O$ = 10Vrms | | 0.001 | | % |
| | | f = 1kHz, $V_O$ = 10Vrms | | 0.0005 | | % |
| Noise Floor, RTO[1] | | 20kHz BW | | –98 | | dBu |
| Headroom, RTO[1] | | THD+N < 1% | | +27 | | dBu |
| **INPUT** | | | | | | |
| Input Impedance[2] | $Z_{IN}$ | | | 10 | | kΩ |
| Input Current | $I_{IN}$ | $V_{IN}$ = ±7.07V | | ±700 | ±1000 | µA |
| **GAIN** | | $[(+V_O) - (-V_O)]/V_{IN}$ | | | | |
| Differential | | $V_{IN}$ = ±10V | | | | |
| Initial | | | 5.8 | 6 | | dB |
| Error | | | | ±0.1 | ±2 | % |
| vs Temperature | | | | ±10 | | ppm/°C |
| Single-Ended | | $V_{IN}$ = ±5V | | | | |
| Initial | | | 5.8 | 6 | | dB |
| Error | | | | ±0.7 | ±2 | % |
| vs Temperature | | | | ±10 | | ppm/°C |
| Nonlinearity | | | | 0.0003 | | % of FS |
| **OUTPUT** | | | | | | |
| Common-Mode Rejection, f = 1kHz | OCMR | See OCMR Test Circuit, Figure 4 | 46 | 68 | | dB |
| Signal Balance Ratio, f = 1kHz | SBR | See SBR Test Circuit, Figure 5 | 35 | 54 | | dB |
| Output Offset Voltage | | | | | | |
| Offset Voltage, Common-Mode | $V_{OCM}$[3] | $V_{IN}$ = 0 | | ±50 | ±250 | mV |
| vs Temperature | | | | ±150 | | µV/°C |
| Offset Voltage, Differential | $V_{OD}$[4] | $V_{IN}$ = 0 | | ±1 | ±10 | mV |
| vs Temperature | | | | ±5 | | µV/°C |
| vs Power Supply | PSRR | $V_S$ = ±4.5V to ±18V | 80 | 110 | | dB |
| Output Voltage Swing, Positive | | No Load[5] | (V+) – 3 | (V+) – 2.5 | | V |
| Negative | | No Load[5] | (V–) + 2 | (V–) + 1.5 | | V |
| Impedance | | | | 50 | | Ω |
| Load Capacitance, Stable Operation | $C_L$ | $C_L$ Tied to Ground (each output) | | 1 | | µF |
| Short-Circuit Current | $I_{SC}$ | | | ±85 | | mA |
| **FREQUENCY RESPONSE** | | | | | | |
| Small-Signal Bandwidth | | | | 1.5 | | MHz |
| Slew Rate | SR | | | 15 | | V/µs |
| Settling Time: 0.01% | | $V_{OUT}$ = 10V Step | | 2.5 | | µs |
| Overload Recovery | | Output Overdriven 10% | | 3 | | µs |
| **POWER SUPPLY** | | | | | | |
| Rated Voltage | $V_S$ | | | ±18 | | V |
| Voltage Range | | | ±4.5 | | ±18 | V |
| Quiescent Current | $I_Q$ | $I_O$ = 0 | | ±5.2 | ±5.5 | mA |
| **TEMPERATURE RANGE** | | | | | | |
| Specification Range | | | –40 | | +85 | °C |
| Operation Range | | | –55 | | +125 | °C |
| Storage Range | | | –55 | | +125 | °C |
| Thermal Resistance | $\theta_{JA}$ | | | | | |
| 8-Pin DIP | | | | 100 | | °C/W |
| SO-8 Surface Mount | | | | 150 | | °C/W |
| SOL-16 Surface Mount | | | | 80 | | °C/W |

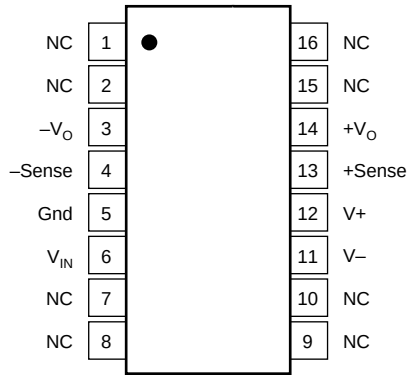
NOTES: (1) dBu = 20log (Vrms/0.7746). (2) Resistors are ratio matched but have ±20% absolute value. (3) $V_{OCM} = [(+V_O) + (-V_O)]/2$. (4) $V_{OD} = (+V_O) - (-V_O)$. (5) Guarantees linear operation. Includes common-mode offset.

## PIN CONFIGURATIONS

**Top View** **8-Pin DIP/SO-8**




**Top View** **SOL-16**




## ABSOLUTE MAXIMUM RATINGS(1)

| | |
|---|---|
| Supply Voltage, V+ to V– | 40V |
| Input Voltage Range | V– to V+ |
| Output Short-Circuit (to ground) | Continuous |
| Operating Temperature | –55°C to +125°C |
| Storage Temperature | –55°C to +125°C |
| Junction Temperature | +150°C |
| Lead Temperature (soldering, 10s) | +300°C |

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may affect device reliability.

## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

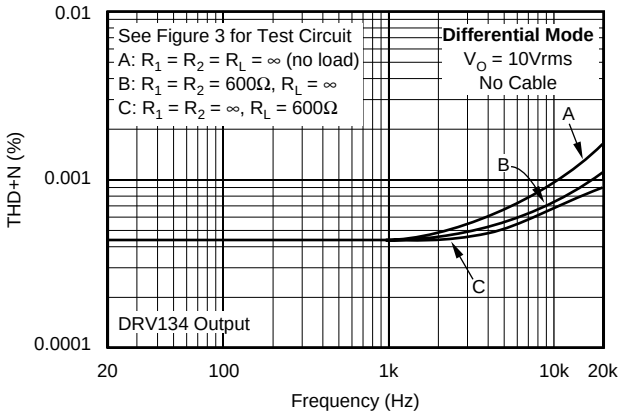
| PRODUCT | PACKAGE | PACKAGE DRAWING NUMBER(1) | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER(2) | TRANSPORT MEDIA |
|---|---|---|---|---|---|
| DRV134PA | 8-Pin DIP | 006 | –40°C to +85°C | DRV134PA | Rails |
| DRV134UA | SOL-16 Surface Mount | 211 | –40°C to +85°C | DRV134UA | Rails |
| " | " | " | " | DRV134UA/1K | Tape and Reel |
| DRV135UA | SO-8 Surface Mount | 182 | –40°C to +85°C | DRV135UA | Rails |
| " | " | " | " | DRV135UA/2K5 | Tape and Reel |

NOTES: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book. For detailed Tape and Reel mechanical information refer to Appendix B of Burr-Brown IC Data Book. (2) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "DRV135UA/2K5" will get a single 2500-piece Tape and Reel. For detailed Tape and Reel mechanical information, refer to Appendix B of Burr-Brown IC Data Book.

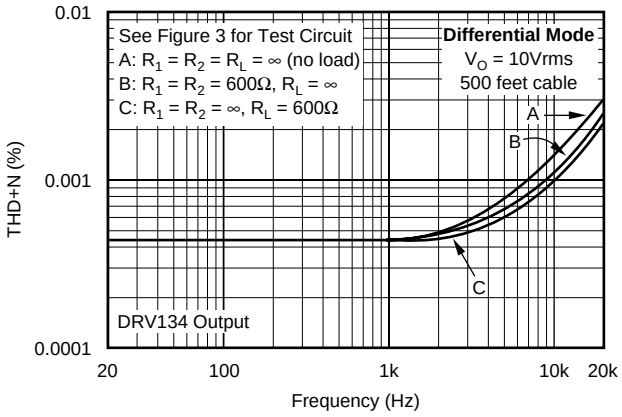
# TYPICAL PERFORMANCE CURVES

At $T_A$ = +25°C, $V_S$ = ±18V, $R_L$ = 600Ω differential connected between $+V_O$ and $-V_O$, unless otherwise noted.

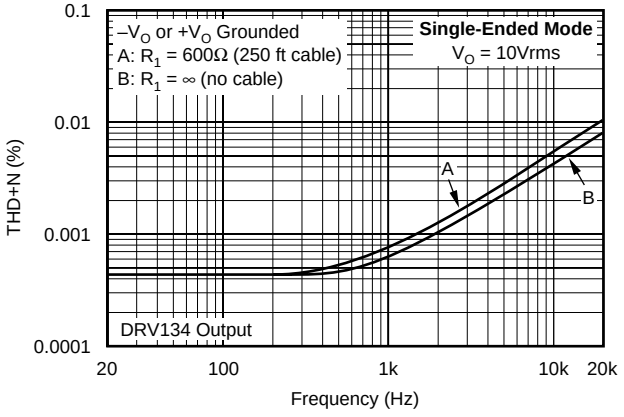
TOTAL HARMONIC DISTORTION+NOISE
vs FREQUENCY



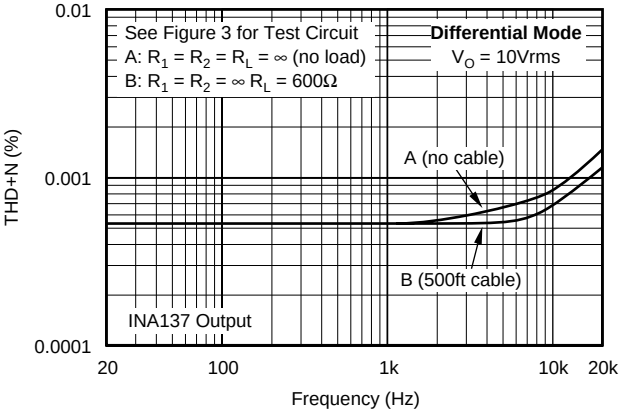

TOTAL HARMONIC DISTORTION+NOISE
vs FREQUENCY



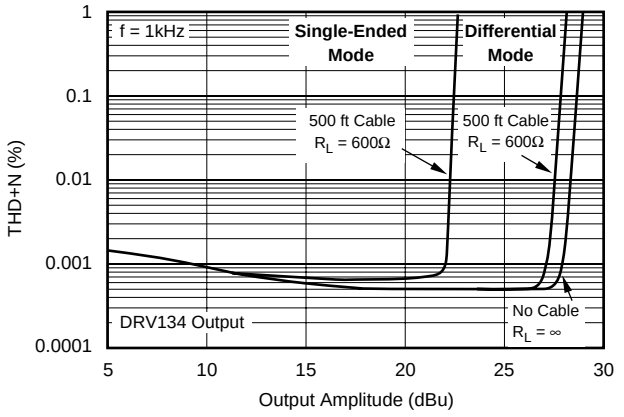

TOTAL HARMONIC DISTORTION+NOISE
vs FREQUENCY



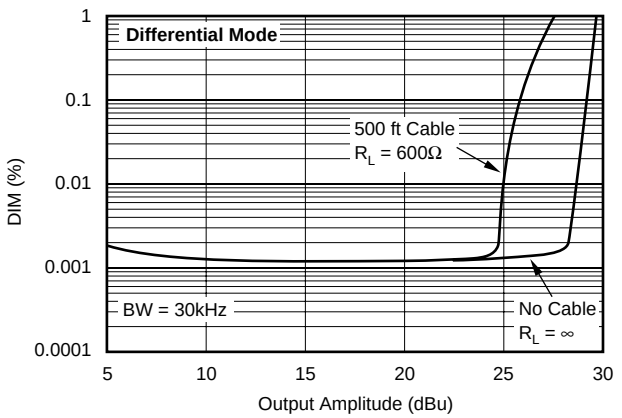

SYSTEM TOTAL HARMONIC DISTORTION+NOISE
vs FREQUENCY




HEADROOM—TOTAL HARMONIC DISTORTION+NOISE
vs OUTPUT AMPLITUDE



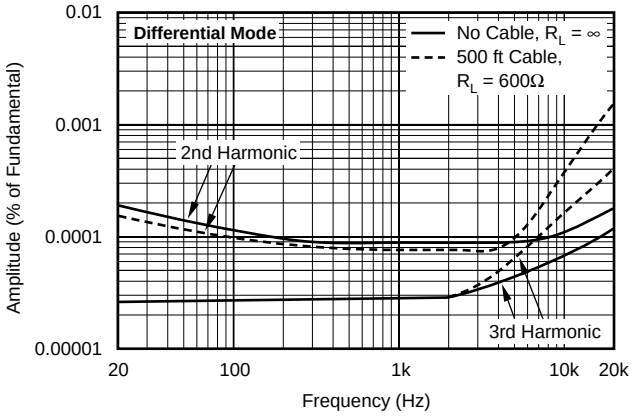

DIM INTERMODULATION DISTORTION
vs OUTPUT AMPLITUDE



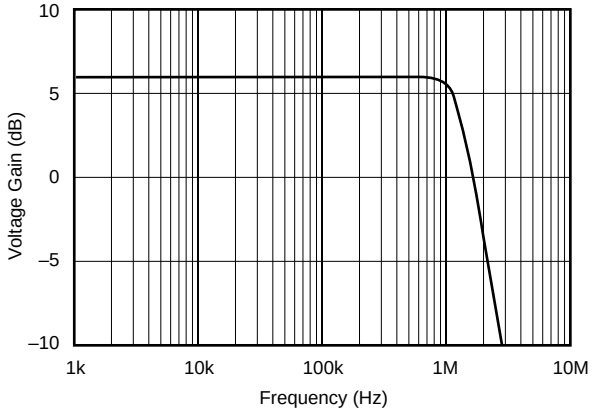
# TYPICAL PERFORMANCE CURVES (CONT)

At $T_A$ = +25°C, $V_S$ = ±18V, $R_L$ = 600Ω differential connected between $+V_O$ and $-V_O$, unless otherwise noted.

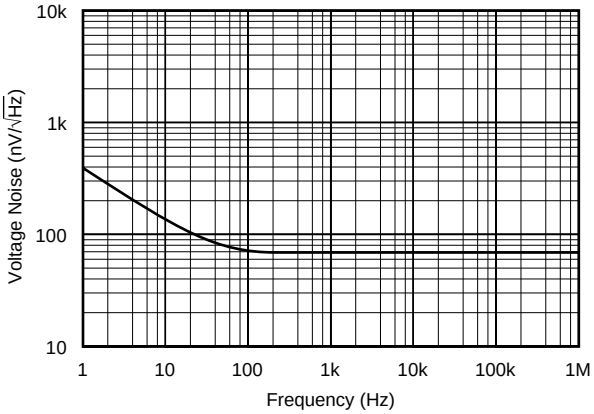
HARMONIC DISTORTION PRODUCTS vs FREQUENCY



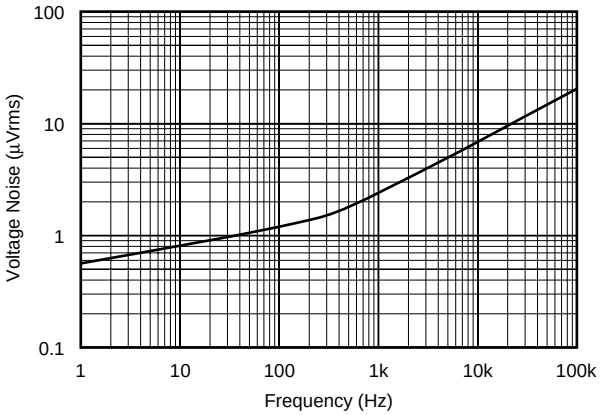

GAIN vs FREQUENCY



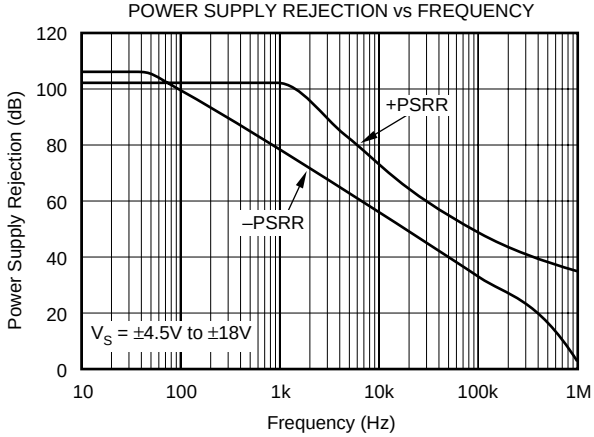

OUTPUT VOLTAGE NOISE SPECTRAL DENSITY vs FREQUENCY



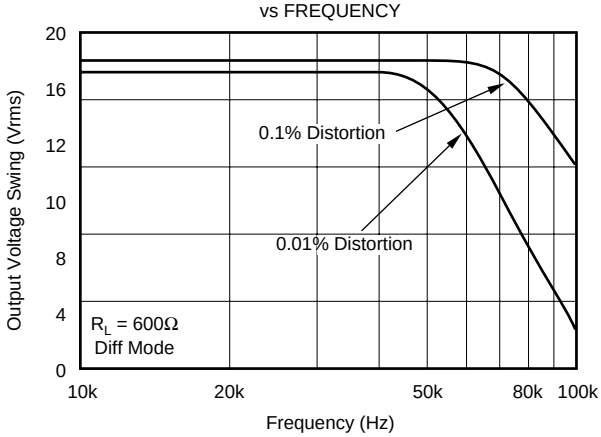

OUTPUT VOLTAGE NOISE vs NOISE BANDWIDTH




POWER SUPPLY REJECTION vs FREQUENCY



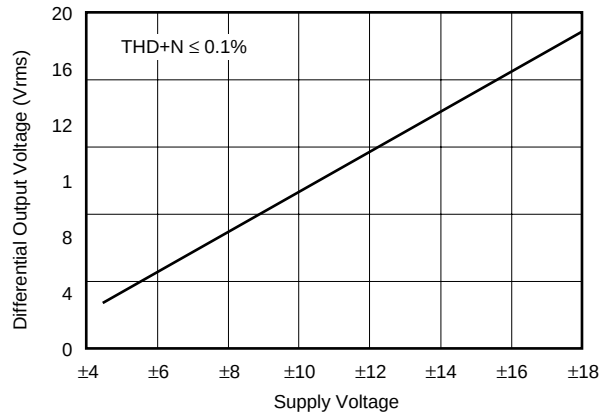

MAXIMUM OUTPUT VOLTAGE SWING vs FREQUENCY



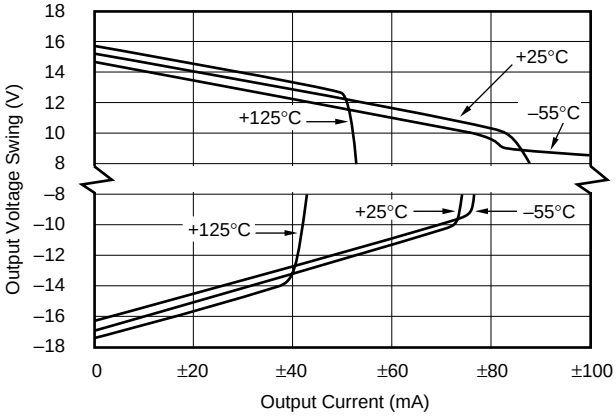
# TYPICAL PERFORMANCE CURVES (CONT)

At $T_A$ = +25°C, $V_S$ = ±18V, $R_L$ = 600Ω differential connected between $+V_O$ and $-V_O$, unless otherwise noted.

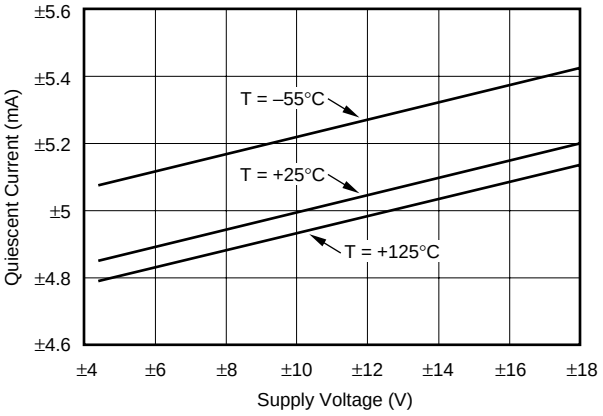
OUTPUT VOLTAGE SWING vs SUPPLY VOLTAGE



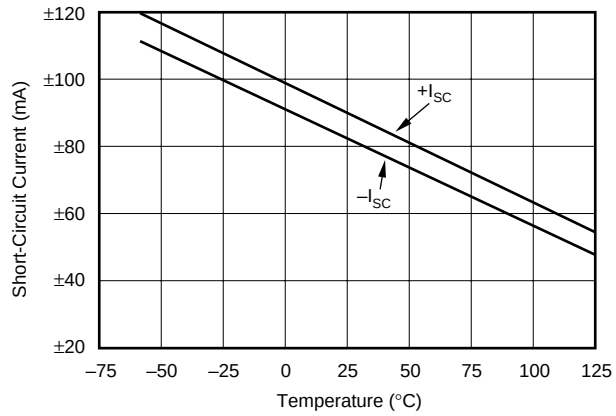

OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



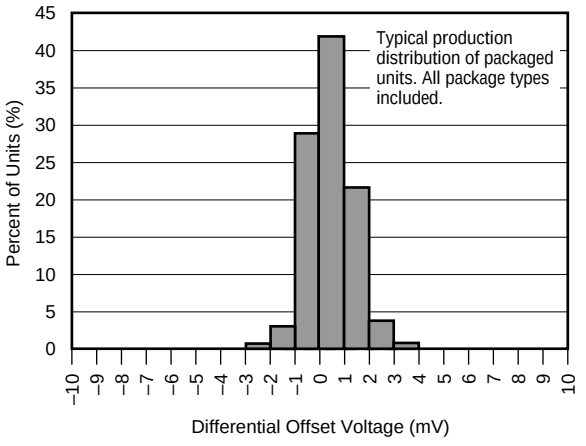

QUIESCENT CURRENT vs SUPPLY VOLTAGE



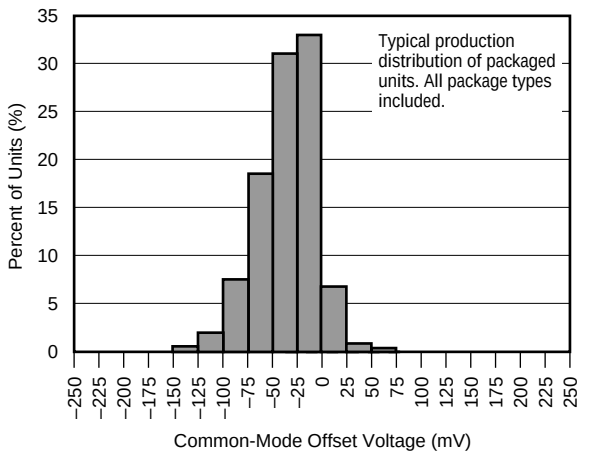

SHORT-CIRCUIT CURRENT vs TEMPERATURE




DIFFERENTIAL OFFSET VOLTAGE PRODUCTION DISTRIBUTION




COMMON-MODE OFFSET VOLTAGE PRODUCTION DISTRIBUTION

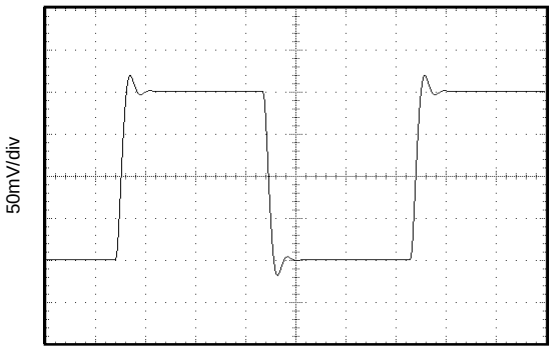


# TYPICAL PERFORMANCE CURVES (CONT)

At $T_A$ = +25°C, $V_S$ = ±18V, $R_L$ = 600Ω differential connected between $+V_O$ and $-V_O$, unless otherwise noted.

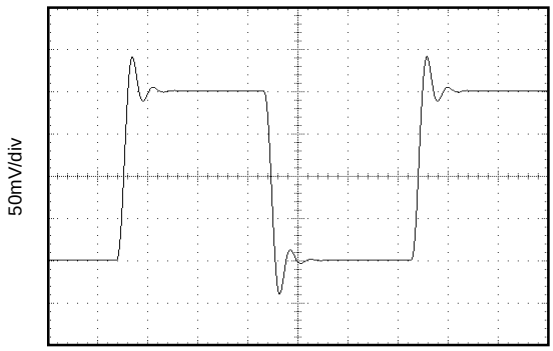
SMALL-SIGNAL STEP RESPONSE

$C_L$ = 100pF



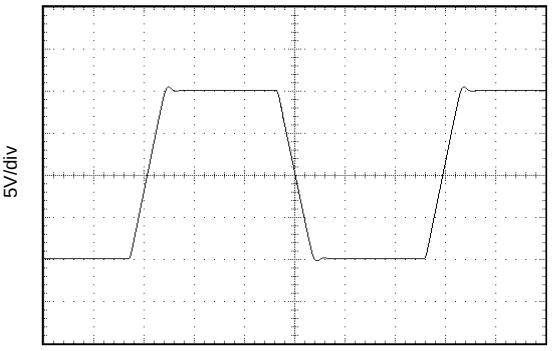

SMALL-SIGNAL STEP RESPONSE

$C_L$ = 1000pF



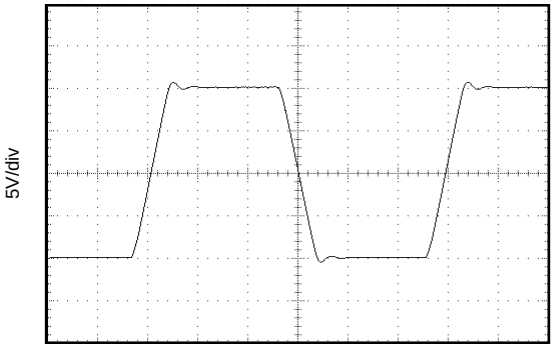

LARGE-SIGNAL STEP RESPONSE

$C_L$ = 100pF

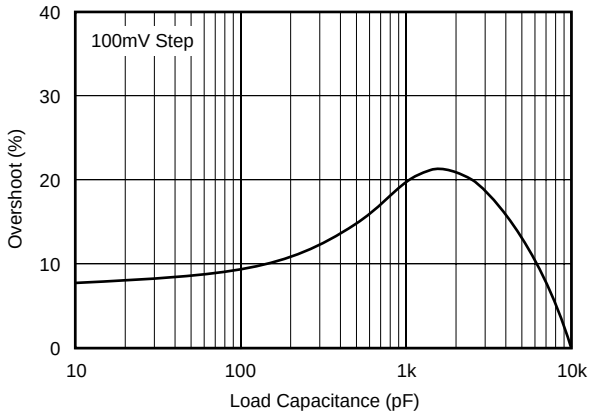



LARGE-SIGNAL STEP RESPONSE

$C_L$ = 1000pF




SMALL-SIGNAL OVERSHOOT
vs LOAD CAPACITANCE



# APPLICATIONS INFORMATION

The DRV134 (and DRV135 in SO-8 package) converts a single-ended, ground-referenced input to a floating differential output with +6dB gain (G = 2). Figure 1 shows the basic connections required for operation. Decoupling capacitors placed close to the device pins are strongly recommended in applications with noisy or high impedance power supplies.

The DRV134 consists of an input inverter driving a cross-coupled differential output stage with 50Ω series output resistors. Characterized by low differential-mode output impedance (50Ω) and high common-mode output impedance (1.6kΩ), the DRV134 is ideal for audio applications. Normally, $+V_O$ is connected to +Sense, $-V_O$ is connected to –Sense, and the outputs are taken from these junctions as shown in Figure 1. For applications with large dc cable offset errors, a 10µF electrolytic nonpolarized blocking capacitor at each sense pin is recommended as shown in Figure 2.

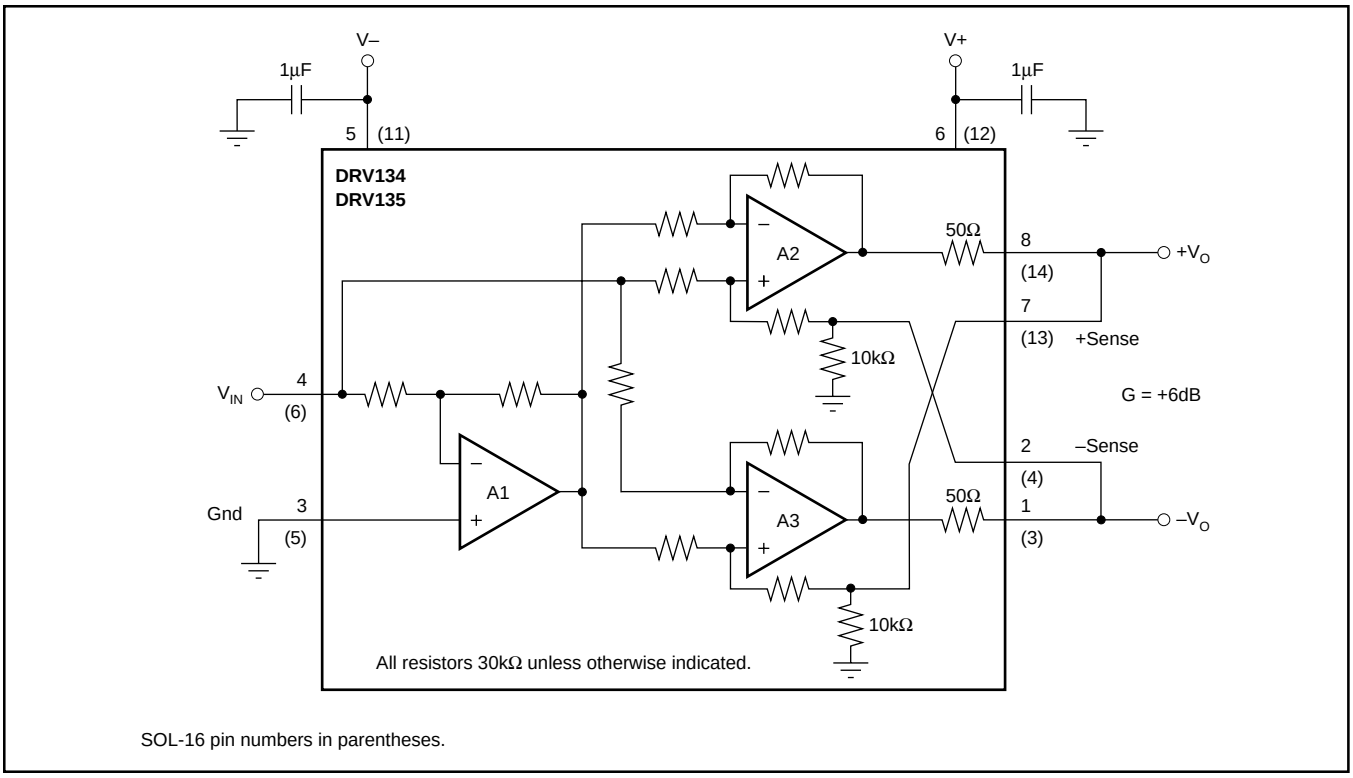



FIGURE 1. Basic Connections.

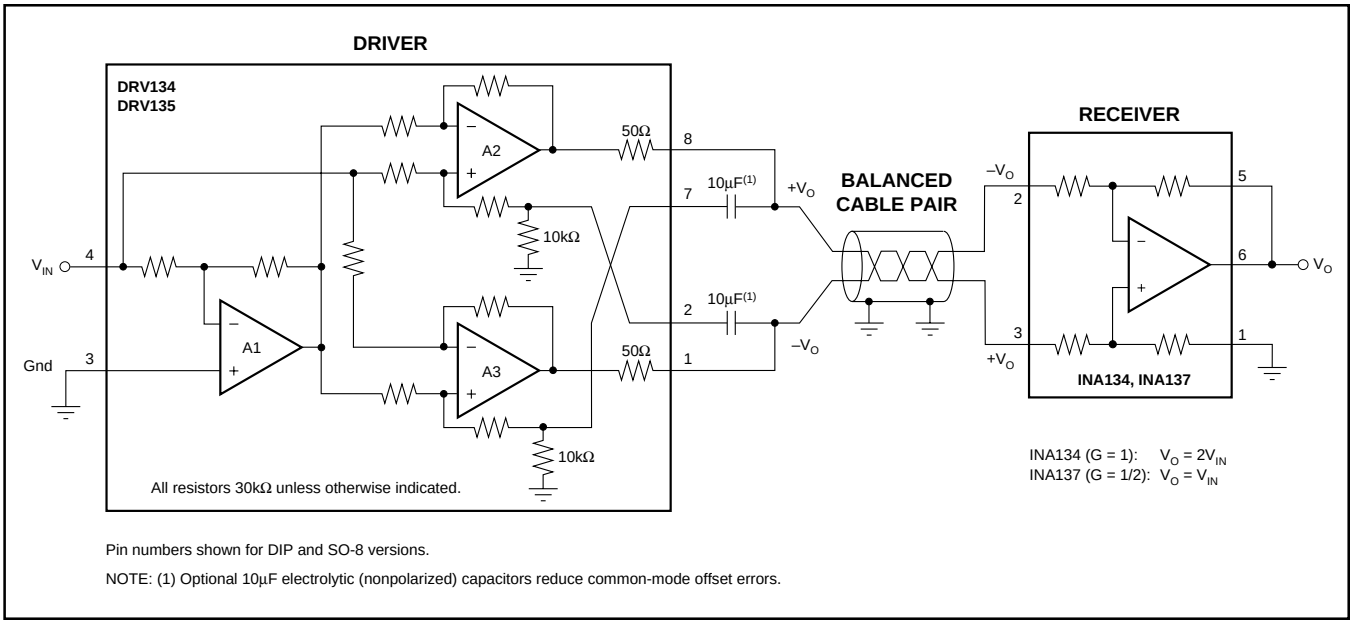



FIGURE 2. Complete Audio Driver/Receiver Circuit.

Excellent internal design and layout techniques provide low signal distortion, high output level (+27dBu), and a low noise floor (–98dBu). Laser trimming of thin film resistors assures excellent output common-mode rejection (OCMR) and signal balance ratio (SBR). In addition, low dc voltage offset reduces errors and minimizes load currents.

For best system performance, it is recommended that a high input-impedance difference amplifier be used as the receiver. Used with the INA134 (G = 0dB) or the INA137 (G = ±6dB) differential line receivers, the DRV134 forms a complete solution for driving and receiving audio signals, replacing input and output coupling transformers commonly used in professional audio systems (Figure 2). When used with the INA137 (G = –6dB) overall system gain is unity.

## AUDIO PERFORMANCE

The DRV134 was designed for enhanced ac performance. Very low distortion, low noise, and wide bandwidth provide superior performance in high quality audio applications. Laser-trimmed matched resistors provide optimum output common-mode rejection (typically 68dB), especially when compared to circuits implemented with op amps and discrete precision resistors. In addition, high slew rate (15V/µs) and fast settling time (2.5µs to 0.01%) ensure excellent dynamic response.

The DRV134 has excellent distortion characteristics. As shown in the distortion data provided in the typical performance curves, THD+Noise is below 0.003% throughout the audio frequency range under various output conditions. Both differential and single-ended modes of operation are shown. In addition, the optional 10µF blocking capacitors used to minimize $V_{OCM}$ errors have virtually no effect on performance. Measurements were taken with an Audio Precision System One (with the internal 80kHz noise filter) using the THD test circuit shown in Figure 3.

Up to approximately 10kHz, distortion is below the measurement limit of commonly used test equipment. Furthermore, distortion remains relatively constant over the wide output voltage swing range (approximately 2.5V from the positive supply and 1.5V from the negative supply). A special output stage topology yields a design with minimum distortion variation from lot-to-lot and unit-to-unit. Furthermore, the small and large signal transient response curves demonstrate the DRV134's stability under load.

## OUTPUT COMMON-MODE REJECTION

Output common-mode rejection (OCMR) is defined as the change in differential output voltage due to a change in output common-mode voltage. When measuring OCMR, $V_{IN}$ is grounded and a common-mode voltage, $V_{CM}$, is applied to the output as shown in Figure 4. Ideally no differential mode signal ($V_{OD}$) should appear. However, a small mode-conversion effect causes an error signal whose magnitude is quantified by OCMR.

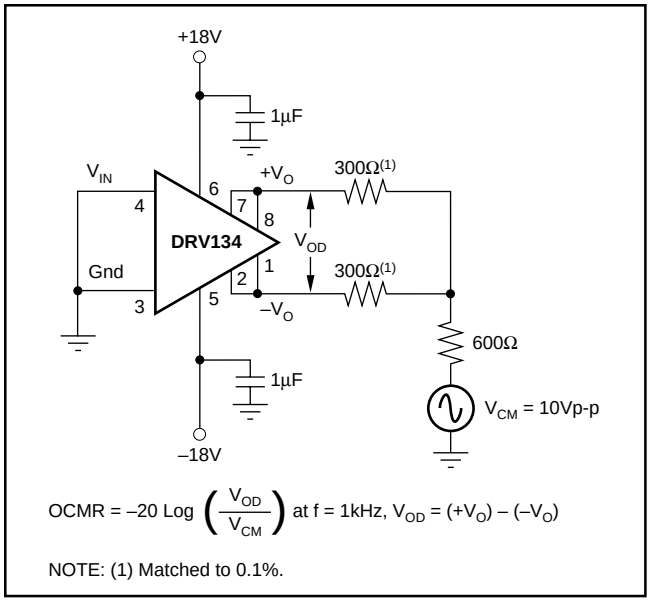



FIGURE 4. Output Common-Mode Rejection Test Circuit.

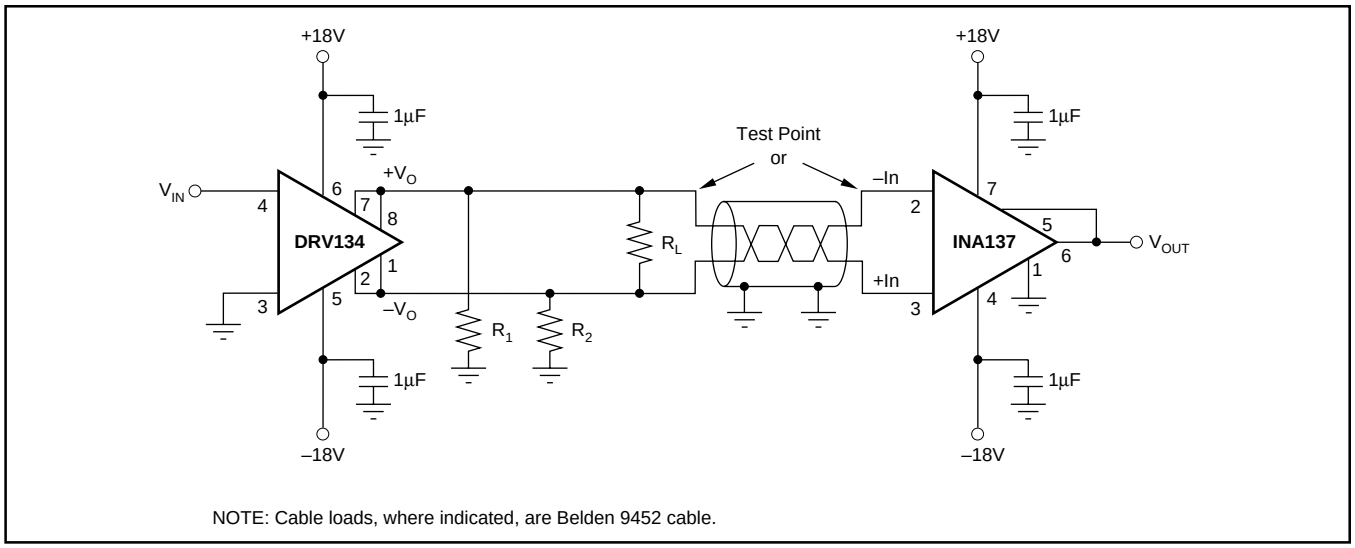



FIGURE 3. Distortion Test Circuit.

## SIGNAL BALANCE RATIO

Signal balance ratio (SBR) measures the symmetry of the output signals under loaded conditions. To measure SBR an input signal is applied and the outputs are summed as shown in Figure 5. $V_{OUT}$ should be zero since each output ideally is exactly equal and opposite. However, an error signal results from any imbalance in the outputs. This error is quantified by SBR. The impedances of the DRV134's out put stages are closely matched by laser trimming to minimize SBR errors. In an application, SBR also depends on the balance of the load network.

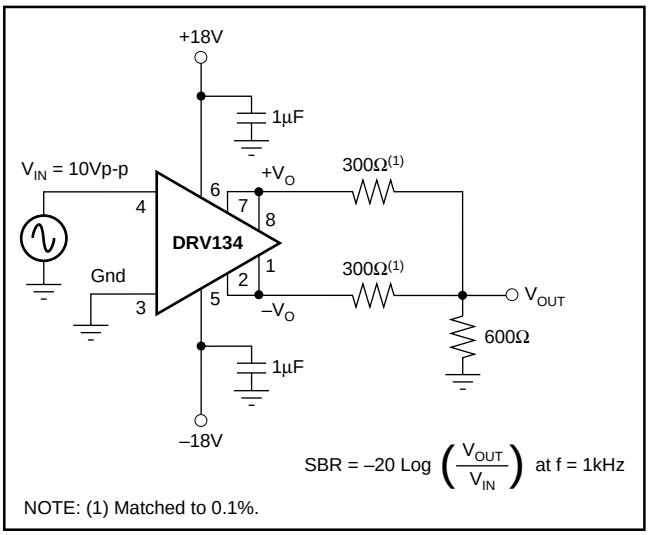



FIGURE 5. Signal Balance Ratio Test Circuit.

## SINGLE-ENDED OPERATION

The DRV134 can be operated in single-ended mode without degrading output drive capability. Single-ended operation requires that the unused side of the output pair be grounded (both the $V_O$ and Sense pins) to a low impedance return path. Gain remains +6dB. Grounding the negative outputs as shown in Figure 6 results in a noninverted output signal (G = +2) while grounding the positive outputs gives an inverted output signal (G = –2).

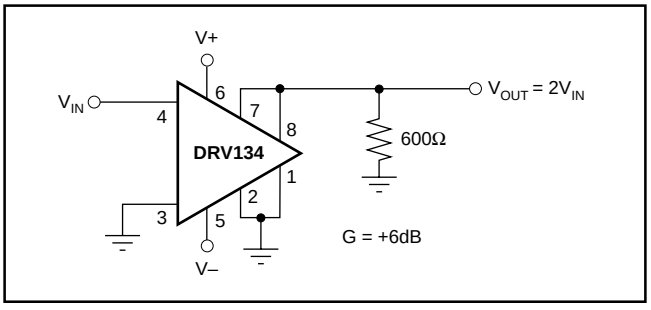



FIGURE 6. Typical Single-Ended Application.

For best rejection of line noise and hum differential mode operation is recommended. However, single-ended performance is adequate for many applications. In general single-ended performance is comparable to differential mode (see THD+N typical performance curves), but the common-mode and noise rejection inherent in balanced-pair systems is lost.

## CABLE

The DRV134 is capable of driving large signals into 600Ω loads over long cables. Low impedance shielded audio cables such as the standard Belden 8451 or 9452 (or similar) are recommended, especially in applications where long cable lengths are required.

## THERMAL PERFORMANCE

The DRV134 and DRV135 have robust output drive capability and excellent performance over temperature. In most applications there is no significant difference between the DIP, SOL-16, and SO-8 packages. However, for applications with extreme temperature and load conditions, the SOL-16 (DRV134UA) or DIP (DRV134PA) packages are recommended. Under these conditions, such as loads greater than 600Ω or very long cables, performance may be degraded in the SO-8 (DRV135UA) package.

## LAYOUT CONSIDERATIONS

A driver/receiver balanced-pair (such as the DRV134 and INA137) rejects the voltage differences between the grounds at each end of the cable, which can be caused by ground currents, supply variations, etc. In addition to proper bypassing, the suggestions below should be followed to achieve optimal OCMR and noise rejection.

- The DRV134 input should be driven by a low impedance source such as an op amp or buffer.
- As is the case for any single-ended system, the source's common should be connected as close as possible to the DRV134's ground. Any ground offset errors in the source will degrade system performance.
- Symmetry on the outputs should be maintained.
- Shielded twisted-pair cable is recommended for all applications. Physical balance in signal wiring should be maintained. Capacitive differences due to varying wire lengths may result in unequal noise pickup between the pair and degrade OCMR. Follow industry practices for proper system grounding of the cables.

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| DRV134PA | ACTIVE | PDIP | P | 8 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | N / A for Pkg Type |
| DRV134PAG4 | ACTIVE | PDIP | P | 8 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | N / A for Pkg Type |
| DRV134UA | ACTIVE | SOIC | DW | 16 | 48 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| DRV134UA/1K | ACTIVE | SOIC | DW | 16 | 1000 | Pb-Free (RoHS) | CU NIPDAU | Level-3-260C-168 HR |
| DRV134UA/1KE4 | ACTIVE | SOIC | DW | 16 | 1000 | Pb-Free (RoHS) | CU NIPDAU | Level-3-260C-168 HR |
| DRV134UAE4 | ACTIVE | SOIC | DW | 16 | 48 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| DRV135UA | ACTIVE | SOIC | D | 8 | 100 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| DRV135UA/2K5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| DRV135UA/2K5E4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| DRV135UAG4 | ACTIVE | SOIC | D | 8 | 100 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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