

# DRV1100

## HIGH POWER DIFFERENTIAL DRIVER AMPLIFIER

### FEATURES

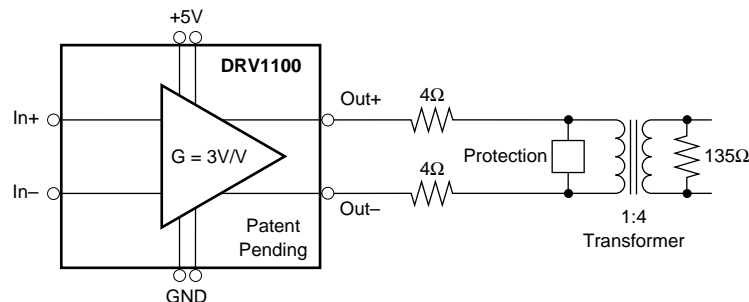
- **HIGH OUTPUT CURRENT: 230mA**
- **SINGLE SUPPLY OPERATION: 5V**
- **5MHz BANDWIDTH: 6Vp-p into 15Ω**
- **VERY LOW THD AT HIGH POWER: -72dBc at 6Vp-p, 100kHz, 100Ω**
- **LOW QUIESCENT CURRENT: 11mA**
- **FIXED DIFFERENTIAL GAIN: 3V/V**

### APPLICATIONS

- **xDSL TWISTED PAIR LINE DRIVER**
- **COMMUNICATIONS LINE DRIVER**
- **TRANSFORMER DRIVER**
- **SOLENOID DRIVER**
- **HIGH POWER AUDIO DRIVER**
- **CRT YOKE DRIVER**

### DESCRIPTION

The DRV1100 is fixed gain differential line driver designed for very low harmonic distortion at the high powers required of xDSL line interface standards. Operating on a single +5V supply, it can deliver 230mA peak output current and 9.5Vp-p differential output voltage swing. This high output power on a single +5V supply makes the DRV1100 an excellent choice for the xDSL applications that require up to 17dBm power onto the line with high crest factors. The DRV1100 is available in both 8-pin plastic DIP and SO-8 packages.



# SPECIFICATIONS

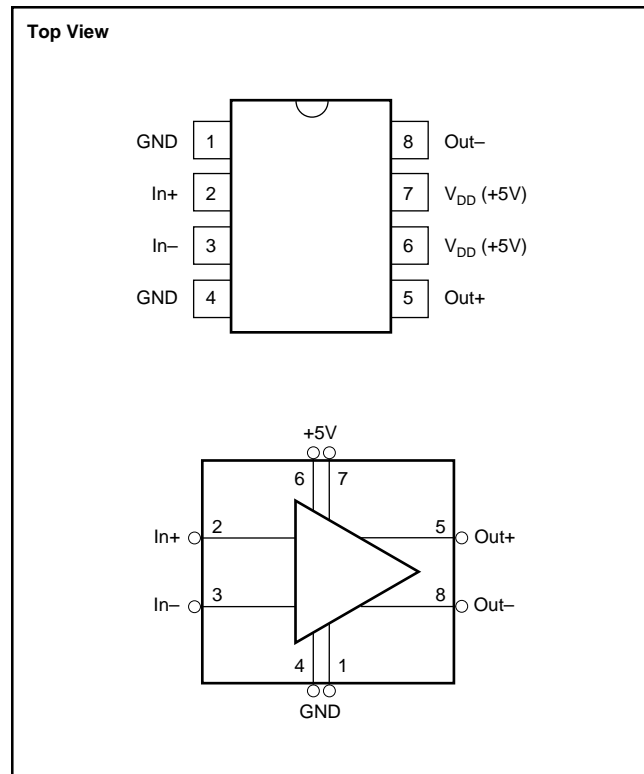
At  $V_{DD} = +5.0V$ ,  $V_{CM} = V_{DD}/2$ ,  $T_A = 25^\circ C$ , unless otherwise specified.

PARAMETER	CONDITIONS	DRV1100P, U			UNITS
		MIN	TYP	MAX	
<b>AC PERFORMANCE</b>					
-3dB Bandwidth	$R_L = 15\Omega$ , $V_O = 1V_{p-p}$		8		MHz
	$R_L \geq 100\Omega$ , $V_O = 1V_{p-p}$		11		MHz
	$R_L = 15\Omega$ , $V_O = 6V_{p-p}$		5		MHz
	$R_L \geq 100\Omega$ , $V_O = 6V_{p-p}$		6		MHz
Differential Slew Rate	$R_L = 100\Omega$ , $V_O = 6V_{p-p}$		80		V/ $\mu s$
Step Response Delay <sup>(1)</sup>	$V_O = 1V_{p-p}$		25		ns
Settling Time to 1%, Step Input	$V_O = 1V_{p-p}$ , $R_L = 100\Omega$		0.25		$\mu s$
Settling Time to 1%, Step Input	$V_O = 6V_{p-p}$ , $R_L = 100\Omega$		0.3		$\mu s$
Settling Time to 0.1%, Step Input	$V_O = 1V_{p-p}$ , $R_L = 100\Omega$		0.8		$\mu s$
Settling Time to 0.1%, Step Input	$V_O = 6V_{p-p}$ , $R_L = 100\Omega$		1.1		$\mu s$
THD, Total Harmonic Distortion <sup>(2)</sup>					
f = 10kHz	$R_L = 100\Omega$ , $V_O = 6V_{p-p}$		-85		dBc
f = 10kHz	$R_L = 15\Omega$ , $V_O = 6V_{p-p}$	-66	-76		dBc
f = 100kHz	$R_L = 100\Omega$ , $V_O = 6V_{p-p}$		-72		dBc
f = 100kHz	$R_L = 15\Omega$ , $V_O = 6V_{p-p}$		-65		dBc
Input Voltage Noise	f = 100kHz		30		nV/ $\sqrt{Hz}$
Input Current Noise	f = 100kHz		0.5		fA/ $\sqrt{Hz}$
<b>INPUT CHARACTERISTICS</b>					
Differential Input Resistance			$10^{11}$		$\Omega$
Differential Input Capacitance			1		pF
Common-Mode Input Resistance			$10^{11}$		$\Omega$
Common-Mode Input Capacitance			6		pF
Input Offset Voltage			5		mV
Input Bias Current			1		pA
Common-Mode Rejection Ratio	Input Referred		62		dB
Power Supply Rejection Ratio	Input Referred	60	76		dB
Input Common-Mode Voltage Range <sup>(3)</sup>		0.5		$V_{DD} - 0.5$	V
<b>OUTPUT CHARACTERISTICS</b>					
Differential Output Offset, RTO			10	25	mV
Differential Output Offset Drift, RTO	$-40^\circ C$ to $+85^\circ C$		30		$\mu V/^\circ C$
Differential Output Resistance			0.16		$\Omega$
Peak Current (Continuous)	$R_L = 15\Omega$	200	230		mA
Differential Output Voltage Swing	$R_L = 1k\Omega$		9.6		Vp-p
	$R_L = 100\Omega$	8.5	9.5		Vp-p
	$R_L = 15\Omega$	6.0	6.6		Vp-p
Output Voltage Swing, Each Side	$R_L = 1k\Omega$	0.125		4.875	V
Gain	Fixed Gain, Differential		3		V/V
Gain Error				$\pm 0.25$	dB
<b>POWER SUPPLY</b>					
Operating Voltage Range		+4.5	+5.0	+5.5	V
Quiescent Current	$V_{DD} = 5.0V$		+11	+16	mA
<b>TEMPERATURE RANGE</b>					
Thermal Resistance, $\theta_{JA}$		-40		+85	$^\circ C$
DRV1100P 8-Pin DIP			100		$^\circ C/W$
DRV1100U 8-Pin SO-8			125		$^\circ C/W$

NOTES: (1) Time from 50% point of input step to 50% point of output step. (2) Measurement Bandwidth = 500kHz. (3) Output common-mode voltage follows input common-mode voltage; therefore, if input  $V_{CM} = V_{DD}/2$ , then output  $V_{CM} = V_{DD}/2$ .

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

## PIN CONFIGURATIONS



## ABSOLUTE MAXIMUM RATINGS

Analog Inputs: Current .....	$\pm 100\text{mA}$ , Momentary
	$\pm 10\text{mA}$ , Continuous
Voltage .....	GND $-0.3\text{V}$ to $V_{\text{DD}} + 0.2\text{V}$
Analog Outputs Short Circuit to Ground ( $+25^\circ\text{C}$ ) .....	Momentary
Analog Outputs Short Circuit to $V_{\text{DD}}$ ( $+25^\circ\text{C}$ ) .....	Momentary
$V_{\text{DD}}$ to GND .....	$-0.3\text{V}$ to $6\text{V}$
Junction Temperature .....	$+150^\circ\text{C}$
Storage Temperature Range .....	$-40^\circ\text{C}$ to $+125^\circ\text{C}$
Lead Temperature (soldering, 3s) .....	$+260^\circ\text{C}$
Power Dissipation .....	(See Thermal/Analysis Discussion)

## PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
DRV1100P	8-Pin PDIP	006
DRV1100U	8-Lead SO-8	182

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

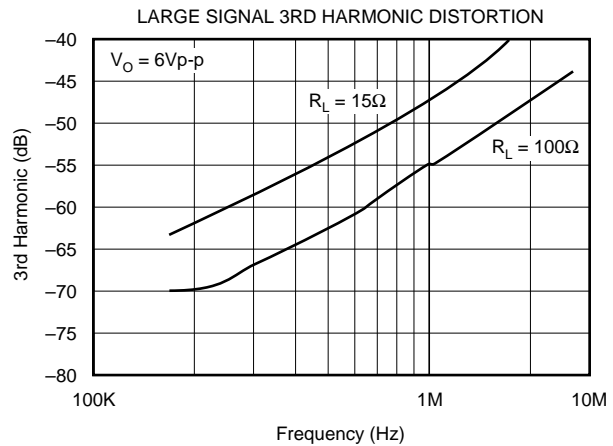
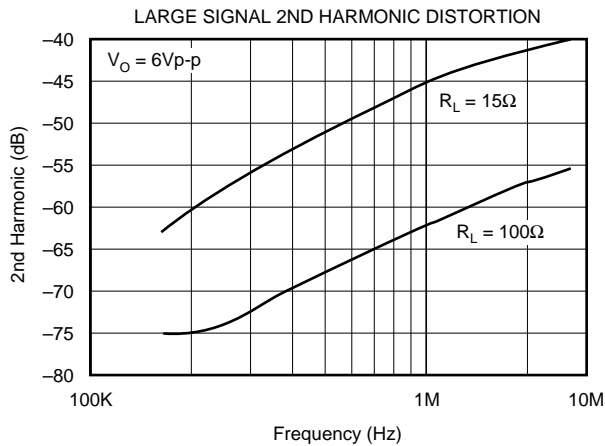
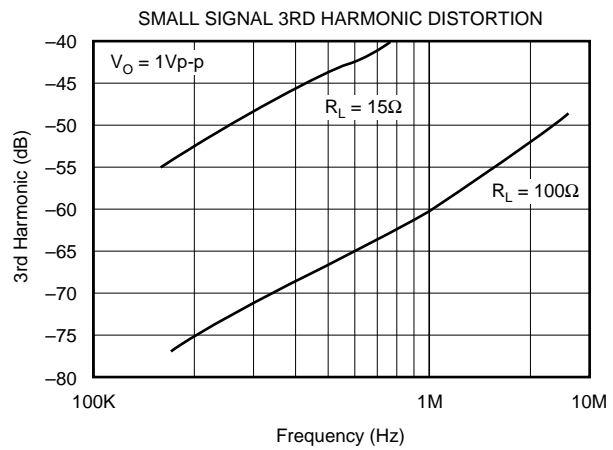
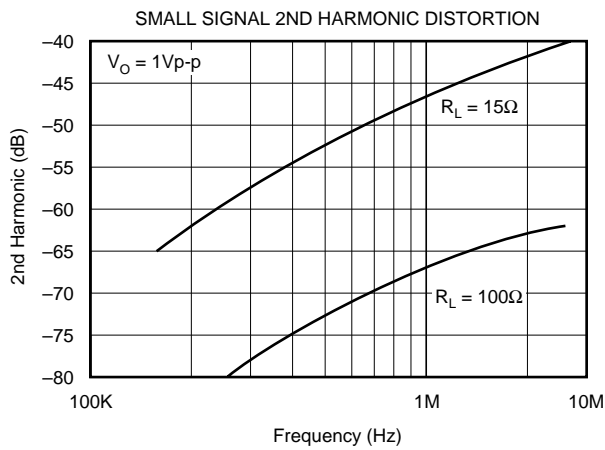
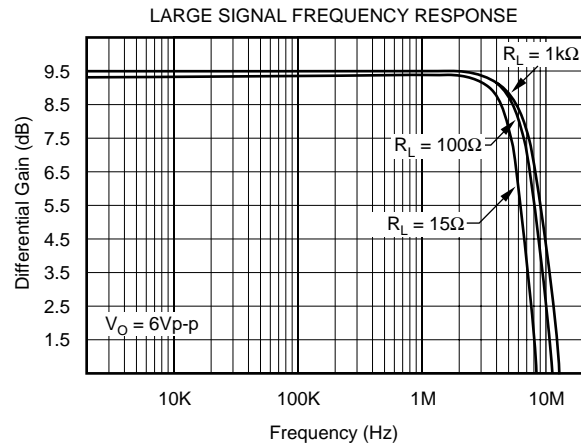
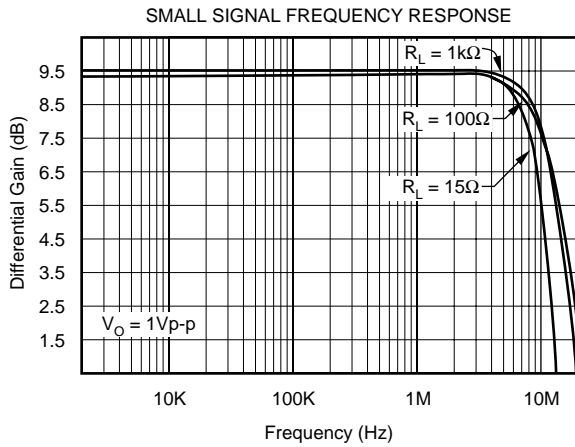
## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

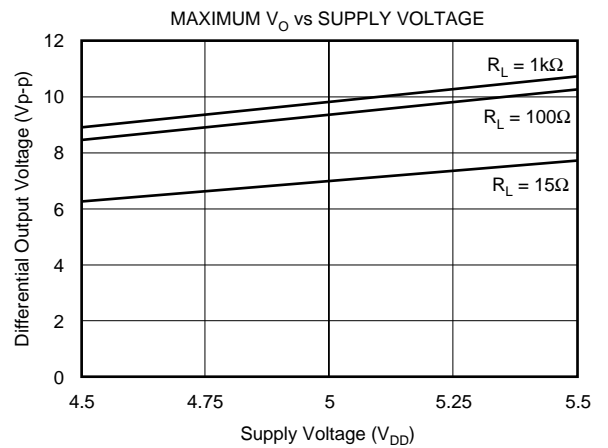
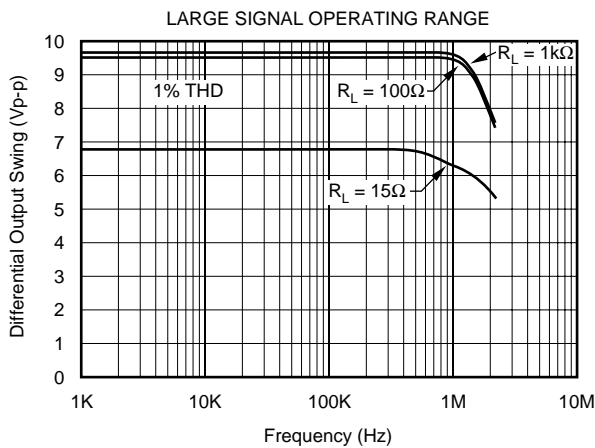
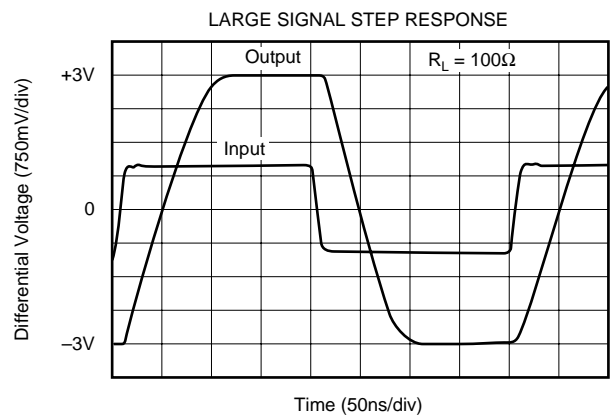
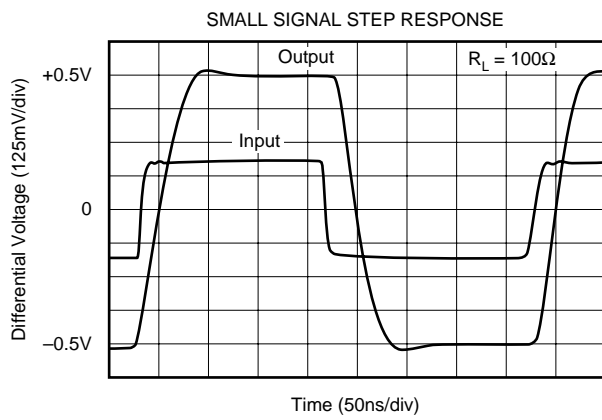
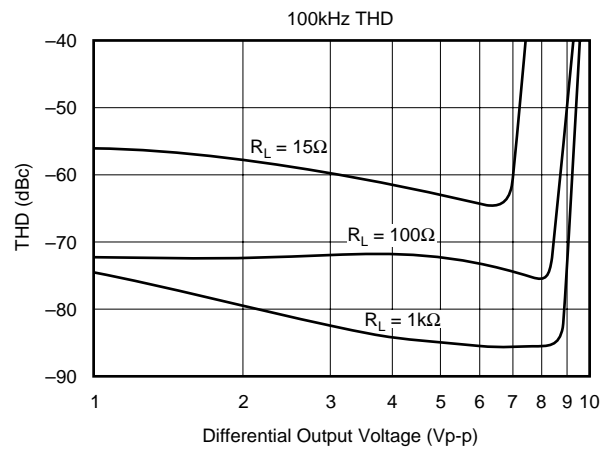
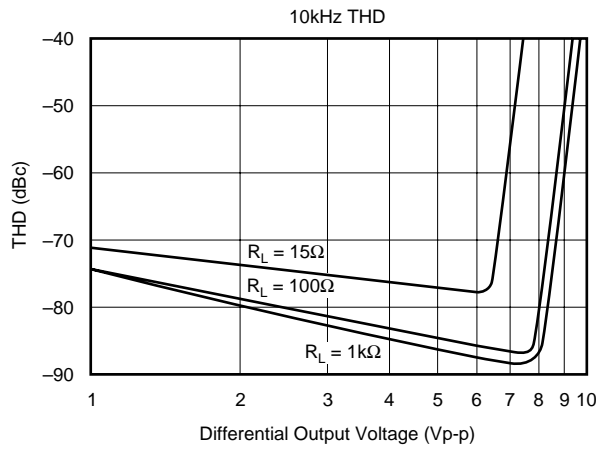
# TYPICAL PERFORMANCE CURVES

At  $V_{DD} = +5.0V$ ,  $V_{CM} = V_{DD}/2$ ,  $T_A = 25^\circ C$ , unless otherwise specified.



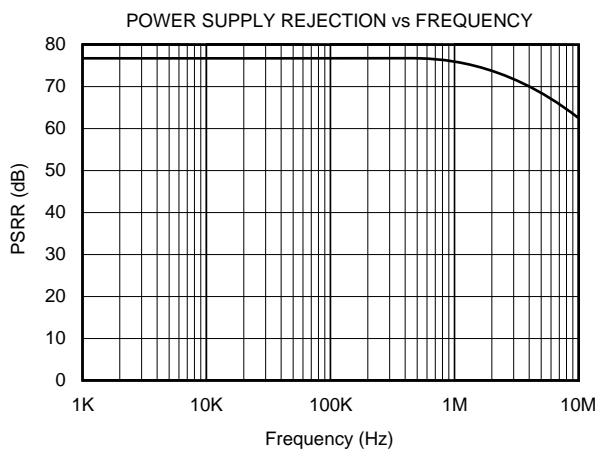
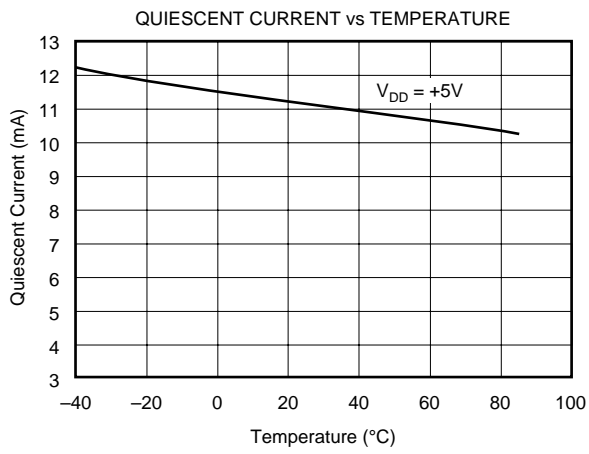
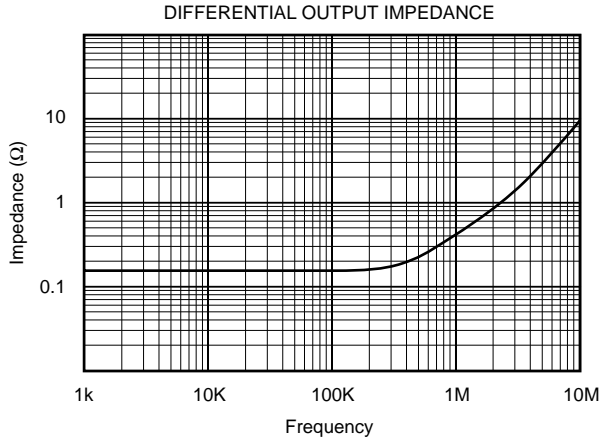
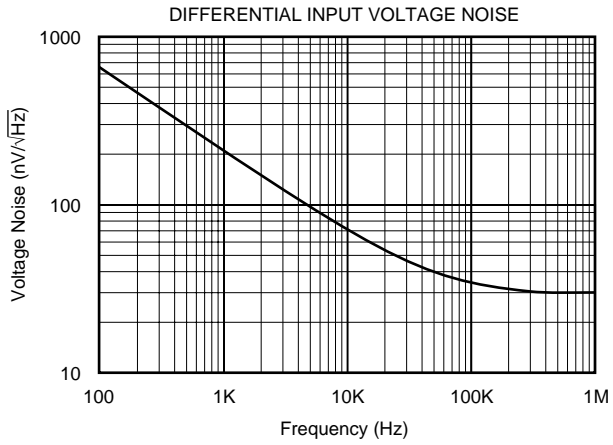
# TYPICAL PERFORMANCE CURVES (CONT)

At  $V_{DD} = +5.0V$ ,  $V_{CM} = V_{DD}/2$ ,  $T_A = 25^\circ C$ , unless otherwise specified.



# TYPICAL PERFORMANCE CURVES (CONT)

At  $V_{DD} = +5.0V$ ,  $V_{CM} = V_{DD}/2$ ,  $T_A = 25^\circ C$ , unless otherwise specified.



# APPLICATIONS INFORMATION

## INTERNAL BLOCK DIAGRAM

The DRV1100 is a true differential input to differential output fixed gain amplifier. Operating on a single +5V power supply, it provides an internally fixed differential gain of +3 and a common-mode gain of +1 from the input to output. Fabricated on an advanced CMOS process, it offers very high input impedance along with a low impedance 230mA output drive. Figure 1 shows a simplified internal block diagram.

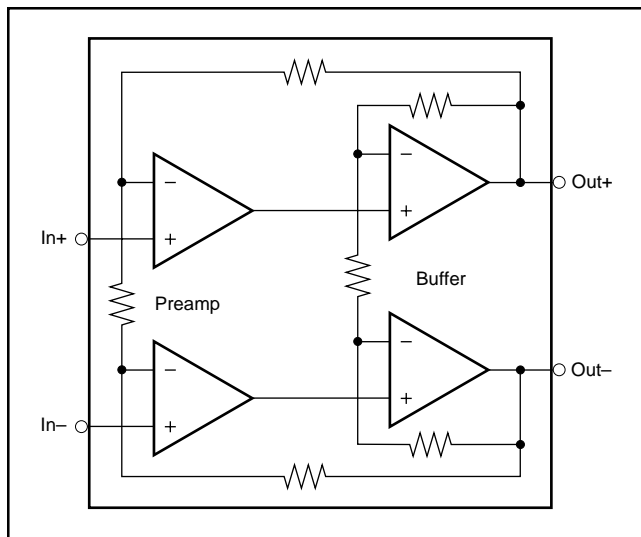


FIGURE 1. Simplified DRV1100 Internal Block Diagram.

To achieve the maximum dynamic range, operate the DRV1100 with the inputs centered at  $V_{DD}/2$ . This will place the output differential swing centered at  $V_{DD}/2$  for maximum swing and lowest distortion. Purely differential input signals will produce a purely differential output signal. A single ended input signal, applied to one input of the DRV1100, with the other input at a fixed voltage, will produce both a differential and common-mode output signal. This is an acceptable mode of operation when the DRV1100 is driving an element with good common-mode rejection (such as a transformer).

## DIFFERENTIAL OUTPUT VOLTAGE AND POWER

Applying the balanced differential output voltage of the DRV1100 to a load between the outputs will produce a peak-to-peak voltage swing that is twice the swing of each individual output. This is illustrated in Figure 2 where the common-mode voltage is  $V_{DD}/2$ . For a load connected between the outputs, the only voltage that matters is the differential voltage between the two outputs—the common-mode voltage does not produce any load current in this case.

The peak power that the DRV1100 can deliver into a differential load is  $V_p^2/R_L$ . The Typical Performance Curves show the maximum  $V_{p-p}$  versus load and frequency. The peak voltage ( $V_p$ ) equals 1/2 of the peak-to-peak voltage

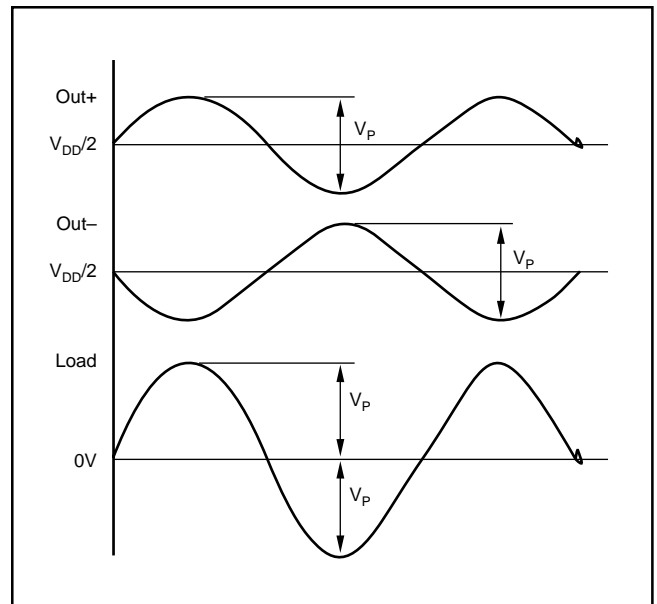


FIGURE 2. DRV1100 Single Ended and Differential Output Waveforms.

( $V_{p-p}$ ). Squaring 1/2 of the  $V_{p-p}$  and dividing by the load will give the peak power. For example, the Typical Performance Curves show that on +5V supply the DRV1100 will deliver 6.8V $_{p-p}$  into 15 $\Omega$  at 500kHz. The peak load power under this condition is  $(6.8V_{p-p}/2)^2/15\Omega = 770mW$ .

## SUPPLY VOLTAGE

The DRV1100 is designed for operation on a single +5V supply. For loads  $> 200\Omega$ , each output will swing rail to rail. This gives a peak-to-peak differential output swing that is approximately  $= 2 \cdot V_{DD}$ . For best distortion performance, the power supply should be decoupled to a good ground plane immediately adjacent to the package with a 0.1 $\mu F$  capacitor. In addition, a larger electrolytic supply decoupling capacitor (6.8 $\mu F$ ) should be near the package but can be shared among multiple devices.

## DIGITAL SUBSCRIBER LINE APPLICATIONS

The DRV1100 is particularly suited to the high power, low distortion, requirements of a twisted pair driver in digital communications applications. These include HDSL (High bit rate Digital Subscriber Lines), ADSL (Asymmetrical Digital Subscriber Lines), and RADSL (Rate adaptive ADSL). Figure 3 shows a typical transformer coupled xDSL line driver configuration. In general, the DRV1100 is usable for output power requirements up to 17dBm with a crest factor up to 6 (crest factor is the ratio of peak to rms voltage).

To calculate the required amplifier power for an xDSL application—

- Determine the average power required onto the line in the particular application. The DRV1100 must be able to deliver twice this power (+3dB) to account for the power

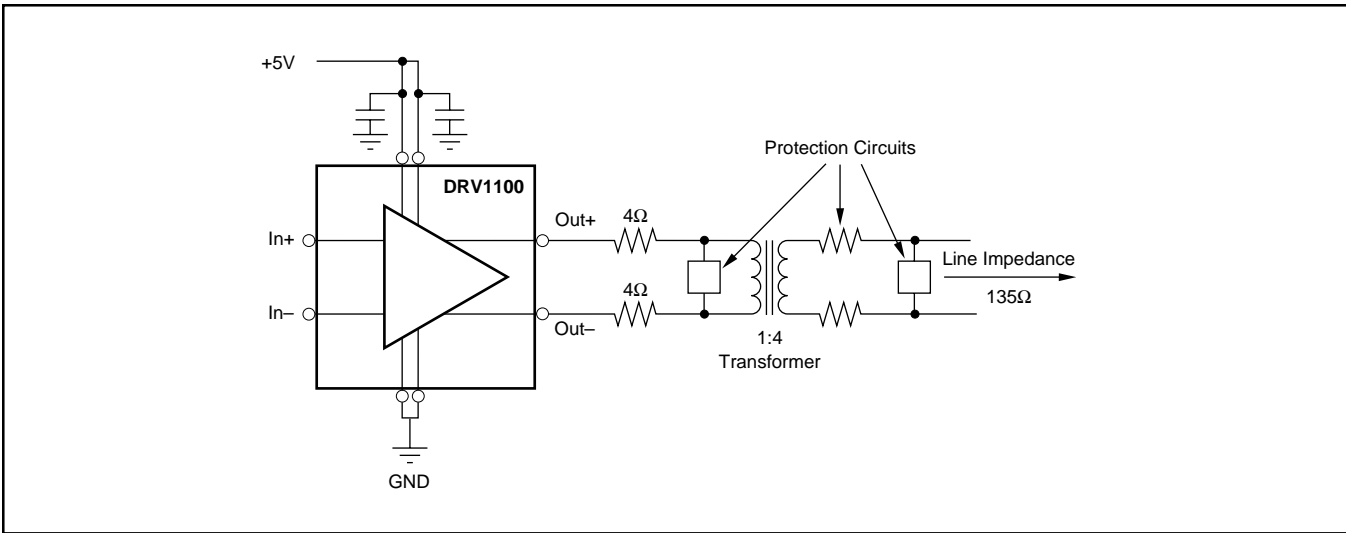


FIGURE 3. Typical Digital Subscriber Line Application.

loss through the series impedance matching resistors shown in Figure 3. **Twice the required line power must be delivered by the DRV1100 through the frequency band of interest with the distortion required by the system.**

- Calculate the RMS voltage required at the output of the DRV1100 with this 2X line power requirement.  $V_{rms} = (2 \cdot P_{LINE} \cdot R_L)^{1/2}$ , where  $R_L$  is the total load impedance that the DRV1100 must drive. Multiply this  $V_{rms}$  by 2 • crest factor to get the total required differential peak-to-peak voltage at the output. **The DRV1100 must be able to drive the peak-to-peak differential voltage into the load impedance.**

Where possible, the transformer turns ratio may be adjusted to keep within the DRV1100 output voltage and current constraints for a given  $R_{LINE}$  and desired power onto the line.

Using the example of Figure 3, assume the average power desired on a 135Ω line is 14dBm (HDSL). Twice this power (17dBm) is required into the matching resistors on the primary side of the transformer. This 135Ω load is reflected through the 1:4 transformer as a  $(135/(4^2)) = 8.4\Omega$  load. The two series 4.1Ω resistors, along with the 0.2Ω differential output impedance of the DRV1100, will provide impedance matching into this 8.4Ω load. The DRV1100 will see approximately a 16.5Ω load under these conditions. The required 17dBm (50mW) into this load will need an output  $V_{rms} = (50mW \cdot 16.5)^{1/2} = 0.91V_{rms}$ . Assuming a crest factor of 3, the differential peak-to-peak output voltage =  $6 \cdot 0.91 = 5.45V_{p-p}$ . The Typical Performance Curves show that, at 100kHz, the DRV1100 can deliver this voltage swing with less than -62dB THD.

## OUTPUT PROTECTION

Figure 3 also shows overvoltage and short circuit protection elements that are commonly included in xDSL applications. Overvoltage suppressors include diodes or MOV's. The outputs of the DRV1100 can be momentarily shorted to

ground or to the supply without damage. The outputs are not, however, designed for a continuous short to ground or the supply.

## POWER DISSIPATION AND THERMAL ANALYSIS

The total internal power dissipation of the DRV1100 is the sum of a quiescent term and the power dissipated internally to deliver the load power. The Typical Performance Curves show the quiescent current over temperature. At +5V supply, the typical no load supply current of 11mA will dissipate 55mW quiescent power. The rms power dissipated in the output circuit to deliver a  $V_{rms}$  to a load  $R_L$  is:

$$P_{rms} = (V_{DD} - V_{rms}) \cdot (V_{rms}/R_L)$$

The internal power dissipation will reach a maximum when  $V_{rms}$  is equal to  $V_{DD}/2$ . For a sinusoidal output, this corresponds to an output  $V_{p-p} = 1.41 \cdot V_{DD}$ .

As an example, compute the power and junction temperature under a worst case condition with  $V_{DD} = +5V$  and  $V_{rms} = 2.5V$  into a 16Ω differential load (peak output current for a sinusoid would be 222mA). The total internal power dissipation would be:

$$(5V \cdot 11mA) + (5V - 2.5V) \cdot (2.5V/16\Omega) = 446mW$$

To compute the internal junctions temperature, this power is multiplied by the junction to ambient thermal impedance (to get the temperature rise above ambient) then added to the ambient temperature. Using the specified maximum ambient temperature of +85°C, the junction temperature for the DRV1100 in an SO-8 package under these worst case conditions will be:

$$T_j = 85^\circ C + 0.446W \cdot 125^\circ C/W = 141^\circ C$$



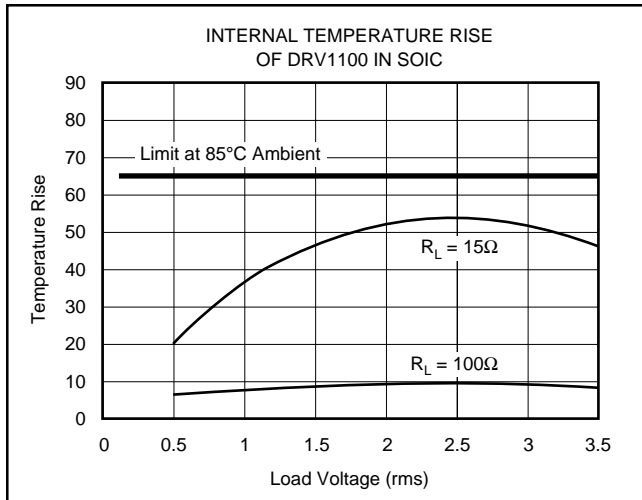


FIGURE 4. Junction Temperature Rise From Ambient for the DRV1100U.

The internal junction temperature should, in all cases, be limited to  $< 150^{\circ}\text{C}$ . For a maximum ambient temperature of  $+85^{\circ}\text{C}$ , this limits the internal temperature rise to less than  $65^{\circ}\text{C}$ . Figure 4 shows the temperature rise from ambient to junction for loads of  $15\Omega$  and  $100\Omega$ . This shows that the internal junction temperature will never exceed the rated maximum for a  $15\Omega$  load.

### INPUT INTERFACE CIRCUITS

Best performance with the DRV1100 is achieved with a differential input centered at  $V_{DD}/2$ . Signals that do not require DC coupling may be connected as shown in Figure 5 through blocking caps to a midpoint reference developed through resistor dividers from the supply voltage. The value for the  $R_B$  resistors determine four performance requirements.

- They bias the inputs at the supply midpoint.
- They provide a DC bias current path for the input to the DRV1100
- They set the AC input impedance for the source signals to  $R_B/2$ .
- They set the low frequency cutoff frequency along with  $C_B$ .

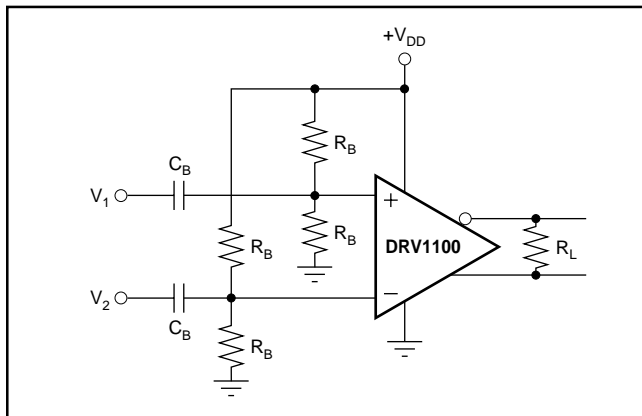


FIGURE 5. AC Coupled Differential Input Interface.

Often, the  $R_B$  resistors will be set to a relatively high value ( $> 10\text{k}\Omega$ ) to minimize quiescent current in the reference path. If a lower input impedance is desired, additional terminating resistors may be added to the input side of the blocking capacitors ( $C_B$ ).

The circuit of Figure 5 may also be operated with only a single ended input. In that case, the reference voltage on the other input should be decoupled to ground with a  $0.1\mu\text{F}$  capacitor. In this connection, the input will generate unbalanced outputs. The differential output voltage will still be 3 times the input peak-to-peak voltage, but since there is now a common-mode voltage input, there will be a common mode voltage output. The output common-mode voltage will be equal to the input signal's peak-to-peak swing. This common-mode component will reduce the available differential output voltage swing. However, if the output load has good common-mode rejection, such as a transformer, this is an acceptable way of using the DRV1100 with a single ended source.

Figure 6 shows a means of translating a ground centered single ended input to a purely differential signal for application to DRV1100 input. This circuit uses a wideband dual op amp in cross coupled feedback configuration.

The outputs of this circuit may then be fed into the inputs of Figure 5. The total gain of Figure 6 is  $2 \cdot (R_F/R_G)$ . The circuit will act to hold all 4 op amp inputs equal to the + input of the lower op amp. Since this is at ground, the midpoint for the input signal (where the two outputs will be equal) is also at  $0\text{V}$ .

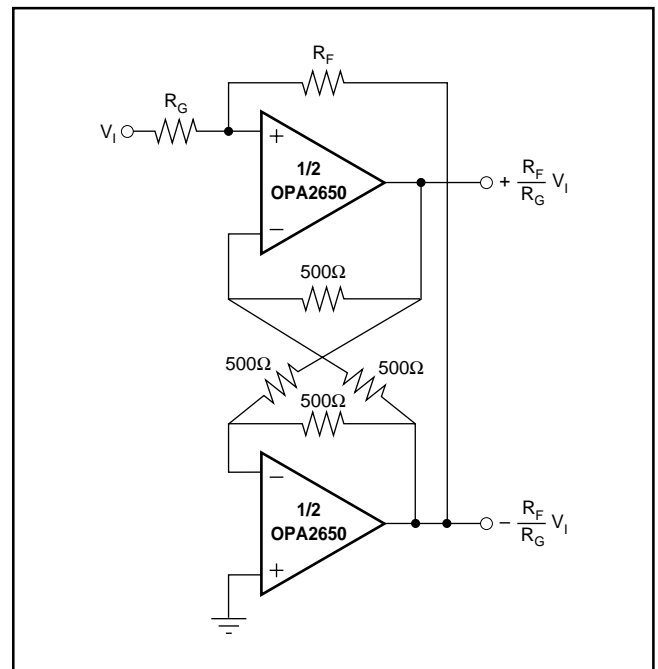


FIGURE 6. Single Ended to Differential Conversion.

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
DRV1100U	NRND	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
DRV1100U/2K5	NRND	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
DRV1100U/2K5G4	NRND	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
DRV1100UG4	NRND	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**



**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DRV1100U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DRV1100U/2K5	SOIC	D	8	2500	346.0	346.0	29.0

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated