

TL441AM LOGARITHMIC AMPLIFIER

SLFS038 – JUNE 1976 – REVISED FEBRUARY 1989

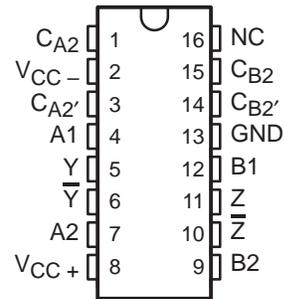
- Excellent Dynamic Range
- Wide Bandwidth
- Built-In Temperature Compensation
- Log Linearity (30 dB Sections) . . . 1 dB Typ
- Wide Input Voltage Range

description

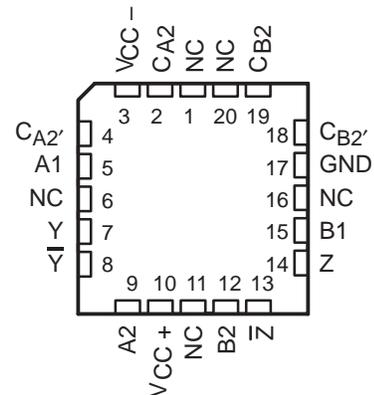
This monolithic amplifier circuit contains four 30-dB logarithmic stages. Gain in each stage is such that the output of each stage is proportional to the logarithm of the input voltage over the 30-dB input voltage range. Each half of the circuit contains two of these 30-dB stages summed together in one differential output that is proportional to the sum of the logarithms of the input voltages of the two stages. The four stages may be interconnected to obtain a theoretical input voltage range of 120-dB. In practice, this permits the input voltage range to be typically greater than 80-dB with log linearity of ± 0.5 -dB (see application data). Bandwidth is from dc to 40 MHz.

This circuit is useful in military weapons systems, broadband radar, and infrared reconnaissance systems. It serves for data compression and analog compensation. This logarithmic amplifier is used in log IF circuitry as well as video and log amplifiers. The TL441AM is characterized for operation over the full military temperature range of -55°C to 125°C .

J PACKAGE
(TOP VIEW)

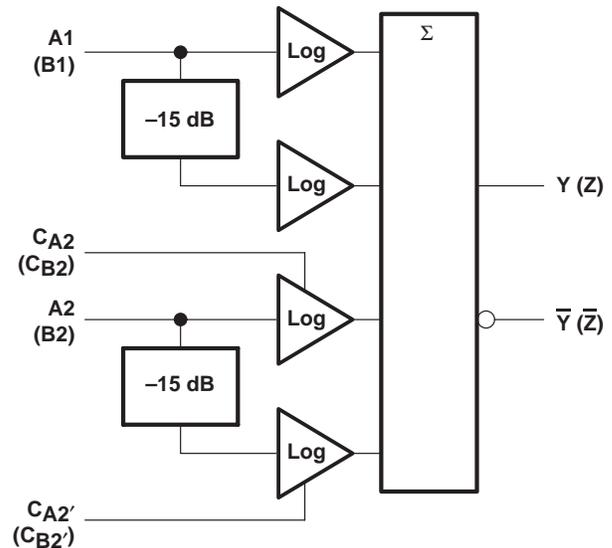


FK PACKAGE
(TOP VIEW)



NC — No internal connection

functional block diagram (one half)

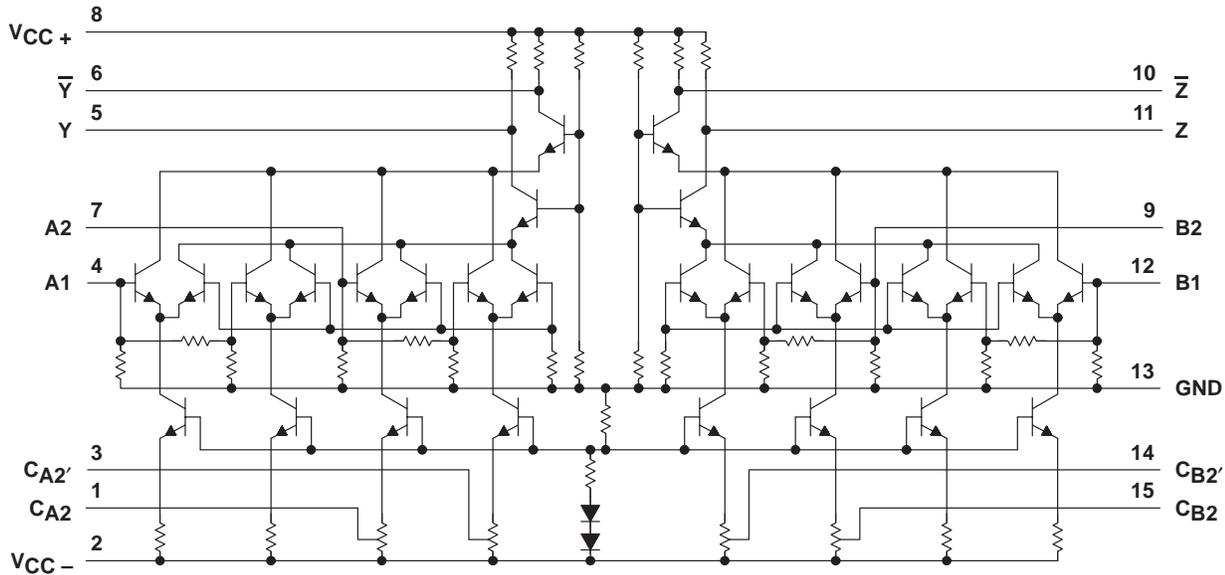


$Y \propto \log A1 + \log A2$; $Z \propto \log B1 + \log B2$
 where: A1, A2, B1, and B2 are in dBV, 0 dBV = 1 V.
 CA2, CA2', CB2, and CB2' are detector compensation inputs.

TL441AM LOGARITHMIC AMPLIFIER

SLFS038 – JUNE 1976 – REVISED FEBRUARY 1989

schematic



Pin numbers shown are for the J package.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltages (see Note 1): V_{CC+}	8 V
V_{CC-}	-8 V
Input voltage (see Note 1)	6 V
Output sink current (any one output)	30 mA
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range	-55°C to 125°C
Storage temperature range	-65°C to 150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300°C

† Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the recommended operating conditions section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltages, except differential output voltages, are with respect to network ground terminal.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
FK	500 mW	11.0 mW/°C	104°C	500 mW	275 mW
J	500 mW	11.0 mW/°C	104°C	500 mW	275 mW

recommended operating conditions

	MIN	MAX	UNIT
Peak-to-peak input voltage for each 30-dB stage	0.01	1	V
Operating free-air temperature, T_A	-55	125	°C



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

electrical characteristics, $V_{CC\pm} = \pm 6\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST FIGURE	MIN	TYP	MAX	UNIT
Differential output offset voltage	1		± 25	± 70	mV
Quiescent output voltage	2	5.45	5.6	5.85	V
DC scale factor (differential output), each 3-dB stage, -35 dBV to -5 dBV	3	7	8	11	mV/dB
AC scale factor (differential output)			8		mV/dB
DC error at -20 dBV (midpoint of -35 dBV to -5 dBV range)	3		1	2.6	dB
Input impedance			500		Ω
Output impedance			200		Ω
Rise time, 10% to 90% points, $C_L = 24\text{ pF}$	4		20	35	ns
Supply current from V_{CC+}	2	14.5	18.5	23	mA
Supply current from V_{CC-}	2	-6	-8.5	-10.5	mA
Power dissipation	2	123	162	201	mW

electrical characteristics over operating free-air temperature range, $V_{CC\pm} = \pm 6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST FIGURE	MIN	MAX	UNIT
Differential output offset voltage	1		± 100	mV
Quiescent output voltage	2	5.3	5.85	V
DC scale factor (differential output) each 30-dB stage, -35 dBV to -5 dBV	3	7	11	mV/dB
DC error at -20 dBV (midpoint of -35 dBV to -5 dBV range)	3		4	dB
			3	
Supply current from V_{CC+}	2	10	31	mA
Supply current from V_{CC-}	2	-4.5	-15	mA
Power dissipation	2	87	276	mW

PARAMETER MEASUREMENT INFORMATION

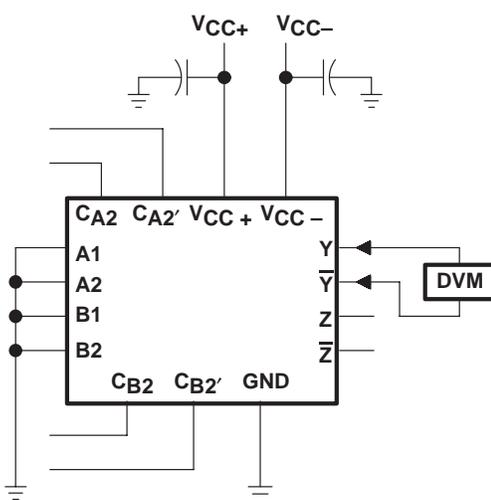


Figure 1

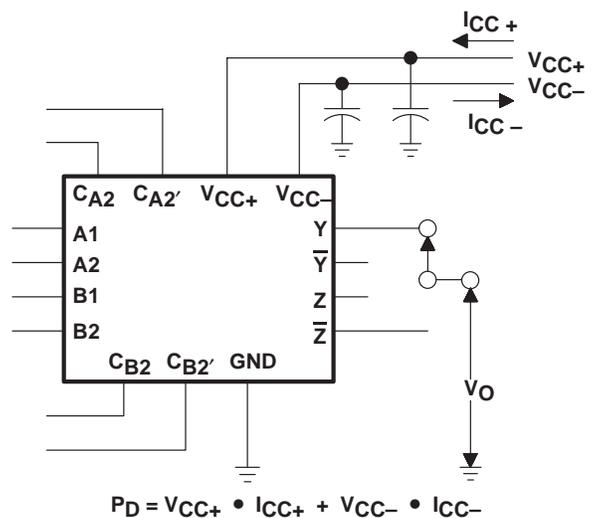


Figure 2

TL441AM LOGARITHMIC AMPLIFIER

SLFS038 – JUNE 1976 – REVISED FEBRUARY 1989

PARAMETER MEASUREMENT INFORMATION

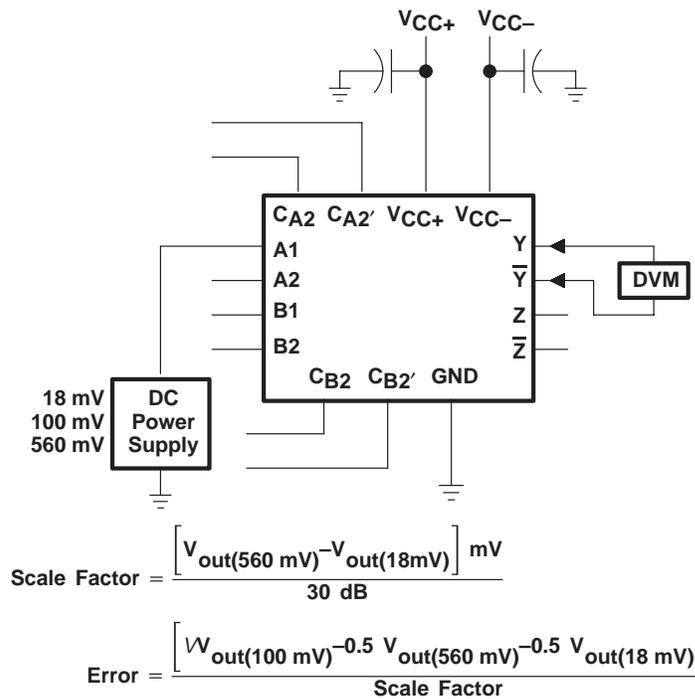
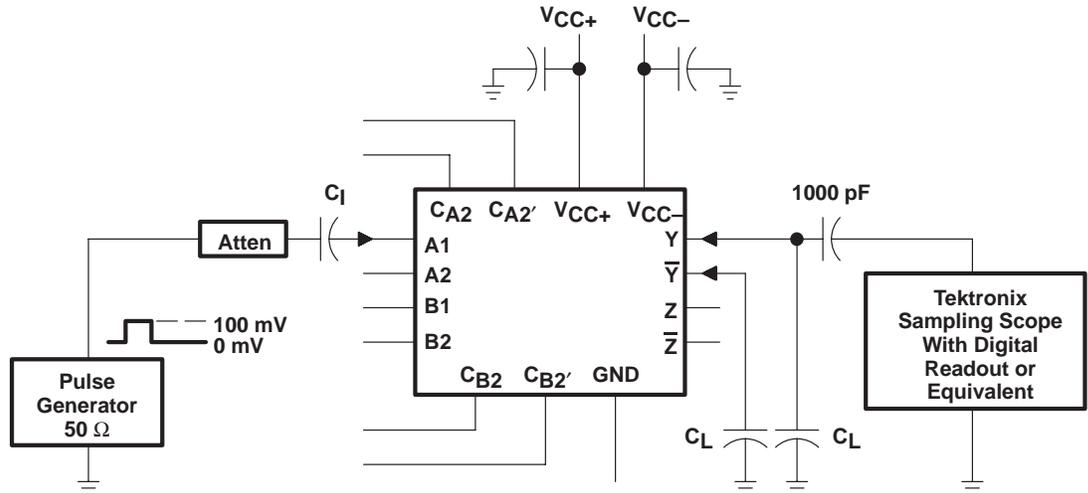


Figure 3



- NOTES: A. The input pulse has the following characteristics: $t_w = 200 \text{ ns}$, $t_r \leq 2 \text{ ns}$, $t_f \leq 2 \text{ ns}$, $\text{PRR} \leq 10 \text{ MHz}$.
 B. Capacitor C_1 consists of three capacitors in parallel: $1 \mu\text{F}$, $0.1 \mu\text{F}$, and $0.01 \mu\text{F}$.
 C. C_L includes probe and jig capacitance.

Figure 4



TYPICAL CHARACTERISTICS

DIFFERENTIAL OUTPUT OFFSET VOLTAGE
vs
FREE-AIR TEMPERATURE

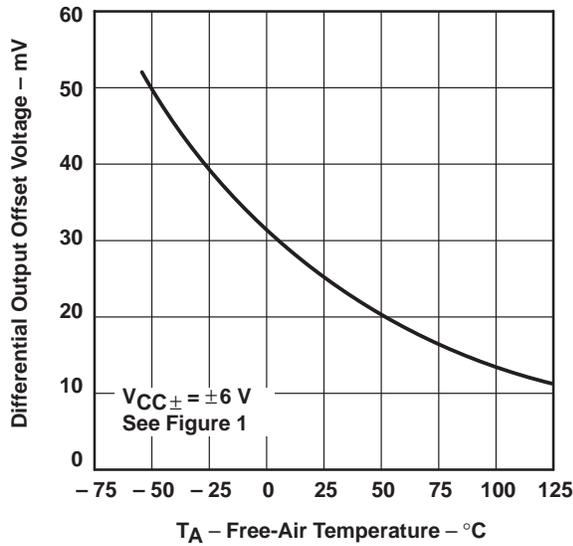


Figure 5

QUIESCENT OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

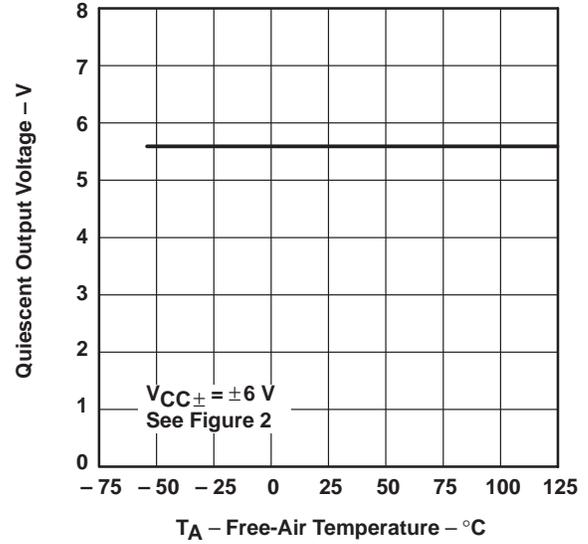


Figure 6

DC SCALE FACTOR
vs
FREE-AIR TEMPERATURE

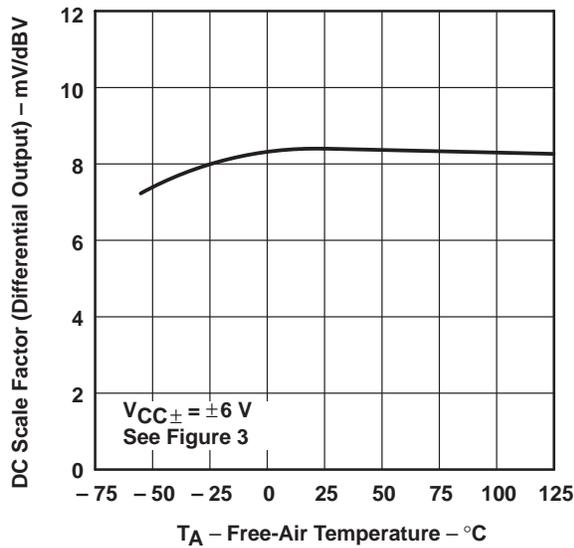


Figure 7

DC ERROR
vs
FREE-AIR TEMPERATURE

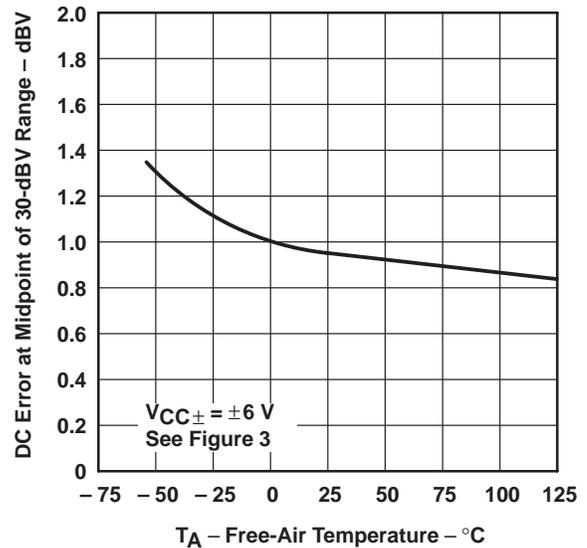


Figure 8

TYPICAL CHARACTERISTICS

OUTPUT RISE TIME
VS
LOAD CAPACITANCE

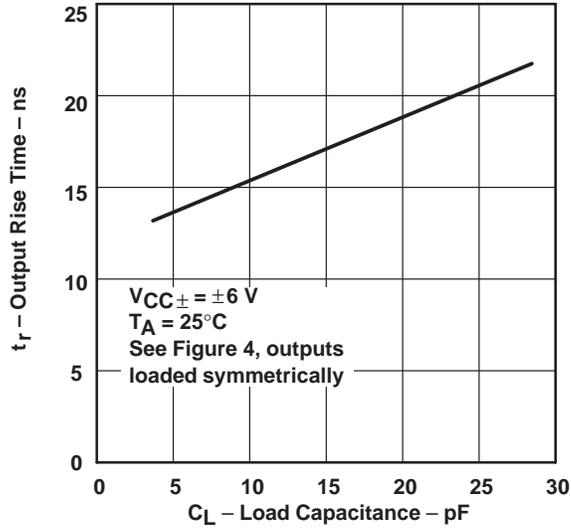


Figure 9

POWER DISSIPATION
VS
FREE-AIR TEMPERATURE

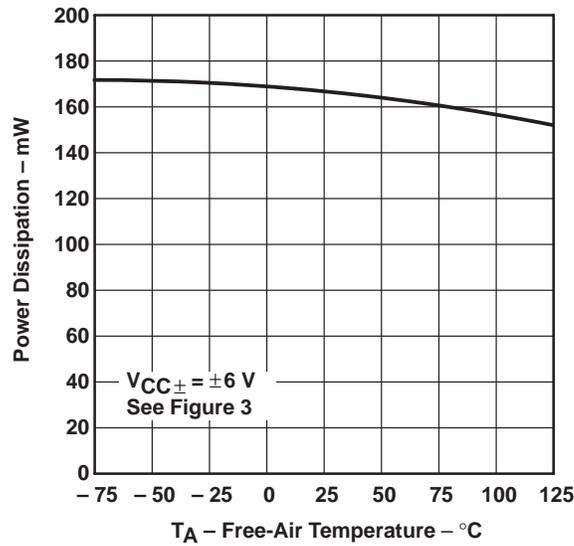


Figure 10

APPLICATION INFORMATION

Although designed for high-performance applications such as broadband radar, infrared detection and weapons systems, this device has a wide range of applications in data compression and analog computation.

basic logarithmic function

The basic logarithmic response is derived from the exponential current-voltage relationship of collector current and base-emitter voltage. This relationship is given in the equation:

$$m \cdot V_{BE} = \ln [(I_C + I_{CES})/I_{CES}]$$

where:

I_C = collector current

I_{CES} = collector current at $V_{BE} = 0$

$m = q/kT$ (in V^{-1})

V_{BE} = base-emitter voltage

The differential input amplifier allows dual-polarity inputs, is self-compensating for temperature variations, and is relatively insensitive to common-mode noise.

functional block diagram

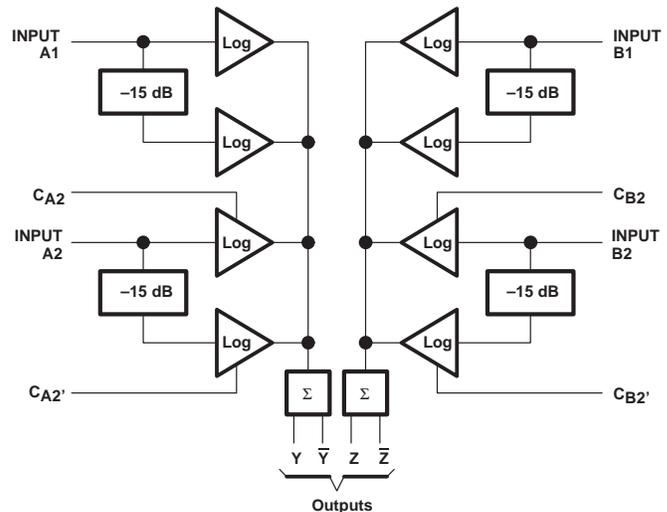


Figure 11

logarithmic sections

As can be seen from the schematic, there are eight differential pairs. Each pair is a 15-dB log subsection, and each input feeds two pairs for a range of 30-dB per stage.

Four compensation points are made available to allow slight variations in the gain (slope) of the two individual 15-dB stages of input A2 and B2. By slightly changing the voltage on any of the compensation pins from its quiescent value, the gain of that particular 15-dB stage can be adjusted to match the other 15-dB stage in the pair. The compensation pins may also be used to match the transfer characteristics of input A2 to A1 or B2 to B1.

The log stages in each half of the circuit are summed by directly connecting their collectors together and summing through a common-base output stage. The two sets of output collectors are used to give two log outputs, Y and \bar{Y} (or Z and \bar{Z}) which are equal in amplitude but opposite in polarity. This increases the versatility of the device.

By proper choice of external connections, linear amplification, and linear attenuation, and many different applications requiring logarithmic signal processing are possible.

input levels

The recommended input voltage range of any one stage is given as 0.01 V to 1 V. Input levels in excess of 1 V may result in a distorted output. When several log sections are summed together, the distorted area of one section overlaps with the next section and the resulting distortion is insignificant. However, there is a limit to the amount of overdrive that may be applied. As the input drive reaches ± 3.5 V, saturation occurs, clamping the collector-summing line and severely distorting the output. Therefore, the signal to any input must be limited to approximately ± 3 V to ensure a clean output.

TL441AM LOGARITHMIC AMPLIFIER

SLFS038 – JUNE 1976 – REVISED FEBRUARY 1989

APPLICATION INFORMATION

output levels

Differential-output-voltage levels are low, generally less than 0.6 V. As demonstrated in Figure 12, the output swing and the slope of the output response can be adjusted by varying the gain by means of the slope control. The coordinate origin may also be adjusted by positioning the offset of the output buffer.

circuits

Figures 12 through 19 show typical circuits using this logarithmic amplifier. Operational amplifiers not otherwise designated are TLC271. For operation at higher frequencies, the TL592 is recommended instead of the TLC271.

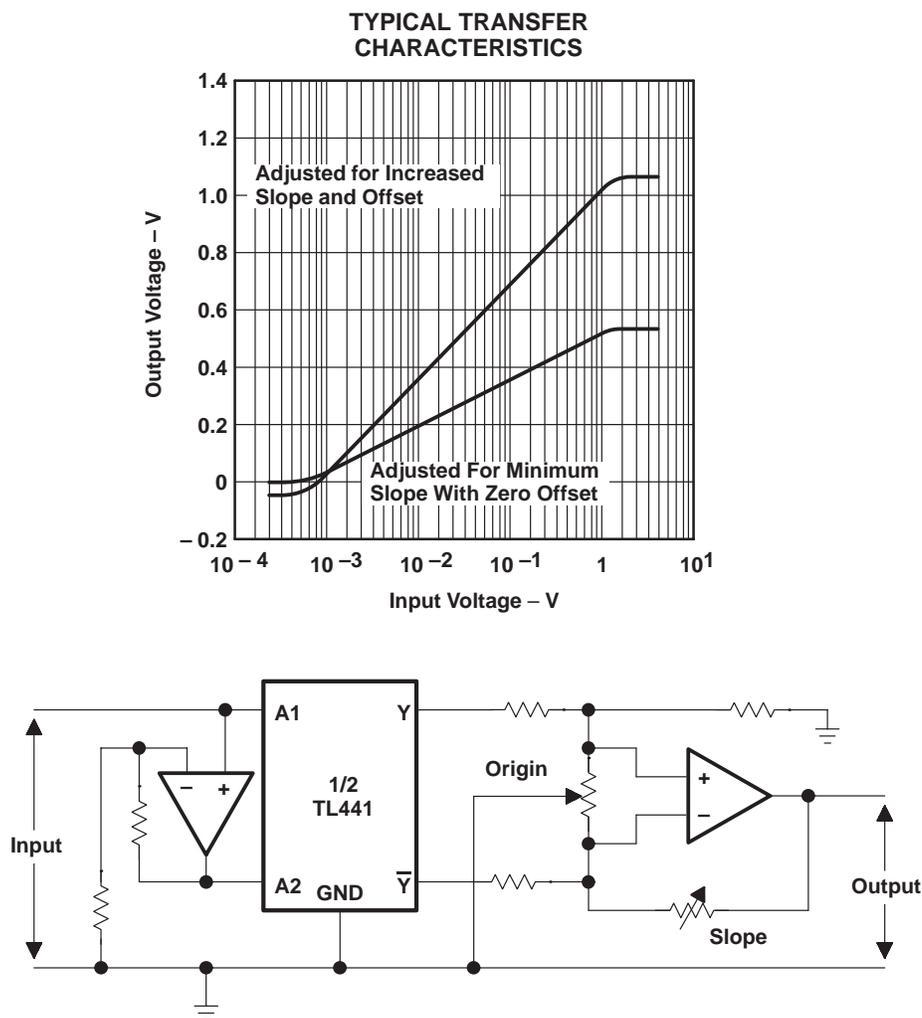


Figure 12. Output Slope and Origin Adjustment

APPLICATION INFORMATION

TRANSFER CHARACTERISTICS
OF TWO TYPICAL INPUT STAGES

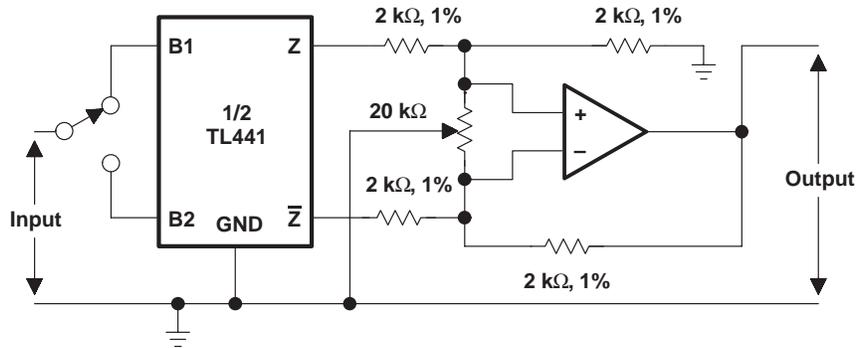
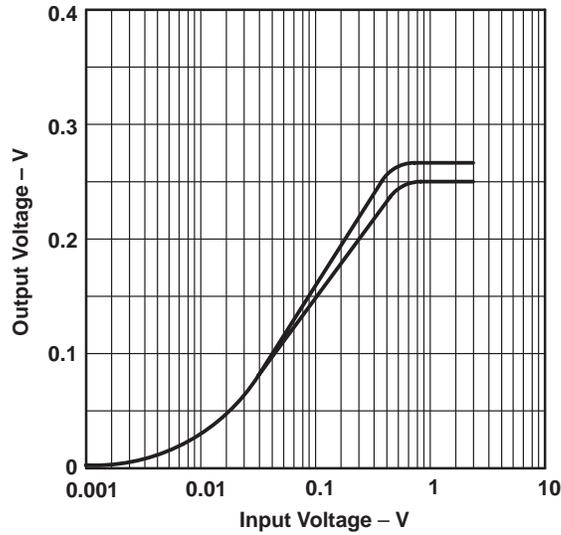


Figure 13. Utilization of Separate Stages

TL441AM LOGARITHMIC AMPLIFIER

SLFS038 – JUNE 1976 – REVISED FEBRUARY 1989

APPLICATION INFORMATION

TRANSFER CHARACTERISTICS WITH BOTH SIDES PARALLELED

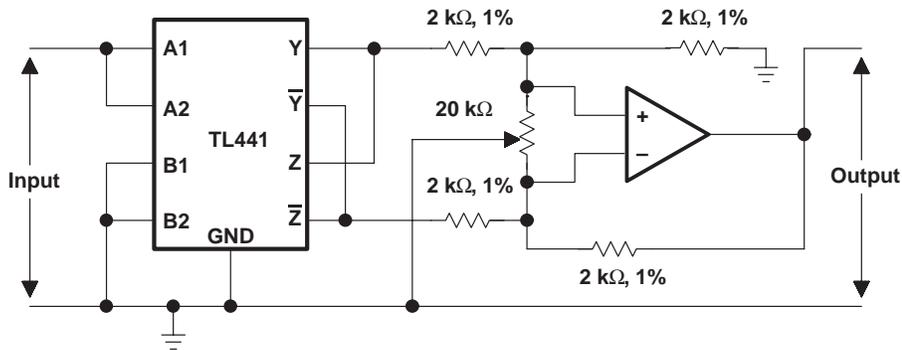
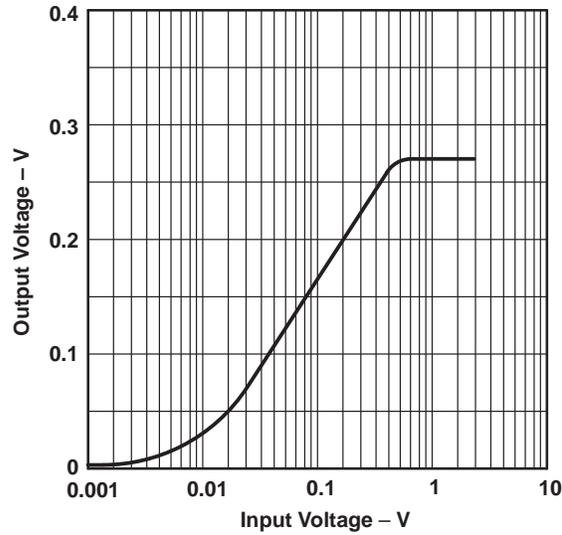
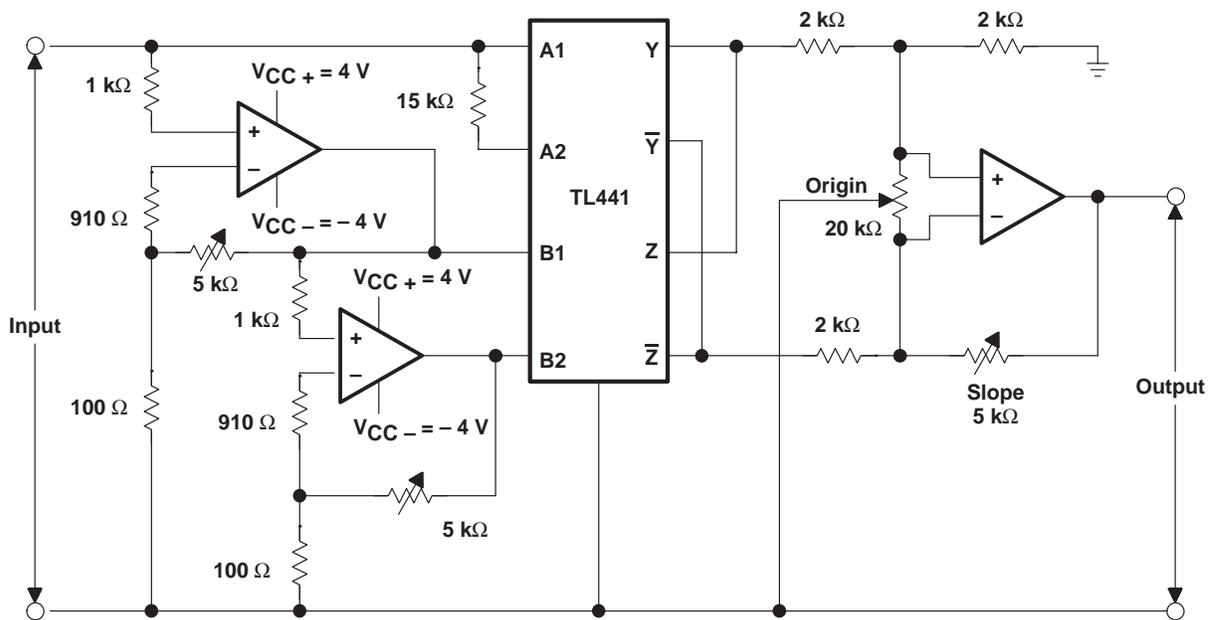
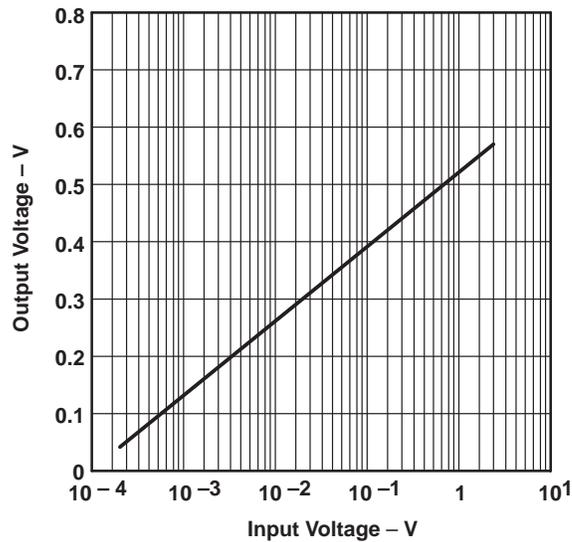


Figure 14. Utilization of Paralleled Inputs

APPLICATION INFORMATION

TRANSFER CHARACTERISTICS



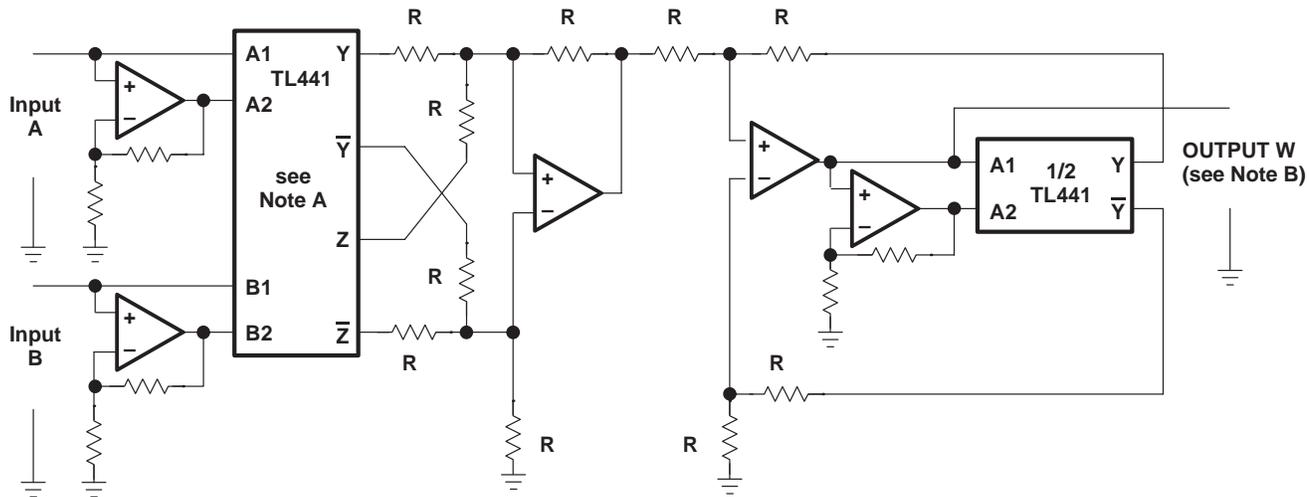
- NOTES: A. Inputs are limited by reducing the supply voltages for the input amplifiers to ± 4 V.
B. The gains of the input amplifiers are adjusted to achieve smooth transitions.

Figure 15. Logarithmic Amplifier With Input Voltage Range Greater Than 80 dB

TL441AM LOGARITHMIC AMPLIFIER

SLFS038 – JUNE 1976 – REVISED FEBRUARY 1989

APPLICATION INFORMATION

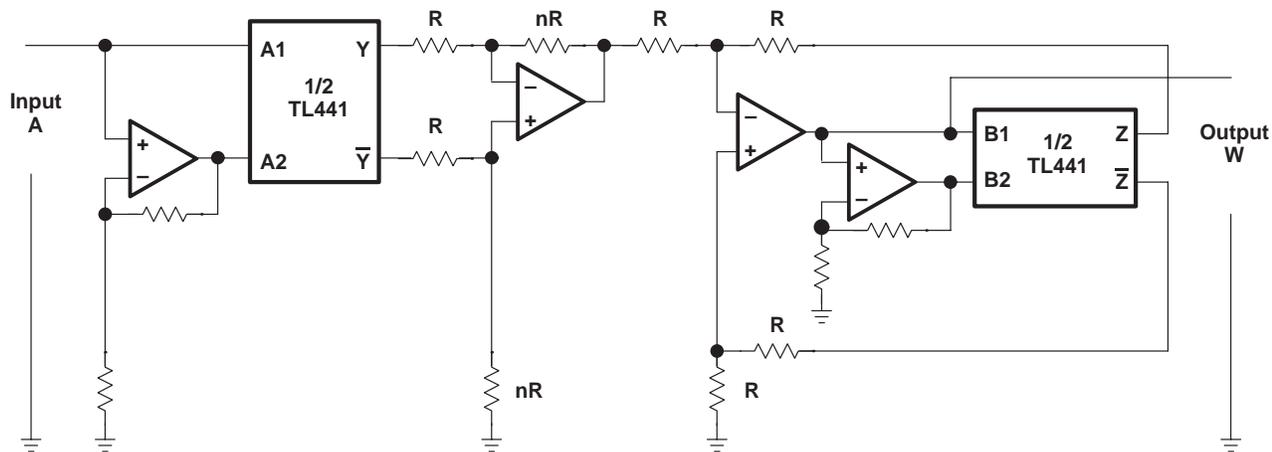


- NOTES: A. Connections shown are for multiplication. For division, Z and \bar{Z} connections are reversed.
 B. Output W may need to be amplified to give actual product or quotient of A and B.
 C. R designates resistors of equal value, typically 2 kΩ to 10 kΩ.

Multiplication: $W = A \cdot B \Rightarrow \log W = \log A + \log B$, or $W = a^{(\log_a A + \log_a B)}$

Division: $W = A/B \Rightarrow \log W = \log A - \log B$, or $W = a^{(\log_a A - \log_a B)}$

Figure 16. Multiplication or Division

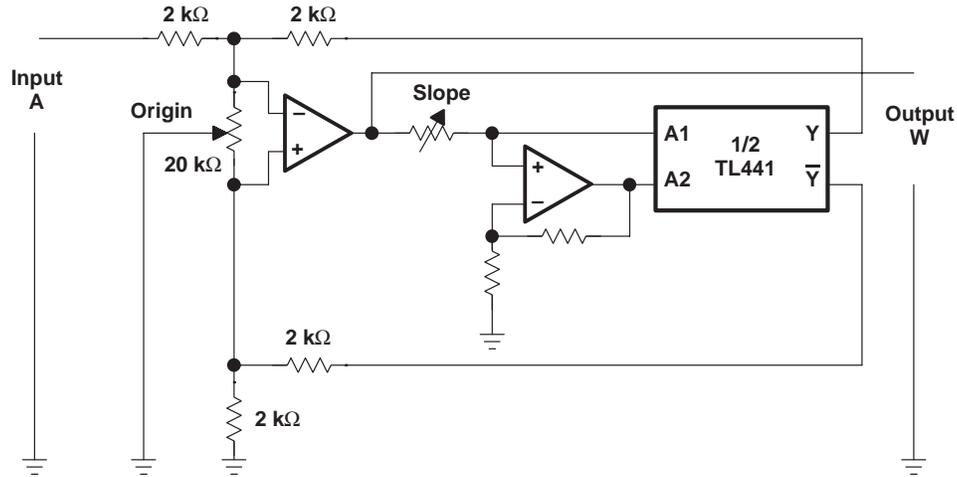


NOTE: R designates resistors of equal value, typically 2 kΩ to 10 kΩ. The power to which the input variable is raised is fixed by setting nR. Output W may need to be amplified to give the correct value.

Exponential: $W = A^n \Rightarrow \log W = n \log A$, or $W = a^{(n \log_a A)}$

Figure 17. Raising a Variable to a Fixed Power

APPLICATION INFORMATION



NOTE: Adjust the slope to correspond to the base "a".
Exponential to any base: $W = a$.

Figure 18. Raising a Fixed Number to a Variable Power

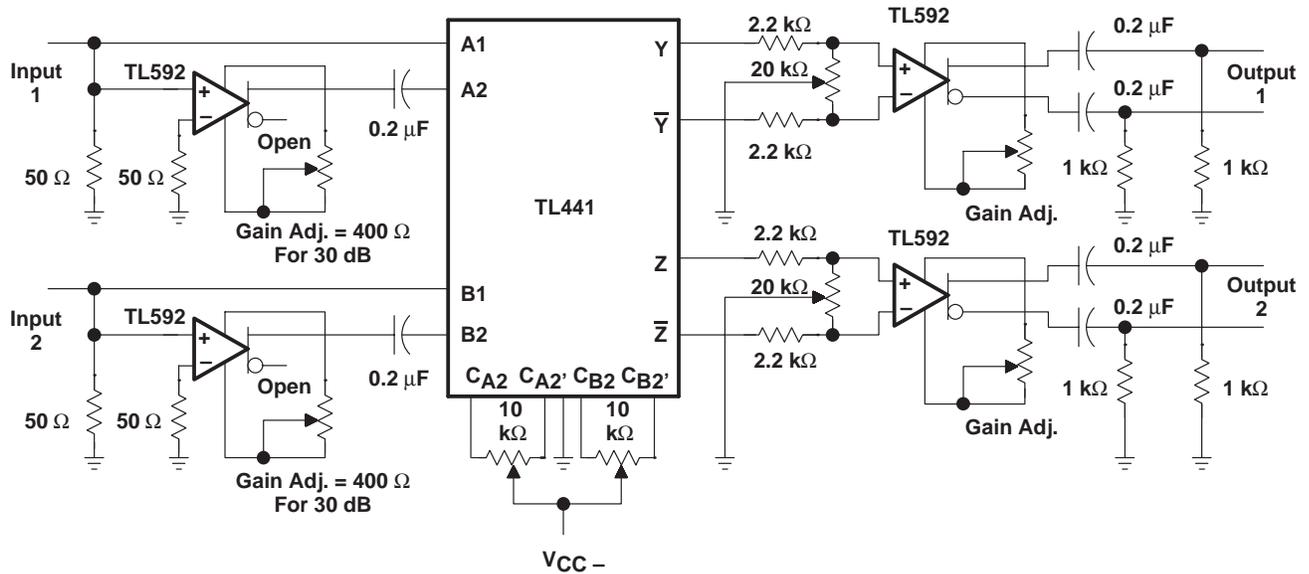


Figure 19. Dual-Channel RF Logarithmic Amplifier With 50-dB Input Range Per Channel at 10 MHz

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/ Ball Finish	MSL Peak Temp ⁽³⁾	Samples (Requires Login)
5962-9176301QEA	ACTIVE	CDIP	J	16	1	TBD	Call TI	Call TI	
TL441AMJ	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	
TL441AMJB	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	

⁽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.

OBSELETE: 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.

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.

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

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated