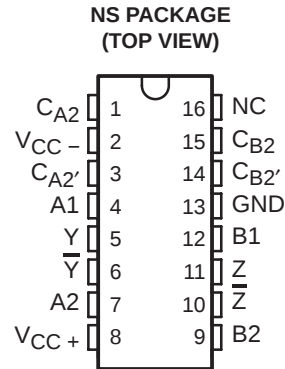


- **Controlled Baseline**
 - One Assembly/Test Site, One Fabrication Site
- **Extended Temperature Performance of –55°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree[†]**
- **Excellent Dynamic Range**
- **Wide Bandwidth**
- **Built-In Temperature Compensation**
- **Log Linearity (30-dB Sections) . . . 1 dB Typ**
- **Wide Input Voltage Range**

[†] Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.



NC — No internal connection

DESCRIPTION

This 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 typically to be 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 data compression and analog compensation. This logarithmic amplifier is used in log IF circuitry as well as video and log amplifiers.

The TL441M is characterized for operation over the full military temperature range of –55°C to 125°C.

ORDERING INFORMATION

TA	PACKAGE [†]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–55°C to 125°C	SOP (NS)	Tape and reel	TL441MNSREP	TL441MEP

[†] Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS
INSTRUMENTS**

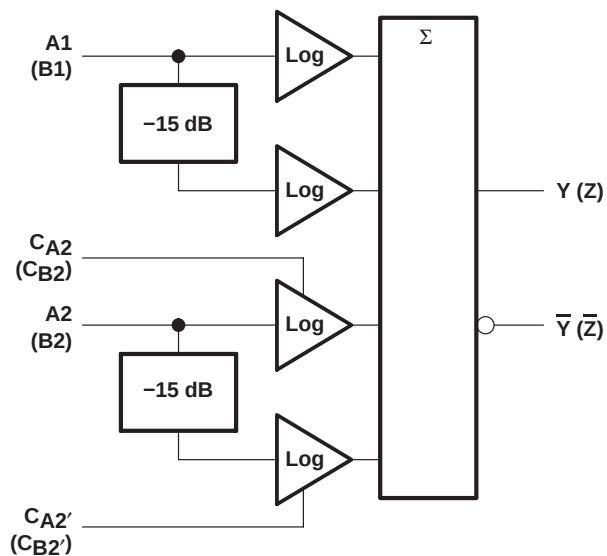
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2004, Texas Instruments Incorporated

TL441-EP LOGARITHMIC AMPLIFIER

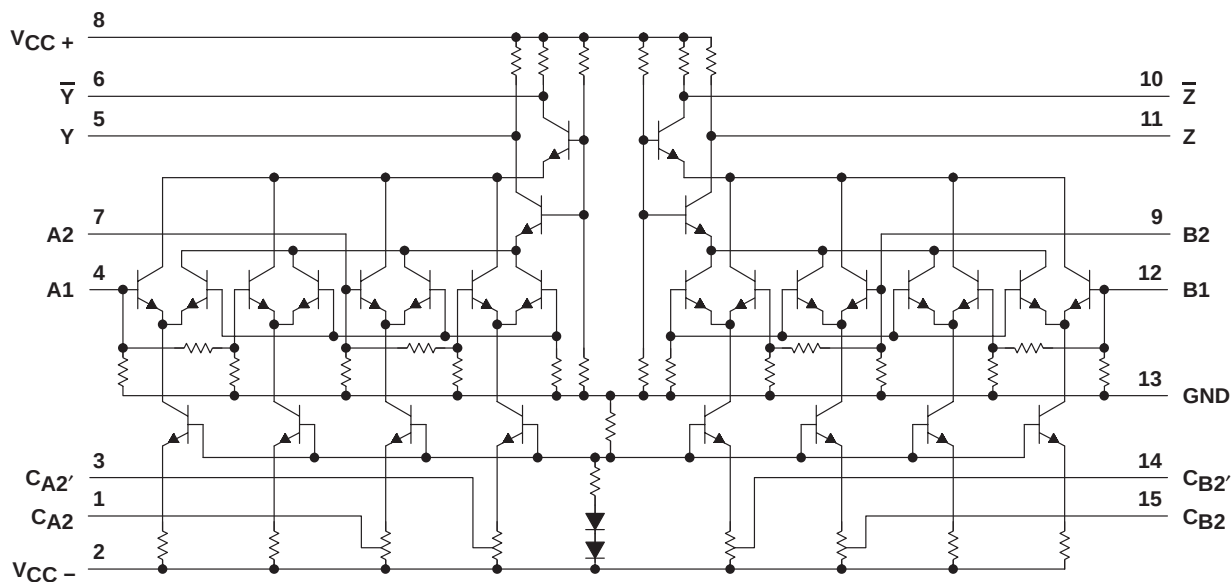
SGLS268 – OCTOBER 2004

FUNCTIONAL LOGIC DIAGRAM (one half)



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

SCHEMATIC



ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (unless otherwise noted)[†]

		TL441-EP
V _{CC+}	Supply voltages (see Note 1)	8 V
V _{CC-}		-8 V
Input voltage (see Note 1)		6 V
Output sink current (any one output)		30 mA
θ _{JA}	Package thermal impedance (see Notes 2 and 3)	83°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds		260°C
T _{stg}	Storage temperature range (see Note 4)	-65°C to 150°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 under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltages, except differential out voltages, are with respect to network ground terminal.
 2. Maximum power dissipation is a function of T_{J(max)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} - T_A)/θ_{JA}. Operating at the absolute maximum T_J of 150°C can affect reliability.
 3. The package thermal impedance is calculated in accordance with JESD 51-7.
 4. Long-term high-temperature storage and/or extended use at maximum recommended operating conditions may result in a reduction of overall device life. See http://www.ti.com/ep_quality for additional information on enhanced plastic packaging.

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

ELECTRICAL CHARACTERISTICS, V_{CC±} = ±6 V, T_A = 25°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 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

TL441-EP

LOGARITHMIC AMPLIFIER

SGLS268 – OCTOBER 2004

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	±125		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	6	11	mV/dB
DC error at −20 dBV (midpoint of −35 dBV to −5 dBV range)	T _A = −55°C	3	4		dB
	T _A = 125°C		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

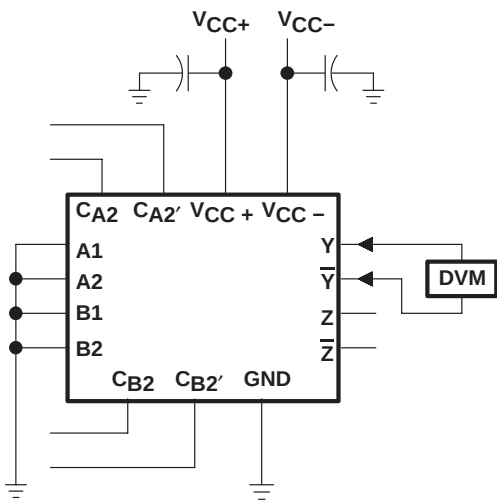


Figure 1

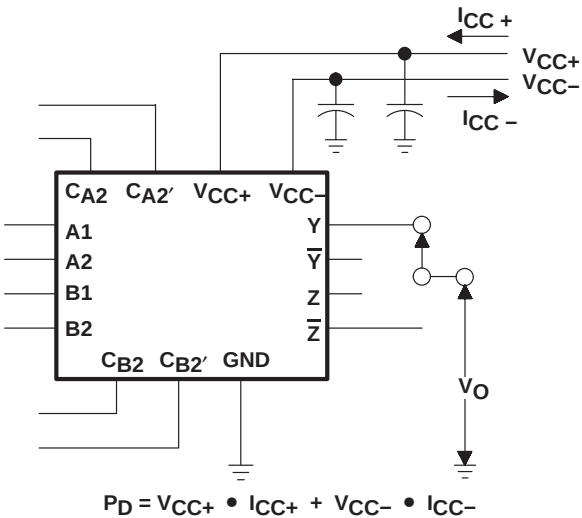


Figure 2

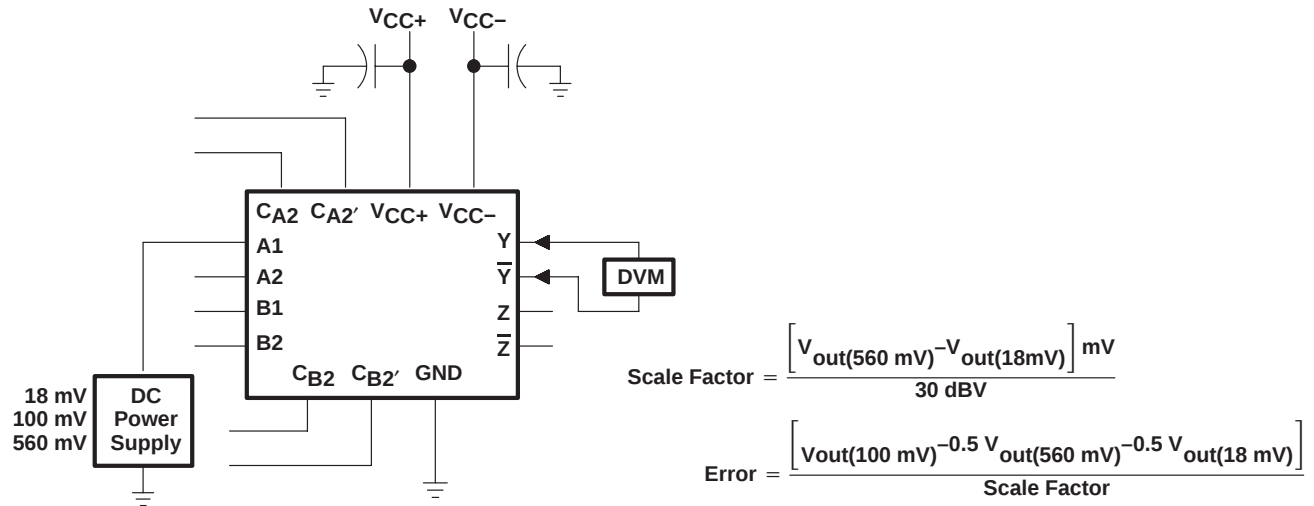
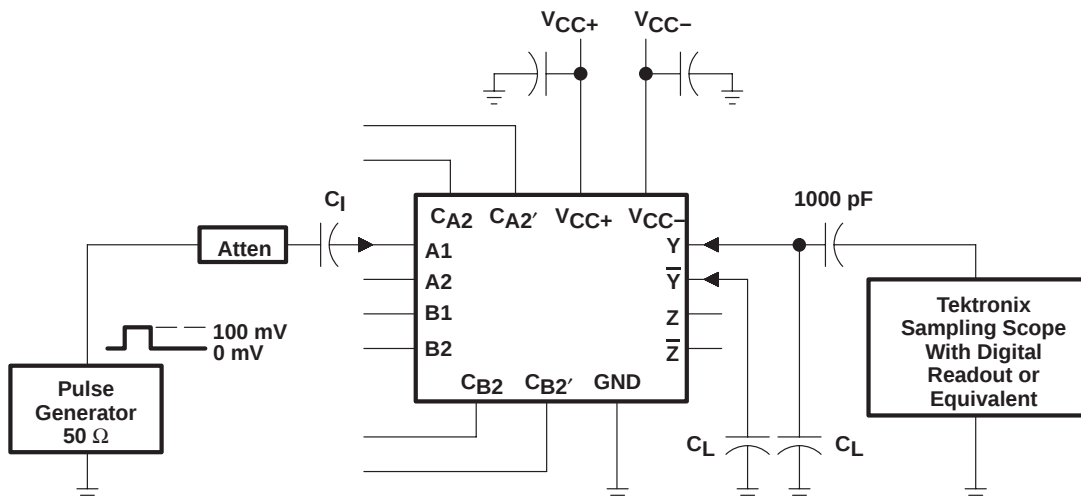


Figure 3



- 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: $1\text{ }\mu\text{F}$, $0.1\text{ }\mu\text{F}$, and $0.01\text{ }\mu\text{F}$.
 C. C_L includes probe and jig capacitance.

Figure 4

TYPICAL CHARACTERISTICS

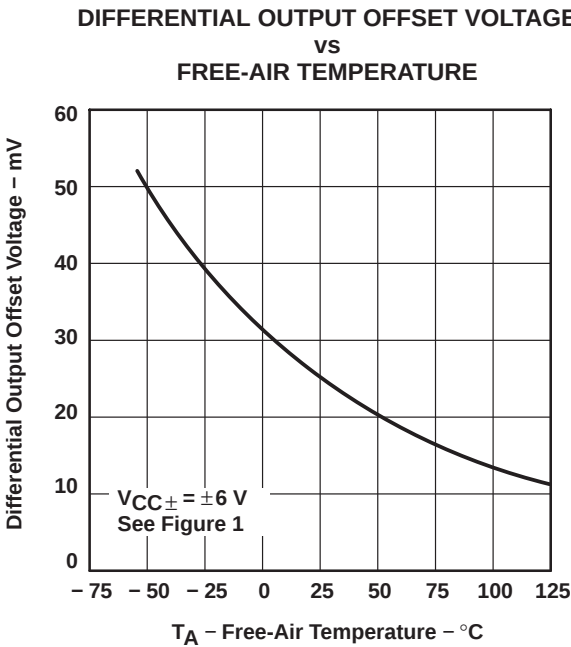


Figure 5

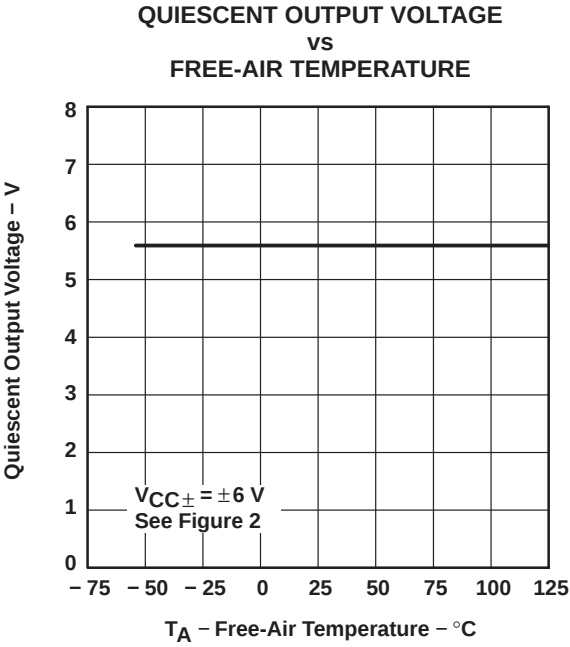


Figure 6

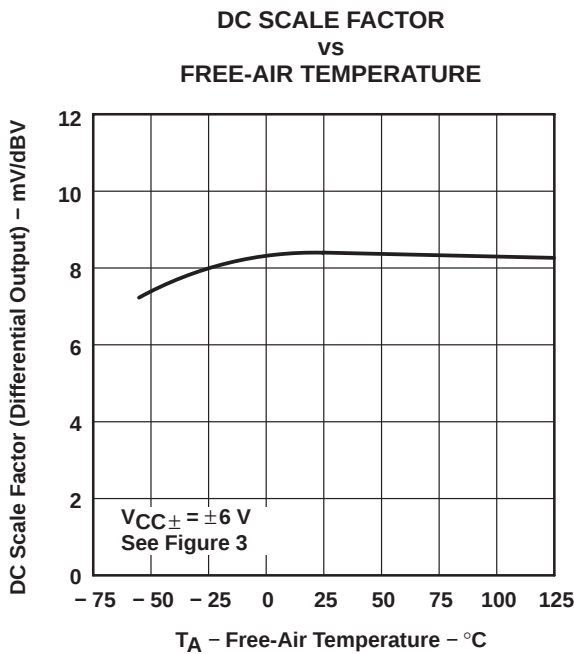


Figure 7

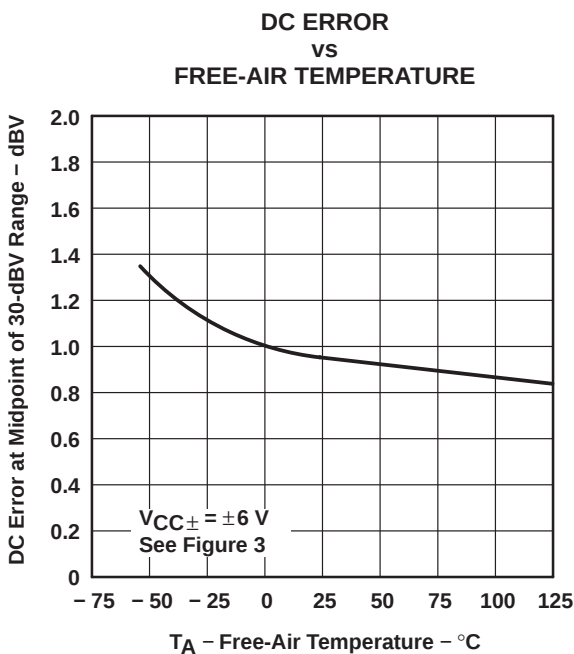


Figure 8

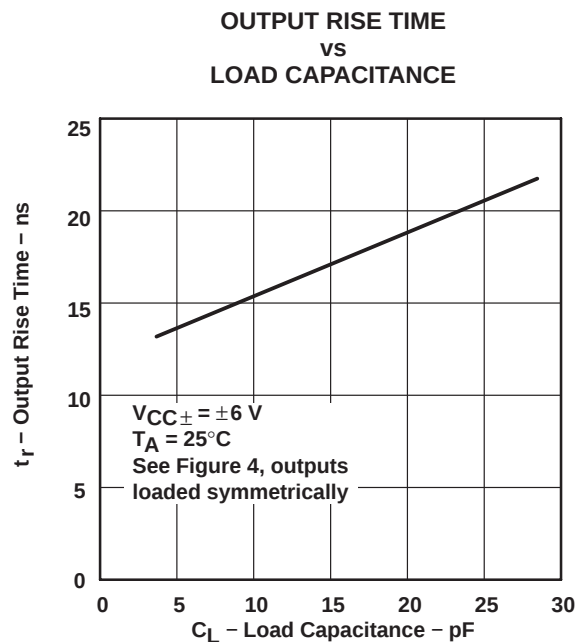


Figure 9

APPLICATION INFORMATION

Although designed for high-performance applications such as infrared detection, 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

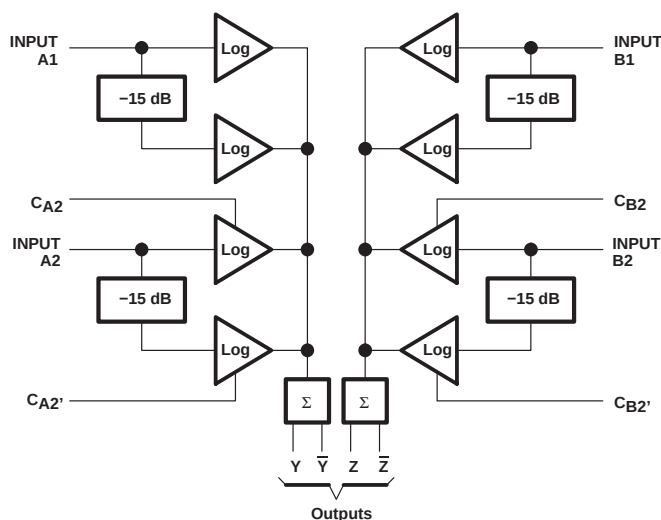


Figure 10

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 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 their quiescent values, the gain of that particular 15-dB stage can be adjusted to match the other 15-dB stage in the pair. The compensation pins also can 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 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 can 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.

Output Levels

Differential-output-voltage levels are low, generally less than 0.6 V. As demonstrated in Figure 11, 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 also can be adjusted by positioning the offset of the output buffer.

Circuits

Figure 11 through Figure 18 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.

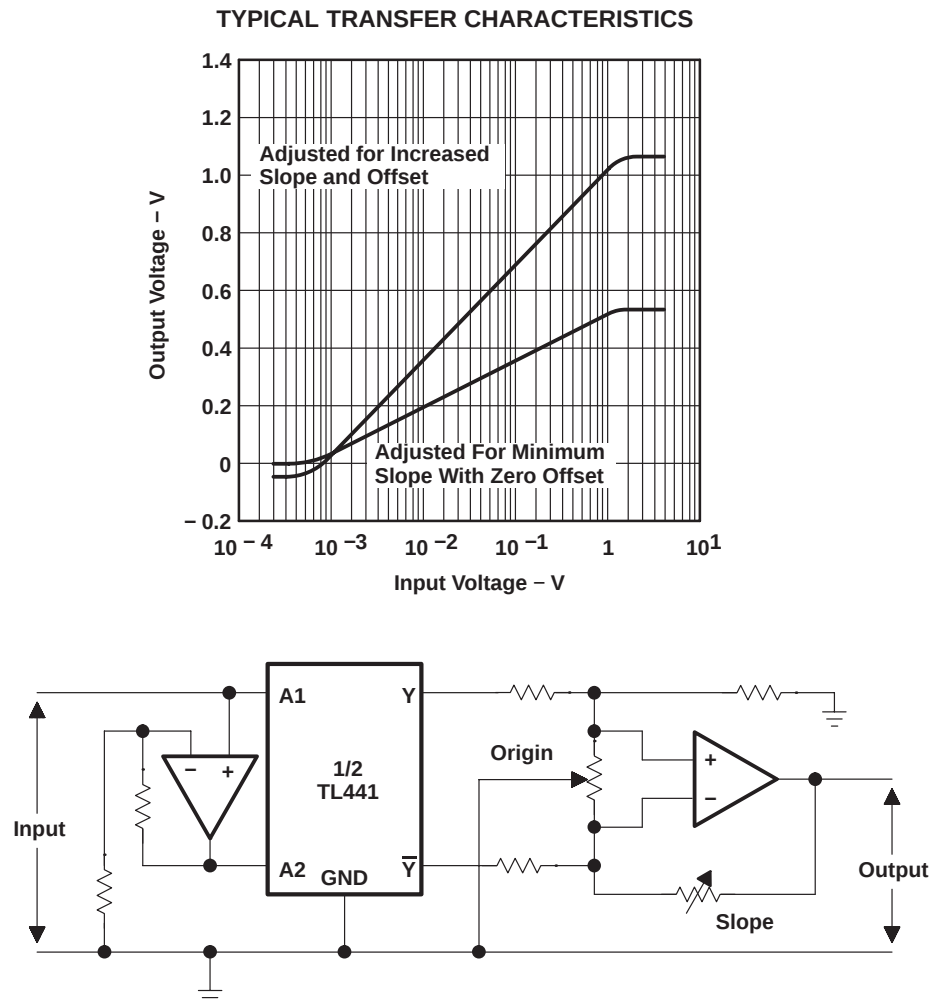


Figure 11. Output Slope and Origin Adjustment

TL441-EP LOGARITHMIC AMPLIFIER

SGLS268 – OCTOBER 2004

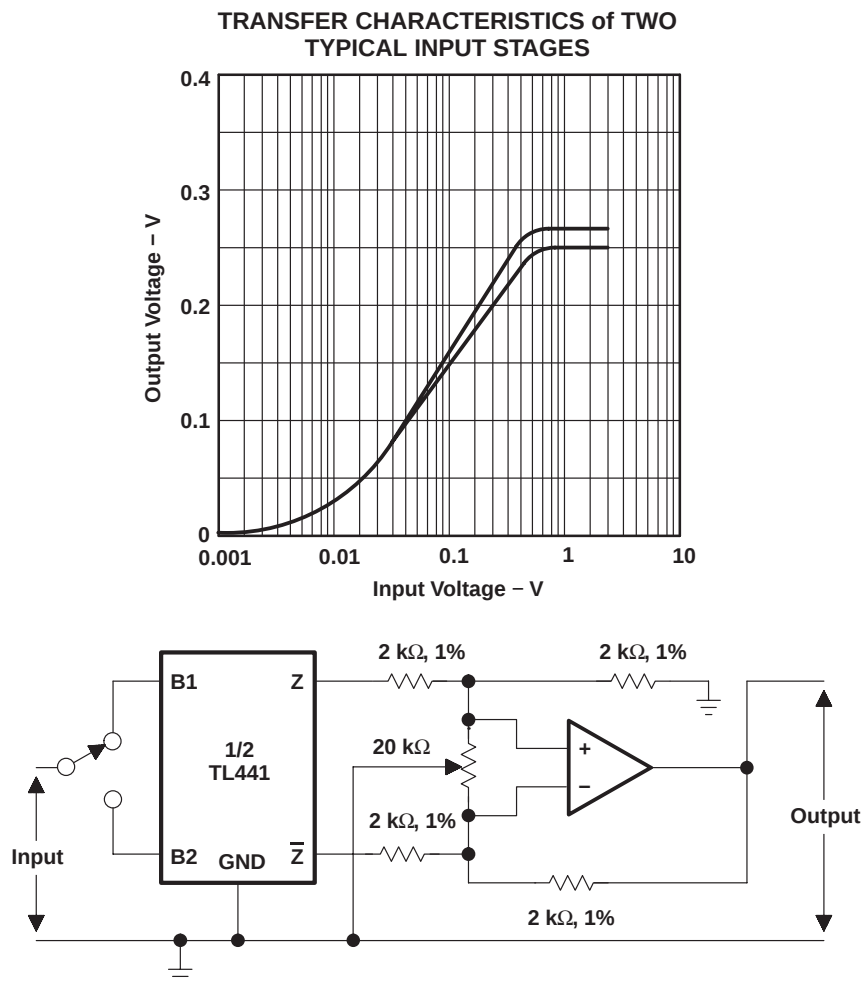


Figure 12. Utilization of Separate Stages

**TRANSFER CHARACTERISTICS
WITH BOTH SIDES PARALLELED**

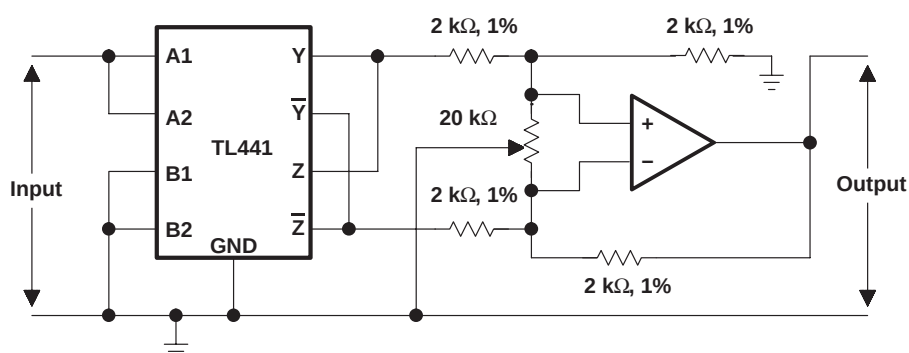
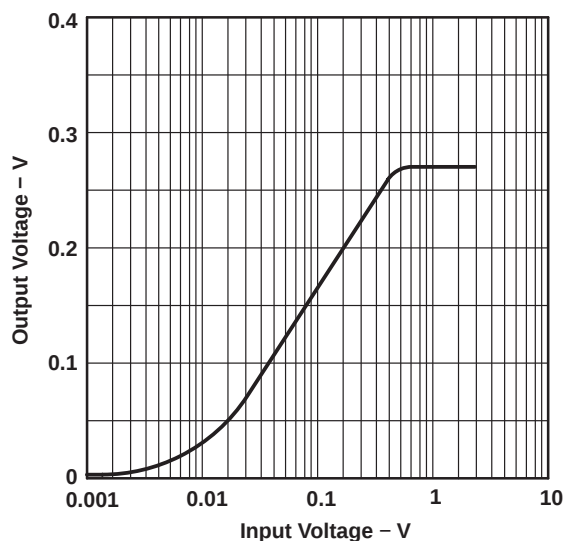
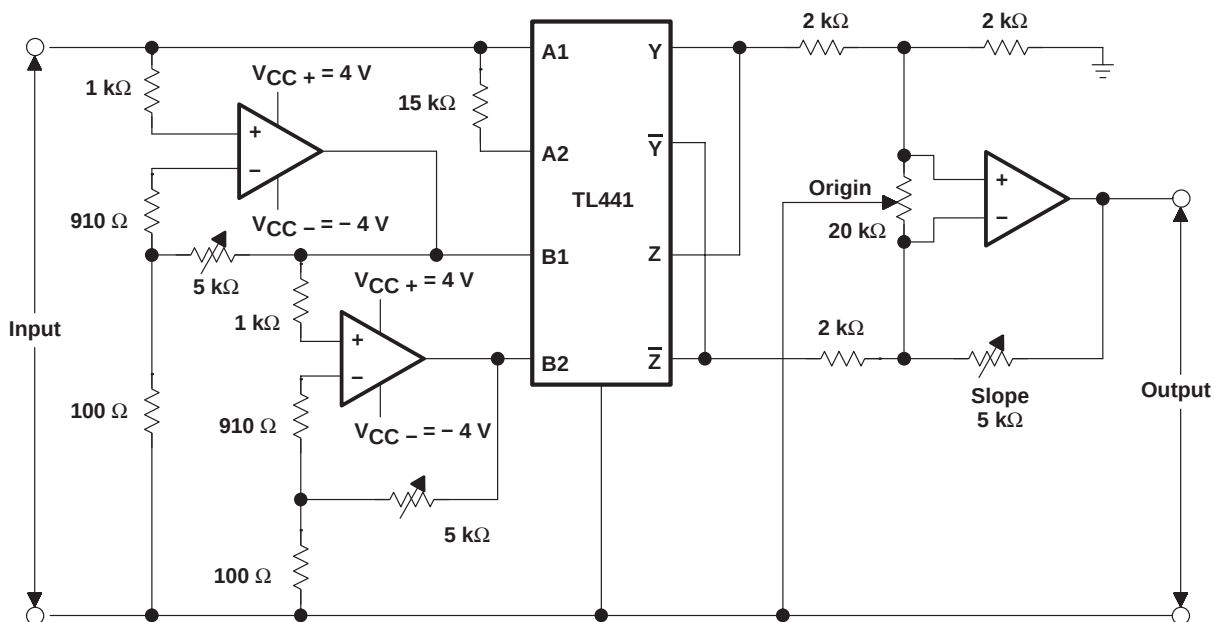
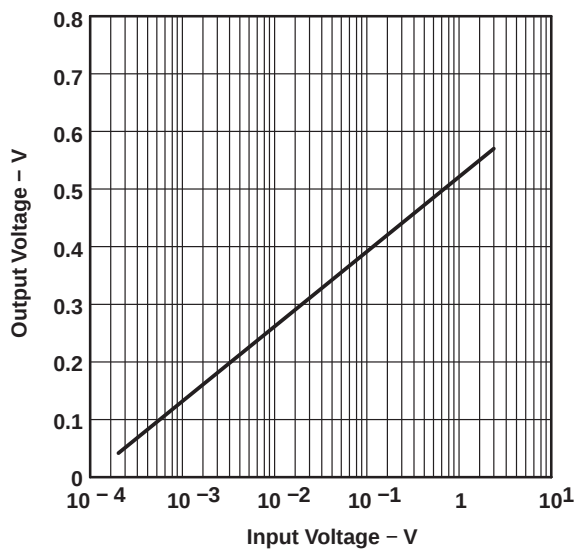


Figure 13. Utilization of Paralleled Inputs

TL441-EP LOGARITHMIC AMPLIFIER

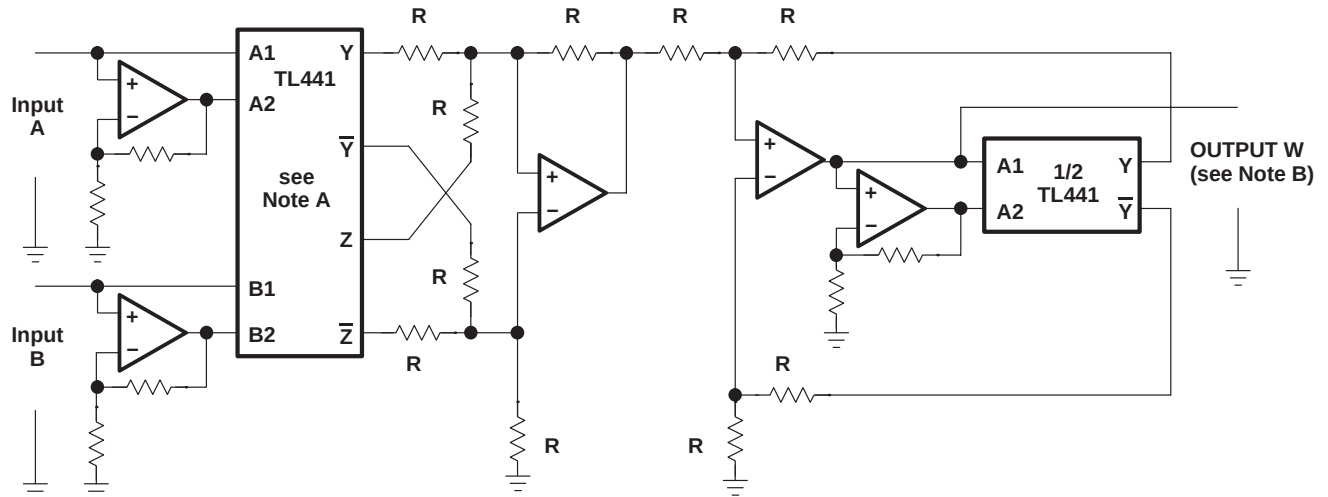
SGLS268 – OCTOBER 2004

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 14. Logarithmic Amplifier With Input Voltage Range Greater Than 80 dB

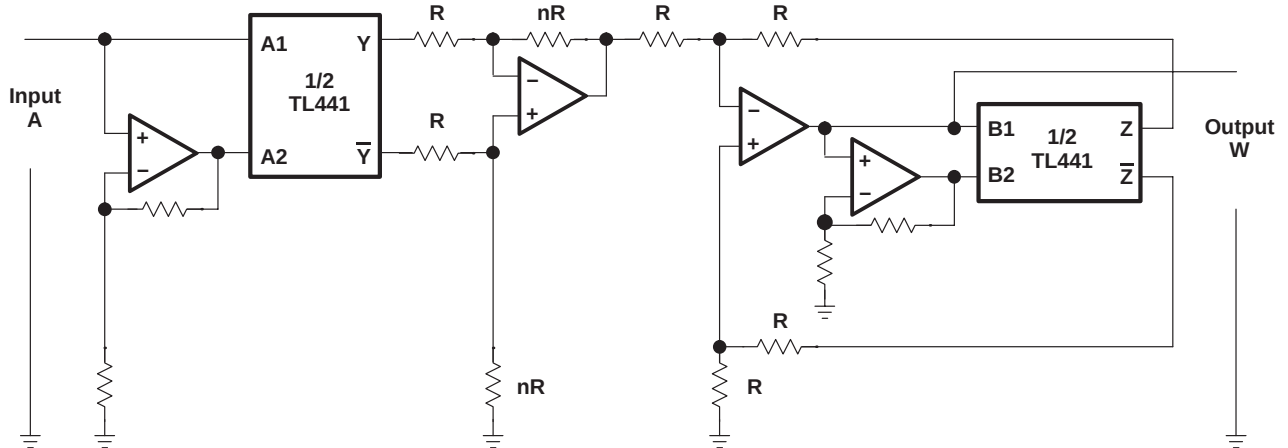


- NOTES: A. Connections shown are for multiplication. For division, Z and $\bar{Z}$ connections are reversed.
 B. Output W may need to be amplified to give actual product or quotient of A and B.
 C. R designates resistors of equal value, typically 2 k Ω to 10 k Ω .

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 15. Multiplication or Division



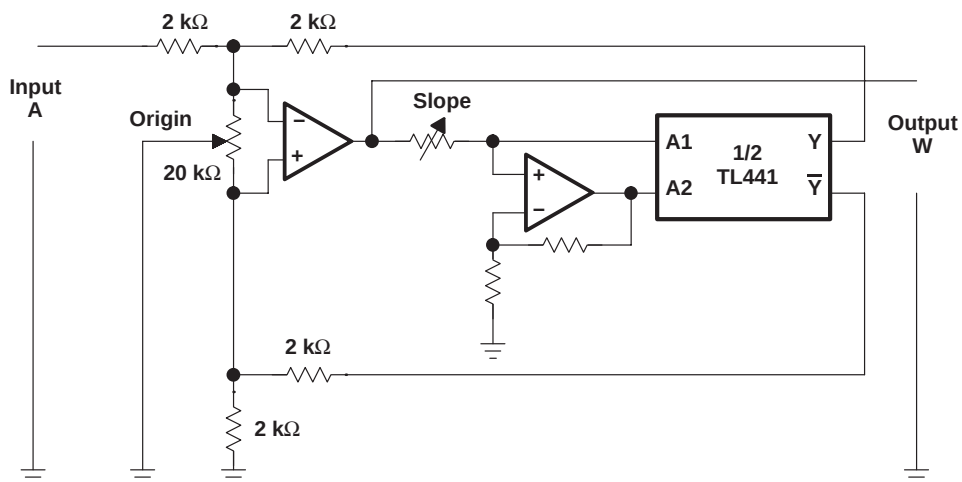
NOTE: R designates resistors of equal value, typically 2 k Ω to 10 k Ω . The power to which the input variable is raised is fixed by setting nR. Output W may need to be amplified to give the correct value.

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

Figure 16. Raising a Variable to a Fixed Power

TL441-EP LOGARITHMIC AMPLIFIER

SGLS268 – OCTOBER 2004



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

Figure 17. Raising a Fixed Number to a Variable Power

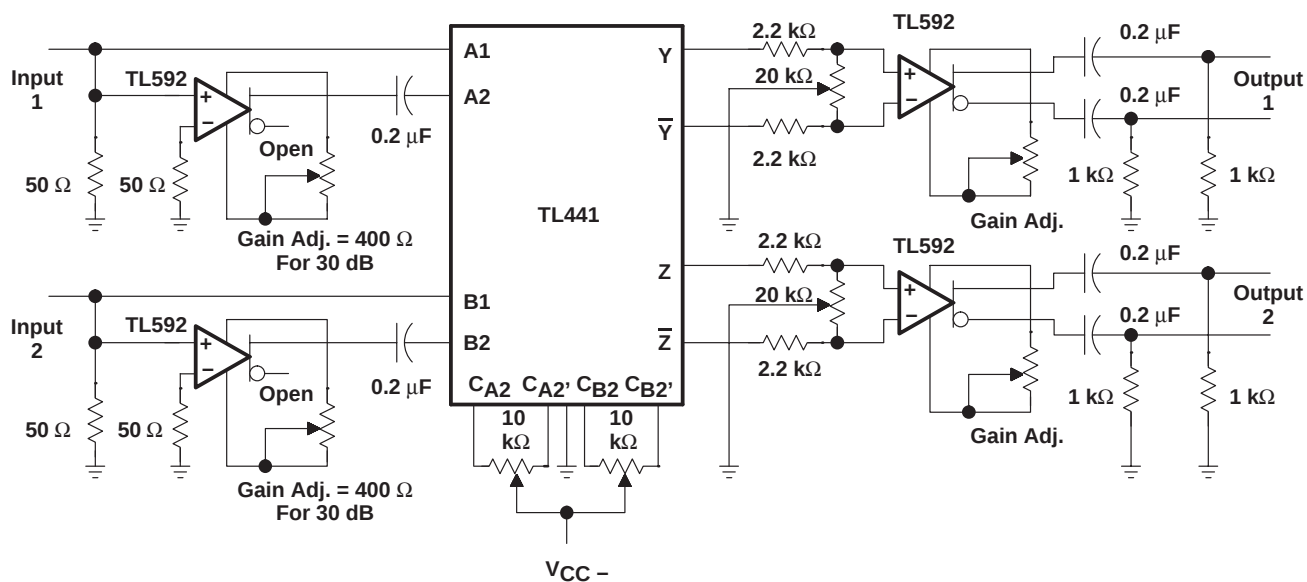


Figure 18. Dual-Channel RF Logarithmic Amplifier With 50-dB Input Range Per Channel at 10 MHz

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TL441MNSREP	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	TL441MEP	Samples
V62/05603-01XE	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	TL441MEP	Samples

(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.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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.

OTHER QUALIFIED VERSIONS OF TL441-EP :

- Catalog: [TL441](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION


*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
TL441MNSREP	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TL441MNSREP	SO	NS	16	2000	367.0	367.0	38.0

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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 Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
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
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com