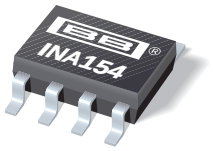
BURR - BROWN®



INA154

For most current data sheet and other product information, visit www.burr-brown.com

High-Speed, Precision DIFFERENCE AMPLIFIER (G = 1)

FEATURES

- DESIGNED FOR LOW COST
- LOW OFFSET VOLTAGE: ±750µV max
- LOW OFFSET DRIFT: ±2µV°C
- LOW GAIN ERROR: ±0.05% max
- WIDE BANDWIDTH: 3MHz
- HIGH SLEW RATE: 14V/µs
- FAST SETTLING TIME: 3µs to 0.01%
- WIDE SUPPLY RANGE: ±4V to ±18V
- LOW QUIESCENT CURRENT: 2.4mA
- SO-8 SURFACE-MOUNT PACKAGE

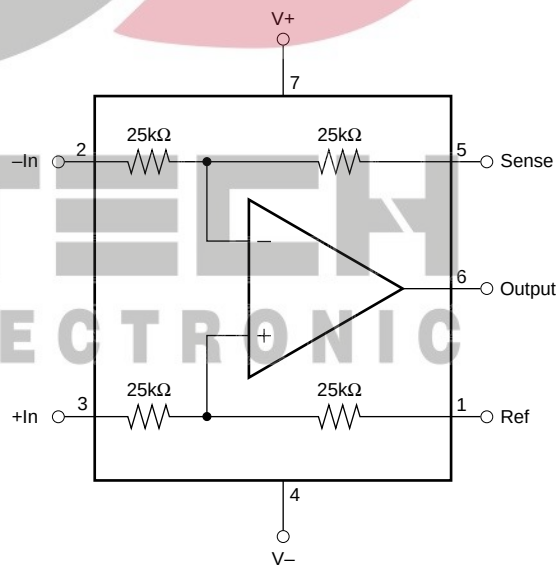
APPLICATIONS

- DIFFERENTIAL INPUT AMPLIFIER
- INSTRUMENTATION AMPLIFIER BUILDING BLOCK
- UNITY-GAIN INVERTING AMPLIFIER
- SUMMING AMPLIFIER
- DIFFERENTIAL CURRENT RECEIVER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- SYNCHRONOUS DEMODULATOR

DESCRIPTION

The INA154 is a high slew rate, unity-gain difference amplifier consisting of a precision op amp with a precision resistor network. The on-chip resistors are laser trimmed for accurate gain and high common-mode rejection. Excellent TCR tracking of the resistors maintains gain accuracy and common-mode rejection over temperature. The input common-mode voltage range extends beyond the positive and negative supply rails. It operates on ±4V to ±18V supplies.

The difference amplifier is the foundation of many commonly used circuits. The INA154 provides this circuit function without using an expensive precision resistor network. The INA154 is available in a SO-8 surface-mount package and is specified for operation over the extended industrial temperature range, –40°C to +85°C.



International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111
Twx: 910-952-1111 • Internet: http://www.burr-brown.com/ • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

Printed in U.S.A. March, 1999

SPECIFICATIONS: V_S = ±15V

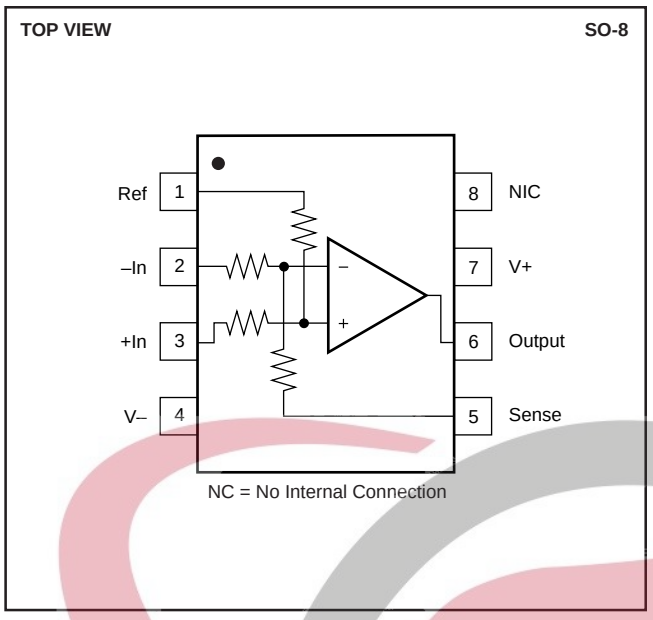
At T_A = +25°C, V_S = ±15V, R_L = 2kΩ connected to ground, and reference pin connected to ground, unless otherwise noted.

PARAMETER	CONDITIONS	INA154U			INA154UA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
OFFSET VOLTAGE[1]	RTO							
Initial			±100	±750		*	±1500	µV
vs Temperature			±2	±20		*	*	µV/°C
vs Power Supply	V_S = ±4V to ±18V		±5	±60		*	*	µV/V
vs Time			0.5			*		µV/mo
INPUT IMPEDANCE[2]								
Differential			50			*		kΩ
Common-Mode			50			*		kΩ
INPUT VOLTAGE RANGE								
Common-Mode Voltage Range								
Positive	V_O = 0V	2(V+) – 5	2(V+) – 4		*	*		V
Negative	V_O = 0V	2(V–) + 5	2(V–) + 2		*	*		V
Common-Mode Rejection Ratio	V_{CM} = –25V to 25V, R_S = 0Ω	80	90		74	*		dB
OUTPUT VOLTAGE NOISE[3]	RTO							
f = 0.1Hz to 10Hz			2.6			*		µVp-p
f = 1kHz			52			*		nV/√Hz
GAIN								
Initial			1			*		V/V
Error	V_O = –13V to +13V		±0.02	±0.05		*	±0.1	%
vs Temperature			±1	±10		*	*	ppm/°C
Nonlinearity	V_O = –13V to +13V		±0.0001	±0.001		*	±0.002	% of FS
OUTPUT								
Voltage, Positive		(V+) – 2	(V+) – 1.8		*	*		V
Negative		(V–) + 2	(V–) + 1.6		*	*		V
Current Limit, Continuous to Common			±60			*		mA
Capacitive Load (stable operation)			500			*		pF
FREQUENCY RESPONSE								
Small-Signal Bandwidth	–3dB		3.1			*		MHz
Slew Rate			14			*		V/µs
Settling Time: 0.1%	10V Step, C_L = 100pF		2			*		µs
0.01%	10V Step, C_L = 100pF		3			*		µs
Overload Recovery Time	50% Overdrive		3			*		µs
POWER SUPPLY								
Rated Voltage			±15			*		V
Operating Voltage Range		±4		±18	*		*	V
Quiescent Current	I_O = 0mA		±2.4	±2.9		*	*	mA
TEMPERATURE RANGE								
Specified		–40		+85	*		*	°C
Operation		–55		+125	*		*	°C
Storage		–55		+125	*		*	°C
Thermal Resistance, Θ_{JA}								
SO-8 Surface-Mount			150			*		°C/W

*Specifications the same as INA154U.

NOTES: (1) Includes effects of amplifier's input bias and offset currents. (2) 25kΩ resistors are ratio matched but have ±20% absolute value. (3) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

PIN CONFIGURATION



ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage, V+ to V–	40V
Input Voltage Range	±80V
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 degrade 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

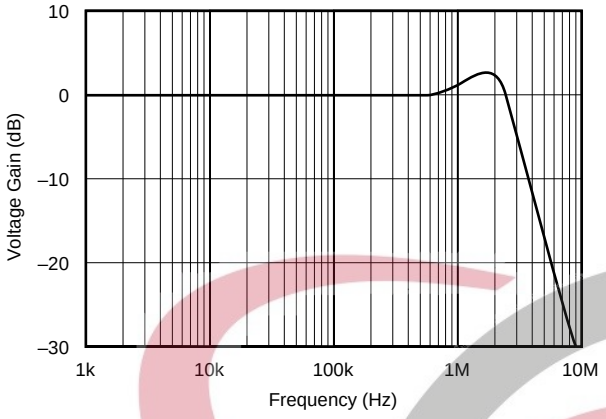
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER[1]	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER[2]	TRANSPORT MEDIA
INA154U	SO-8 Surface-Mount	182	–40°C to +85°C	INA154U	INA154U	Rails
"	"	"	"	"	INA154U/2K5	Tape and Reel
INA154UA	SO-8 Surface-Mount	182	–40°C to +85°C	INA154UA	INA154UA	Rails
"	"	"	"	"	INA154UA/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. (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 "INA154U/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.

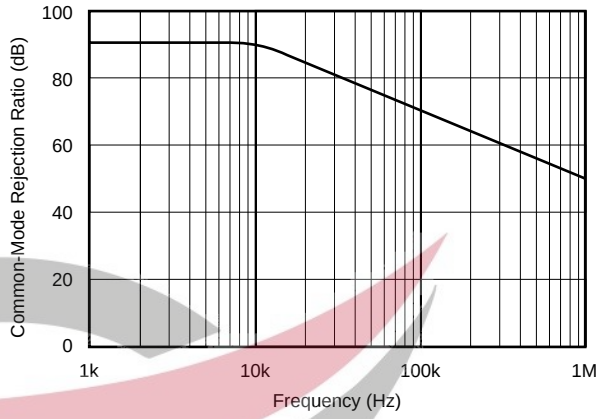
TYPICAL PERFORMANCE CURVES

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

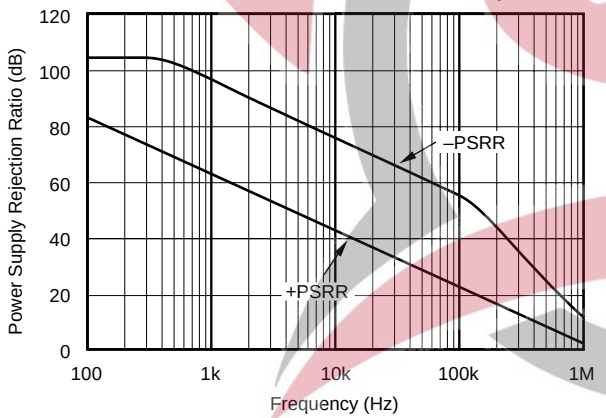
GAIN vs FREQUENCY



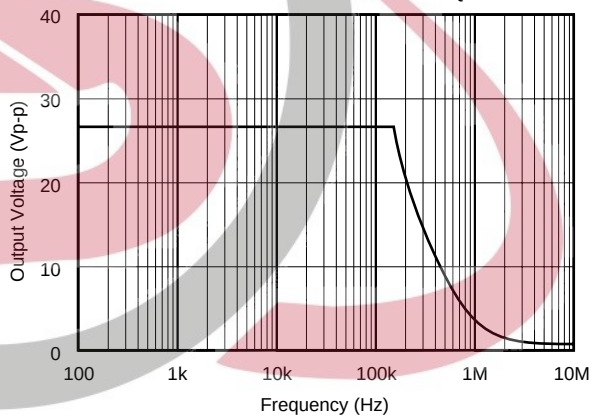
COMMON-MODE REJECTION RATIO vs FREQUENCY



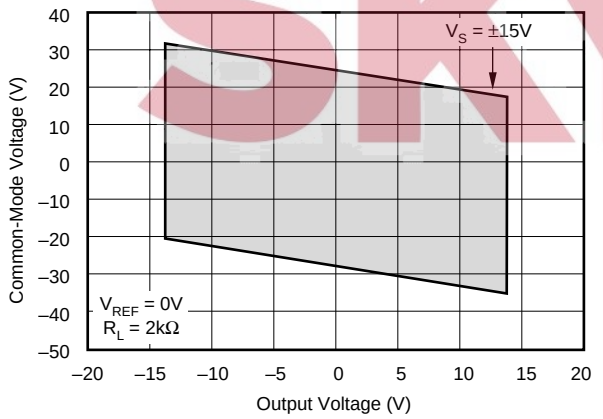
POWER SUPPLY REJECTION RATIO vs FREQUENCY



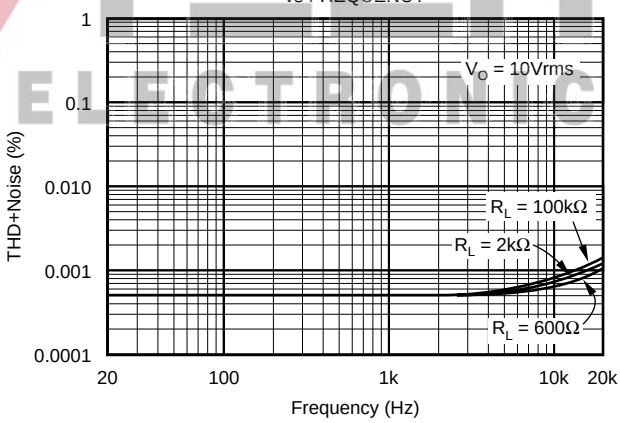
MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



INPUT COMMON-MODE VOLTAGE RANGE vs OUTPUT VOLTAGE



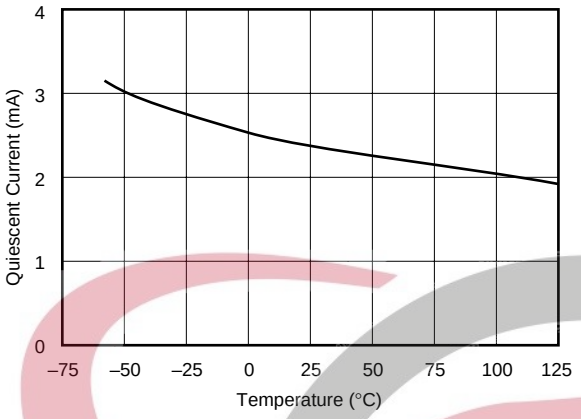
TOTAL HARMONIC DISTORTION + NOISE vs FREQUENCY



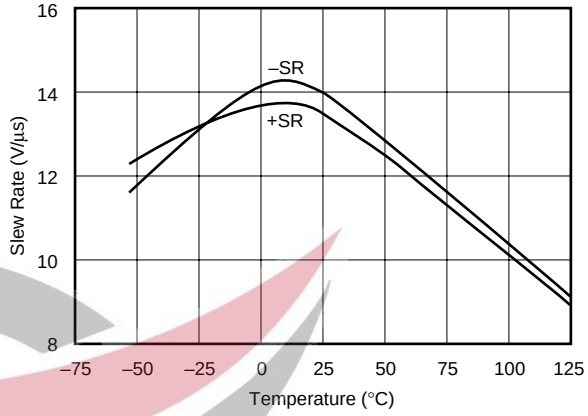
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C, and V_S = ±15V, unless otherwise noted.

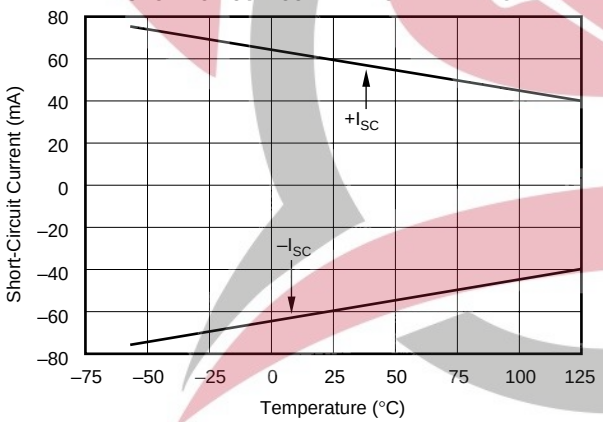
QUIESCENT CURRENT vs TEMPERATURE



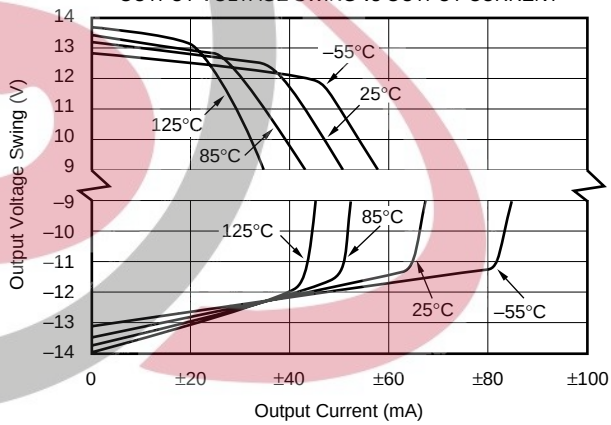
SLEW RATE vs TEMPERATURE



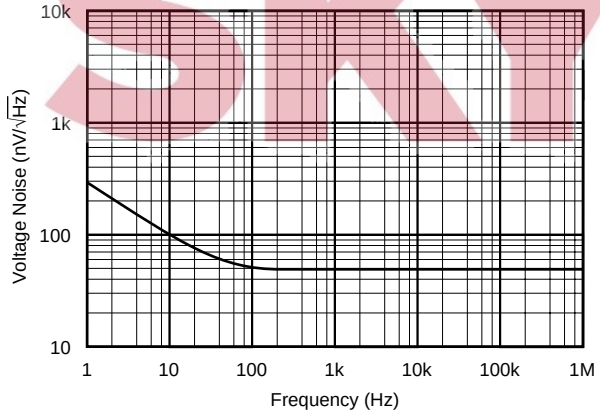
SHORT-CIRCUIT CURRENT vs TEMPERATURE



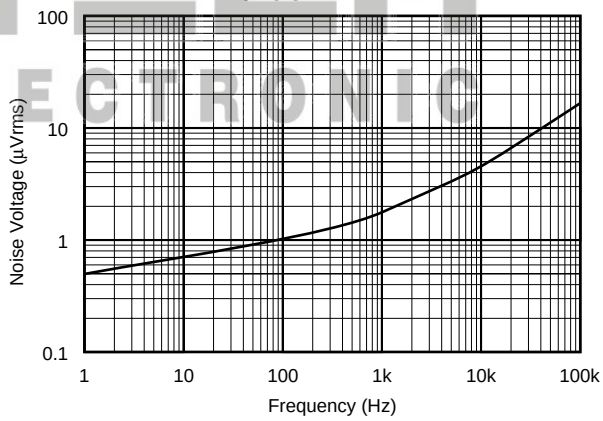
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



OUTPUT VOLTAGE NOISE SPECTRAL DENSITY vs FREQUENCY



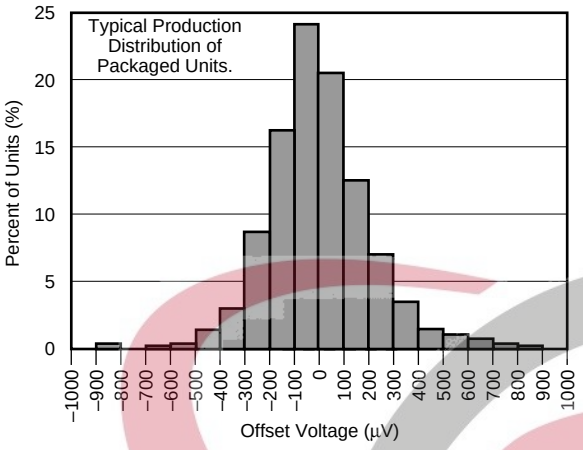
OUTPUT NOISE VOLTAGE vs NOISE BANDWIDTH



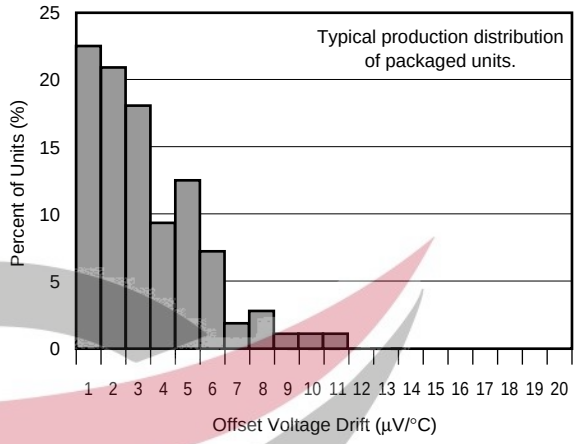
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C, and V_S = ±15V, unless otherwise noted.

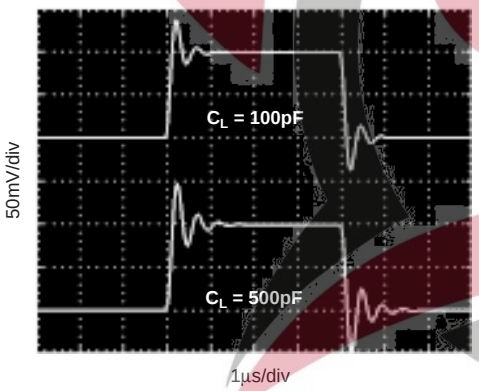
OFFSET VOLTAGE
PRODUCTION DISTRIBUTION



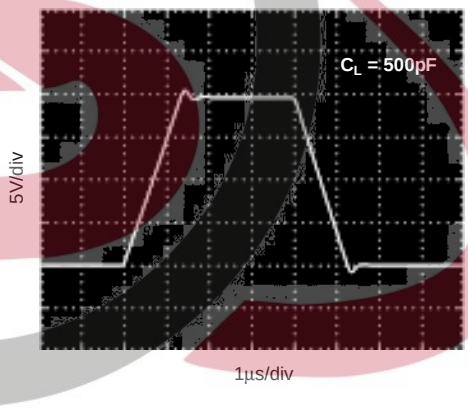
OFFSET VOLTAGE DRIFT
PRODUCTION DISTRIBUTION



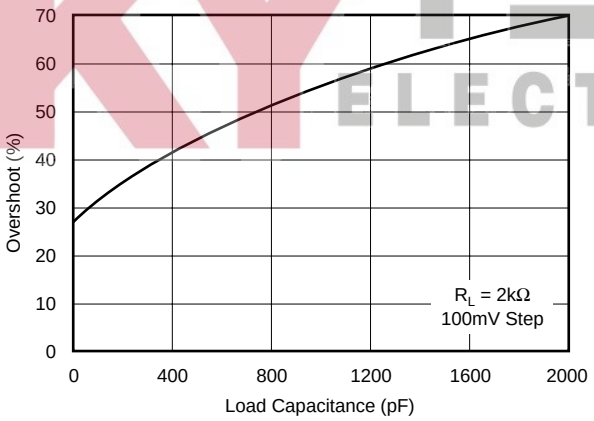
SMALL-SIGNAL STEP RESPONSE



LARGE-SIGNAL STEP RESPONSE



SMALL-SIGNAL OVERSHOOT
vs LOAD CAPACITANCE



APPLICATIONS INFORMATION

Figure 1 shows the basic connections required for operation of the INA154. Decoupling capacitors are strongly recommended in applications with noisy or high impedance power supplies. The capacitors should be placed close to the device pins as shown in Figure 1.

As shown in Figure 1, the output is referred to the reference terminal (pin 1). A voltage applied to this pin will be summed with output signal. The differential input signal is connected to pins 2 and 3. The source impedances connected to the pinouts must be nearly equal to assure good common-mode rejection. A 5Ω mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 80dB (a 10Ω mismatch degrades CMR to 74dB). If the source has a known impedance mismatch, an additional resistor in series with the opposite input can be used to preserve good common-mode rejection.

Do not interchange pins 1 and 3 or pins 2 and 5, even though nominal resistor values are equal. The resistors are laser trimmed for precise resistor ratios to achieve accurate gain and highest CMR. Interchanging these pins would not provide specified performance.

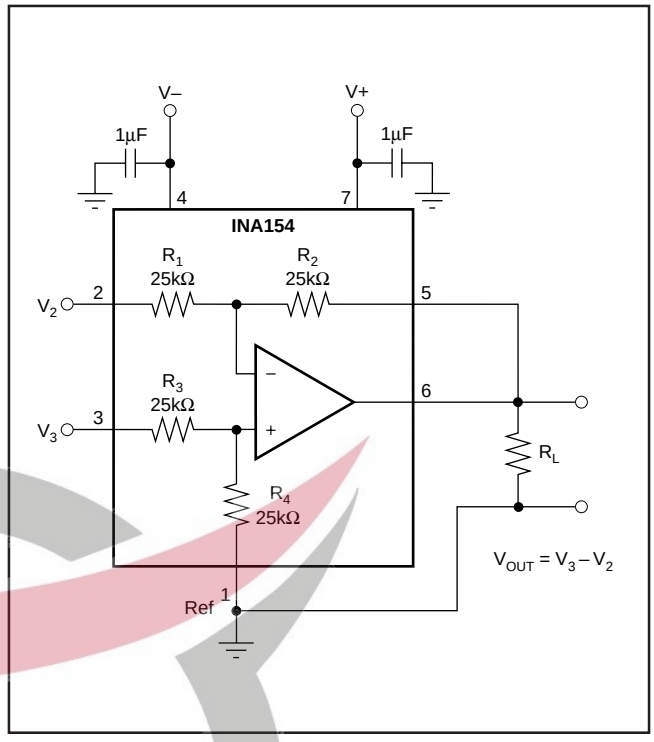


FIGURE 1. Basic Power Supply and Signal Connections.

OPERATING VOLTAGE

The INA154 operates from ±4V to ±18V supplies with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the Typical Performance Curves.

INPUT VOLTAGE RANGE

The INA154 can accurately measure differential signals that are beyond the positive or negative power supply rails. The linear common-mode range extends from 2•(V+) – 5V to 2•(V–) +5V. See the Typical Performance Curve, "Input Common-Mode Range vs Output Voltage."

OFFSET VOLTAGE TRIM

The INA154 is laser trimmed for low offset voltage and drift. Most applications require no external offset adjustment. Figure 2 shows an optional circuit for trimming the output offset voltage. The output is referred to the output reference terminal (pin 1), which is normally grounded. A voltage applied to the Ref terminal will be summed with the output signal. This can be used to null offset voltage as shown in Figure 2. The source impedance of a signal applied to the Ref terminal should be less than 10Ω to maintain good common-mode rejection.

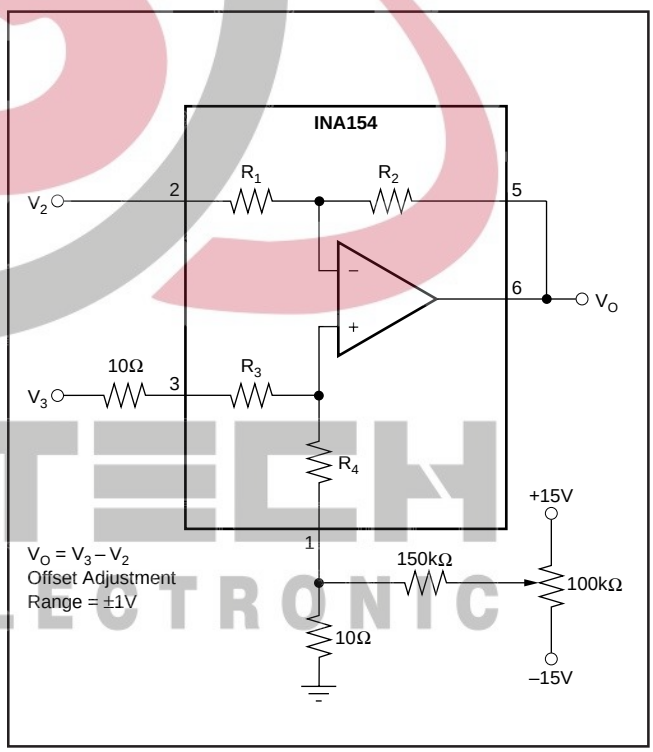


FIGURE 2. Offset Adjustment.

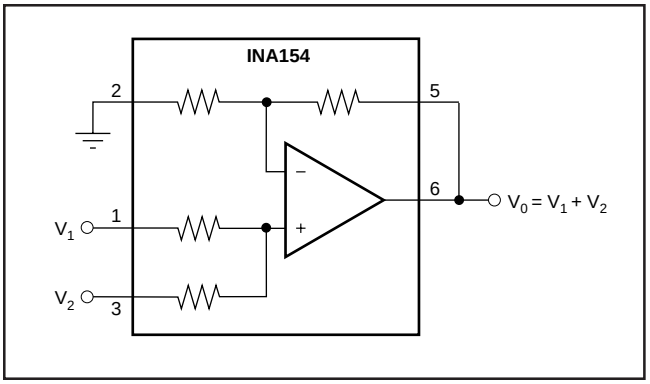


FIGURE 3. Precision Summing Amplifier.

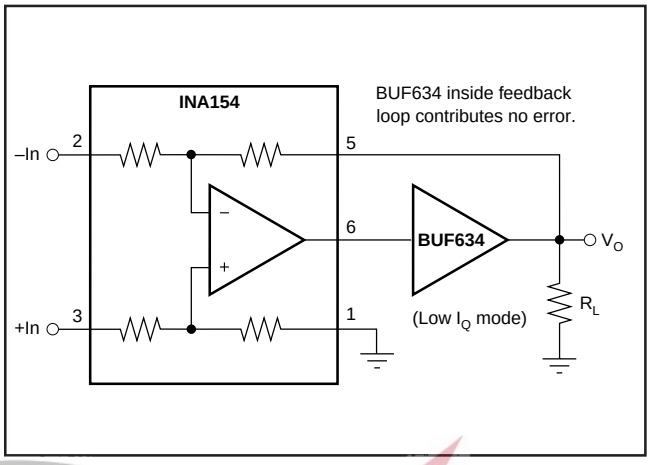
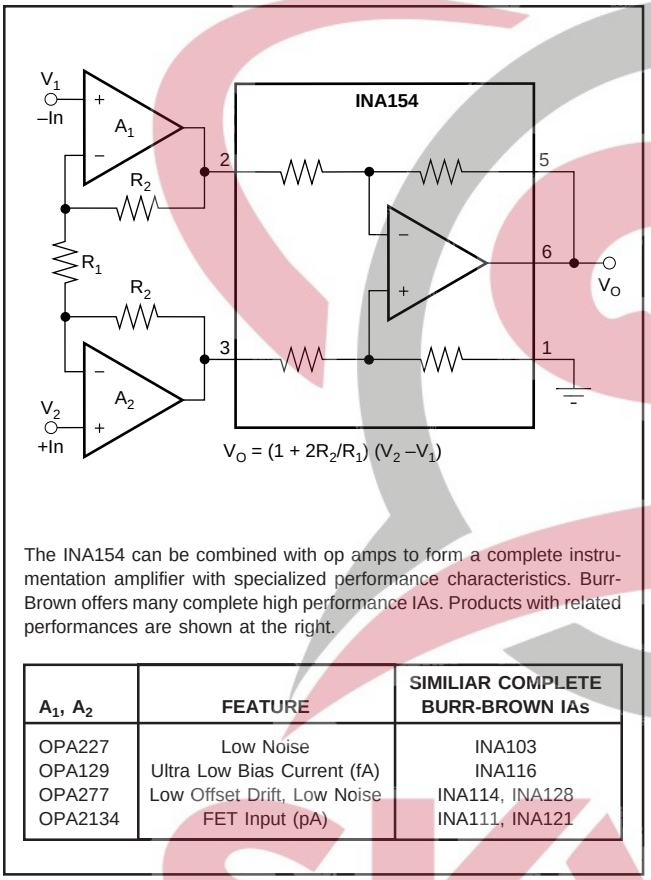


FIGURE 5. Boosting Output Current.



The INA154 can be combined with op amps to form a complete instrumentation amplifier with specialized performance characteristics. Burr-Brown offers many complete high performance IAs. Products with related performances are shown at the right.

A_1, A_2	FEATURE	SIMILIAR COMPLETE BURR-BROWN IAs
OPA227	Low Noise	INA103
OPA129	Ultra Low Bias Current (fA)	INA116
OPA277	Low Offset Drift, Low Noise	INA114, INA128
OPA2134	FET Input (pA)	INA111, INA121

FIGURE 4. Precision Instrumentation Amplifier.

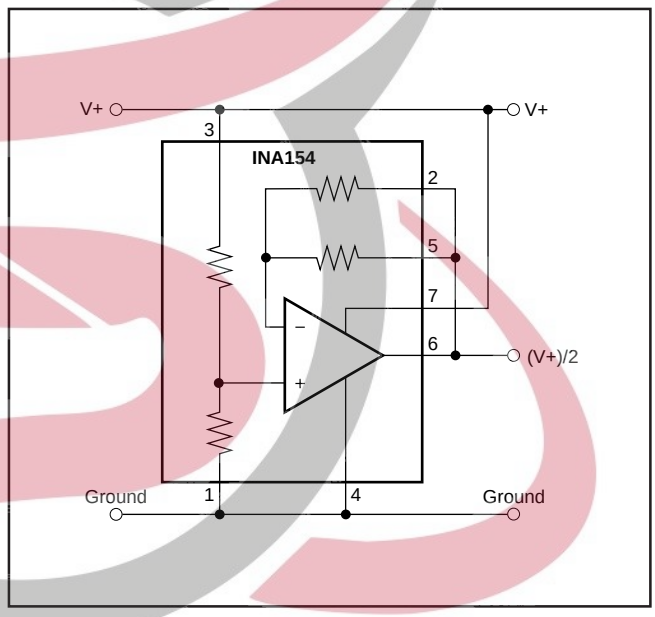


FIGURE 6. Pseudoground Generator.

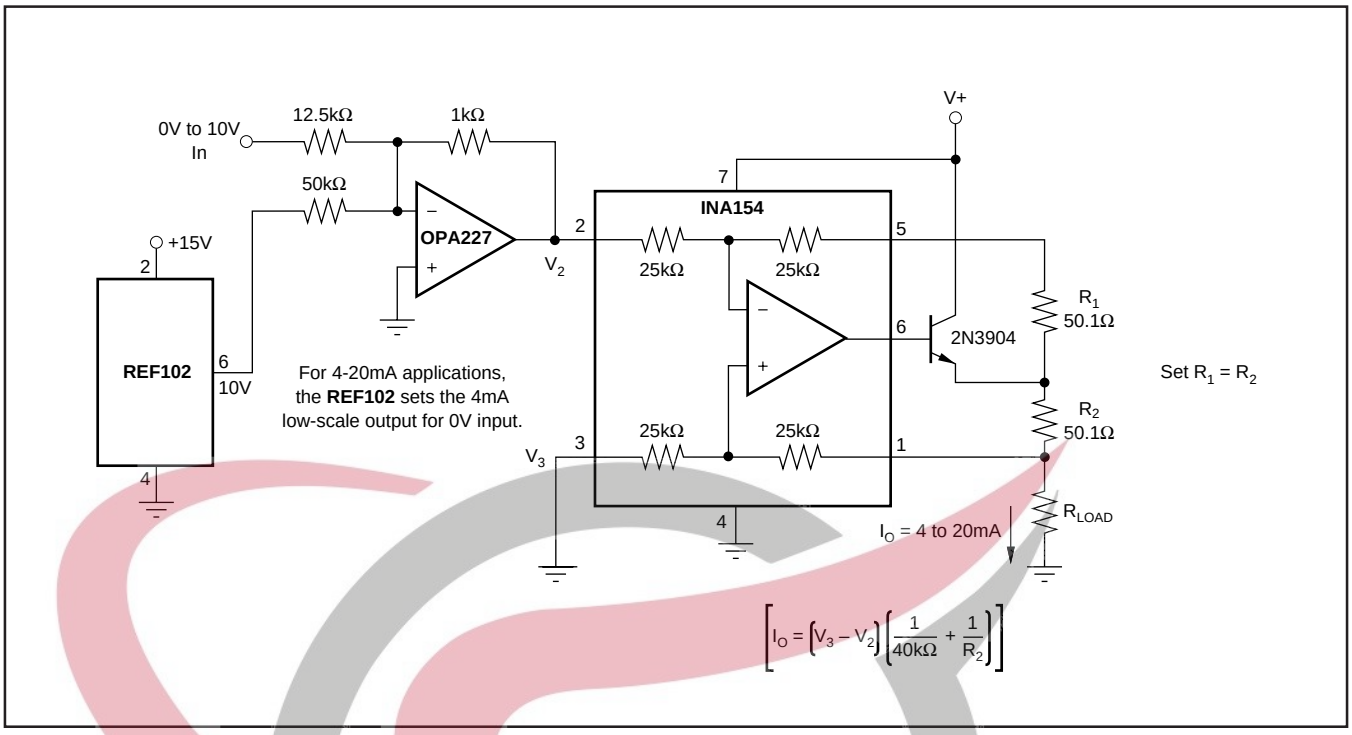


FIGURE 7. Precision Voltage-to-Current Conversion.

The difference amplifier is a highly versatile building block that is useful in a wide variety of applications. See the INA105 data sheet for additional applications ideas, including:

- Current Receiver with Compliance to Rails
- Precision Unity-Gain Inverting Amplifier
- ±10V Precision Voltage Reference
- ±5V Precision Voltage Reference
- Precision Unity-Gain Buffer
- Precision Average Value Amplifier
- Precision G = 2 Amplifier (see INA157)
- Precision G = 1/2 Amplifier (see INA157)
- Precision Bipolar Offsetting
- Precision Summing Amplifier with Gain
- Instrumentation Amplifier Guard Drive Generator
- Precision Summing Instrumentation Amplifier
- Precision Absolute Value Buffer
- Precision Voltage-to-Current Converter with Differential Inputs
- Differential Input Voltage-to-Current Converter for Low I_{OUT}
- Isolating Current Source
- Differential Output Difference Amplifier
- Isolating Current Source with Buffering Amplifier for Greater Accuracy
- Window Comparator with Window Span and Window Center Inputs
- Precision Voltage-Controlled Current Source with Buffered Differential Inputs and Gain
- Digitally Controlled Gain of ±1 Amplifier

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
INA154U	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA154U/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA154U/2K5E4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA154UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA154UAG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA154UG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

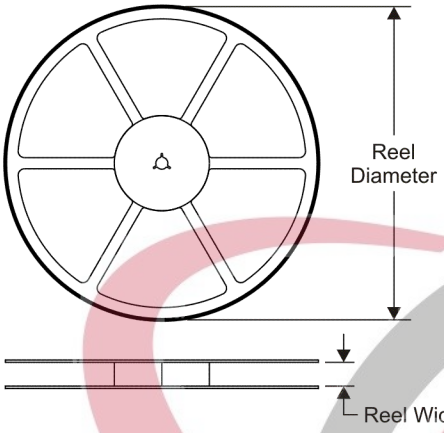
(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, 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)

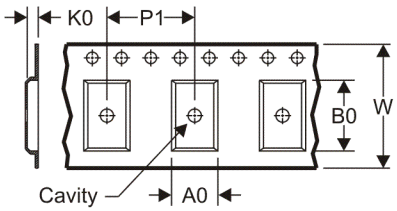
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

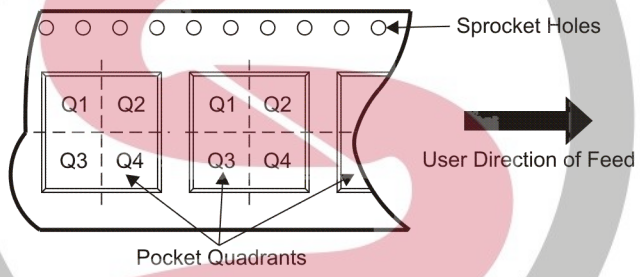


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

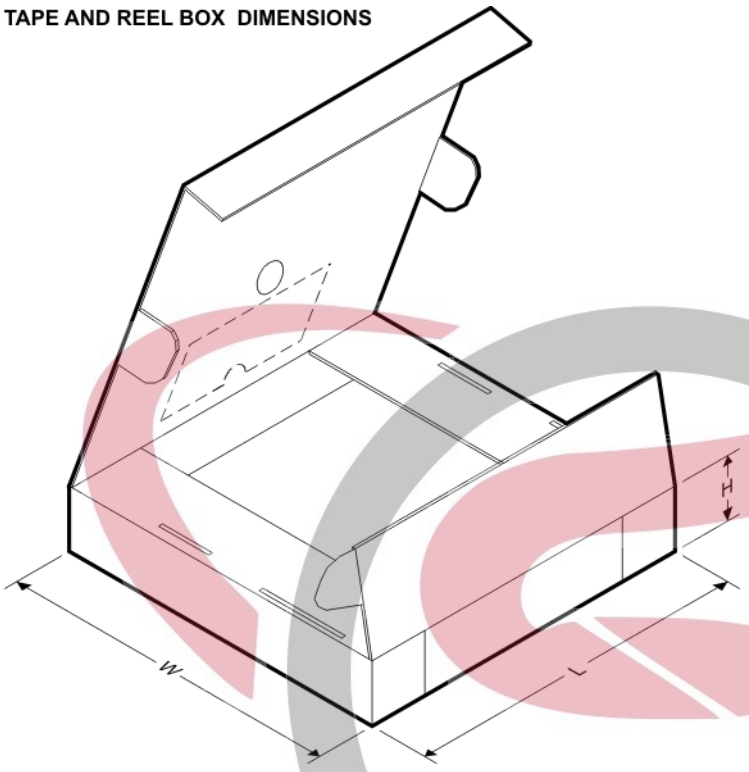
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
INA154U/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)
INA154U/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		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Broadband	www.ti.com/broadband
DSP	dsp.ti.com	Digital Control	www.ti.com/digitalcontrol
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Military	www.ti.com/military
Logic	logic.ti.com	Optical Networking	www.ti.com/opticalnetwork
Power Mgmt	power.ti.com	Security	www.ti.com/security
Microcontrollers	microcontroller.ti.com	Telephony	www.ti.com/telephony
RFID	www.ti-rfid.com	Video & Imaging	www.ti.com/video
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265