Burr-Brown Products
from Texas Instruments

INA152

www.ti.com

Single-Supply DIFFERENCE AMPLIFIER

FEATURES

- **SWING: to Within 200mV of Either Output Rail**
- **LOW OFFSET DRIFT: ±3µV/°C**
- **LOW OFFSET VOLTAGE: ±250µV**
- **HIGH CMR: 94dB**
- **LOW GAIN ERROR: 0.01%**
- **LOW GAIN ERROR DRIFT: 1ppm/°C**
- **WIDE SUPPLY RANGE:**
  - **Single: 2.7V to 20V**
  - **Dual: ±1.35V to ±10V**
- **MSOP-8 PACKAGE**

APPLICATIONS

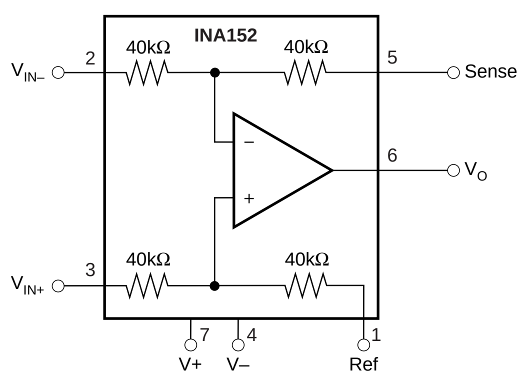
- **DIFFERENCE INPUT AMPLIFIER BUILDING BLOCK**
- **UNITY-GAIN INVERTING AMPLIFIER**
- **GAIN = 1/2**
- **AMPLIFIER GAIN = 2 AMPLIFIER**
- **SUMMING AMPLIFIER**
- **SYNCHRONOUS DEMODULATOR**
- **CURRENT AND DIFFERENTIAL LINE RECEIVER**
- **VOLTAGE-CONTROLLED CURRENT SOURCE**
- **BATTERY-POWERED SYSTEMS**
- **LOW-COST AUTOMOTIVE INSTRUMENTATION**

DESCRIPTION

The INA152 is a small (MSOP-8), low-power, unity-gain difference amplifier consisting of a CMOS op amp and a precision resistor network. The on-chip resistors are laser trimmed for accurate gain and high common-mode rejection. Excellent TCR tracking of the resistor maintains gain accuracy and common-mode rejection over temperature. The input common-mode voltage range extends to above the positive and negative rails and the output swings to within 50mV of either rail.

The difference amplifier is the foundation of many commonly used circuits. The INA152 provides precision circuit function without using an expensive precision network.

The INA152 is specified for operation over the extended industrial temperature range, –40°C to +85°C.



TEXAS INSTRUMENTS

SPECIFICATIONS: $V_S = \pm 10V$

$T_A = +25°C$, $V_S = \pm 10V$, $R_L = 10k\Omega$ connected to ground, and reference pin connected to ground, unless otherwise noted.

PARAMETER	CONDITIONS	INA152EA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE	RTO(1) (2)				
Input Offset Voltage	$V_{CM} = 0V$		±250	±1500	μV
vs Temperature	$T_A = -40°C$ to $+85°C$		±3	±15	μV/°C
vs Power Supply	$V_S = \pm 1.35V$ to $\pm 10V$		5	30	μV/V
vs Time			0.5		μV/mo
INPUT VOLTAGE RANGE(3)					
Common-Mode Voltage Range					
	$V_{IN+} - V_{IN-} = 0V$	2(V–)		2(V+) – 2	V
Common-Mode Rejection		80	94		dB
INPUT IMPEDANCE(4)					
Differential			80		kΩ
Common-Mode			80		kΩ
OUTPUT NOISE VOLTAGE(1) (5)	RTO				
$f_O = 10Hz$			97		$nV/\sqrt{Hz}$
$f_O = 1kHz$			87		$nV/\sqrt{Hz}$
$f_B = 0.1Hz$ to $10Hz$			2.4		μVp-p
GAIN					
Initial(6)			1		V/V
Gain Error			±0.01	±0.1	%
Gain Temperature Drift Coefficient			±1	±10	ppm/°C
Nonlinearity	$(V-) + 0.3V < V_O < (V+) - 0.350V$		±0.002	±0.005	% of FS
FREQUENCY RESPONSE					
Small Signal			800		kHz
Slew Rate			0.4		V/μs
Settling Time, 0.1%	9V Step		23		μs
, 0.01%	9V Step		25		μs
Overload Recovery	50% Overdrive		5		μs
OUTPUT					
Voltage	$R_L = 10k\Omega$ to GND	(V+) – 0.35	(V+) – 0.02		V
		(V–) + 0.3	(V–) + 0.15		V
Load Capacitance Stability			500		pF
Short-Circuit Curent	Continuous to Common		+7, –12		mA
POWER SUPPLY					
Rated Voltage			±10		V
Voltage Range		±1.35		±10	V
		2.7		20	V
Current, Quiescent	$I_O = 0mA$		500	650	μA
TEMPERATURE RANGE					
Specification		–40		+85	°C
Operating		–55		+125	°C
θ_{JA}, Junction to Ambient			150		°C/W

NOTES: (1) Referred to output in unity-gain difference configuration. Note that this circuit has a gain of 2 for the op amp's offset voltage and noise voltage. (2) Includes effects of amplifier's input bias and offset currents. (3) Limit I_{IN} through 40kΩ resistors to 1mA. (4) 40kΩ resistors are ratio matched but have ±20% absolute value. (5) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network. (6) Connected as difference amplifier.

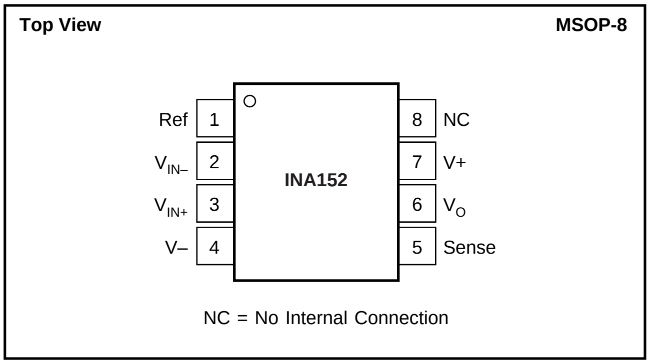
SPECIFICATIONS: V_S = +5V

T_A = +25°C, V_S = +5V, Ref connected to $V_S/2$, R_L = 10kΩ connected to $V_S/2$, unless otherwise noted.

PARAMETER	CONDITIONS	INA152EA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE	RTO(1) (2)				
Input Offset Voltage	$V_{CM} = V_{OUT}$ = 0V		±250	±1500	µV
vs Temperature	T_A = –40°C ≤ T_A ≤ 85°C		±3	±15	µV/°C
INPUT VOLTAGE RANGE(3)					
Voltage Range, Common-Mode	$V_{IN}+ - V_{IN}-$ = 0V	–2.5		+5.5	V
Common-Mode Rejection	0V < V_{CM} < +5V, R_{SRC} = 0Ω	80	94		dB
OUTPUT					
Voltage		(V+) – 0.2			V
		(V–) + 0.2			V
	R_L = 10kΩ to GND		(V–) + 0.05		V

NOTES: (1) Referred to output in unity-gain difference configuration. Note that this circuit has a gain of 2 for the op amp's offset voltage and noise voltage. (2) Includes effects of amplifier's input bias and offset currents. (3) Limit I_{IN} through 40kΩ resistors to 1mA.

PIN CONFIGURATION



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.

ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage, V+ to V–	+22V
Signal Input Terminals	+20V Continuous
Output Short-Circuit to GND Duration	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

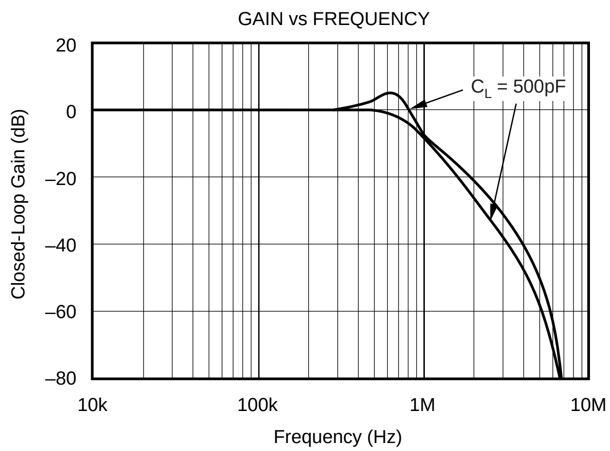
PACKAGE/ORDERING INFORMATION

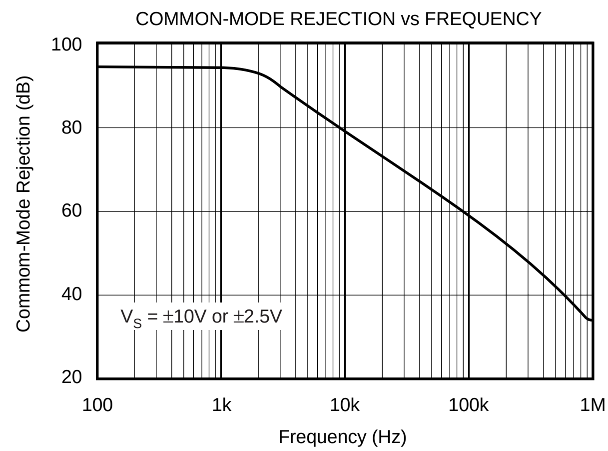
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(1)	TRANSPORT MEDIA
INA152EA	MSOP-8	337	–40°C to +85°C	B52	INA152EA/250	Tape and Reel
"	"	"	"	"	INA152EA/2K5	Tape and Reel

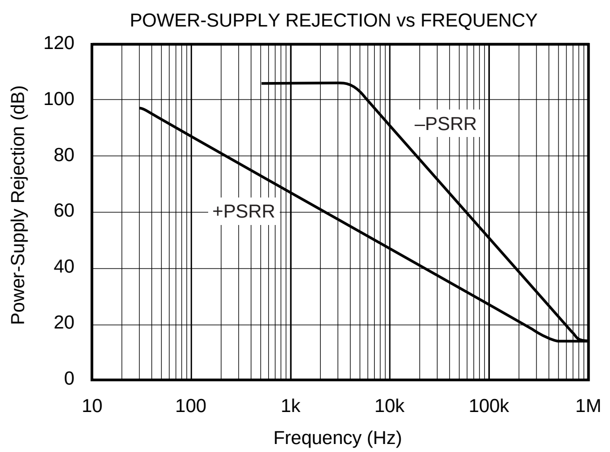
NOTE: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "INA152EA/2K5" will get a single 2500-piece Tape and Reel.

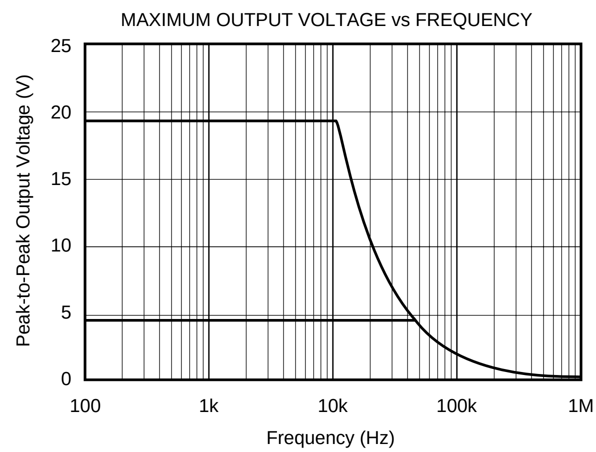
TYPICAL PERFORMANCE CURVES

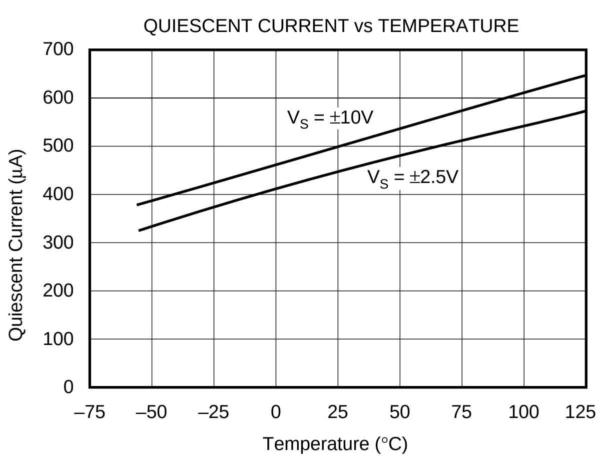
At T_A = +25°C, V_S = ±10V, R_L = 10kΩ connected to GND, and Ref = GND, unless otherwise noted.

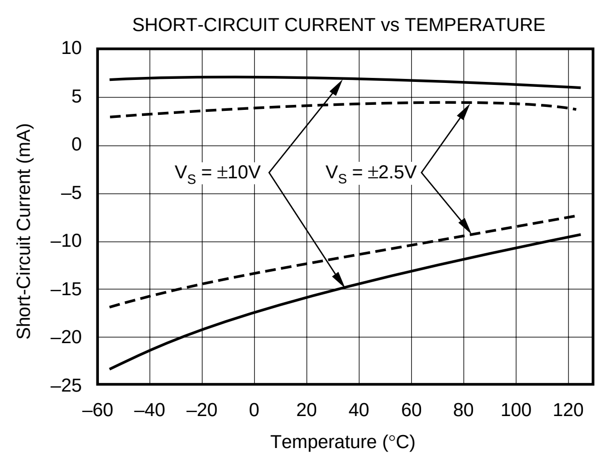






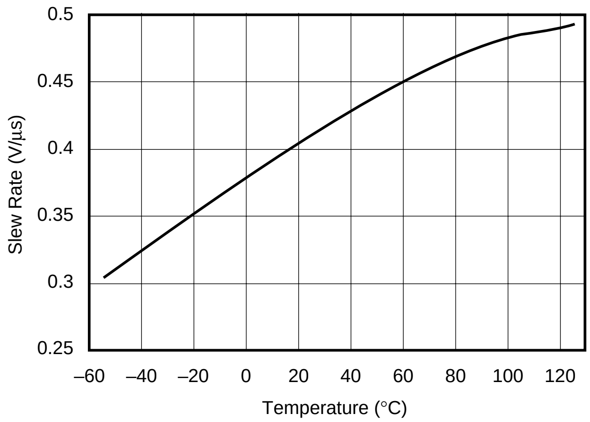




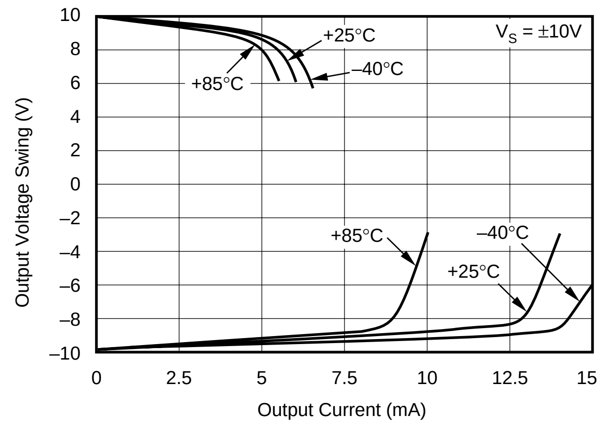


At T_A = +25°C, V_S = ±10V, R_L = 10kΩ connected to GND, and Ref = GND, unless otherwise noted.

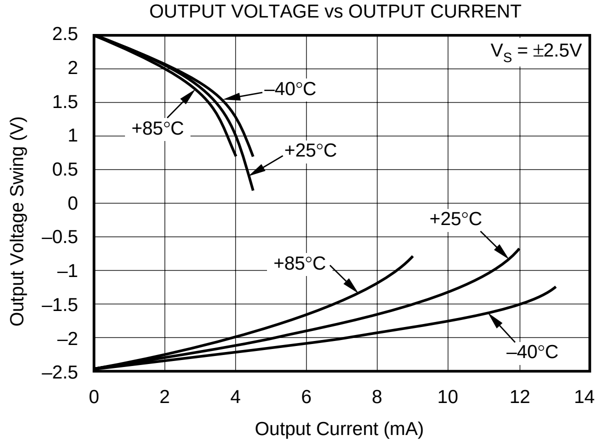
SLEW RATE vs TEMPERATURE



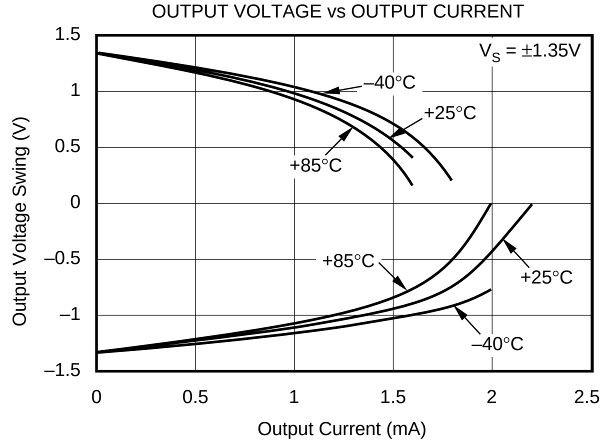
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



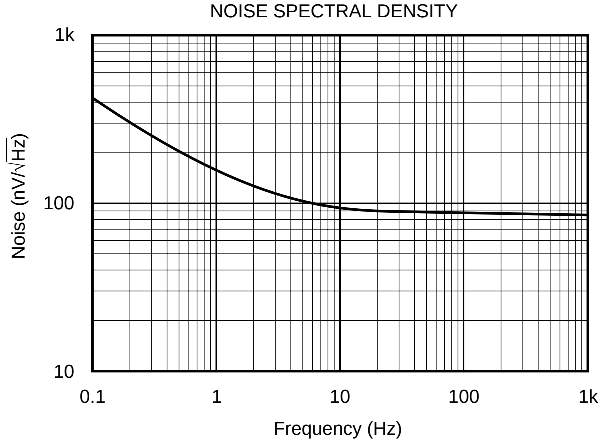
OUTPUT VOLTAGE vs OUTPUT CURRENT



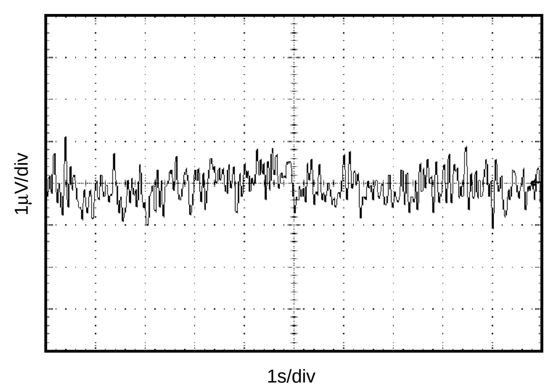
OUTPUT VOLTAGE vs OUTPUT CURRENT



NOISE SPECTRAL DENSITY



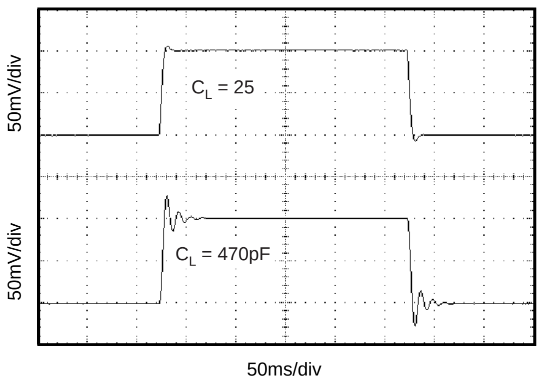
0.1Hz TO 10Hz PEAK-TO-PEAK VOLTAGE NOISE



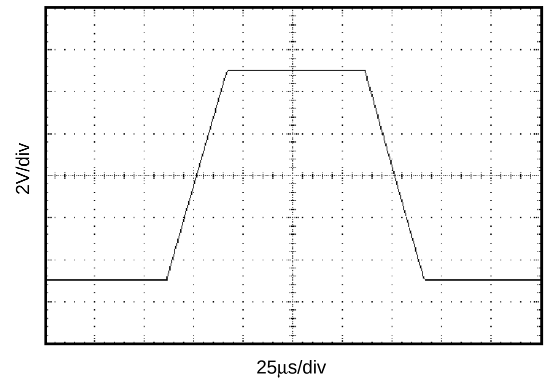
TYPICAL PERFORMANCE CURVES (Cont.)

At T_A = +25°C, V_S = ±10V, R_L = 10kΩ connected to GND, and Ref = GND, unless otherwise noted.

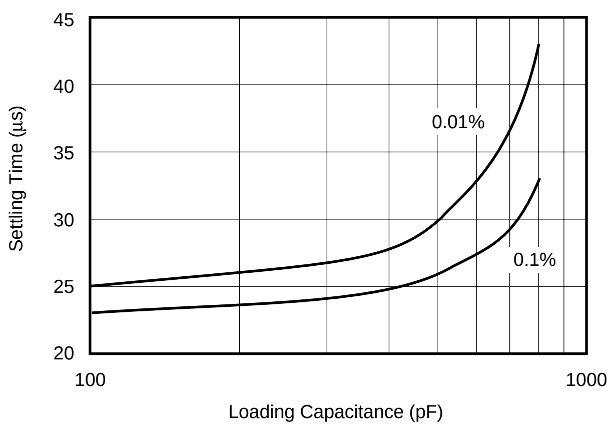
SMALL-SIGNAL STEP RESPONSE



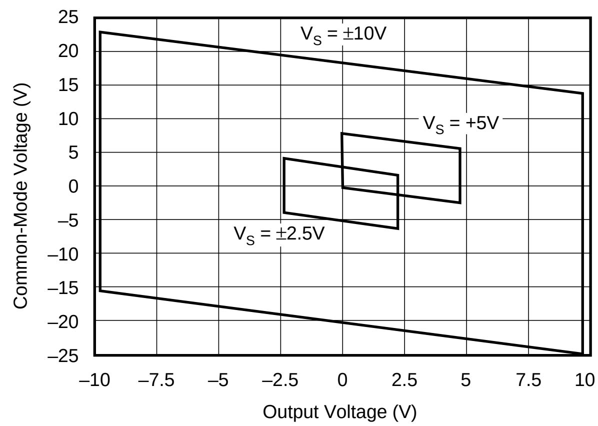
LARGE-SIGNAL STEP RESPONSE



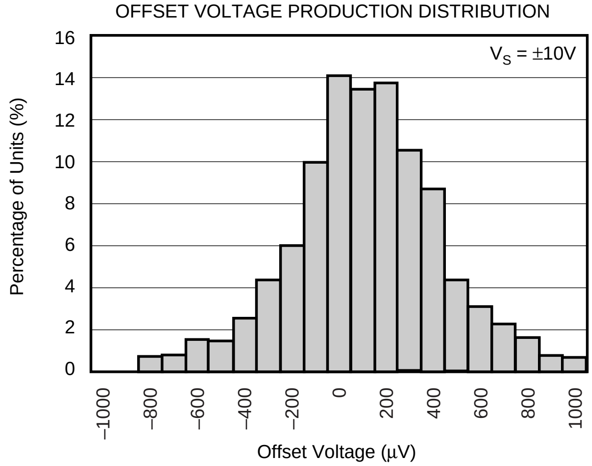
SETTLING TIME vs LOAD CAPACITANCE



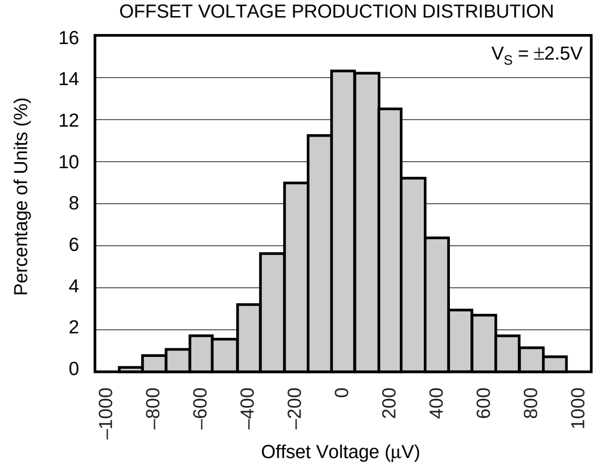
INPUT COMMON-MODE VOLTAGE
vs OUTPUT VOLTAGE



OFFSET VOLTAGE PRODUCTION DISTRIBUTION

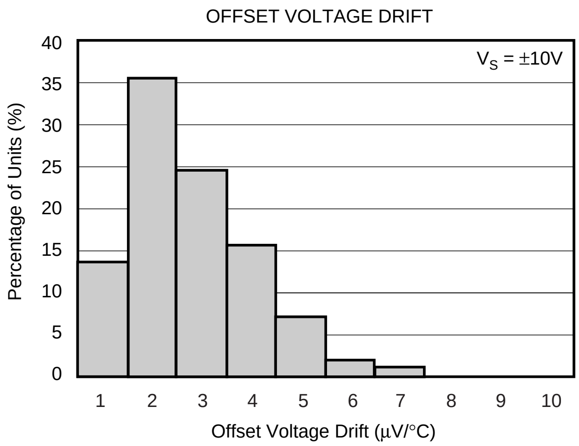


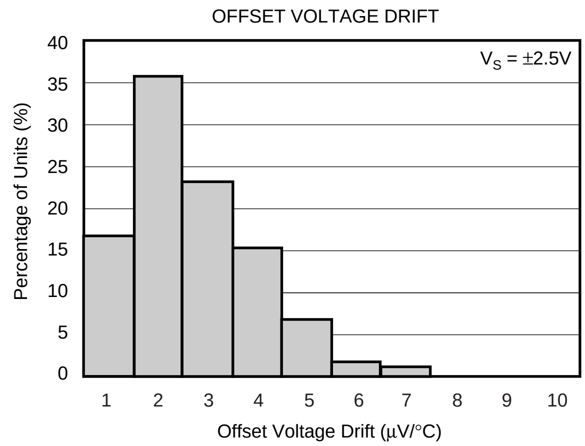
OFFSET VOLTAGE PRODUCTION DISTRIBUTION



TYPICAL PERFORMANCE CURVES (Cont.)

At T_A = +25°C, V_S = ±10V, R_L = 10kΩ connected to GND, and Ref = GND, unless otherwise noted.





APPLICATIONS INFORMATION

The INA152 is a low-power difference amplifier suitable for a wide range of general-purpose applications. Figure 1 shows the basic connections required for operation of the INA152. 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 differential input signal is connected to pins 2 and 3. The source impedances connected to the inputs must be nearly equal to assure good common-mode rejection. An 8Ω mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 80dB (a 16Ω 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.

The INA152's internal resistors are accurately ratio trimmed to match. That is, R_1 is trimmed to match R_2, and R_3 is trimmed to match R_4. However, the absolute values may not be equal ($R_1 + R_2$ may be slightly different than $R_3 + R_4$). Thus, large series resistors on the input (greater than 250Ω), even if well matched, will degrade common-mode rejection.

Circuit-board layout constraints might suggest possible variations in connections of the internal resistors. It might appear that pins 1 and 3 could be interchanged, however, because of the ratio trimming technique used (see paragraph above) CMRR will be degraded. If pins 1 and 3 are interchanged, pins 2 and 5 must also be interchanged to maintain proper ratio matching.

OPERATING VOLTAGE

The INA152 operates from single (+2.7V to +20V) or dual (±1.35V to ±10V) supplies with excellent performance. Specifications are production tested with +5V and ±10V supplies. Most behavior remains unchanged throughout the full operating voltage range. Parameters that vary significantly with operating voltage are shown in the typical performance curves.

INPUT VOLTAGE

The INA152 can accurately measure differential signals that are above and below the supply rails. Linear common-mode range extends from 2 • [(V+) – 1V] to 2 • (V–) (nearly twice the supplies). See the typical performance curve, "Input Common-Mode Voltage vs Output Voltage".

OFFSET VOLTAGE TRIM

The INA152 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.

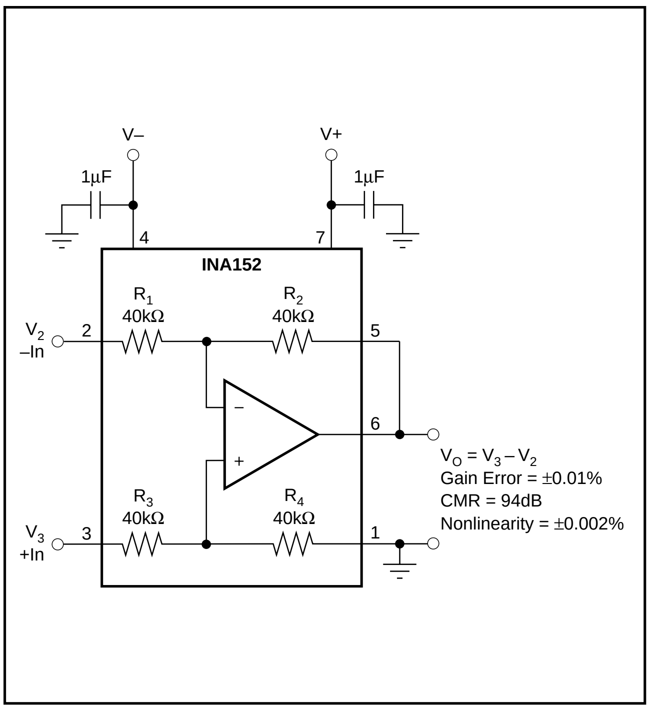


FIGURE 1. Precision Difference Amplifier (Basic Power Supply and Signal Connections).

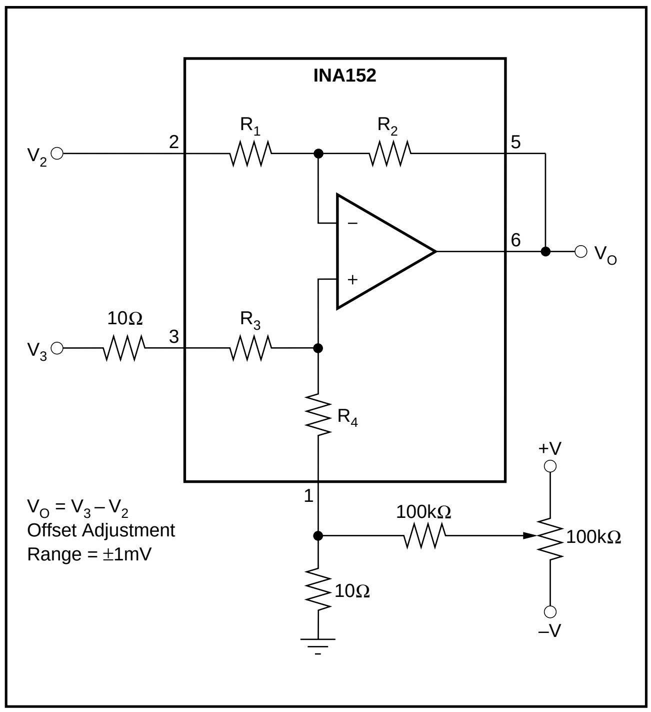
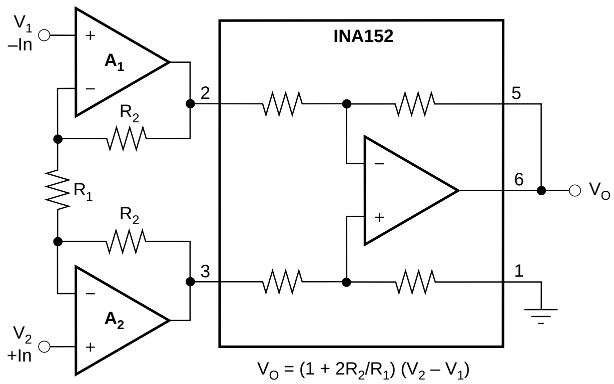


FIGURE 2. Offset Adjustment.

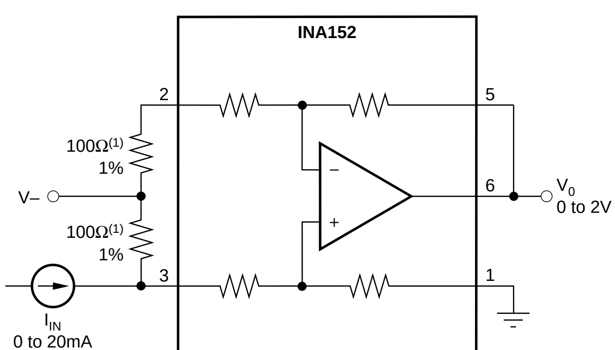
TYPICAL APPLICATIONS



The INA152 can be combined with op amps to form a complete Instrumentation Amplifier (IA) with specialized performance characteristics. Texas Instruments offers many complete high performance IAs. Products with related performances are shown at the right in the table below.

A_1, A_2	FEATURE	SIMILAR COMPLETE TEXAS INSTRUMENTS IA
OPA2227	Low Noise	INA163
OPA129	Ultra Low Bias Current (fA)	INA116
OPA2277	Low Offset Drift, Low Noise	INA114, INA128
OPA2130	Low Power, FET-Input (pA)	INA121
OPA2234	Single Supply, Precision, Low Power	INA122, INA118

FIGURE 3. Precision Instrumentation Amplifier.



NOTE: (1) Input series resistors should be less than 250Ω (1% max mismatch) to maintain excellent CMR. With 100Ω resistors, gain error is increased to 0.5%.

FIGURE 4. Current Receiver with Compliance to Rails.

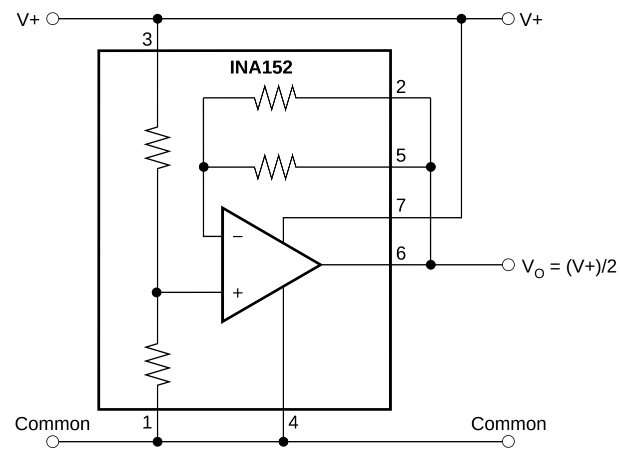


FIGURE 5. Pseudoground Generator.

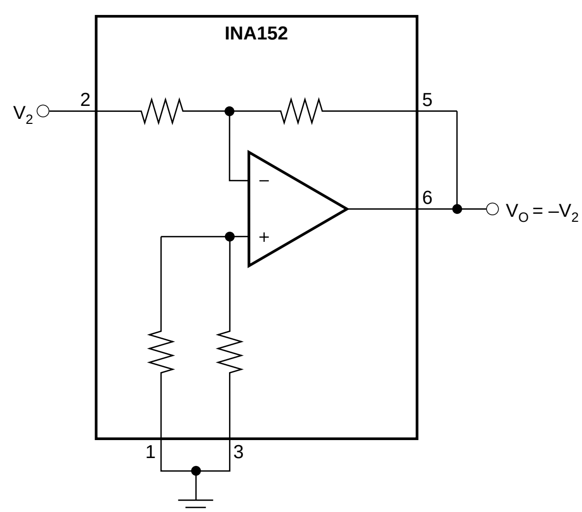


FIGURE 6. Precision Unity-Gain Inverting Amplifier.

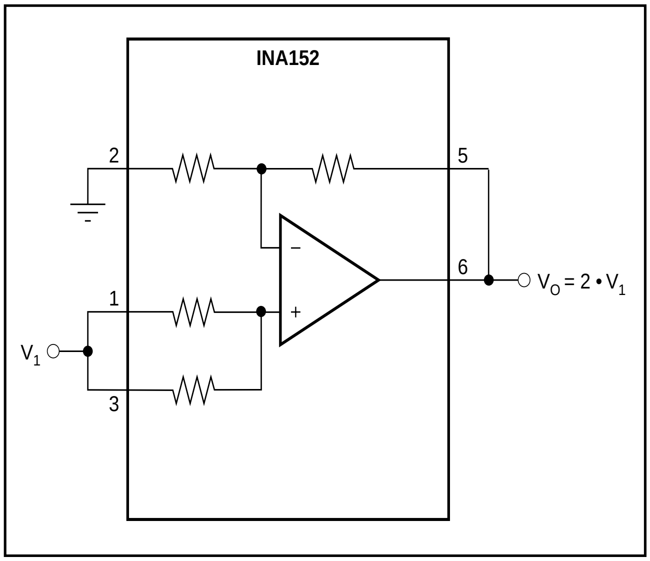


FIGURE 7. Precision Gain = 2 Amplifier.

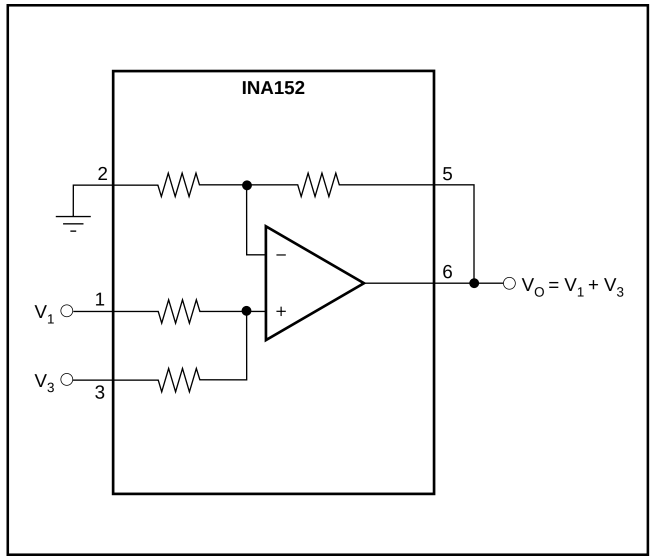


FIGURE 10. Precision Summing Amplifier.

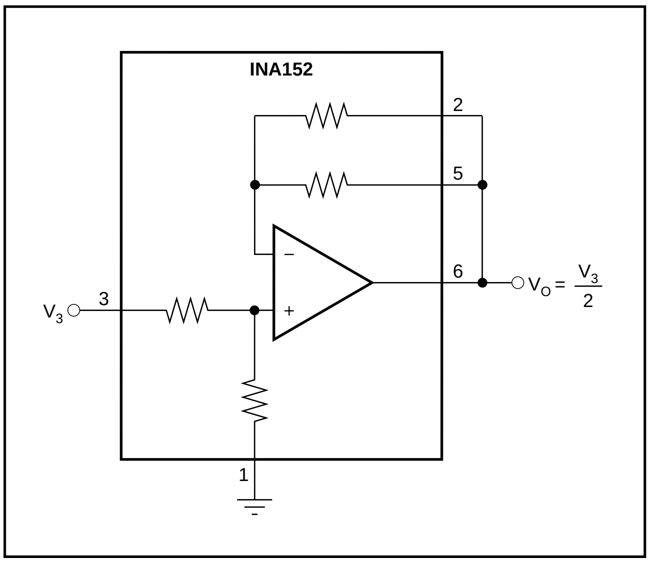


FIGURE 8. Precision Gain = 1/2 Amplifier.

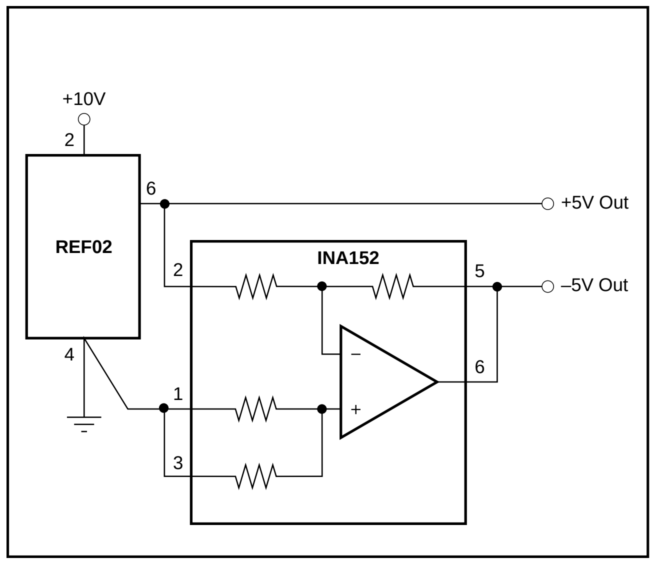


FIGURE 11. ±5V Precision Voltage Reference.

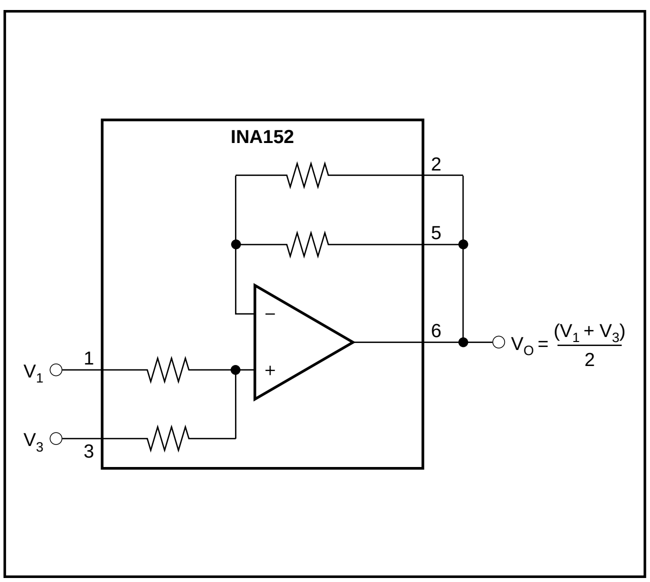


FIGURE 9. Precision Average Value Amplifier.

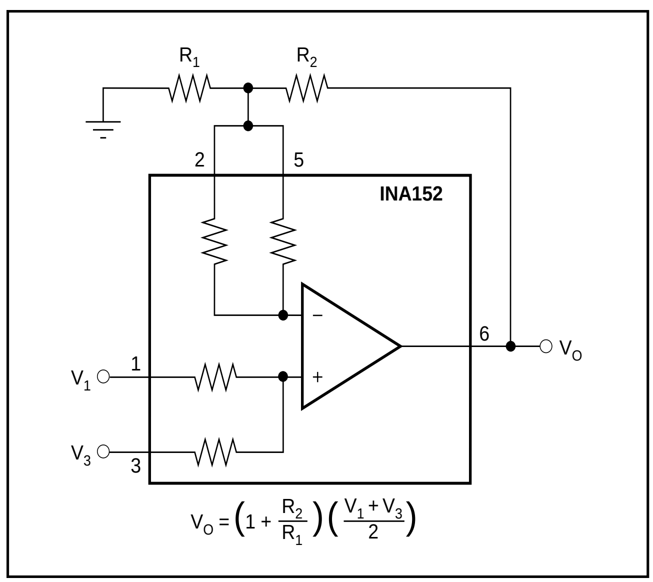


FIGURE 12. Precision Summing Amplifier with Gain.

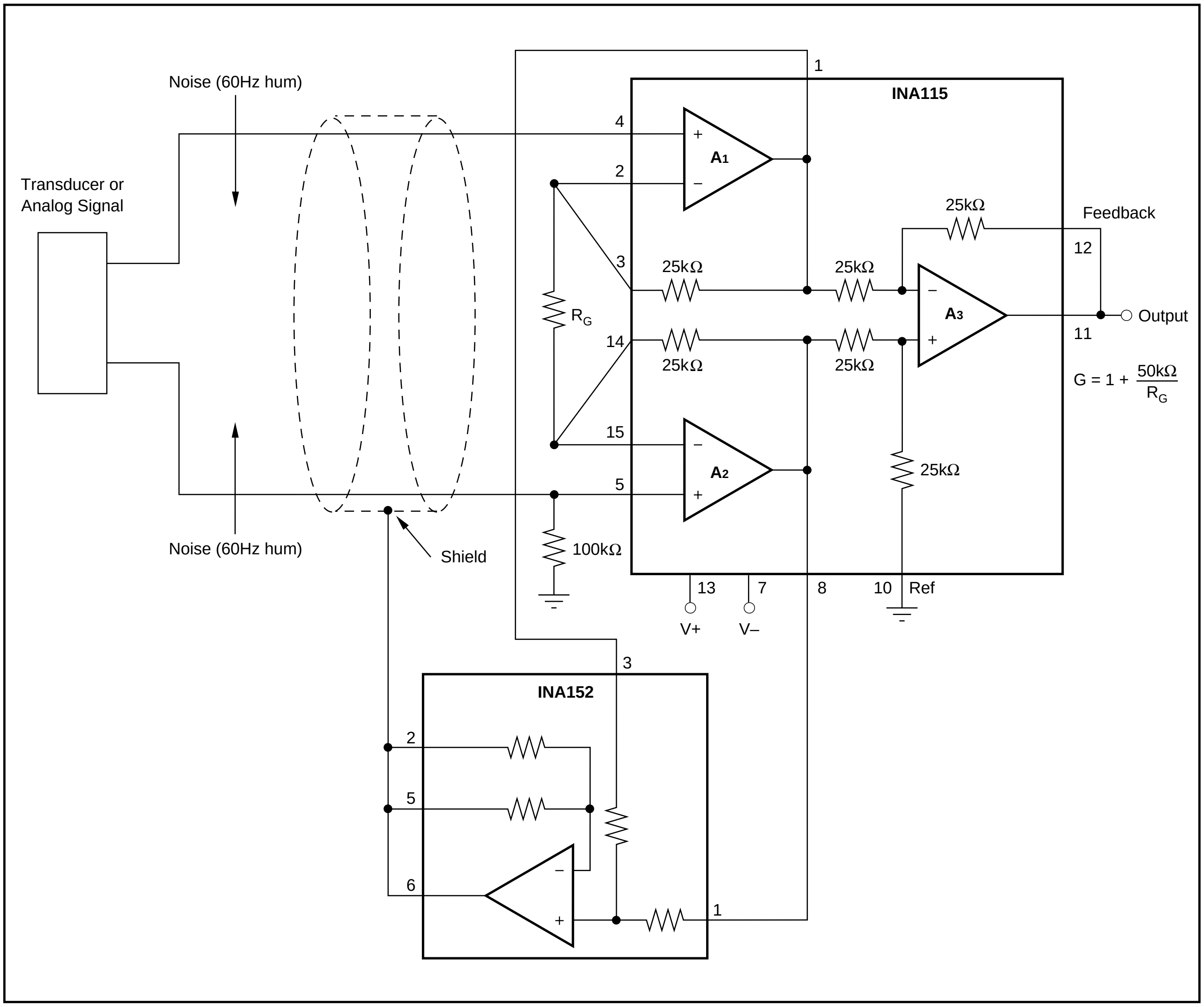


FIGURE 13. Instrumentation Amplifier Guard Drive Generator.

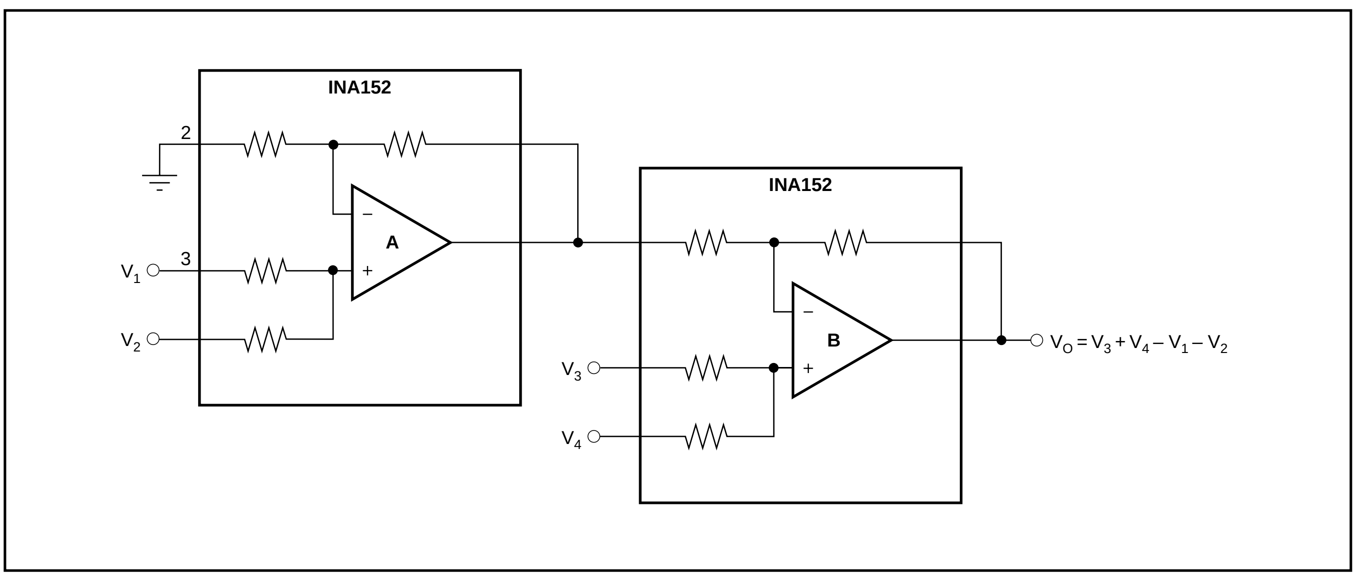


FIGURE 14. Precision Summing Instrumentation Amplifier.

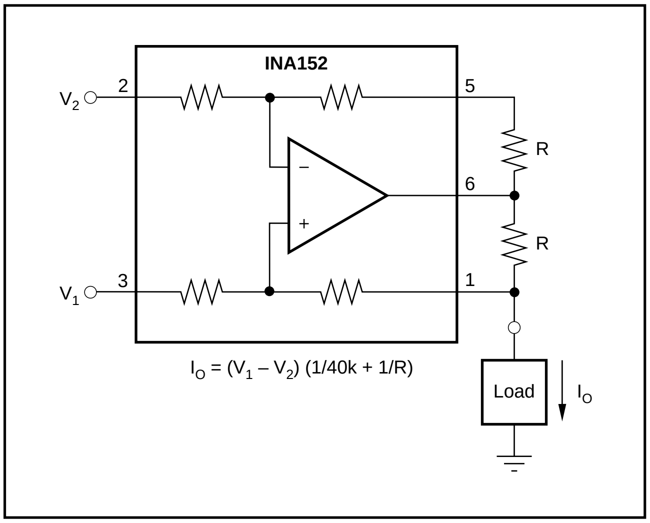


FIGURE 15. Precision Voltage-to-Current Converter with Differential Inputs.

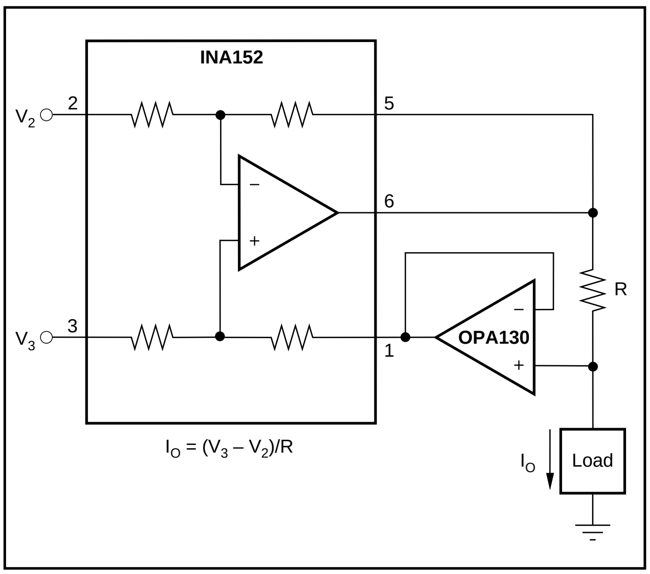


FIGURE 16. Differential Input Voltage-to-Current Converter for Low I_{OUT}.

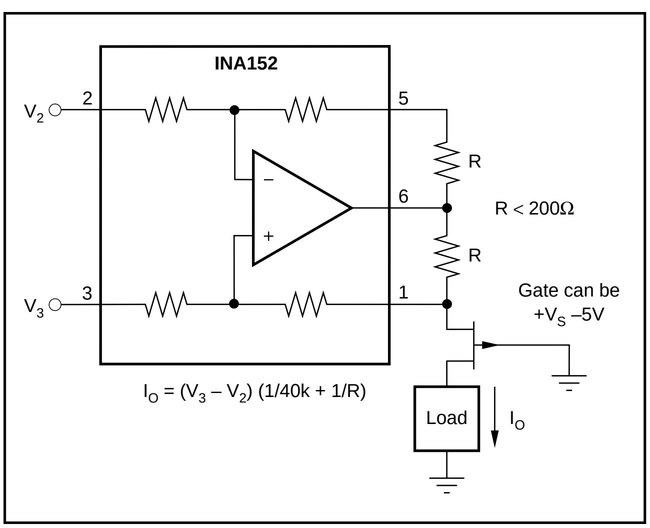


FIGURE 17. Isolating Current Source.

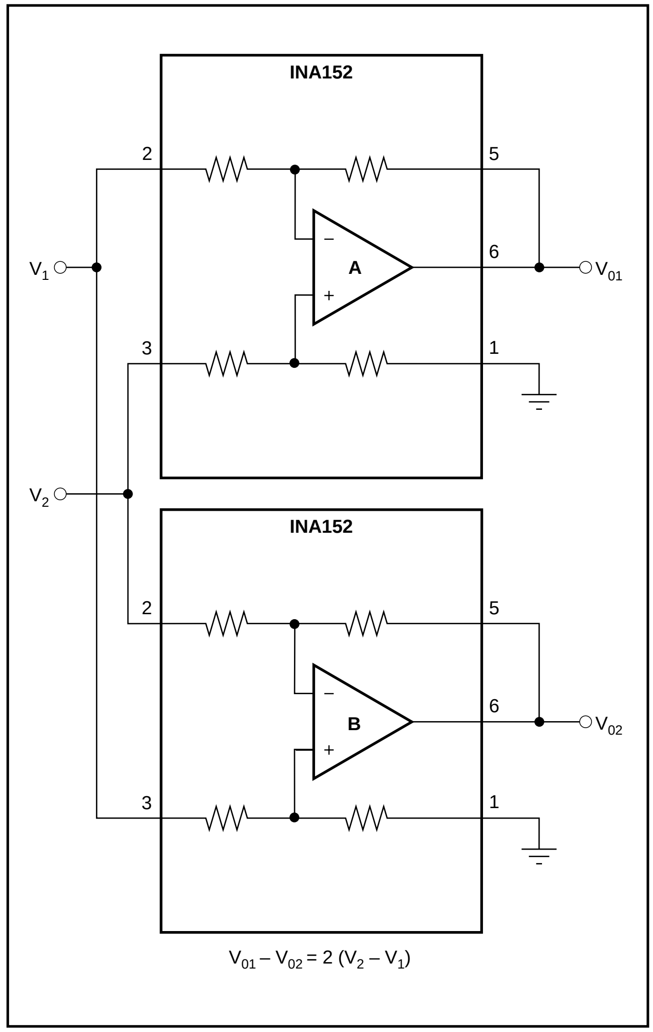


FIGURE 18. Differential Output Difference Amplifier.

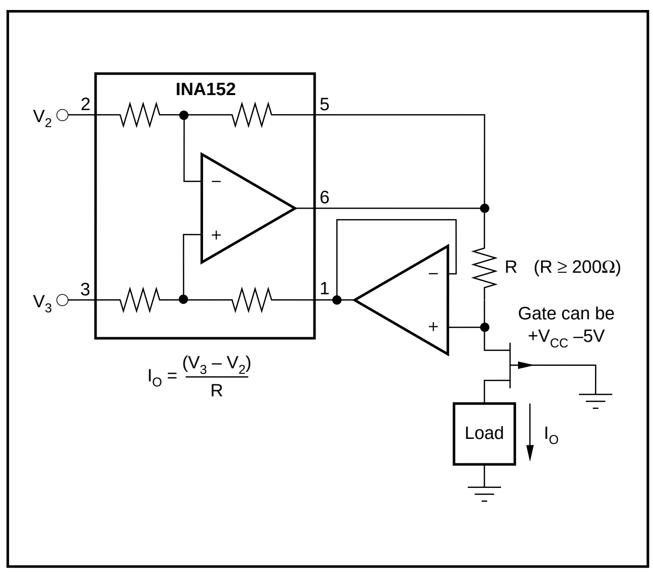


FIGURE 19. Isolating Current Source with Buffering Amplifier for Greater Accuracy.

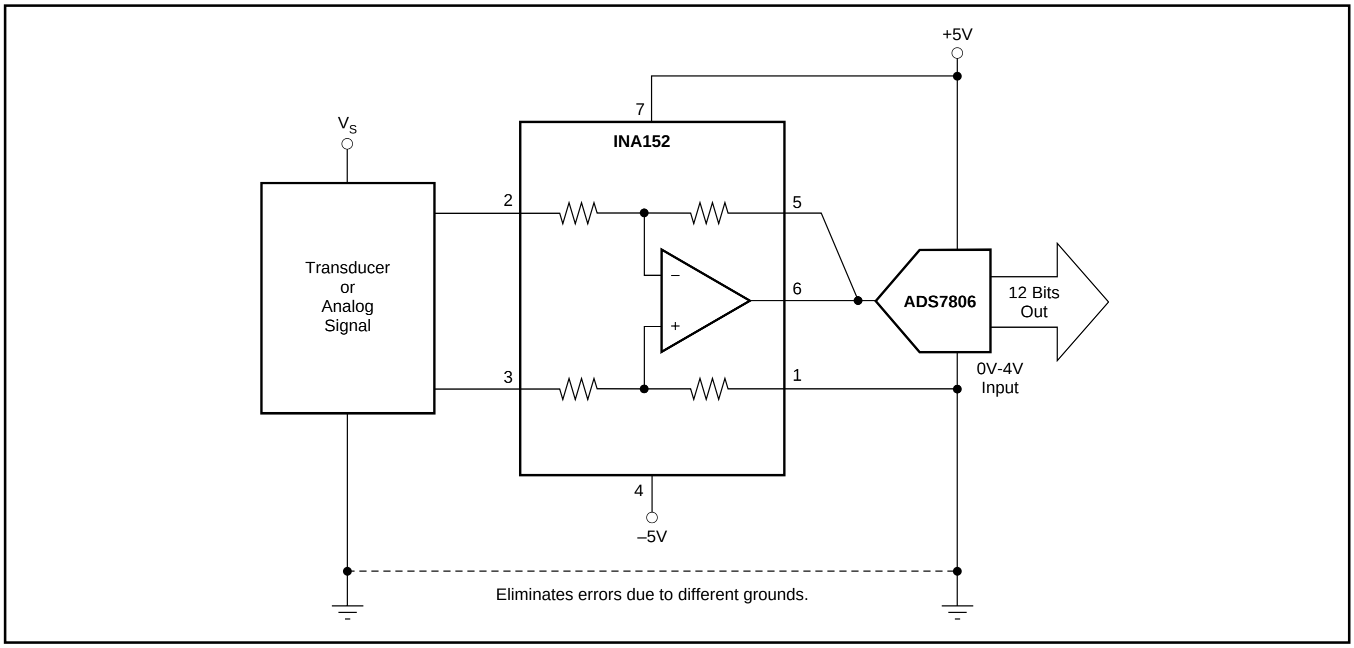
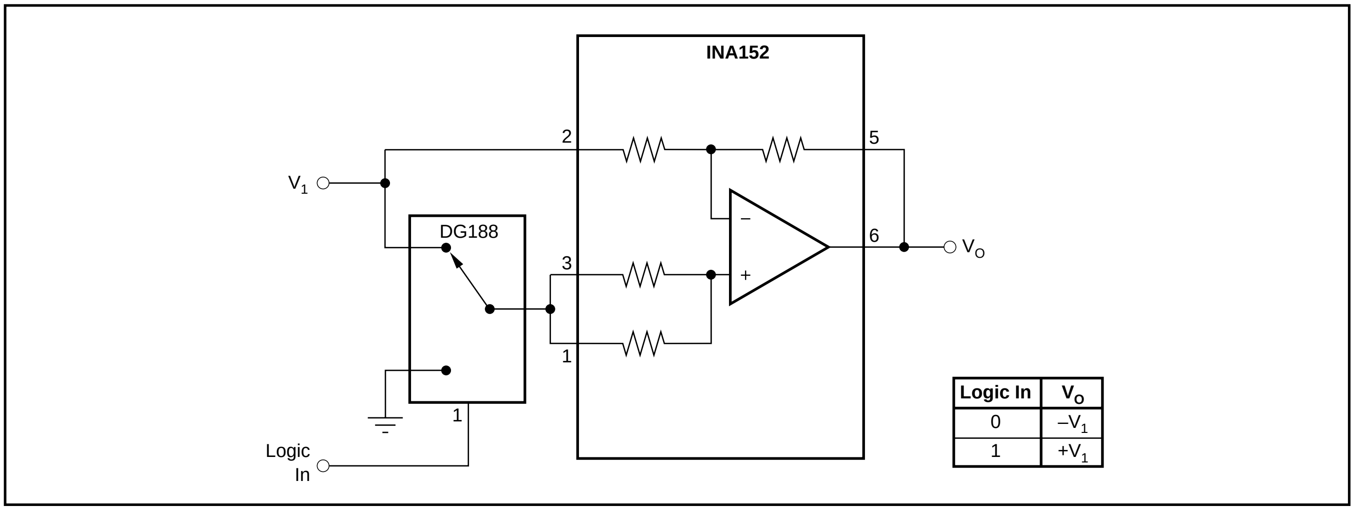


FIGURE 20. Differential Input Data Acquisition.



Logic In	V_O
0	$-V_1$
1	$+V_1$

FIGURE 21. Digitally Controlled Gain of ±1 Amplifier.

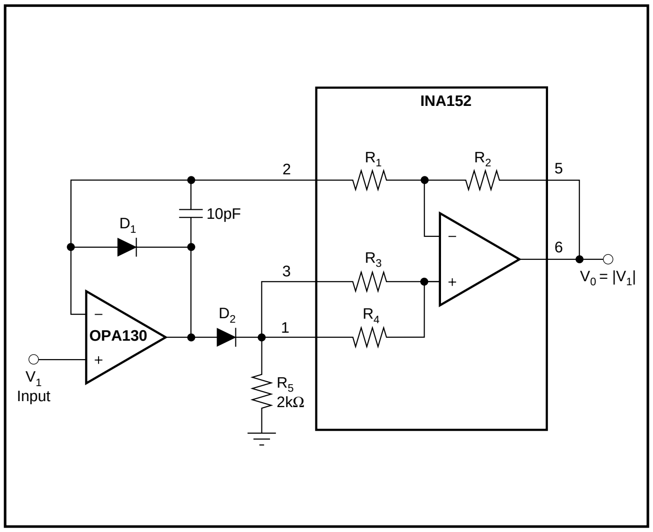


FIGURE 22. Precision Absolute Value Buffer.

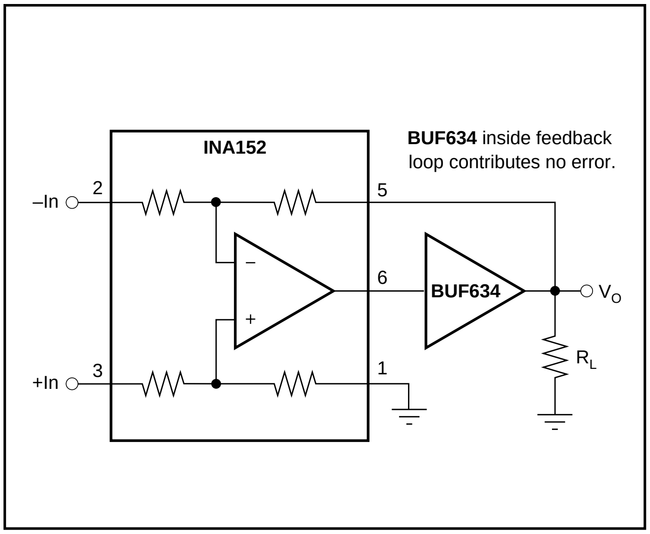


FIGURE 23. High Output Current Precision Difference Amplifier.

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
INA152EA/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-3-260C-168 HR	-40 to 85	B52	Samples
INA152EA/250G4	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-3-260C-168 HR	-40 to 85	B52	Samples
INA152EA/2K5	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-3-260C-168 HR	-40 to 85	B52	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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

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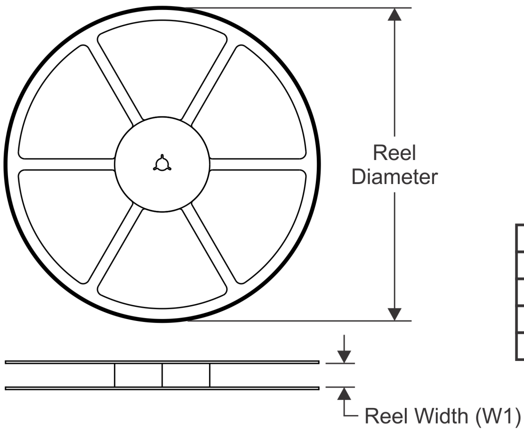
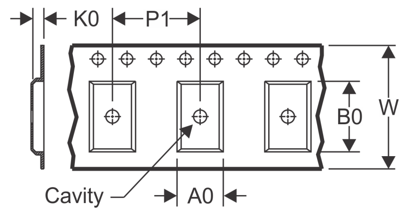
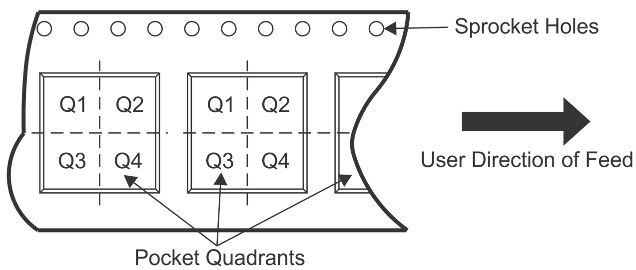
TAPE AND REEL INFORMATION





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

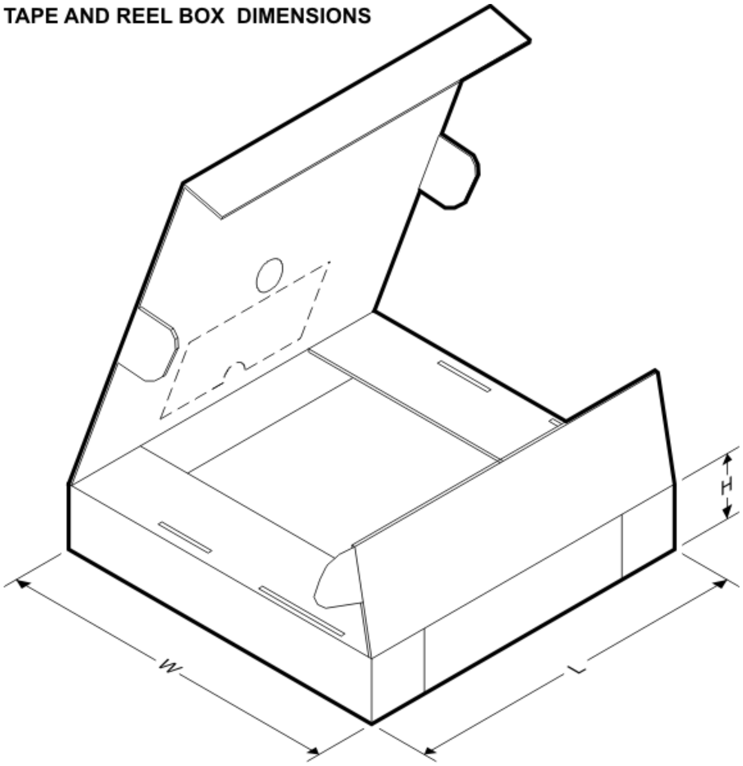
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
INA152EA/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
INA152EA/2K5	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	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)
INA152EA/250	VSSOP	DGK	8	250	210.0	185.0	35.0
INA152EA/2K5	VSSOP	DGK	8	2500	367.0	367.0	35.0