

# INA105

## Precision Unity Gain DIFFERENTIAL AMPLIFIER

### FEATURES

- CMR 86dB min OVER TEMPERATURE
- GAIN ERROR: 0.01% max
- NONLINEARITY: 0.001% max
- NO EXTERNAL ADJUSTMENTS REQUIRED
- EASY TO USE
- COMPLETE SOLUTION
- HIGHLY VERSATILE
- LOW COST
- PLASTIC DIP, TO-99 HERMETIC METAL, AND SO-8 SOIC PACKAGES

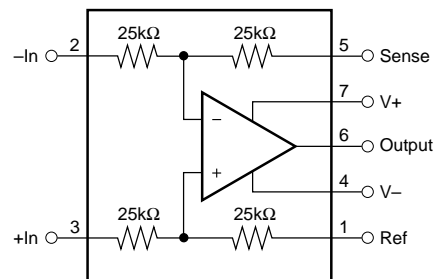
### APPLICATIONS

- DIFFERENTIAL AMPLIFIER
- INSTRUMENTATION AMPLIFIER BUILDING BLOCK
- UNITY-GAIN INVERTING AMPLIFIER
- GAIN-OF-1/2 AMPLIFIER
- NONINVERTING GAIN-OF-2 AMPLIFIER
- AVERAGE VALUE AMPLIFIER
- ABSOLUTE VALUE AMPLIFIER
- SUMMING AMPLIFIER
- SYNCHRONOUS DEMODULATOR
- CURRENT RECEIVER WITH COMPLIANCE TO RAILS
- 4mA TO 20mA TRANSMITTER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- ALL-PASS FILTERS

### DESCRIPTION

The INA105 is a monolithic Gain = 1 differential amplifier consisting of a precision op amp and on-chip metal film resistors. The 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 differential amplifier is the foundation of many commonly used circuits. The INA105 provides this precision circuit function without using an expensive precision resistor network. The INA105 is available in 8-pin plastic DIP, SO-8 surface-mount and TO-99 metal packages.



# SPECIFICATIONS

## ELECTRICAL

At +25°C, V<sub>CC</sub> = ±15V unless otherwise noted.

PARAMETER	CONDITIONS	INA105AM			INA105BM			INA105KP, KU			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
<b>GAIN</b>											
Initial <sup>(1)</sup>			1			*			*		V/V
Error			0.005	0.01		*	*		0.01	0.025	%
vs Temperature			1	5		*	*		*	*	ppm/°C
Nonlinearity <sup>(2)</sup>			0.0002	0.001		*	*		*	*	%
<b>OUTPUT</b>											
Rated Voltage	I <sub>O</sub> = +20mA, -5mA	10	12		*	*		*	*		V
Rated Current	V <sub>O</sub> = 10V	+20, -5			*			*			mA
Impedance			0.01			*			*		Ω
Current Limit	To Common		+40/-10			*			*		mA
Capacitive Load	Stable Operation		1000			*			*		pF
<b>INPUT</b>											
Impedance <sup>(3)</sup>	Differential		50			*			*		kΩ
	Common-Mode		50			*			*		kΩ
Voltage Range <sup>(4)</sup>	Differential	±10			*			*			V
	Common-Mode	±20			*			*			V
Common-Mode Rejection <sup>(5)</sup>	T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	80	90		86	100		72	*		dB
<b>OFFSET VOLTAGE</b>											
Initial	RTO <sup>(6), (7)</sup>		50	250		*	*		*	500	μV
vs Temperature			5	20		5	10		*	*	μV/°C
vs Supply	±V <sub>S</sub> = 6V to 18V		1	25		*	15		*	*	μV/V
vs Time			20			*			*	*	μV/mo
<b>OUTPUT NOISE VOLTAGE</b>											
f <sub>B</sub> = 0.01Hz to 10Hz	RTO <sup>(6), (8)</sup>		2.4			*			*		μVp-p
f <sub>O</sub> = 10kHz			60			*			*		nV/√Hz
<b>DYNAMIC RESPONSE</b>											
Small Signal Bandwidth	-3dB		1			*			*		MHz
Full Power Bandwidth	V <sub>O</sub> = 20Vp-p	30	50		*	*		*	*		kHz
Slew Rate		2	3		*	*		*	*		V/μs
Settling Time: 0.1%	V <sub>O</sub> = 10V Step		4			*			*		μs
0.01%	V <sub>O</sub> = 10V Step		5			*			*		μs
0.01%	V <sub>CM</sub> = 10V Step, V <sub>DIFF</sub> = 0V		1.5			*			*		μs
<b>POWER SUPPLY</b>											
Rated			±15			*			*		V
Voltage Range	Derated Performance	±5		±18	*	*	*	*	*	*	V
Quiescent Current	V <sub>O</sub> = 0V		±1.5	±2		*	*		*	*	mA
<b>TEMPERATURE RANGE</b>											
Specification		-40		+85	*		*	*		*	°C
Operation		-55		+125	*		*	-40		+85	°C
Storage		-65		+150	*		*	-40		+125	°C

\* Specification same as for INA105AM.

NOTES: (1) Connected as difference amplifier (see Figure 4). (2) Nonlinearity is the maximum peak deviation from the best-fit straight line as a percent of full-scale peak-to-peak output. (3) 25kΩ resistors are ratio matched but have ±20% absolute value. (4) Maximum input voltage without protection is 10V more than either ±15V supply (±25V). Limit I<sub>IN</sub> to 1mA. (5) With zero source impedance (see "Maintaining CMR" section). (6) Referred to output in unity-gain difference configuration. Note that this circuit has a gain of 2 for the operational amplifier's offset voltage and noise voltage. (7) Includes effects of amplifier's input bias and offset currents. (8) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

## ABSOLUTE MAXIMUM RATINGS

Supply .....	±18V
Input Voltage Range .....	±V <sub>S</sub>
Operating Temperature Range: M .....	-55°C to +125°C
P, U .....	-40°C to +85°C
Storage Temperature Range: M .....	-65°C to +150°C
P, U .....	-40°C to +125°C
Lead Temperature (soldering, 10s) M, P .....	+300°C
Wave Soldering (3s, max) U .....	+260°C
Output Short Circuit to Common .....	Continuous

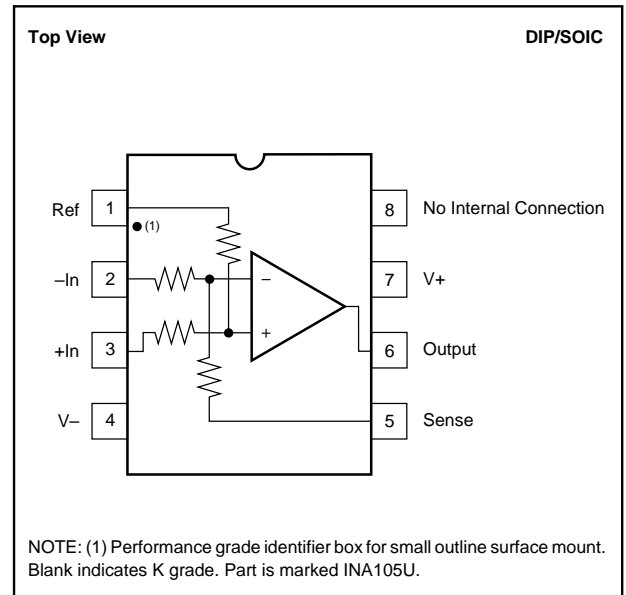
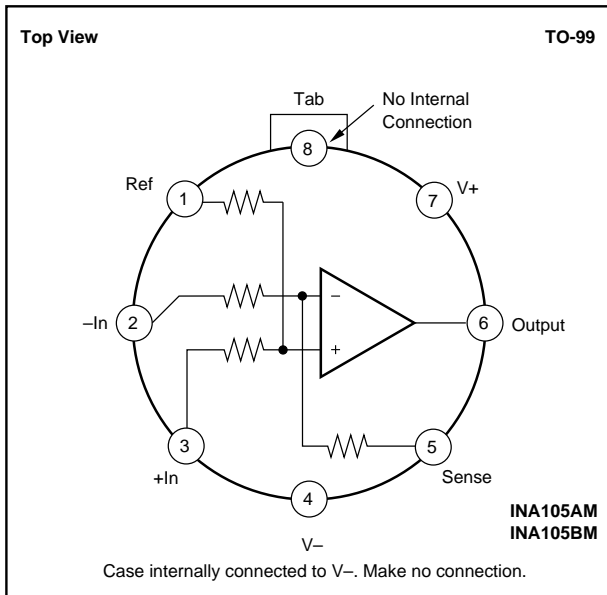
## PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
INA105AM	TO-99 Metal	001
INA105BM	TO-99 Metal	001
INA105KP	8-Pin Plastic DIP	006
INA105KU	8-Pin SOIC	182

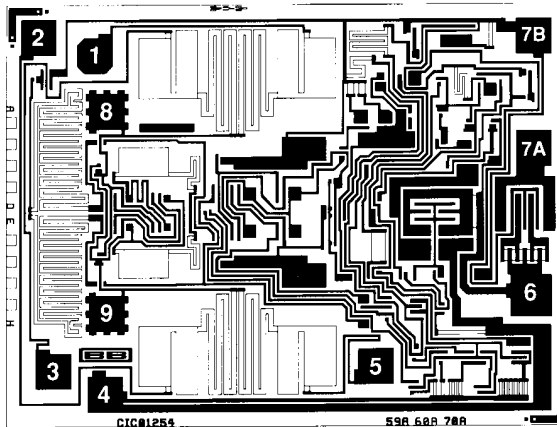
NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

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

## PIN DESIGNATIONS



## DICE INFORMATION



**INA105 DIE TOPOGRAPHY**

PAD	FUNCTION
1	Reference
2	-In
3	+In
4	V-
5	Sense
6	Output
7A	V+ (Connect Both)
7B	V+ (Connect Both)
8	(Op Amp +In)
9	(Op Amp -In)

**Substrate Bias:** Electrically connected to V- supply.

## MECHANICAL INFORMATION

	MILS (0.001")	MILLIMETERS
Die Size	83 x 63 ±5	2.11 x 1.60 ±0.13
Die Thickness	20 ±3	0.51 ±0.08
Min. Pad Size	4 x 4	0.10 x 0.10
Backing		Gold

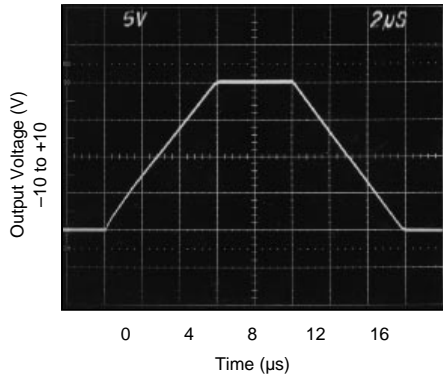
## ORDERING INFORMATION

MODEL	PACKAGE	TEMPERATURE
INA105AM	TO-99 Metal	-40°C to +85°C
INA105BM	TO-99 Metal	-40°C to +85°C
INA105KP	8-Pin Plastic DIP	-40°C to +85°C
INA105KU	8-Pin SOIC	-40°C to +85°C

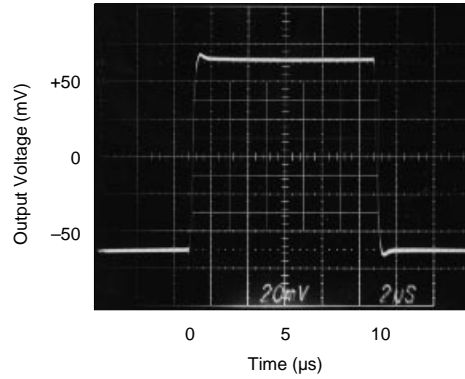
# TYPICAL PERFORMANCE CURVES

$T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$  unless otherwise noted.

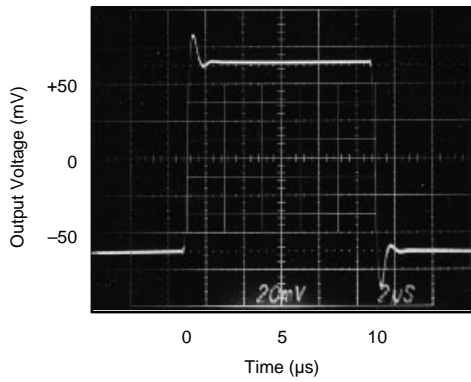
STEP RESPONSE



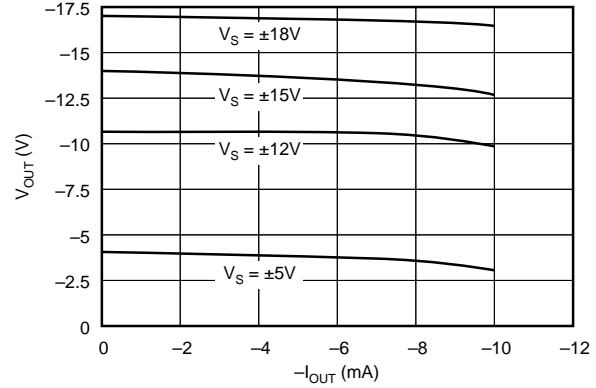
SMALL SIGNAL RESPONSE  
(No Load)



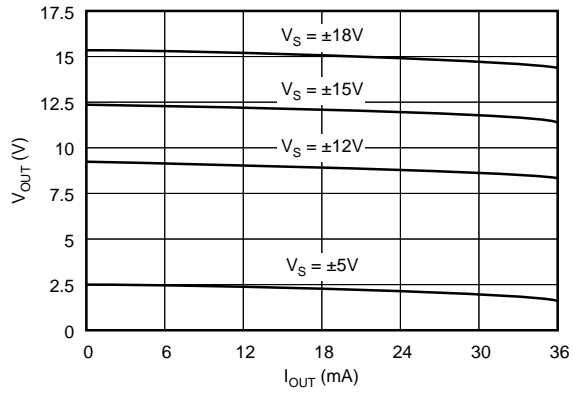
SMALL SIGNAL RESPONSE  
( $R_{\text{LOAD}} = \infty\Omega$ ,  $C_{\text{LOAD}} = 1000\text{pF}$ )



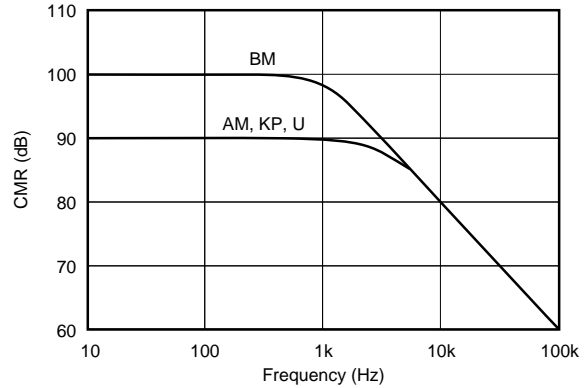
MAXIMUM  $V_{\text{OUT}}$  vs  $I_{\text{OUT}}$   
(Negative Swing)



MAXIMUM  $V_{\text{OUT}}$  vs  $I_{\text{OUT}}$   
(Positive Swing)

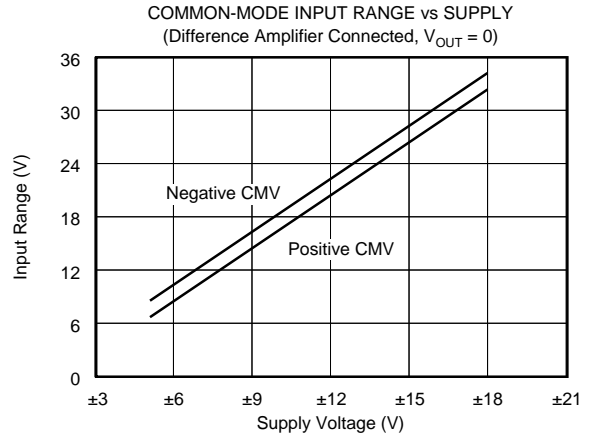
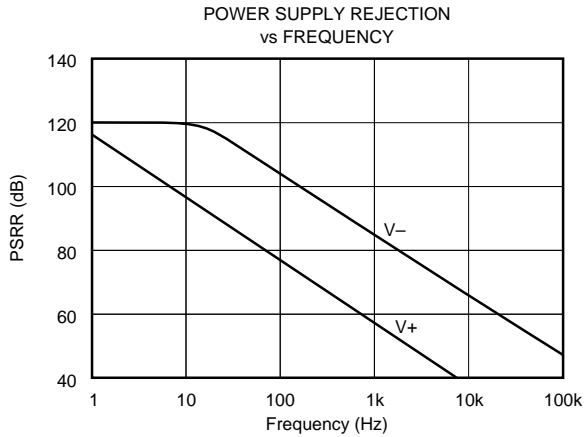


CMR vs FREQUENCY



# TYPICAL PERFORMANCE CURVES (CONT)

$T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$  unless otherwise noted.



## 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.

## APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA105. Power supply bypass capacitors should be connected close to the device pins.

The differential input signal is connected to pins 2 and 3 as shown. The source impedances connected to the inputs must be nearly equal to assure good common-mode rejection. A  $5\Omega$  mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 80dB. If the source has a known mismatch in source impedance, an additional resistor in series with one input can be used to preserve good common-mode rejection.

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  $10\Omega$  to maintain good common-mode rejection.

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

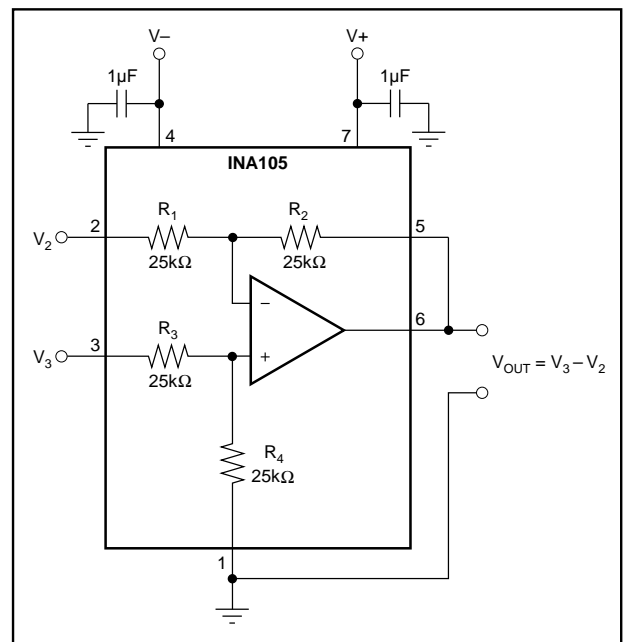


FIGURE 1. Basic Power Supply and Signal Connections.

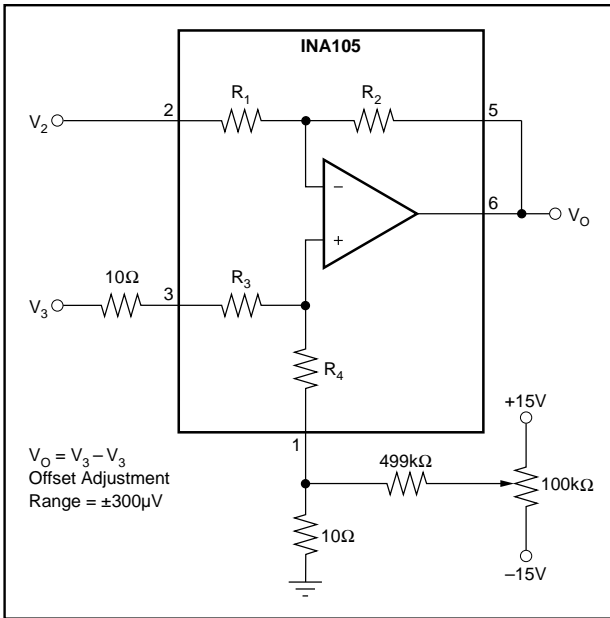


FIGURE 2. Offset Adjustment.

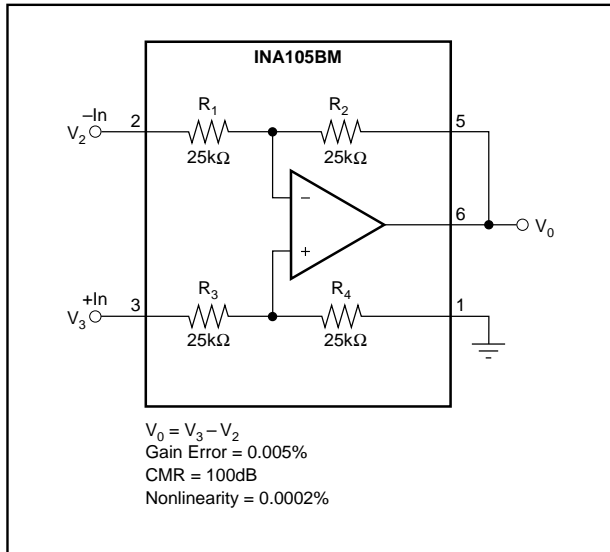


FIGURE 3. Precision Difference Amplifier.

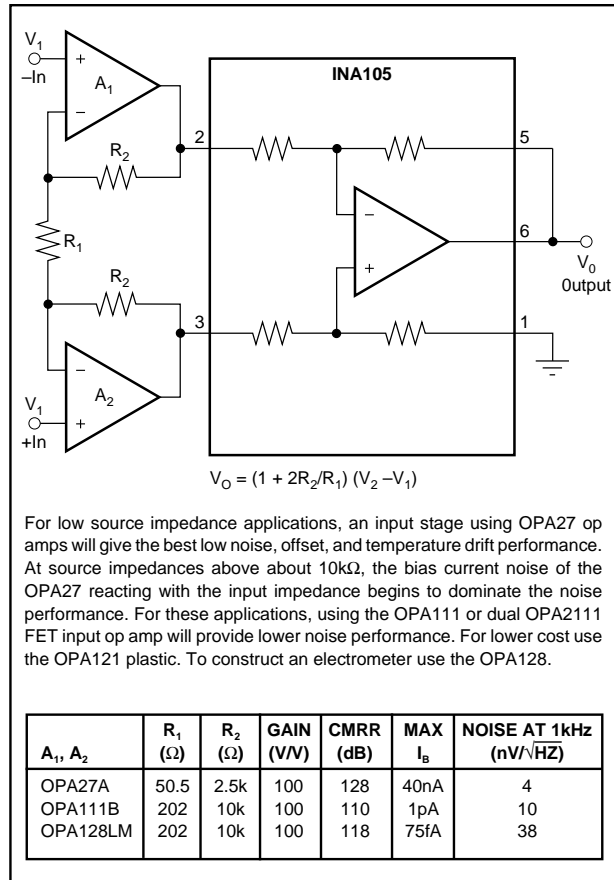


FIGURE 4. Precision Instrumentation Amplifier.

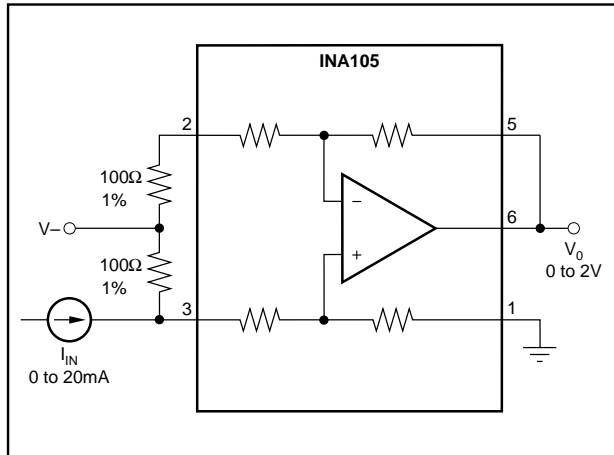


FIGURE 5. Current Receiver with Compliance to Rails.

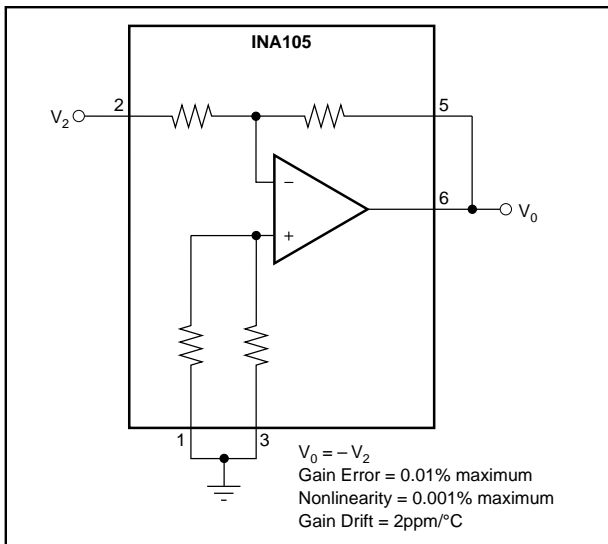


FIGURE 6. Precision Unity-Gain Inverting Amplifier.

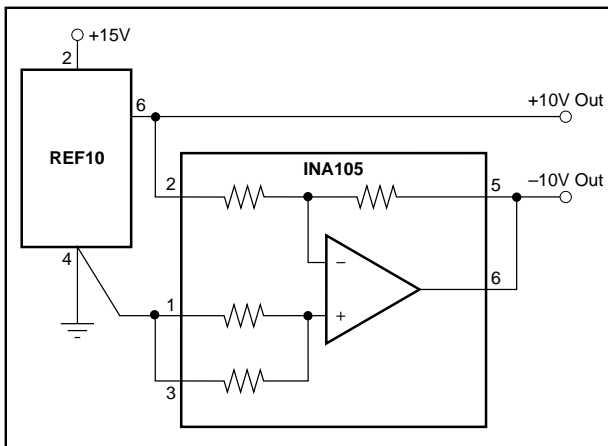


FIGURE 7. ±10V Precision Voltage Reference.

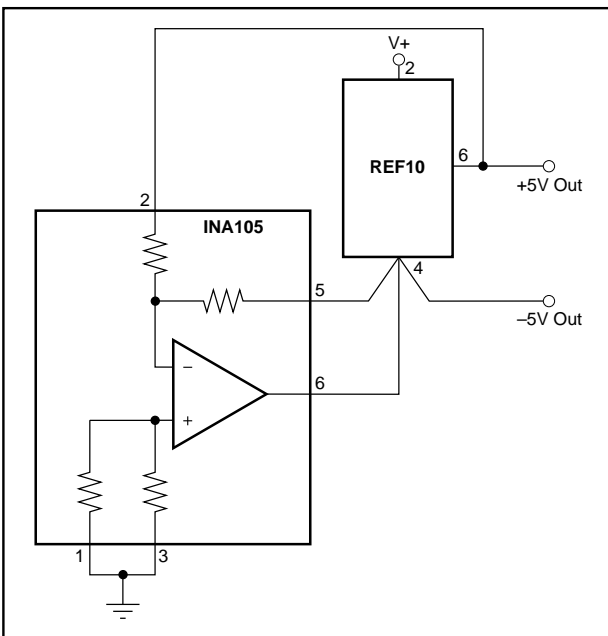


FIGURE 8. ±5V Precision Voltage Reference.

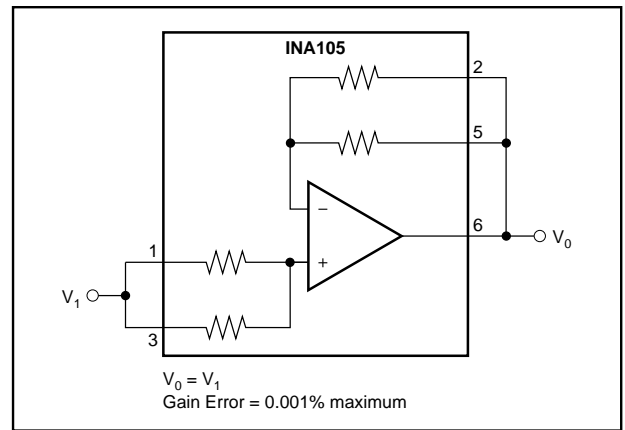


FIGURE 9. Precision Unity-Gain Buffer.

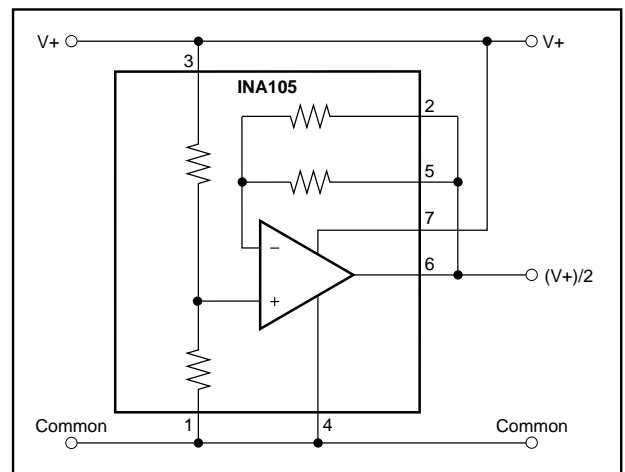


FIGURE 10. Pseudoground Generator.

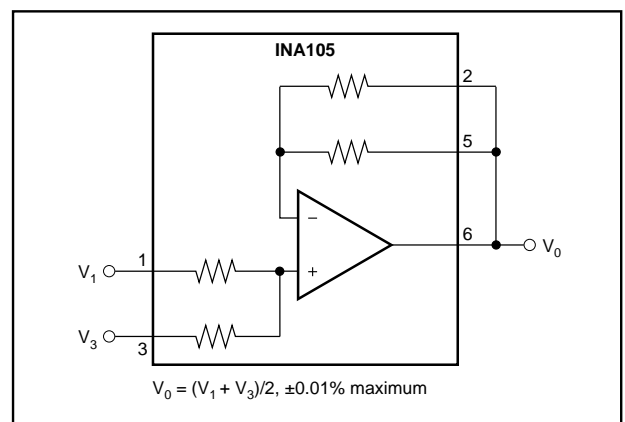


FIGURE 11. Precision Average Value Amplifier.

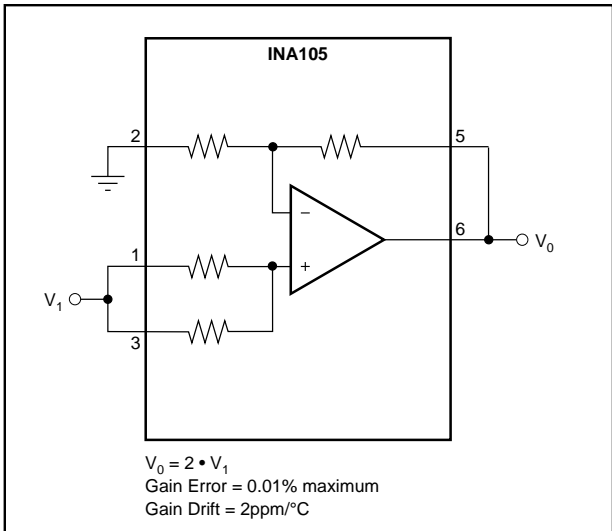


FIGURE 12. Precision (G = 2) Amplifier.

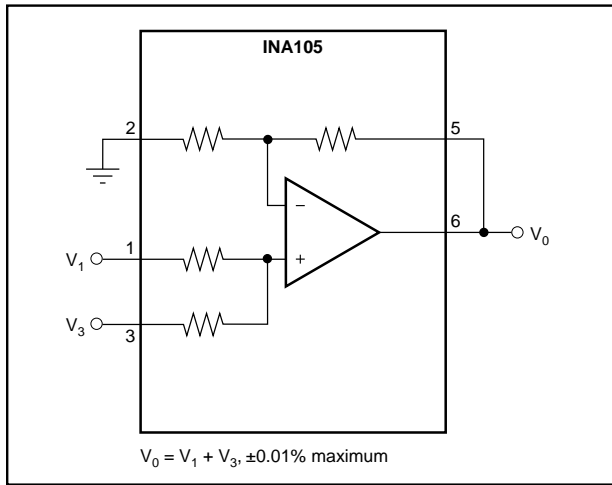


FIGURE 13. Precision Summing Amplifier.

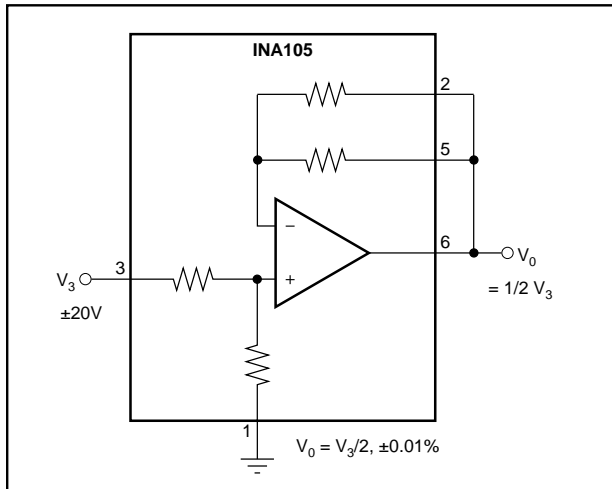


FIGURE 14. Precision Gain = 1/2 Amplifier.

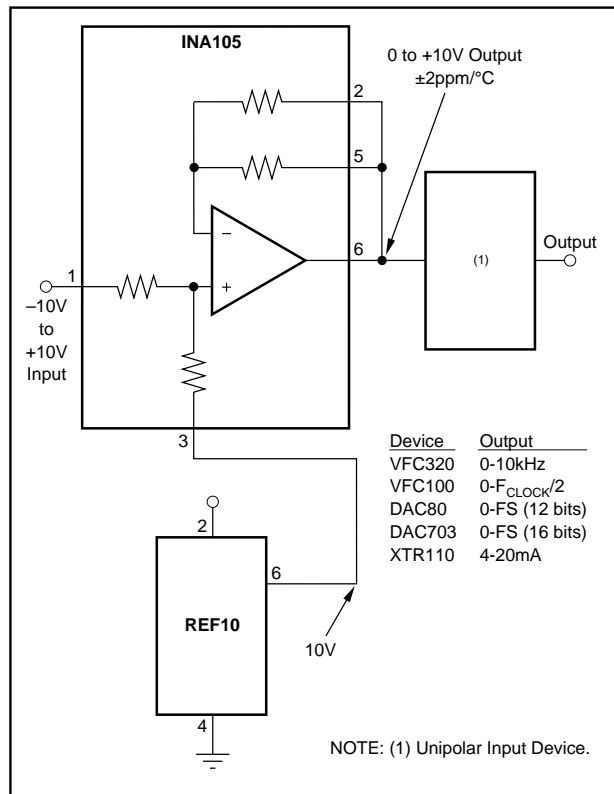


FIGURE 15. Precision Bipolar Offsetting.

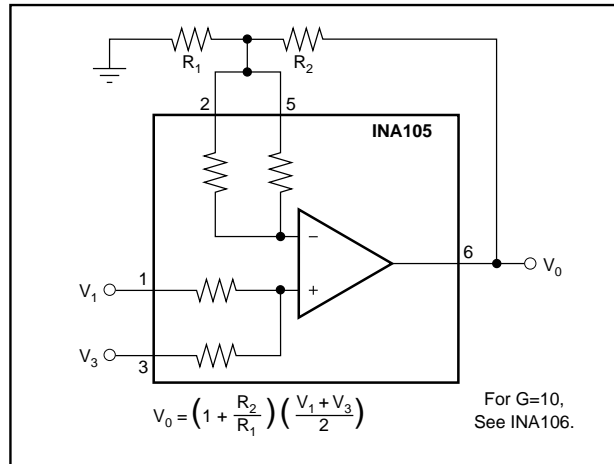


FIGURE 16. Precision Summing Amplifier with Gain.



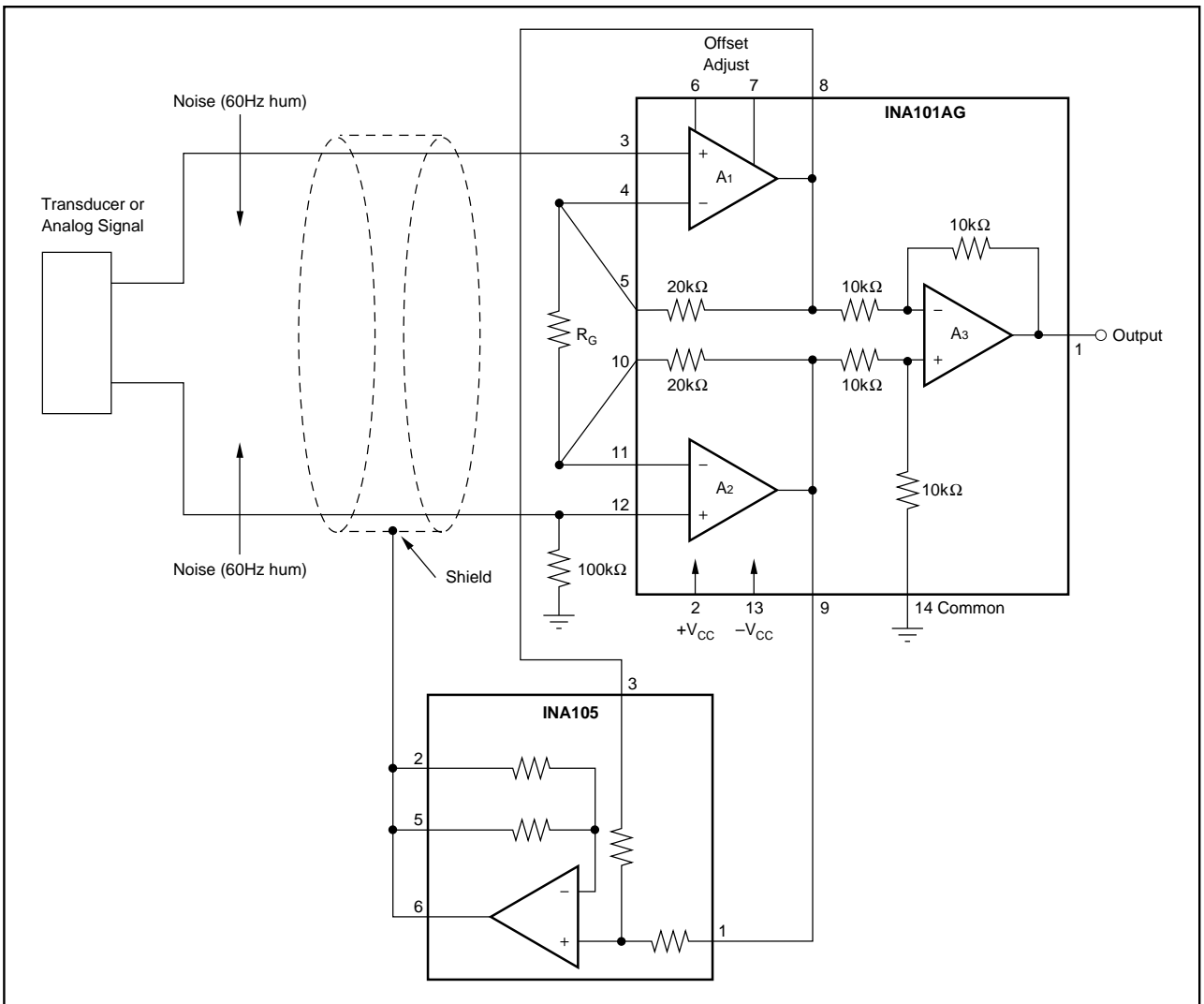


FIGURE 17. Instrumentation Amplifier Guard Drive Generator.

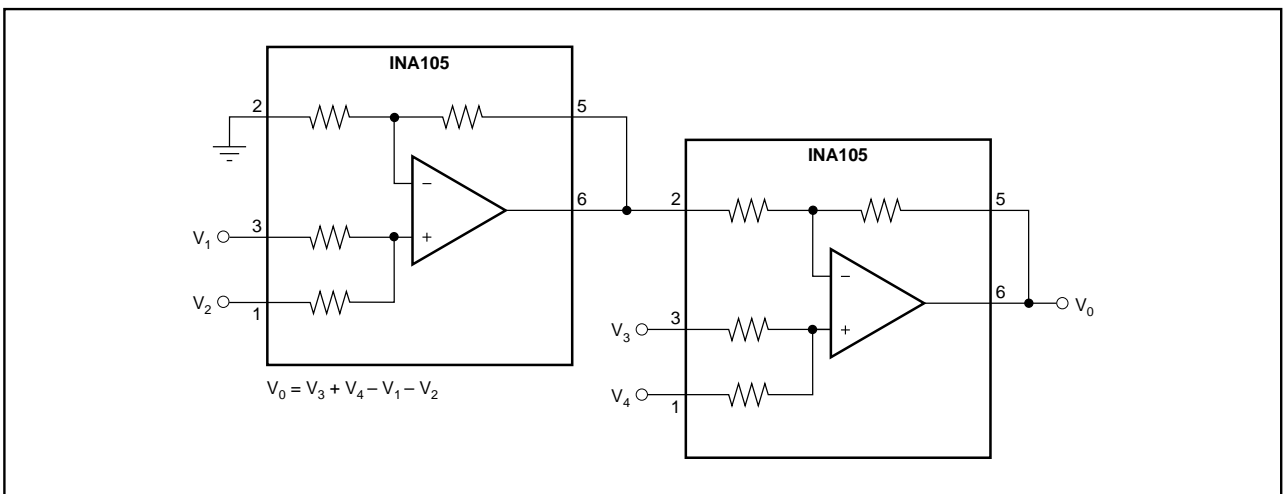


FIGURE 18. Precision Summing Instrumentation Amplifier.

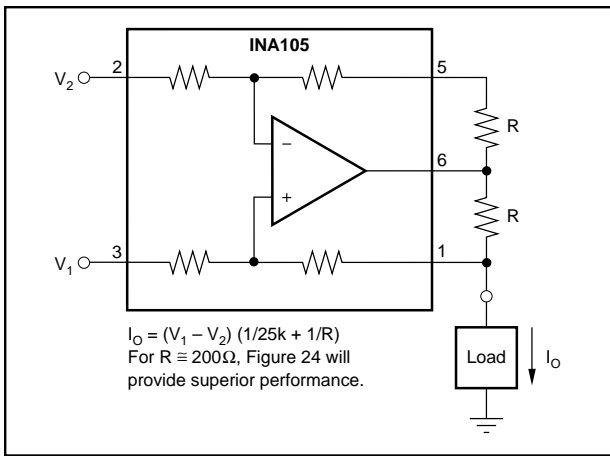


FIGURE 19. Precision Voltage-to-Current Converter with Differential Inputs.

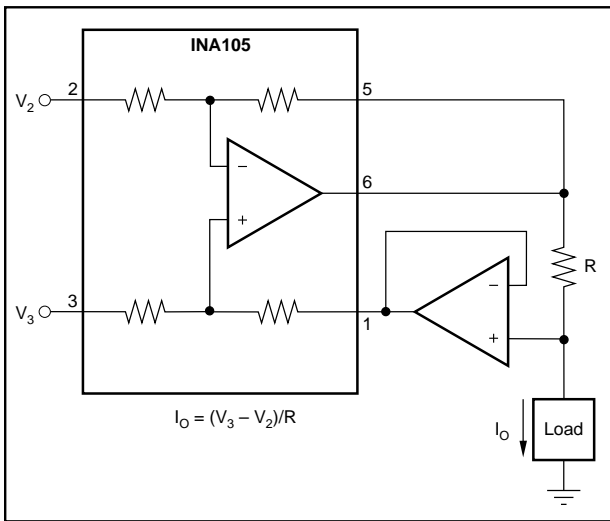


FIGURE 20. Differential Input Voltage-to-Current Converter for Low  $I_{OUT}$ .

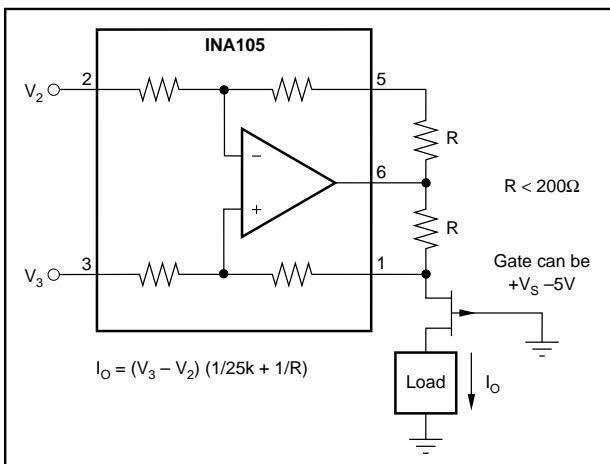


FIGURE 21. Isolating Current Source.

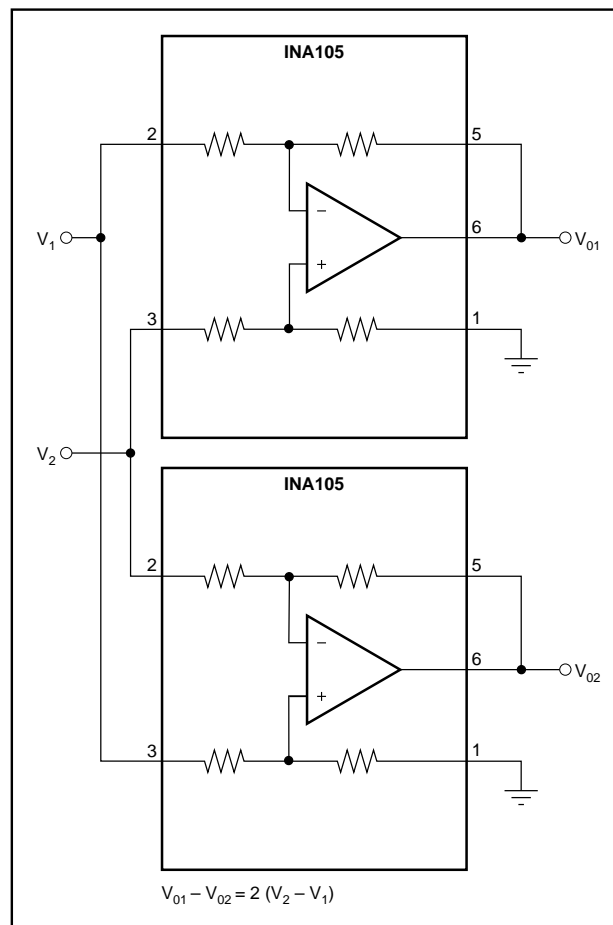


FIGURE 22. Differential Output Difference Amplifier.

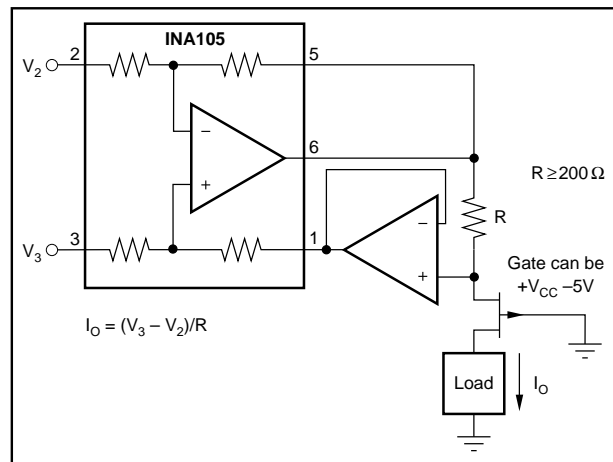


FIGURE 23. Isolating Current Source with Buffering Amplifier for Greater Accuracy.

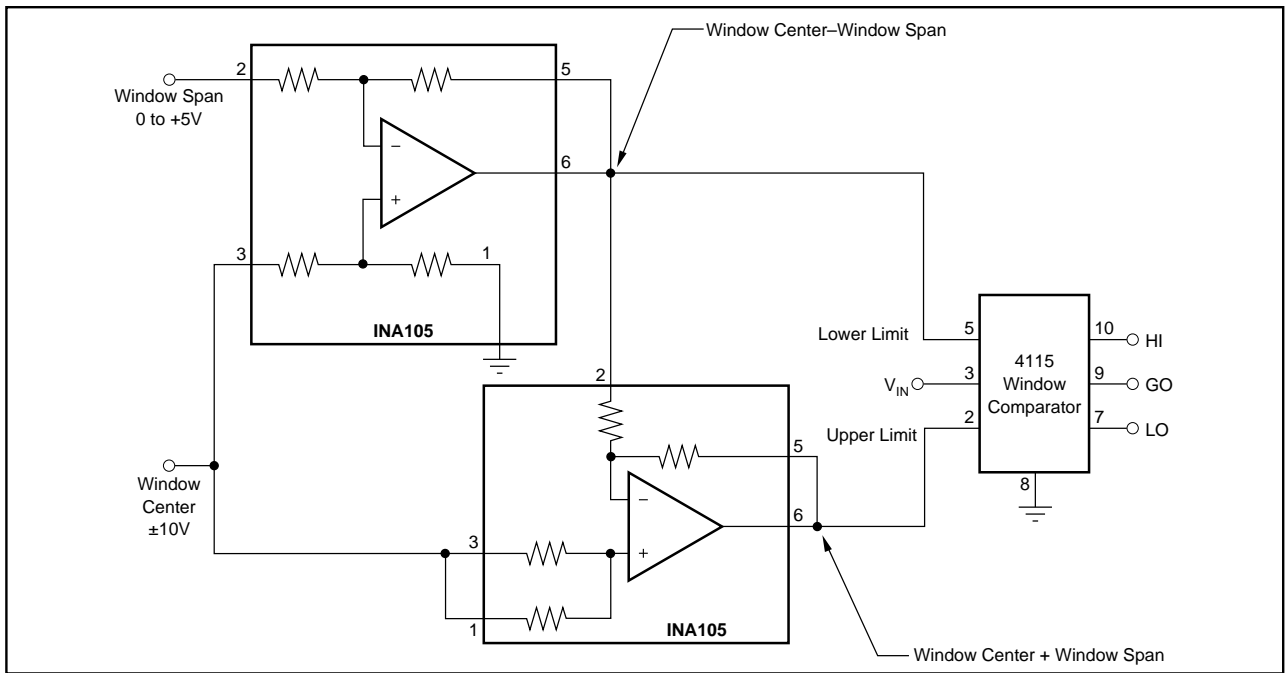


FIGURE 24. Window Comparator with Window Span and Window Center Inputs.

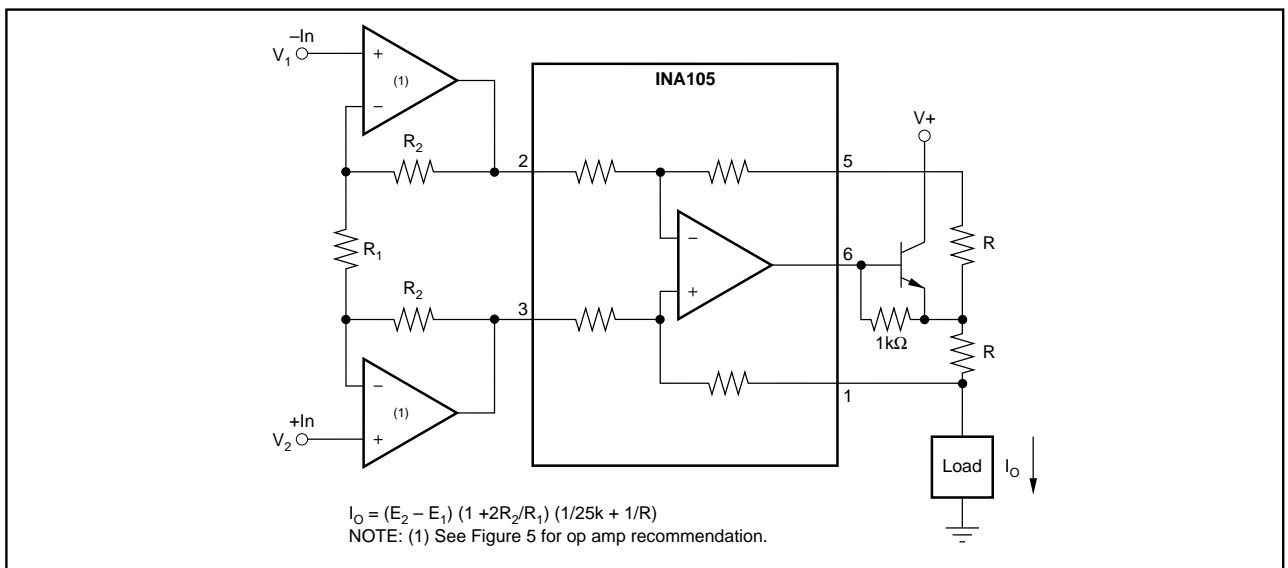


FIGURE 25. Precision Voltage-Controlled Current Source with Buffered Differential Inputs and Gain.

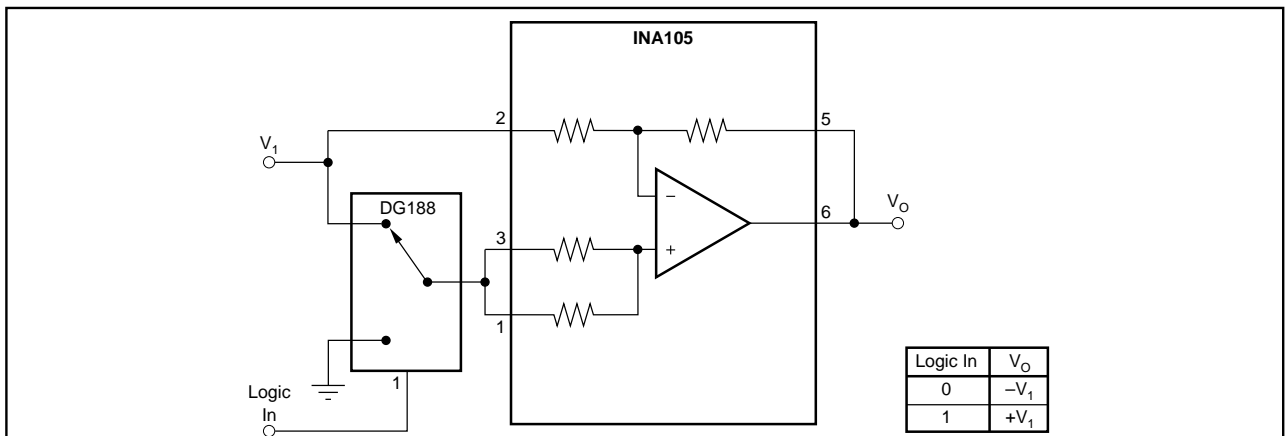


FIGURE 26. Digitally Controlled Gain of ±1 Amplifier.

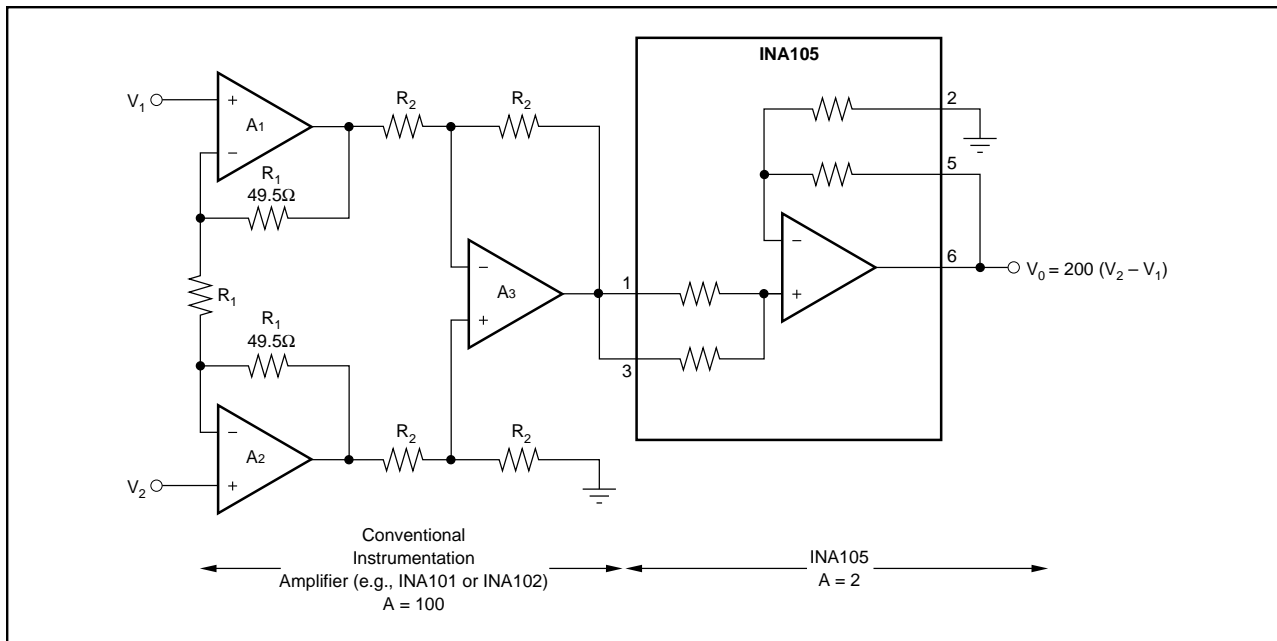


FIGURE 27. Boosting Instrumentation Amplifier Common-Mode Range From  $\pm 5$  to  $\pm 7.5$ V with 10V Full-Scale Output.

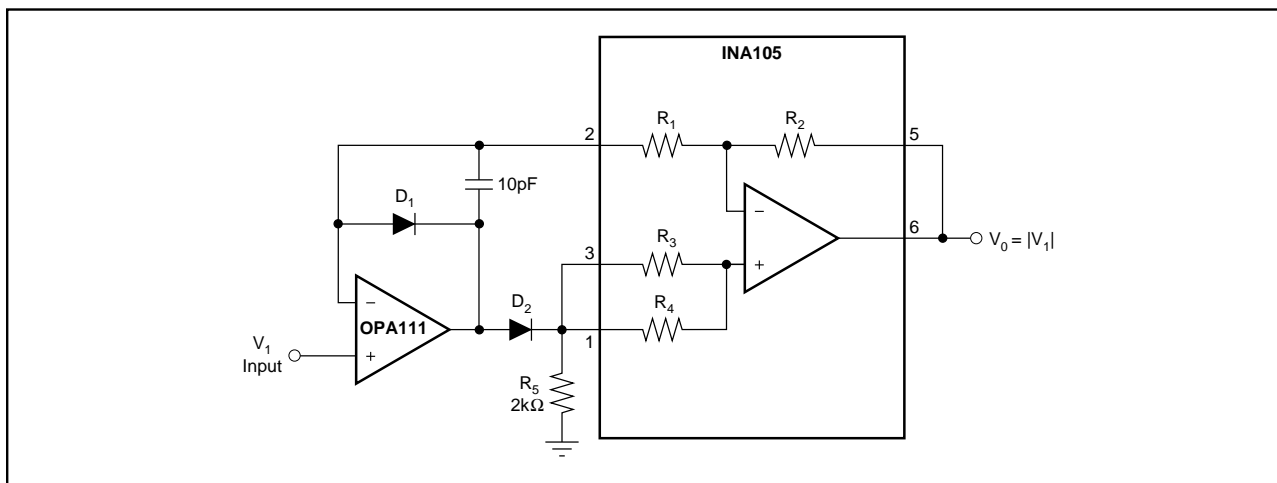


FIGURE 28. Precision Absolute Value Buffer.

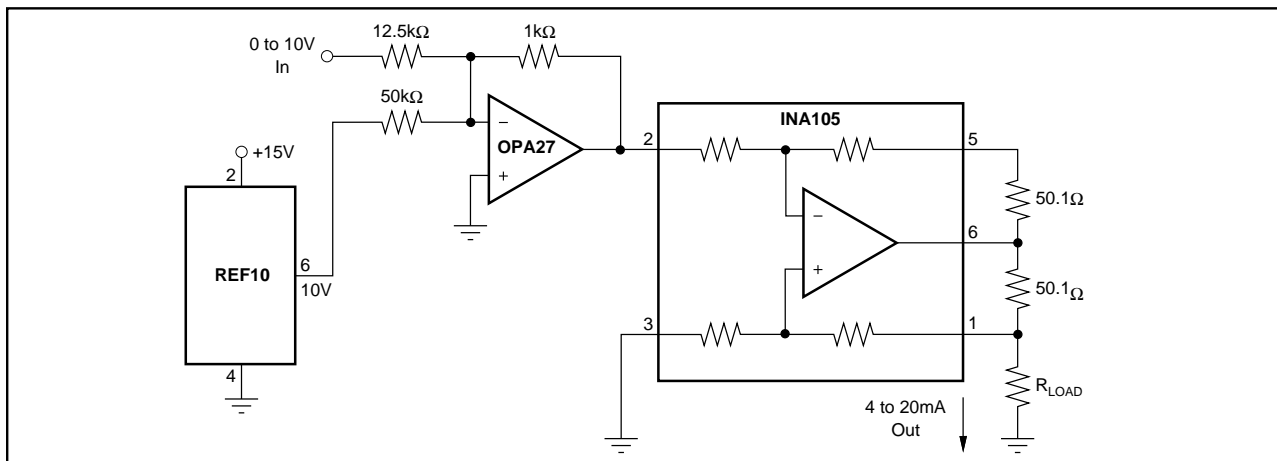
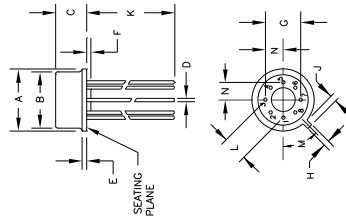


FIGURE 29. Precision 4-20mA Current Transmitter.

# PACKAGE DRAWINGS

Package Number 001 - Metal TO-99

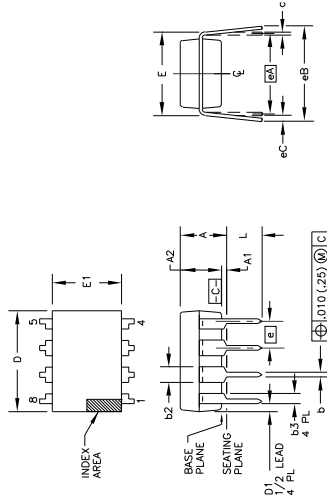


DIM	INCHES		MILLIMETERS		N	DIM	INCHES		MILLIMETERS		N
	MIN.	MAX.	MIN.	MAX.			MIN.	MAX.	MIN.	MAX.	
A	.325	.380	8.51	9.65	1	A	.0125	.0150	0.318	0.381	1
B	.305	.335	7.75	8.51	1	B	.0115	.0125	0.292	0.318	1
C	.165	.185	4.19	4.70	1	C	.0065	.0075	0.165	0.191	1
D	.016	.021	0.41	0.53	1	D	.0005	.0007	0.013	0.018	1
E	.010	.040	0.25	1.02	1	E	.0004	.0160	0.010	0.406	1
F	.010	.040	0.25	1.02	1	F	.0004	.0160	0.010	0.406	1
G	.038	.048	0.97	1.22	1	G	.0030	.0394	0.076	1.000	1
H	.028	.045	0.71	1.14	1	H	.0023	.0354	0.058	0.894	1
I	.028	.045	0.71	1.14	1	I	.0023	.0354	0.058	0.894	1
J	.028	.045	0.71	1.14	1	J	.0023	.0354	0.058	0.894	1
K	.500	--	12.7	--	1	K	.0100	--	0.254	--	1
L	.110	.160	2.79	4.06	1	L	.0044	.0406	0.112	1.030	1
M	.45	BASIC	45	BASIC	1	M	.0113	BASIC	2.87	BASIC	1
N	.095	.105	2.41	2.67	1	N	.0037	.0267	0.094	0.676	1

NOTES:  
 1. LEADS IN TRUE POSITION WITHIN .010" (.25mm) R @ MMC AT SEATING PLANE.  
 2. PIN NUMBERS SHOWN FOR REFERENCE ONLY. NUMBERS MAY NOT BE MARKED ON PACKAGE.

PACKAGE NUMBER: Z2001  
 JEDEC NUMBER: UNKNOWN  
 REV.: B

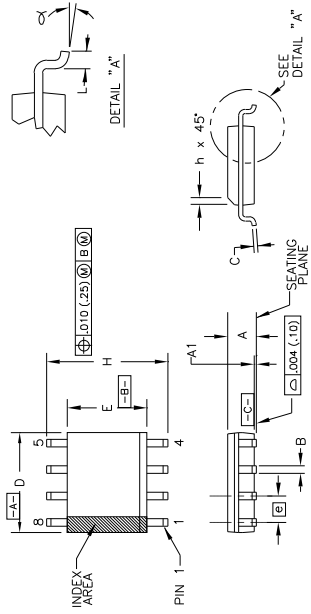
Package Number 006 - 8-Pin Plastic, Single-Wide DP



DIM	INCHES		MILLIMETERS		N	DIM	INCHES		MILLIMETERS		N
	MIN.	MAX.	MIN.	MAX.			MIN.	MAX.	MIN.	MAX.	
A	.015	.020	0.38	0.51	1	A	.0005	.0007	0.013	0.018	1
A1	.015	.020	0.38	0.51	1	A1	.0005	.0007	0.013	0.018	1
A2	.014	.022	0.36	0.56	1	A2	.0004	.0056	0.010	0.141	1
b	.045	.070	1.14	1.78	9	b	.0030	.0178	0.076	0.451	9
b3	.030	.045	0.76	1.14	9	b3	.0020	.0114	0.051	0.290	9
c	.008	.014	0.20	0.36	4	c	.0003	.0036	0.008	0.091	4
D	.355	.400	9.02	10.16	4	D	.0140	.0160	0.354	0.406	4
D1	.005	.013	0.13	0.33	4	D1	.0002	.0033	0.005	0.084	4
E	.005	.013	0.13	0.33	4	E	.0002	.0033	0.005	0.084	4
E1	.240	.280	6.10	7.11	4	E1	.0094	.0141	0.239	0.357	4
e	.100	BASIC	2.54	BASIC	5	e	.0039	BASIC	0.100	BASIC	5
eA	.300	BASIC	7.62	BASIC	5	eA	.0118	BASIC	2.99	BASIC	5
eB	--	.430	--	10.92	6	eB	--	.0169	--	0.429	6

NOTES:  
 1. ALL DIMENSIONS ARE IN INCHES.  
 2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982, AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.  
 3. DIMENSIONS OF LEADS TO BE INCLUDED IN MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 (.25mm).  
 4. DIMENSIONS OF LEADS TO BE INCLUDED IN MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 (.25mm).  
 5. CONTOUR OF LEADS TO BE PERPENDICULAR TO DATUM [E-C].  
 6. [E-C] AND [E-D] ARE MEASURED AT THE UNCONSTRAINED POSITION.  
 7. N IS THE MAXIMUM OF TERMINAL POSITIONS.  
 8. POINTS OR ROUNDED LEAD TIPS ARE PREFERRED TO FLARE INSERTION.  
 9. b2 AND b3 MAXIMUM DIMENSIONS DO NOT INCLUDE DAMBAR PROTRUSIONS. DAMBAR PROTRUSIONS SHALL NOT EXCEED .010 (.25mm).  
 10. DISTANCE BETWEEN LEADS INCLUDING DAMBAR PROTRUSIONS TO BE INCLUDED IN MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 (.25mm).  
 11. A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE CROSS-HATCHED AREA.  
 12. THE CHAMFER ON THE TOP SURFACE (STEP, MESA, ETC.) SHALL BE SYMMETRICAL ABOUT THE LATERAL CENTERLINES.  
 PACKAGE NUMBER: Z2006  
 JEDEC NUMBER: MS-001-BA  
 REV.: E

Package Number 182 - 8-Lead SOIC



DIM	INCHES		MILLIMETERS		N	DIM	INCHES		MILLIMETERS		N
	MIN.	MAX.	MIN.	MAX.			MIN.	MAX.	MIN.	MAX.	
A	.0532	.0668	1.35	1.75	1	A	.0020	.0025	0.051	0.064	1
A1	.004	.0098	0.10	0.23	1	A1	.0002	.0025	0.005	0.064	1
B	.013	.020	0.33	0.51	1	B	.0005	.0051	0.013	0.129	1
C	.0098	.0098	0.20	0.25	2	C	.0004	.0025	0.010	0.064	2
D	.1497	.1574	3.80	4.00	3	D	.0060	.0400	0.152	1.016	3
E	.050	BASIC	1.27	BASIC	3	E	.0020	BASIC	0.051	BASIC	3
F	.2284	.244	5.80	6.20	1	F	.0090	.0102	0.228	0.259	1
H	.0099	.0196	0.25	0.50	1	H	.0004	.0152	0.010	0.381	1
L	.016	.050	0.41	1.27	5	L	.0006	.0127	0.015	0.323	5
XX	0	0	0	0	6	XX	0	0	0	0	6

NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.  
 2. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH OR GATE BURRS. MOLD FLASH OR PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .006 IN.  
 3. INTER-LEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 IN. (0.25 mm).  
 4. THE CHAMFER ON THE BODY IS OPTIONAL, IF IT IS NOT PRESENT.  
 A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE CROSS-HATCHED AREA.  
 5. "L" IS THE LENGTH OF TERMINAL FOR SOLDERING TO A SUBSTRATE.  
 6. "N" IS THE NUMBER OF TERMINAL POSITIONS.  
 7. THE LEAD WIDTH "F", AS MEASURED .014 IN. (0.36 mm) OR GREATER ABOVE THE SEATING PLANE, SHALL NOT EXCEED A MAXIMUM VALUE OF .024 IN. (0.61 mm).  
 8. LEAD TO LEAD COPLANARITY SHALL NOT EXCEED .010 IN. (0.25 mm).  
 9. LEAD TO LEAD COPLANARITY SHALL NOT EXCEED .010 IN. (0.25 mm).  
 PACKAGE NUMBER: Z2182  
 JEDEC NUMBER: MS-012-AA  
 REV.: C