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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.

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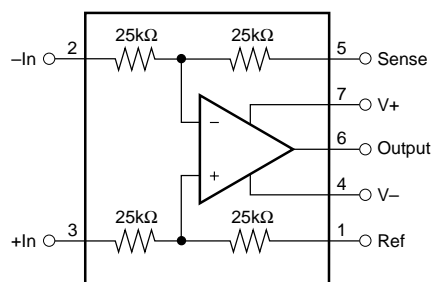
SPECIFICATIONS

ELECTRICAL

At +25°C, V_{CC} = ±15V, unless otherwise noted.

PARAMETER	CONDITIONS	INA105AM MIN	INA105AM TYP	INA105AM MAX	INA105BM MIN	INA105BM TYP	INA105BM MAX	INA105KP, KU MIN	INA105KP, KU TYP	INA105KP, KU MAX	UNITS
GAIN											
Initial[1]			1			*			*		V/V
Error			0.005	0.01		*	*		0.01	0.025	%
vs Temperature			1	5		*	*		*	*	ppm/°C
Nonlinearity[2]			0.0002	0.001		*	*		*	*	%
OUTPUT											
Rated Voltage	I_O = +20mA, −5mA	10	12		*	*		*	*		V
Rated Current	V_O = 10V	+20, −5			*			*			mA
Impedance			0.01			*			*		Ω
Current Limit	To Common		+40/−10			*			*		mA
Capacitive Load	Stable Operation		1000			*			*		pF
INPUT											
Impedance[3]	Differential		50			*			*		kΩ
	Common-Mode		50			*			*		kΩ
Voltage Range[4]	Differential	±10			*			*			V
	Common-Mode	±20			*			*			V
Common-Mode Rejection[5]	T_A = T_{MIN} to T_{MAX}	80	90		86	100		72	*		dB
OFFSET VOLTAGE	RTO[6], [7]										
Initial			50	250		*	*		*	500	μV
vs Temperature			5	20		5	10		*	*	μV/°C
vs Supply	±V_S = 6V to 18V		1	25		*	15		*	*	μV/V
vs Time			20			*			*		μV/mo
OUTPUT NOISE VOLTAGE	RTO[6], [8]										
f_B = 0.01Hz to 10Hz			2.4			*			*		μVp-p
f_O = 10kHz			60			*			*		nV/√Hz
DYNAMIC RESPONSE											
Small Signal Bandwidth	−3dB		1			*			*		MHz
Full Power Bandwidth	V_O = 20Vp-p	30	50		*	*		*	*		kHz
Slew Rate		2	3		*	*		*	*		V/μs
Settling Time: 0.1%	V_O = 10V Step		4			*			*		μs
0.01%	V_O = 10V Step		5			*			*		μs
0.01%	V_{CM} = 10V Step, V_{DIFF} = 0V		1.5			*			*		μs
POWER SUPPLY											
Rated			±15			*			*		V
Voltage Range	Derated Performance	±5		±18	*		*	*		*	V
Quiescent Current	V_O = 0V		±1.5	±2		*	*		*	*	mA
TEMPERATURE RANGE											
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_{IN} 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.

PIN CONFIGURATIONS

Top View   **TO-99**

Case internally connected to V–. Make no connection.

INA105AM
INA105BM

Top View   **DIP/SOIC**

NOTE: (1) Performance grade identifier box for small outline surface mount. Blank indicates K grade. Part is marked INA105U.
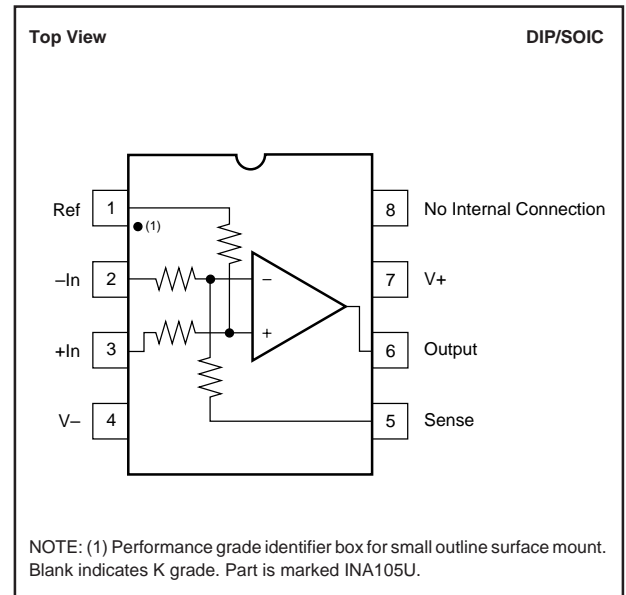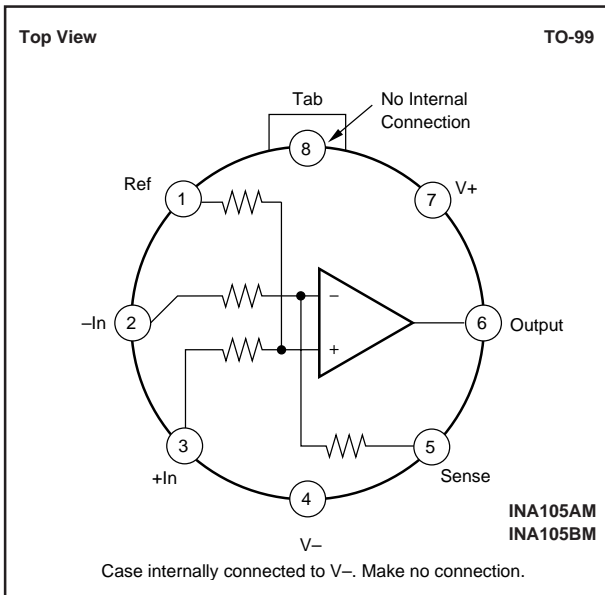
ABSOLUTE MAXIMUM RATINGS

Supply .... ±18V
Input Voltage Range .... ±V_S
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/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER(1)	TEMPERATURE RANGE
INA105AM	TO-99 Metal	001	–40°C to +85°C
INA105BM	TO-99 Metal	001	–40°C to +85°C
INA105KP	8-Pin Plastic DIP	006	–40°C to +85°C
INA105KU	8-Pin SOIC	182	–40°C to +85°C

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

⚠ 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.

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TYPICAL PERFORMANCE CURVES

At T_A = 25°C, V_S = ±15V, unless otherwise noted.
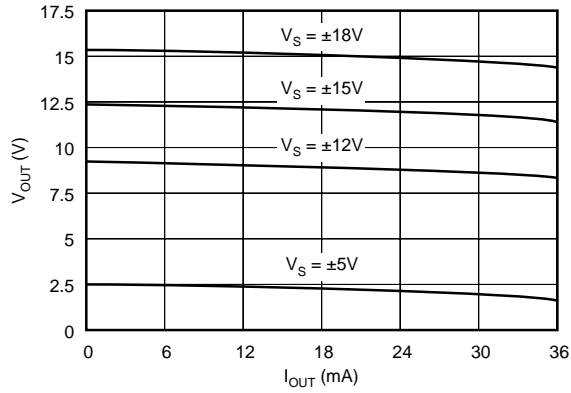
STEP RESPONSE

SMALL SIGNAL RESPONSE
(No Load)

SMALL SIGNAL RESPONSE
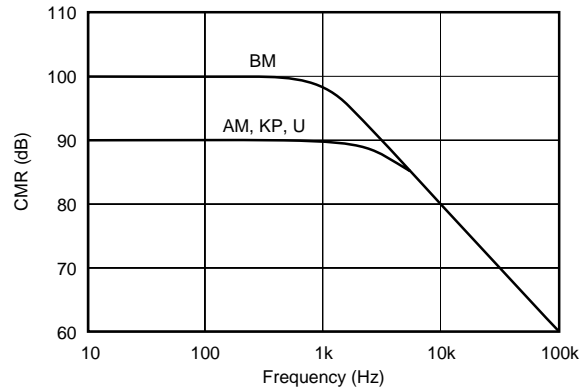(R_{LOAD} = ∞Ω, C_{LOAD} = 1000pF)

MAXIMUM V_{OUT} vs I_{OUT}
(Negative Swing)
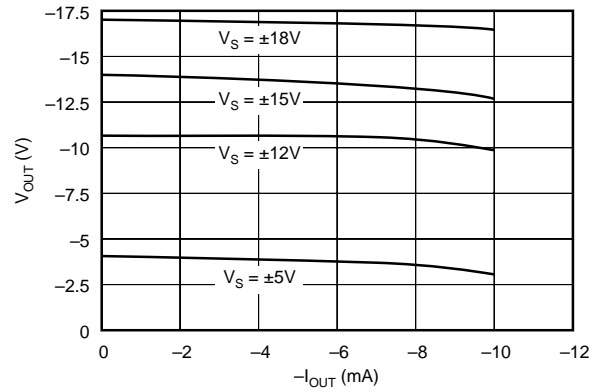
MAXIMUM V_{OUT} vs I_{OUT}
(Positive Swing)

CMR vs FREQUENCY

TYPICAL PERFORMANCE CURVES (CONT)

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

POWER SUPPLY REJECTION
vs FREQUENCY

COMMON-MODE INPUT RANGE vs SUPPLY
(Difference Amplifier Connected, $V_{OUT} = 0$)

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 5Ω 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 10Ω 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.

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$$V_O = V_3 - V_3$$
Offset Adjustment
Range = ±300µV

FIGURE 2. Offset Adjustment.

$$V_0 = V_3 - V_2$$
Gain Error = 0.005%
CMR = 100dB
Nonlinearity = 0.0002%

FIGURE 3. Precision Difference Amplifier.

$$V_O = (1 + 2R_2/R_1)(V_2 - V_1)$$

For low source impedance applications, an input stage using OPA27 op amps will give the best low noise, offset, and temperature drift performance. At source impedances above about 10kΩ, the bias current noise of the OPA27 reacting with the input impedance begins to dominate the noise performance. For these applications, using the OPA111 or dual OPA2111 FET input op amp will provide lower noise performance. For lower cost use the OPA121 plastic. To construct an electrometer use the OPA128.

A_1, A_2	R_1 (Ω)	R_2 (Ω)	GAIN (V/V)	CMRR (dB)	MAX I_B	NOISE AT 1kHz (nV/√HZ)
OPA27A	50.5	2.5k	100	128	40nA	4
OPA111B	202	10k	100	110	1pA	10
OPA128LM	202	10k	100	118	75fA	38

FIGURE 4. Precision Instrumentation Amplifier.
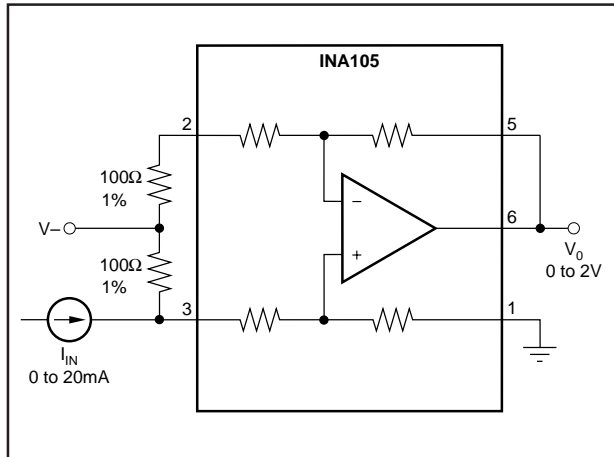
FIGURE 5. Current Receiver with Compliance to Rails.

$V_0 = -V_2$
Gain Error = 0.01% maximum
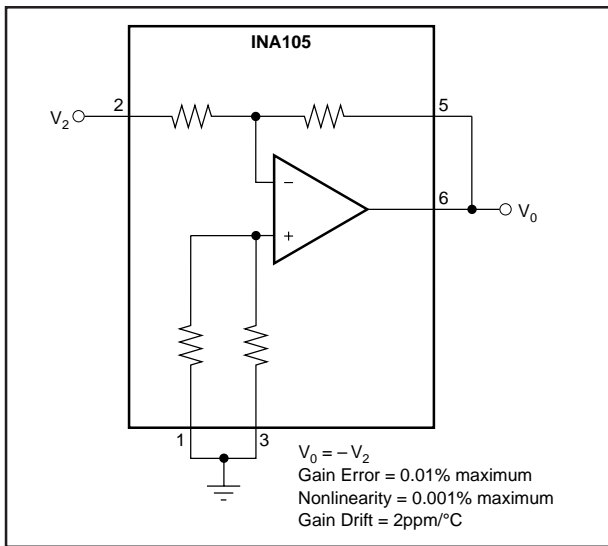Nonlinearity = 0.001% maximum
Gain Drift = 2ppm/°C

FIGURE 6. Precision Unity-Gain Inverting Amplifier.

FIGURE 7. ±10V Precision Voltage Reference.

FIGURE 8. ±5V Precision Voltage Reference.

$V_0 = V_1$
Gain Error = 0.001% maximum

FIGURE 9. Precision Unity-Gain Buffer.

FIGURE 10. Pseudoground Generator.

$V_0 = (V_1 + V_3)/2$, ±0.01% maximum
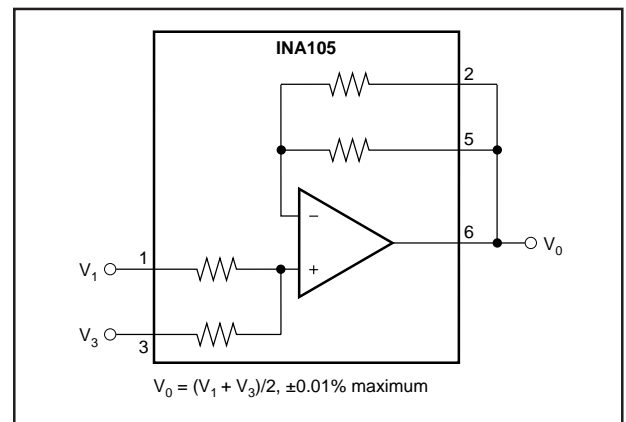
FIGURE 11. Precision Average Value Amplifier.

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FIGURE 12. Precision (G = 2) Amplifier.

$$V_0 = 2 \cdot V_1$$
Gain Error = 0.01% maximum
Gain Drift = 2ppm/°C

FIGURE 13. Precision Summing Amplifier.

$$V_0 = V_1 + V_3, \pm 0.01\% \text{ maximum}$$

FIGURE 14. Precision Gain = 1/2 Amplifier.

$$V_0 = V_3/2, \pm 0.01\%$$

FIGURE 15. Precision Bipolar Offsetting.

Device	Output
VFC320	0-10kHz
VFC100	0-F_{CLOCK}/2
DAC80	0-FS (12 bits)
DAC703	0-FS (16 bits)
XTR110	4-20mA

NOTE: (1) Unipolar Input Device.
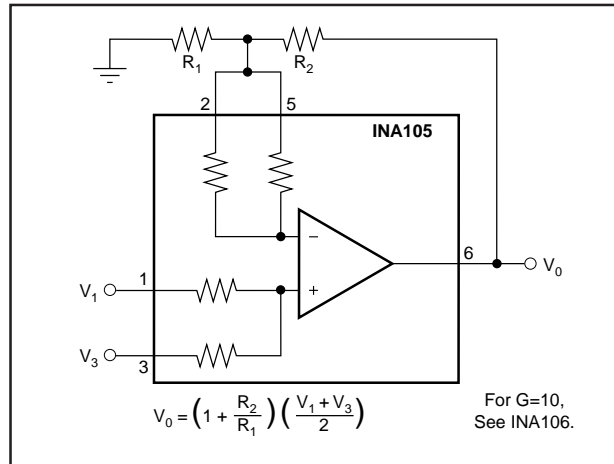
FIGURE 16. Precision Summing Amplifier with Gain.

$$V_0 = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{V_1 + V_3}{2}\right)$$

For G=10,
See INA106.

FIGURE 17. Instrumentation Amplifier Guard Drive Generator.

FIGURE 18. Precision Summing Instrumentation Amplifier.

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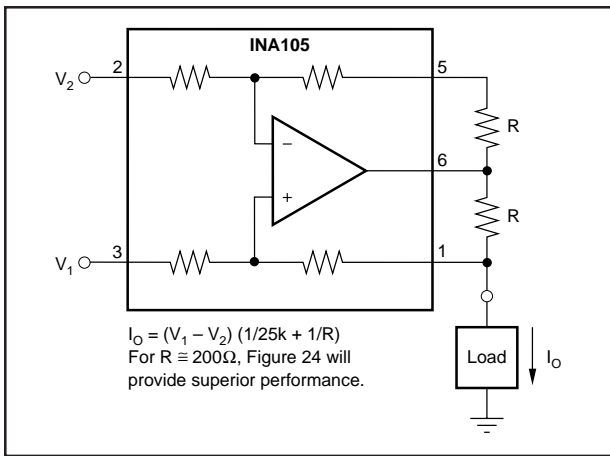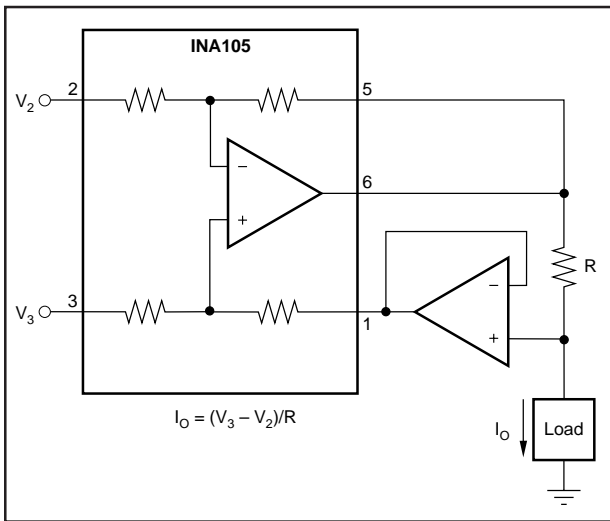FIGURE 19. Precision Voltage-to-Current Converter with Differential Inputs.

$$I_O = (V_1 - V_2)(1/25k + 1/R)$$
For $R \cong 200\Omega$, Figure 24 will provide superior performance.

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

$$I_O = (V_3 - V_2)/R$$
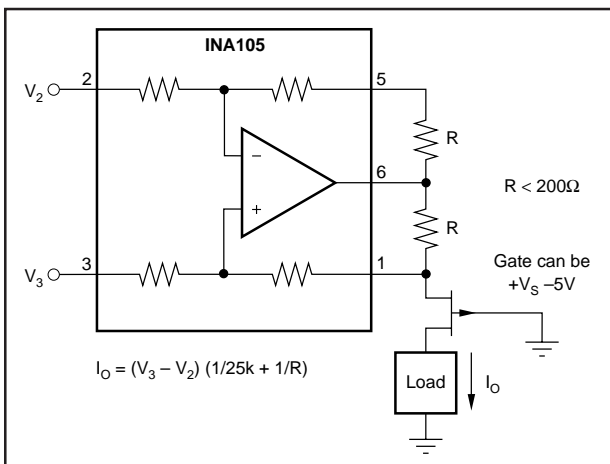
FIGURE 21. Isolating Current Source.

$$I_O = (V_3 - V_2)(1/25k + 1/R)$$
$R < 200\Omega$
Gate can be $+V_S - 5V$

$$V_{01} - V_{02} = 2(V_2 - V_1)$$

FIGURE 22. Differential Output Difference Amplifier.

$$I_O = (V_3 - V_2)/R$$
$R \geq 200\Omega$
Gate can be $+V_{CC} - 5V$

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

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

$$I_O = (E_2 - E_1)(1 + 2R_2/R_1)(1/25k + 1/R)$$
NOTE: (1) See Figure 5 for op amp recommendation.

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

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

FIGURE 26. Digitally Controlled Gain of ±1 Amplifier.

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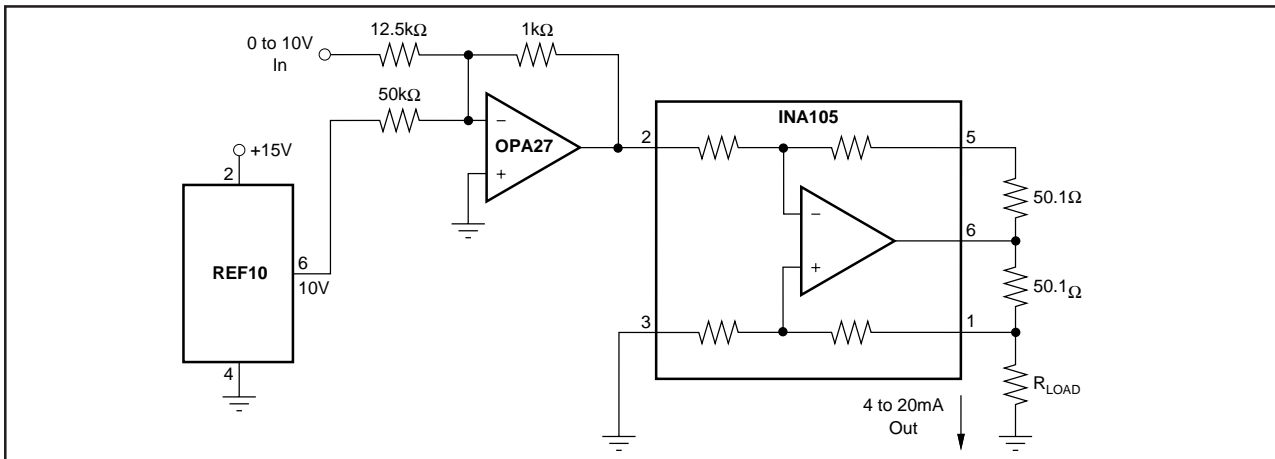

FIGURE 28. Precision Absolute Value Buffer.

FIGURE 29. Precision 4-20mA Current Transmitter.

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