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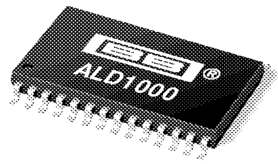



# ALD1000

# Precision Programmable CURRENT/VOLTAGE TRANSMITTER

## FEATURES

- SWITCHABLE OUTPUT ±10V OR 4-20mA
- DRIVES 1000Ω || 1µF AT 20mA
- VOLTAGE AND CURRENT SENSE
- GROUND NOISE SUPPRESSION
- ERROR DETECTION FLAG
- OUTPUT DISABLE
- ACCURACY: 0.05% max
- WIDE SUPPLY RANGE: ±11V TO +24/–15V

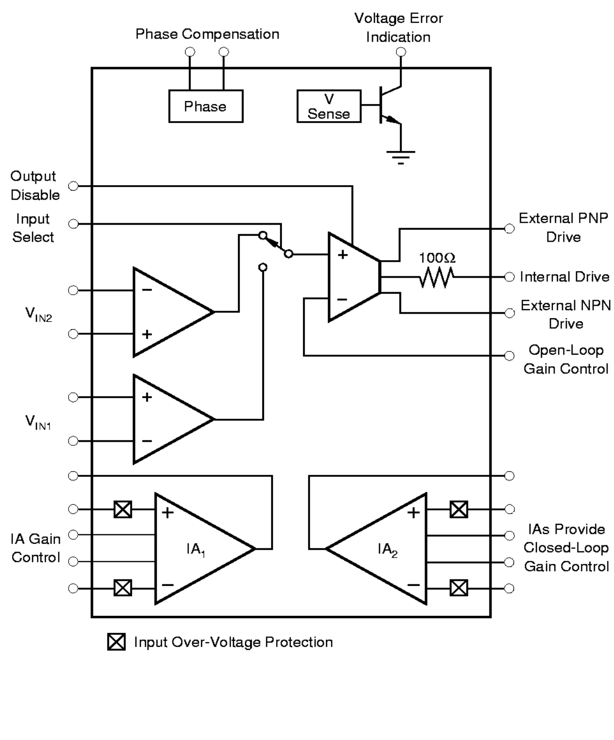
## APPLICATIONS

- PROGRAMMABLE CONTROLLERS
- STANDARDIZED OUTPUTS FOR TERMINATION PANELS
- INDUSTRIAL PROCESS CONTROL
- PROGRAMMABLE CURRENT SOURCE
- MOTOR CONTROL SYSTEMS
- PC AND VME BASED INSTRUMENTATION
- CONDITIONER FOR STANDARD SENSOR OUTPUTS
- TEST EQUIPMENT PIN DRIVER

## DESCRIPTION

This product is a monolithic programmable voltage-to-current or voltage-to-voltage analog line driver circuit. It can convert a ±10V input into either an output voltage or current with remote sensing. It provides drive for external transistors to boost output current to greater than ±25mA levels.

Current and voltage sensing can be performed simultaneously. Current sensing is achieved through a single external sense resistor. Voltage sensing is performed directly across the load. The logic inputs provide for both output disable and switching between constant current or constant voltage output functions. An open collector output provides an error flag for open circuit loads. The output disable function allows full control of the output even during power-on and power-off sequencing. The instrumentation amplifiers are designed to insure that load noise is not circulated within the control loop.





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/ • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132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# SPECIFICATIONS

At $+V_S$ = 24V, $-V_S$ = 15V, $T_{AMB}$ = 25°C, and 2N2222, 2N2907 external transistors, unless otherwise noted.

| PARAMETER | CONDITIONS | ALD1000U MIN | ALD1000U TYP | ALD1000U MAX | UNITS |
|---|---|---|---|---|---|
| **TRANSMITTER** | | | | | |
| **SWOP INPUTS** | | | | | |
| Linear Range Min | Internal Drive Transistors | | | –10 | V |
| Linear Range Max | 5mA Load | 10 | | | V |
| Input Bias Current | | | 50 | | pA |
| **XTR OUTPUT** | | | | | |
| Positive Overvoltage Sense | | | 19.5 | | V |
| Negative Overvoltage Sense | Internal Drive Transistors | | –10.5 | | V |
| Positive Overcurrent Sense | | | +25 | | mA |
| Negative Overcurrent Sense | | | –15 | | mA |
| **LOGIC INPUTS** | | | | | |
| Logic Low | | | | 0.8 | V |
| Logic High | | 4.0 | 2.6 | | V |
| **LOGIC OUTPUTS** | | | | | |
| Logic High | 5V Logic Supply | 4.0 | | | V |
| Logic Low | with 10k pull-up resistor | | | 0.8 | V |
| **OUTPUT—VOLTAGE MODE** (Gain = 1 unless otherwise specified) | | | | | |
| Span Error | | | 0.5 | 1 | % |
| Span Drift | | | 50 | | ppm/°C of FS |
| Linear Range Min | 0.1% of FS | | | –10 | |
| Linear Range Max | 0.1% of FS | 10 | | | |
| Output Current Min | Internal Drive Transistors | | | –5 | mA |
| Output Current Max | Internal Drive Transistors | 5 | | | mA |
| Short-Circuit Current | Internal Drive Transistors | | 25 | | mA |
| Short-Circuit Current | Internal Drive Transistors | | –15 | | mA |
| Non-Linearity | | | 0.005 | 0.05 | % |
| Initial Offset Voltage—RTI | | | 2 | | mV |
| Offset Voltage vs Temperature | | | 20 | | µV/°C |
| **OUTPUT—CURRENT MODE** (Gain = 5 with 50Ω shunt resistor unless otherwise specified) | | | | | |
| Span Error | | | 5 | | % |
| Span Drift | Gain = 1(1) | | 50 | | ppm/°C of FS |
| Output Current Min | Internal Drive Transistors(2) | | | –5 | mA |
| Output Current Max | Internal Drive Transistors(2) | 5 | | | mA |
| Compliance Min | | –10 | | | V |
| Compliance Max | | | | 15 | V |
| Offset Current Min | | | | –25 | µA |
| Offset Current Min | | 25 | | | µA |
| **INSTRUMENTATION AMPLIFIERS $R_{LOAD}$ = 10k** | | | | | |
| **IA INPUTS** | | | | | |
| Linear Input Voltage Min | | | | –10 | V |
| Linear Input Voltage Max | | 20 | | | V |
| Common-Mode Input Voltage Min | $V_{IN}$ = 0 | | | –10 | V |
| Common-Mode Input Voltage Max | $V_{IN}$ = 0 | 20 | | | V |
| Input Bias Current | | | 100 | | nA |
| Initial Offset Voltage | G = 1 | –1 | | 1 | mV |
| CMRR | G = 10 | 80 | 100 | | |
| **IA OUTPUTS (with 10k Load)** | | | | | |
| Output Voltage Max | | 20 | | | V |
| Output Voltage Min | | | | –10 | V |
| + Short Circuit Current | | | 5 | | mA |
| – Short Circuit Current | | | –12 | | mA |
| **GAIN EQUATION (gain = 1+50k/$R_G$)** | | | | | |
| Gain Error, G = 1 | | | | 0.3 | %±FS |
| G = 5 | | | | 0.6 | %±FS |
| G = 100 | | | | 0.8 | %±FS |
| Non-Linearity, G = 1 | | | | 0.004 | %±FS |
| G = 5 | | | | 0.008 | %±FS |
| G = 100 | | | | 0.02 | %±FS |



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# SPECIFICATIONS (CONT)

At $+V_S$ = 24V, $-V_S$ = 15V, $T_{AMB}$ = 25°C, and 2N2222, 2N2907 external transistors, unless otherwise noted.

| PARAMETER | CONDITIONS | ALD1000U MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| **FREQUENCY RESPONSE** | | | | | |
| G = 1 | | | 700 | | kHz |
| G = 5 | | | 400 | | kHz |
| G = 100 | | | 50 | | kHz |
| Slew Rate | $V_O$ = ±10V, G = 10 | | 4 | | V/µS |
| **SETTLING TIME, 0.01%** | | | | | |
| G = 1 | | | 20 | | µS |
| G = 5 | | | 20 | | µS |
| G = 100 | | | 30 | | µS |
| **POWER SUPPLY** | | | | | |
| Quiescent Current | Internal Drive Transistors | | 5 | | mA |
| **TEMPERATURE RANGE** | | | | | |
| Operating | | –40 | | +85 | °C |
| Storage | | –65 | | +150 | °C |

NOTES: (1) Gain drift depends on tempco of 50K factor on gain equation when gain is greater than 1. (2) External Drive capacity varies with configuration. See Application Note.

## ABSOLUTE MAXIMUM RATINGS

| | |
|---|---|
| Supply Voltage ($\pm V_S$) | +25V, –18V |
| IA Inputs | ±40V |
| SWOP Inputs | $\pm V_S$ |
| Logic Inputs | $+V_S$, $-V_S$ + 0.5V |
| Junction Temperature | 150°C |
| Storage Temperature | –65°C to +150°C |
| Lead Temperature (soldering, 10s) | +300°C |
| Output Short-to-Ground at 25°C | Continuous |

## PACKAGE/ORDERING INFORMATION

| PRODUCT | PACKAGE | PACKAGE DRAWING NUMBER[1] |
|---|---|---|
| ALD1000U | 28-Pin SOIC | 217 |

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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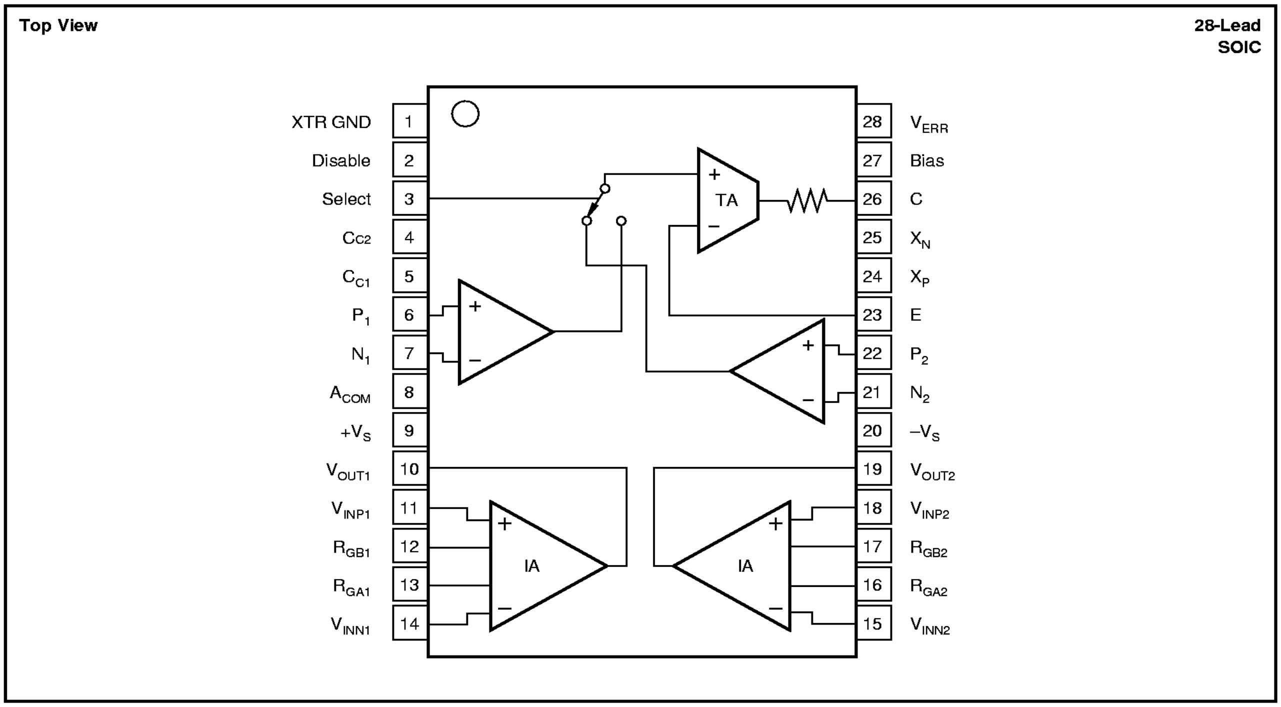
## PIN CONFIGURATION




## PIN ASSIGNMENTS

| PIN # | NAME | DESCRIPTION |
|---|---|---|
| 1 | XTR GND | Power ground pin. |
| 2 | Disable | A 5V signal puts the internal drive in a high impedance state and limits the external drive capacity. |
| 3 | Select | Selects the SWOP amp input. A 5V signal selects inputs N1 and P1. |
| 4 | $C_{C2}$ | $C_{C1}$ and $C_{C2}$ are for the external compensation capacitor. |
| 5 | $C_{C1}$ | $C_{C1}$ and $C_{C2}$ are for the external compensation capacitor. |
| 6 | $P_1$ | Non-inverting input to the XTR SWOP amp 1. |
| 7 | $N_1$ | Inverting input to the XTR SWOP amp 1. |
| 8 | $A_{COM}$ | Signal ground for the instrumentation amplifiers. |
| 9 | $+V_S$ | Positive power supply voltage. |
| 10 | $V_{OUT1}$ | Output of the instrumentation amplifier 1. |
| 11 | $V_{INP1}$ | Non-inverting input to instrumentation amplifier 1. |
| 12 | $R_{GB1}$ | Gain set resistor for instrumentation amplifier 1. |
| 13 | $R_{GA1}$ | Gain set resistor for instrumentation amplifier 1. |
| 14 | $V_{INN1}$ | Inverting input of instrumentation amplifier 1. |
| 15 | $V_{INN2}$ | Inverting input of instrumentation amplifier 2. |
| 16 | $R_{GA2}$ | Gain set resistor for instrumentation amplifier 2. |
| 17 | $R_{GB2}$ | Gain set resistor for instrumentation amplifier 2. |
| 18 | $V_{INP2}$ | Non-inverting input to instrumentation amplifier 2. |
| 19 | $V_{OUT2}$ | Output of the instrumentation amplifier 2. |
| 20 | $-V_S$ | Negative power supply voltage. |
| 21 | $N_2$ | Inverting input to the XTR SWOP amp 2. |
| 22 | $P_2$ | Non-inverting input to the XTR SWOP amp 2. |
| 23 | E | Inverting input (emitter) of the output transconductance amplifier. |
| 24 | $X_P$ | Base drive for an external, PNP, driver transistor (optional). |
| 25 | $X_N$ | Base drive for an external, NPN, driver transistor (optional). |
| 26 | C | Output (collector) of the output transconductance amplifier. |
| 27 | Bias | Open collector output indicating an internal overcurrent condition. |
| 28 | $V_{ERR}$ | Open collector output indicating an overvoltage condition. |

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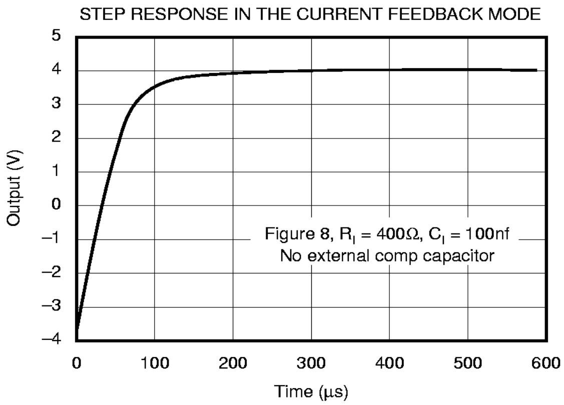
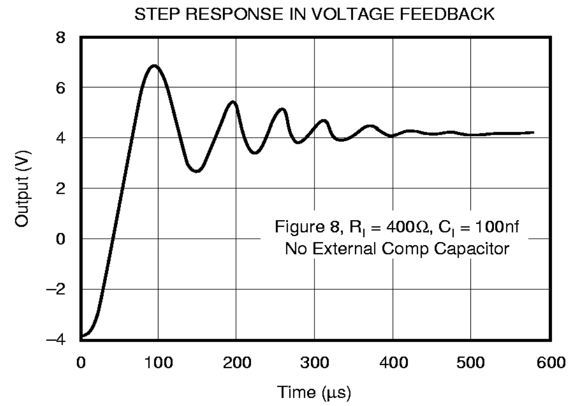
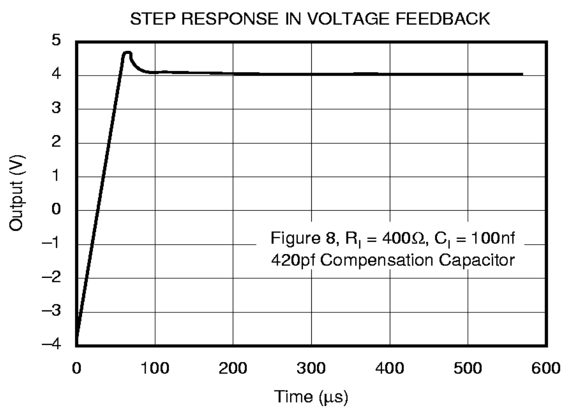
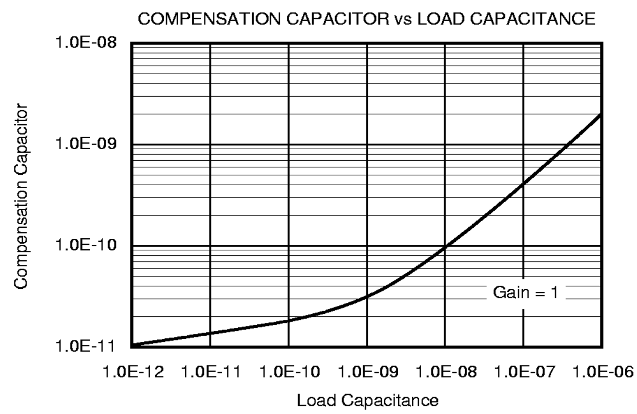
## TYPICAL PERFORMANCE CURVES

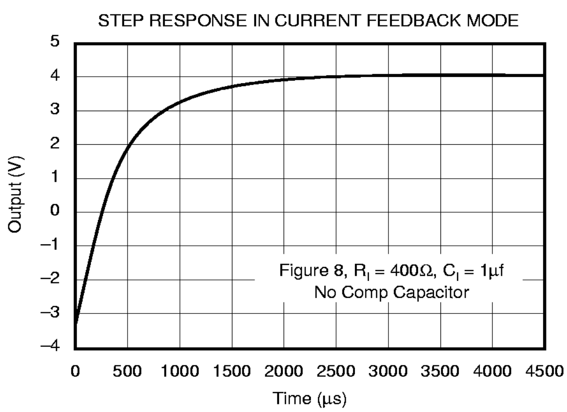
At $T_A = +25°C$; $+V_S = 24V$, $-V_S = -15V$, unless otherwise noted.

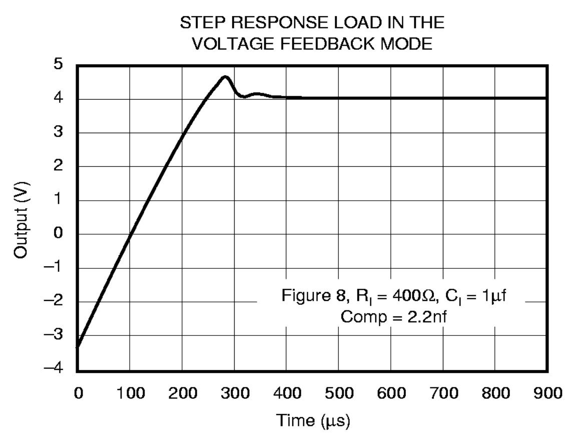


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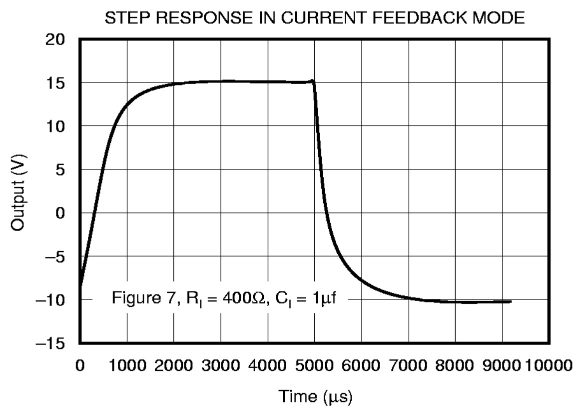
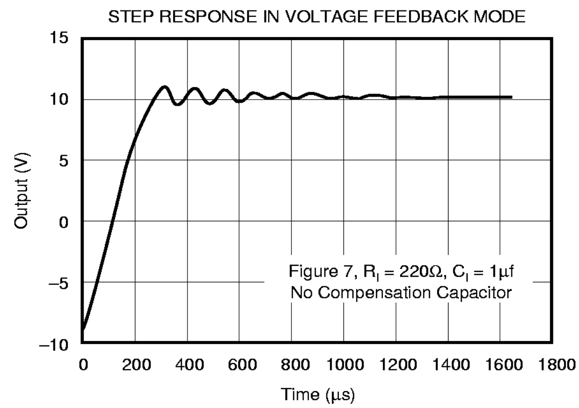
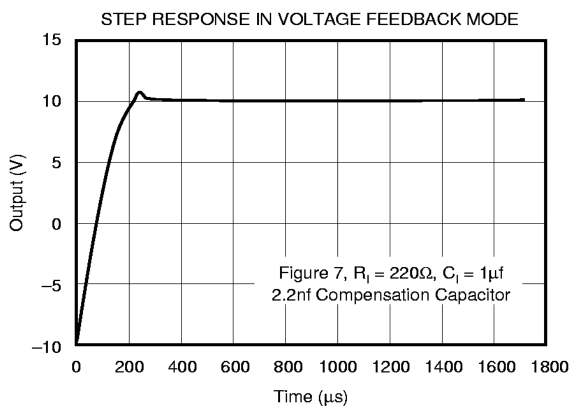
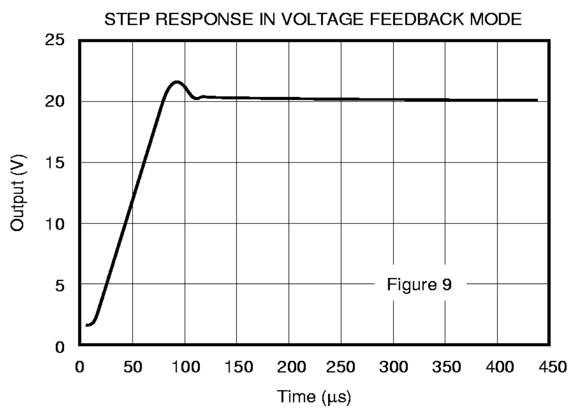
# TYPICAL PERFORMANCE CURVES (CONT)

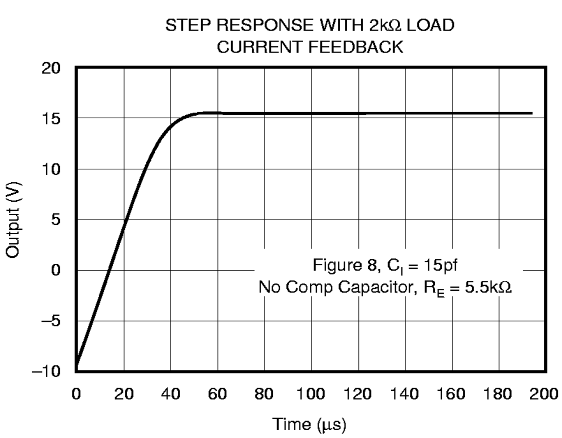
At $T_A$ = +25°C; $+V_S$ = +24V, $-V_S$ = –15V, unless otherwise noted.

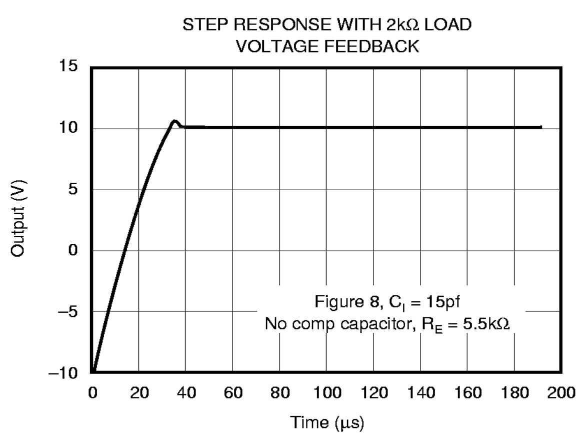






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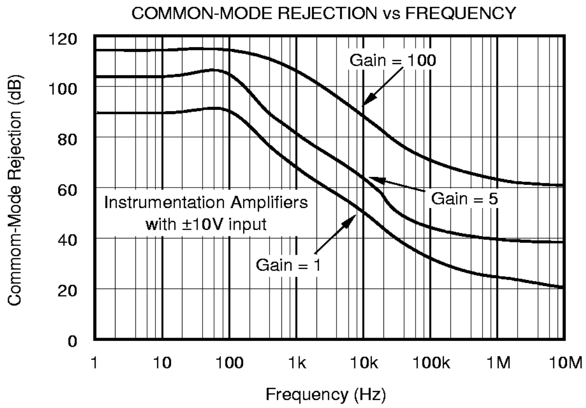
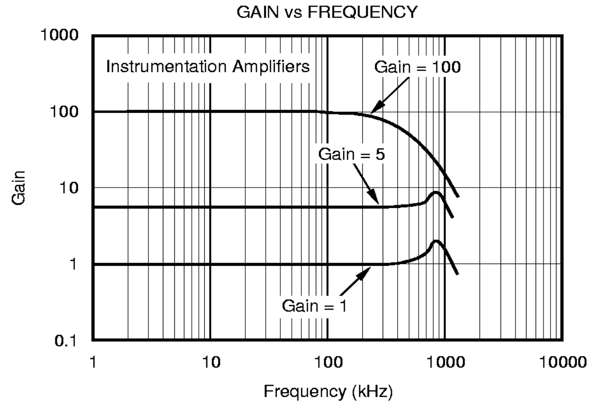
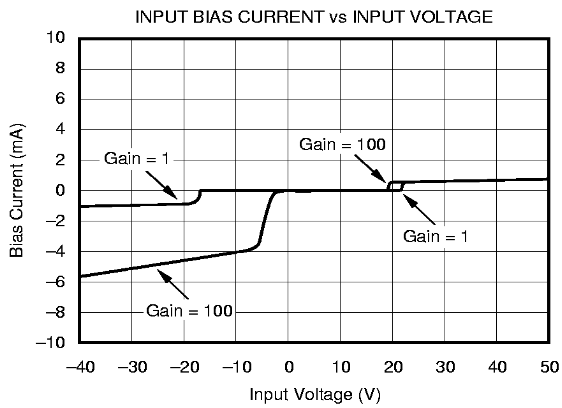
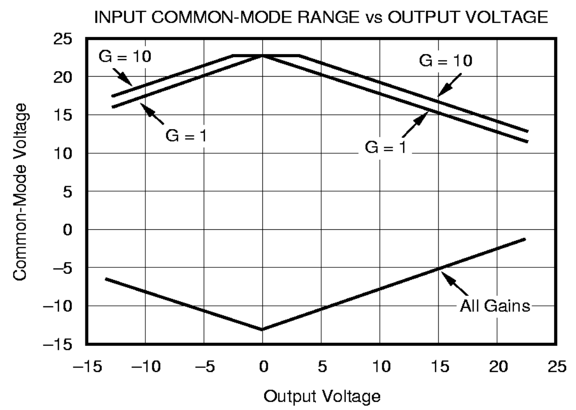
## TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25°C$; $+V_S = +24V$, $-V_S = -15V$, unless otherwise noted.




# BASIC OPERATION

### ALD1000 FUNCTIONAL BLOCKS

The typical ALD1000 control loop comprises three primary functional blocks (see Figure 1): the current transmitter (XTR), the load, and the instrumentation amplifier (IA). The XTR can be further viewed as divided into the switchable input operational amplifier (SWOP amp), and the voltage to current, transconductance amplifier (TA). Each of these blocks plays a role in the dynamic performance of the control loop, particularly in terms of loop stability with reactive loads.

### THE CURRENT TRANSMITTER (XTR)

The XTR produces the forward gain necessary for error amplification. It also controls the frequency response which must be adjusted to balance the trade-off between step response and stability when driving reactive loads.

Within the XTR the SWOP amp serves as the input stage. It amplifies the error between the input and output signals to produce a precise signal to the TA to drive the load. The SWOP amp has two pairs of inputs to provide flexibility of application. The SELECT logic input can switch between two input and feedback signals. Take care, however, to insure that the loop remains stable if switching between current and voltage feedback.

The ALD1000 handles a wide range of load conditions in either a voltage or current feedback application. The frequency characteristics of the potential load conditions vary widely. To accommodate these varying frequency characteristics the XTR includes a compensation network. It consists of a simple resistor divider network which forms a single pole, high pass, RC filter when a compensation capacitor is connected externally.

The transconductance amplifier converts the output voltage of the SWOP amp into an output current to drive the load. Whether used in a current feedback or a voltage feedback loop, the ALD1000 transmitter should be viewed as a source of current not voltage. In a voltage loop, the output current is converted to a feedback voltage by the load. In a current loop the output current is converted to a feedback voltage by the shunt resistor. The external, XTR gain resistor, tied to E (Pin 23, Figure 1), sets the voltage to current ratio.



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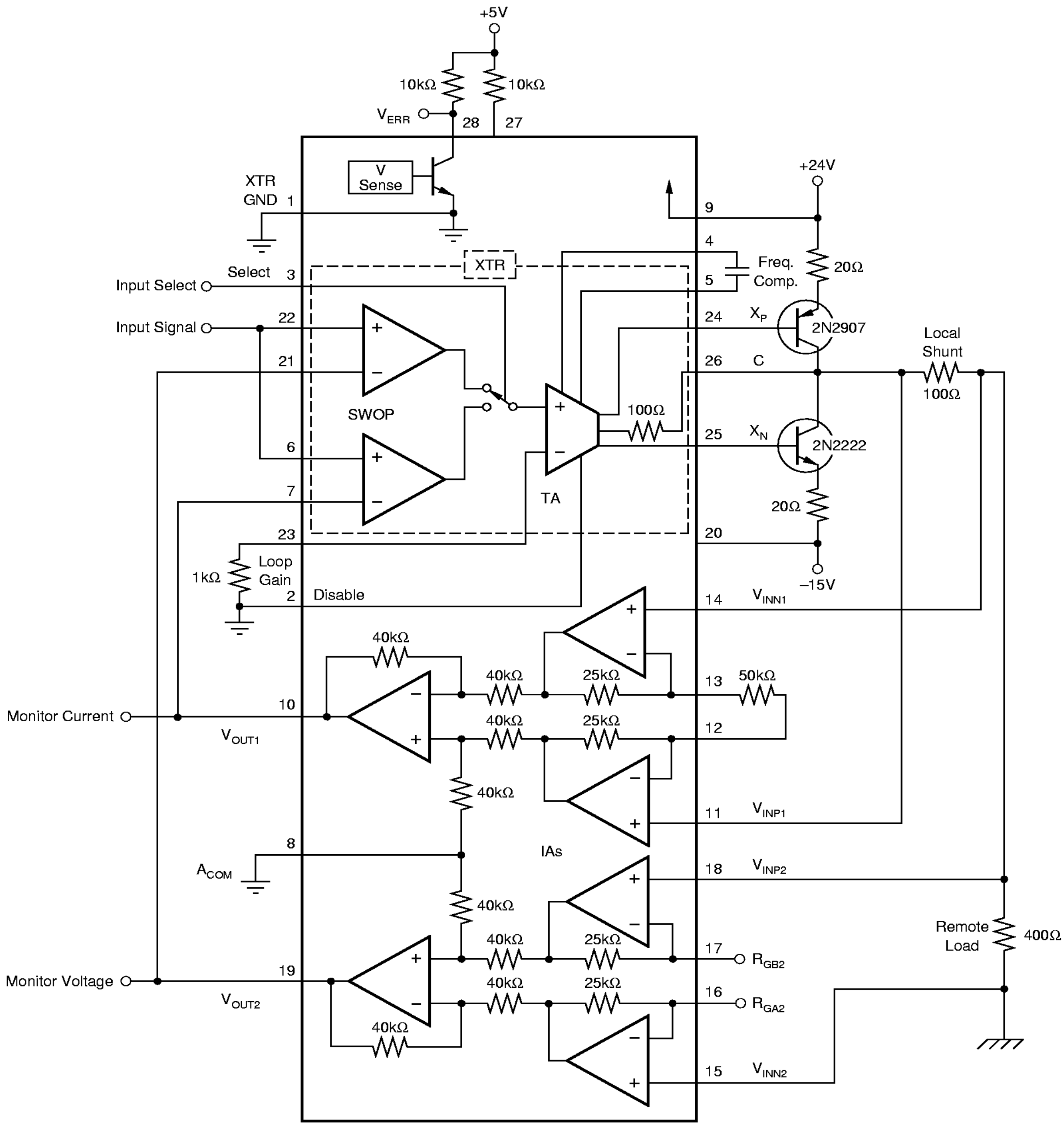


| $V_{IN}$ | $I_{OUT}$ | $V_{OUT}$ | SELECT | DISABLE |
|---|---|---|---|---|
| 0-2 | 0-10mA | | 1 | 0 |
| 0-10 | 0-50mA | | 1 | 0 |
| 0.8-4 | 4-20mA | | 1 | 0 |
| 2-10 | 10-50mA | | 1 | 0 |
| 0-5 | | 0-5V | 0 | 0 |
| 0-10 | | 0-10V | 0 | 0 |
| ±5 | | ±5V | 0 | 0 |
| ±10 | | ±10V | 0 | 0 |
| X | OFF | OFF | X | 1 |

FIGURE 1.



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### THE INSTRUMENTATION AMPLIFIERS (IA)

The ALD1000 includes two, general purpose, uncommitted, 3-op amp, instrumentation amplifiers (see Figure 1). The two IAs are connected to the common power supply and operate at full supply voltage. They share the same analog common reference. Otherwise they are configured independently for maximum flexibility.

The instrumentation amplifier senses the feedback signal, reduces any common-mode component, and scales it to the level required.

A more comprehensive discussion of the instrumentation amplifiers follows in a later section.

## ALD1000 LOGIC

The logic inputs used for the SWOP amp select and the XTR disable functions are simple, differential pair comparators as shown in Figure 2.

The logic outputs are open collector NPN transistors with their emitters at ground (pin 1).

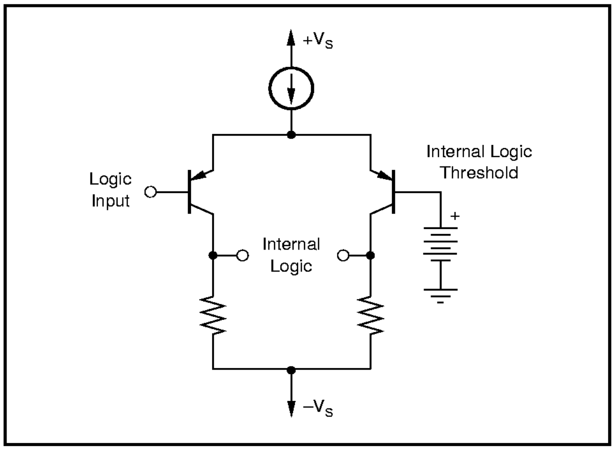


FIGURE 2. Simplified Diagram of the Internal ALD1000 Logic Input Circuitry.

### VOLTAGE ERROR INDICATION

The $V_{ERR}$ error signal at pin 28 triggers when the voltage at C (pin 26) exceeds the Positive Overvoltage Sense or the Negative Overvoltage Sense (see SPECIFICATIONS) internal thresholds. When external transistors are used without connecting them to C, as shown in Figure 7, the load voltage cannot be detected. The logic signal will generally trigger to an error state (low). However, consider it indeterminate under these conditions.

## INSTRUMENTATION AMPLIFIERS

### SETTING THE GAIN

The IA gain is set by connecting a single, external resistor, Rg in Figure 3, between the gain set pins.

$$G = 1 + \frac{50k\Omega}{R_G}$$

### INPUT PROTECTION

The inputs of the ALD1000 instrumentation amplifiers are individually protected against over-voltage. Internal circuitry on each input provides low series impedance under normal signal conditions. If the input is overloaded, the protection circuitry limits the input current to a safe value of approximately 1ma to 5ma. Refer to the typical performance curve "Input Bias Current vs Input Voltage." The inputs are protected even if the power supplies are disconnected or turned off.

### IA INPUT OVERLOAD AND INPUT COMMON-MODE RANGE

The linear voltage range of the input circuitry of the ALD1000 instrumentation amplifiers is from approximately 0.6V below the positive supply to 1V above the negative supply. However, the output swing of the input amplifiers

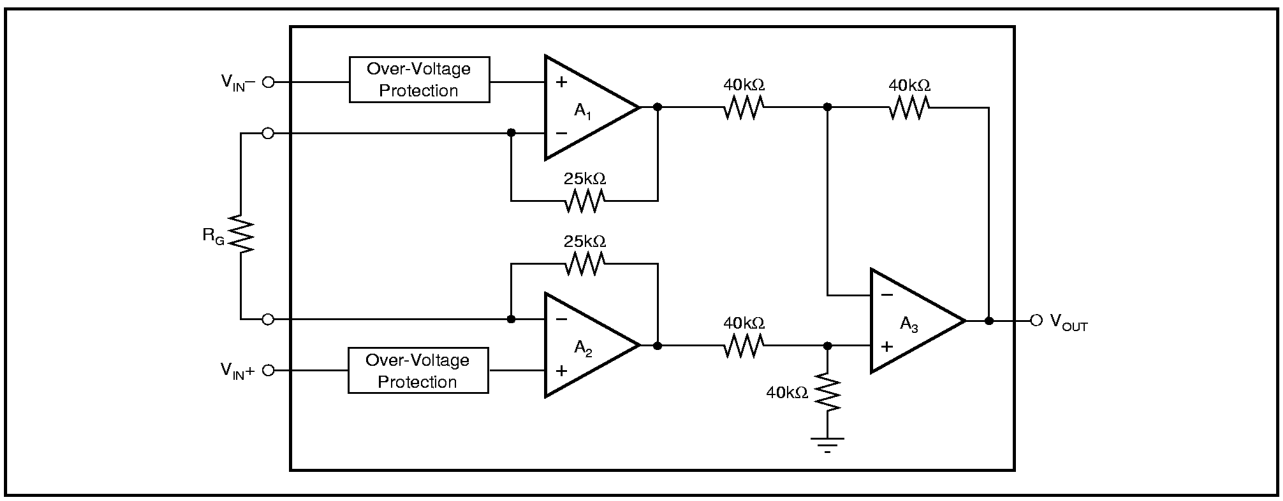


FIGURE 3. Simplified Schematic of the Instrumentation Amplifiers. Resistor RG Controls the Gain.



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limit this range when a differential input voltage causes the output voltage to increase. Thus, the linear common-mode range relates to the output voltage of the complete amplifier. This behavior also depends in supply voltage—see performance curve "Input Common-Mode Range vs Output Voltage."

The combination of a significant differential signal and a high common-mode voltage as occurs in the current feedback configuration reduces the common-mode range. Exceeding the common-mode range results in a reduced IA output voltage. When this occurs the feedback loop can no longer balance. The forward gain of the ALD1000 amplifies this false error signal, the output voltage tries to increase, and this holds the IA in an overloaded condition.

The ALD1000 applies two defenses against this problem. First, there is a 100Ω resistor in series with the transmitter output. This resistor, which primarily provides protection from over-voltage damage to the output terminal, acts to limit the output swing under high current conditions. Second, the ALD1000's error detection circuitry signals when the transmitter output voltage exceeds rating. This serves to detect a potential lock condition.

Limiting the transmitter's output swing to within the instrumentation amplifier's input range allows the loop to recover without reducing the input signal should a transient voltage level exceed the common-mode input range. However, the common-mode range of the instrumentation amplifiers varies with application specific factors. Lock-up can occur. The application designer must provide defenses against this condition where it is warranted.

### USING THE INSTRUMENTATION AMPLIFIERS WITH A FLOATING SIGNAL SOURCE

The input impedance of the ALD1000 instrumentation amplifiers are very high—about $10^6\Omega$. Within a feedback loop, as shown in the examples, this characteristic acts to minimize errors caused by loading of the feedback signal. However, if used as an amplifier for a thermocouple, microphone, or other isolated signal source a path is needed for the input bias current. This current is nominally about 100nA. Without a return path the inputs will float to a potential that exceeds the common-mode range of the amplifier. See Figure 10.

## LOOP STABILITY

The stability of a closed loop system such as the intended application of the ALD1000 requires adequate phase margin. In contrast, excessive phase margin will reduce the circuit's transient response to fast changing signals. It is the intent of this section to give an insight into how the ALD1000 circuits blocks affect dynamic performance. Selection of the loop architecture and compensation can then be done empirically.

### LOOP STABILITY AND THE XTR

There are two critical parameters that must be controlled to insure adequate transient response and loop stability: loop gain and phase. Together loop gain and phase set the phase margin which defines dynamic performance.

Loop gain is the product of the forward voltage to current ratio, the load impedance, and the IA gain. The input error voltage is converted to an output current. The output current is converted to a feedback voltage by the load impedance. The feedback voltage is gained up by the feedback IA. All three blocks affect loop stability.

The XTR gain resistor, which is connected to the E pin of the ALD1000, adjusts the voltage to current relationship. Increasing this resistor decreases loop gain. This, in turn, increases phase margin and slows step response. This resistor will typically be between 250Ω and 2500Ω.

In a voltage feedback loop the frequency at which the loop gain starts to roll off decreases with increasing capacitance. It is necessary to compensate for the loss of bandwidth caused by load capacitance. The compensation network provides this capability. Typical performance curve "Compensation Capacitor vs Load Capacitance" illustrates typical compensation capacitor values for load capacitance varying from 1pf to 1µf. Exact capacitor values will vary with the load resistance, the XTR gain resistor value, IA gain, and variability of the open loop gain of the ALD1000 SWOP amp. This curve provides a starting point for empirical selection of the compensation capacitor value.

The effect described above is much less significant with a current feedback loop since the shunt resistor's capacitance can be easily controlled. The current feedback loop will be more robust when load conditions are unknown or varying.

### LOOP STABILITY AND THE INSTRUMENTATION AMPLIFIERS

The frequency characteristics and gain of the instrumentation amplifiers affect loop stability when they are used in a feedback loop. There are two main contributions. First, the IA gain directly multiplies loop gain. As a result high IA gains reduce phase margin. Second, when the input exceeds the IA range the IA output can no longer provide the necessary feedback. This can result in a lock condition. Both of these situations are discussed further below.

### LOOP GAIN AND THE INSTRUMENTATION AMPLIFIERS

The ALD1000 is designed for use in a feedback loop. When one of the instrumentation amplifiers is used as the feedback amplifier its gain directly contributes to loop gain. The loop can become unstable if the loop gain is too large. Conversely, it may be possible to stabilize a difficult loop by reducing the gain of the IA.

Refer to Figure 4. In this circuit the ALD1000 is configured in a current loop with a 50Ω shunt resistor. A 20ma full scale current through the 50Ω shunt results in a 1V feedback signal. The IA must remove the common-mode level from the shunt voltage and scale the resulting differential signal up to the input signal level.



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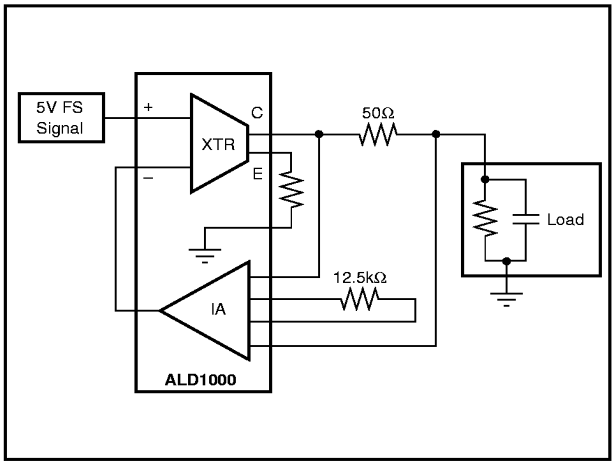


FIGURE 4. Simplified Block Diagram of a 20ma Current Loop. The IA is in a Gain of 5 to Match the 1V Full Scale Shunt Signal to the 5V Full Scale Input Signal.

Here the input signal affects loop stability. A 10V full scale input signal would require an IA gain of 10. A lower input signal, 5V as shown in Figure 4, allows the IA gain to be reduced to 5. This results in a lower loop gain and increased phase margin.

Note that it is possible to reduce the IA gain to less than 1 by using a voltage divider at the IA output.

### VOLTAGE FEEDBACK AND THE INSTRUMENTATION AMPLIFIERS

The instrumentation amplifiers can be used for remote sensing in a voltage feedback loop as illustrated in Figure 5. Here the instrumentation amplifier tends to reject small ground potential differences between the source and load. The voltage loop, however, is more sensitive to reactive load impedance than the current loop. The ALD1000 emitter resistor and compensation capacitor need to be selected for the specific load conditions. Voltage feedback may not be appropriate for variable load conditions.

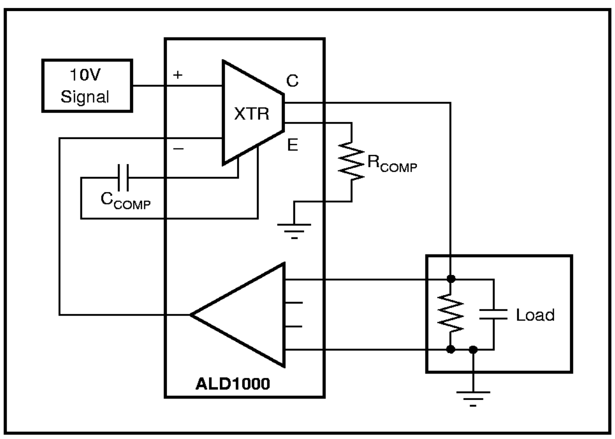


FIGURE 5. Simplified Block Diagram of the ALD1000 in Voltage Feedback.

## USING THE ALD1000 WITH EXTERNAL DRIVE TRANSISTORS

Power dissipated by the internal driver stage affects the built-in instrumentation amplifiers compromising their accuracy. External transistors reduce the internal power dissapation.

The external transistors are configured as current sources. A PNP transistor delivers positive current. An NPN supplies the negative drive. Either or both can be used. For example a 4ma to 20ma current loop may only require a PNP transistor since negative current drive is not required. See Figure 9.

Degeneration resistors are required (refer to $R_1$ and $R_2$ in Figure 6). The value of the degeneration resistors will affect stability, load sharing with the internal driver devices, and the current limit value. These issues are covered in more detail below.

### EXTERNAL TRANSISTORS AND THE CURRENT LIMIT VALUE

The ALD1000 contains circuitry to prevent damage to the internal components due to excess current. When using the internal driver stage by itself, current to the load is limited to about 20ma at room temperature. When using external drivers, the current limit depends, approximately, on the load sharing ratio between the internal and external transistors. Figure 6 illustrates the circuit relationship between the current limit circuitry and external drive transistors.

### THE DEGENERATION RESISTORS

The degeneration resistors, $R_1$ and $R_2$ in Figure 6, control the load sharing between the internal and external transistors. Choose the resistor values by measuring load current, current through the external transistor, and calculating the current being supplied by the internal drive.

### LOOP STABILITY AND THE DEGENERATION RESISTORS

Loop stability depends on loop gain. Because the degeneration resistors affect the voltage to current ratio of the loop the value of these resistors also affect loop gain and thus stability. Smaller resistor values will increase loop gain. It may be necessary to compensate for this by adjusting the value of the XTR gain resistor connected to the E Pin, $R_4$ in Figure 6.

### EXTERNAL TRANSISTORS AND OUTPUT VOLTAGE SWING

The output voltage swing must be limited within the input range of the instrumentation amplifiers. The 100Ω resistor shown in Figure 6 limits output swing under high current conditions. Resistor $R_3$ performs this function with external transistors. $R_3$ must be sized to limit output swing, at the expected full load, within the input range of the instrumentation amplifiers. Refer to the section on the instrumentation amplifiers for further information.



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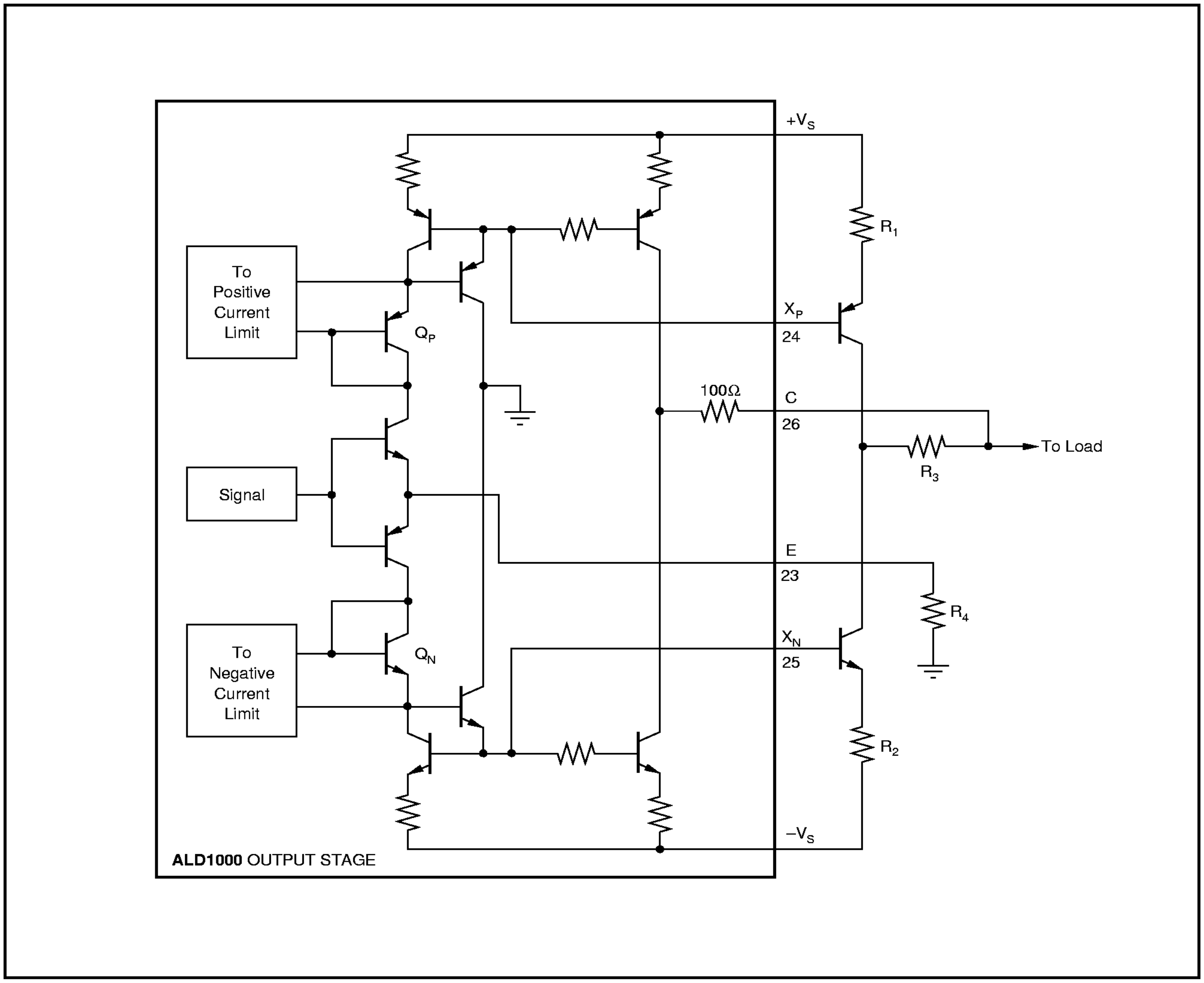


FIGURE 6. Simplified Schematic Showing the Use of External Drive Transistors. $R_1$ and $R_2$ Provide Degeneration that Affects the Current Limit and Loop Stability. $R_4$ Controls the Transconductance Amplifier Gain Affecting Loop Stability and Transient Response. See the Text.



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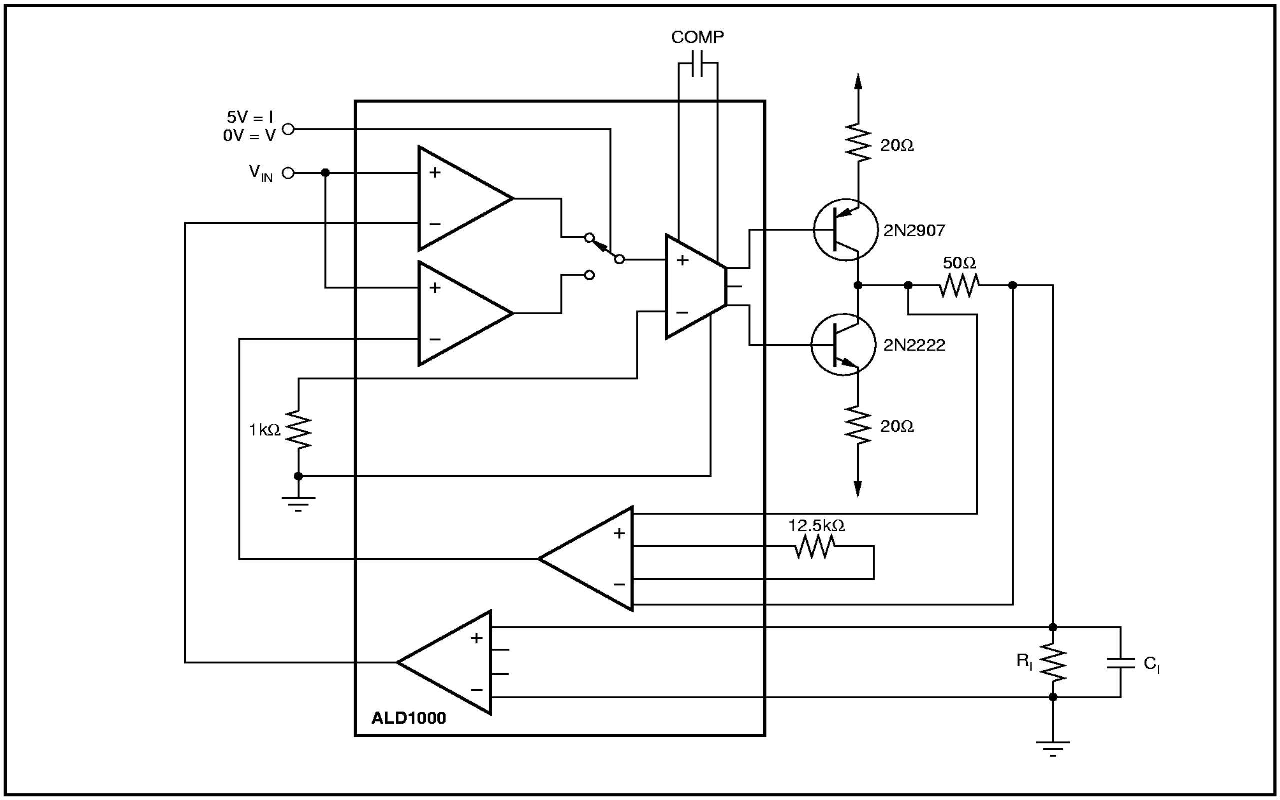


FIGURE 7. Using External Transistors Without Internal Drive. Note that an Overvoltage Condition Can Not Be Detected.

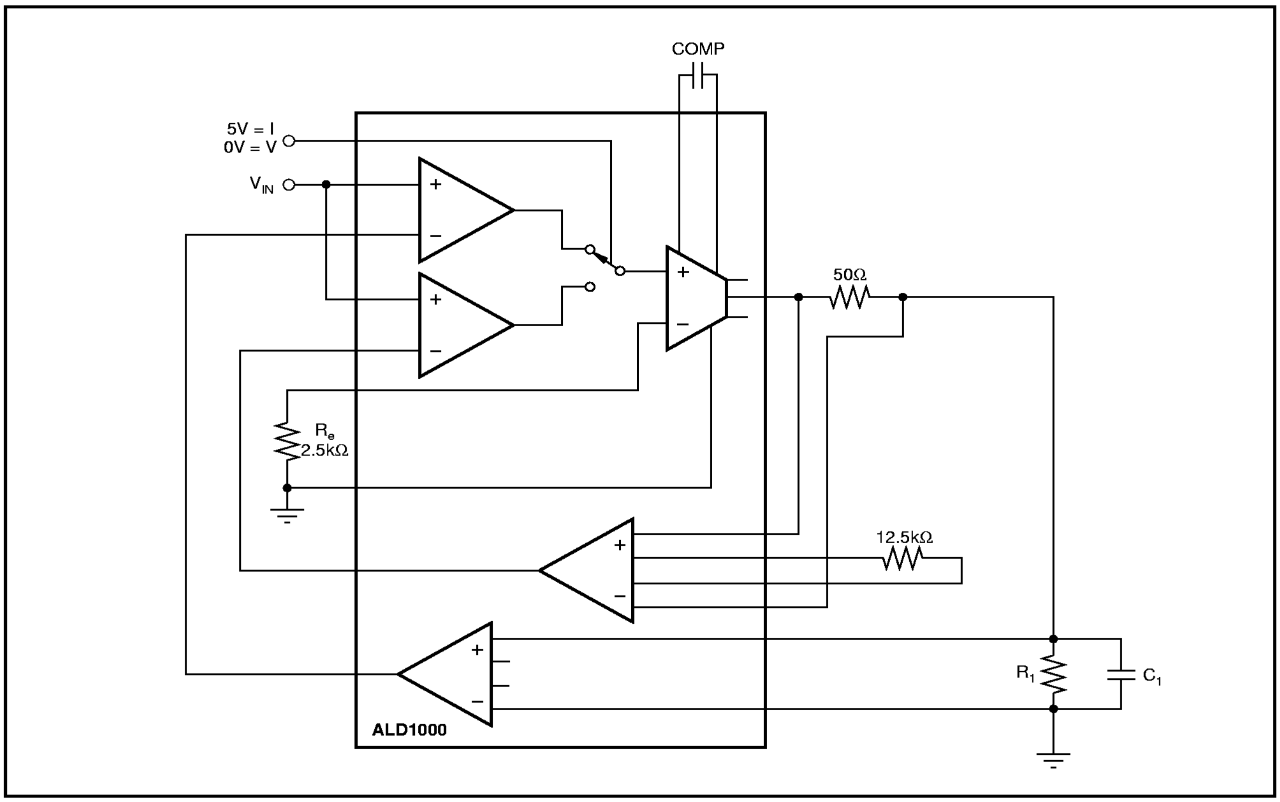


FIGURE 8.Using Internal Drive Transistors.



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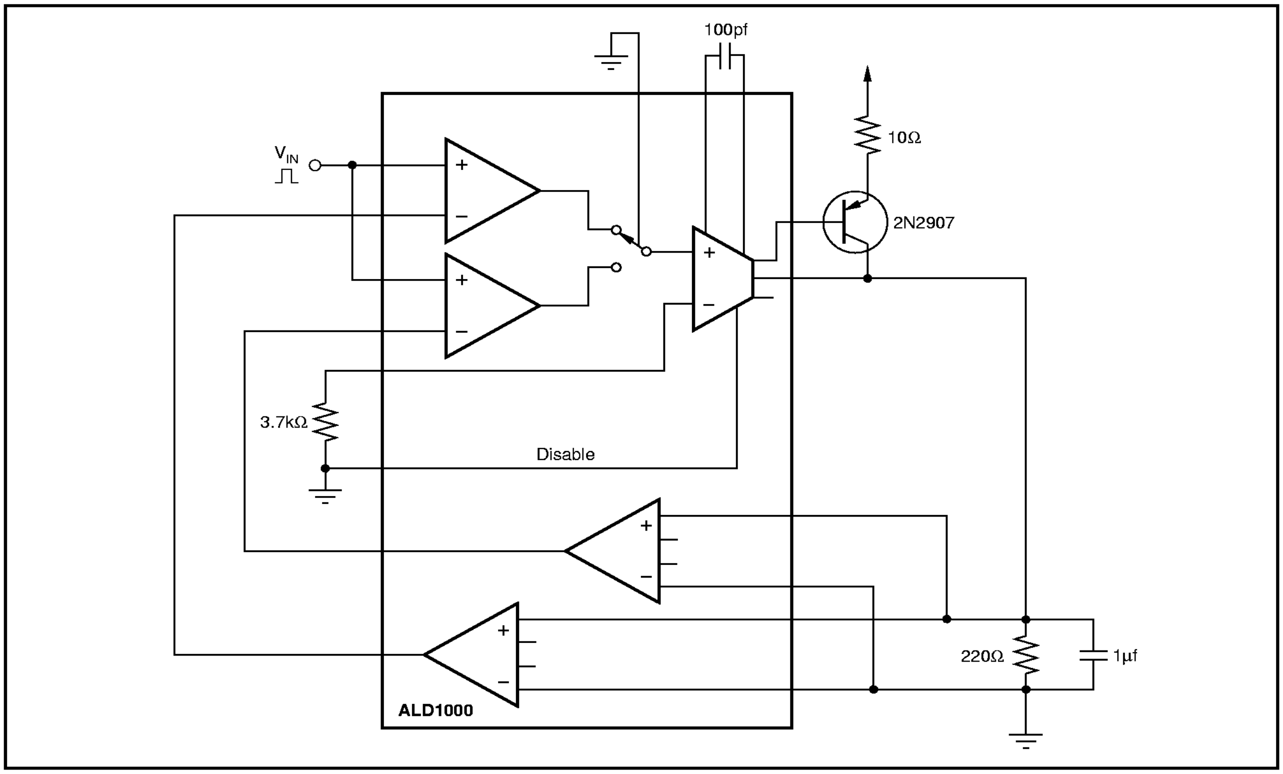


FIGURE 9. Sharing Load Between Internal Drive Transistors and Positive External Drive Transistors to Increase Load Capacity. A Similiar Configuration is Possible with the Negative External Drive Transistor.

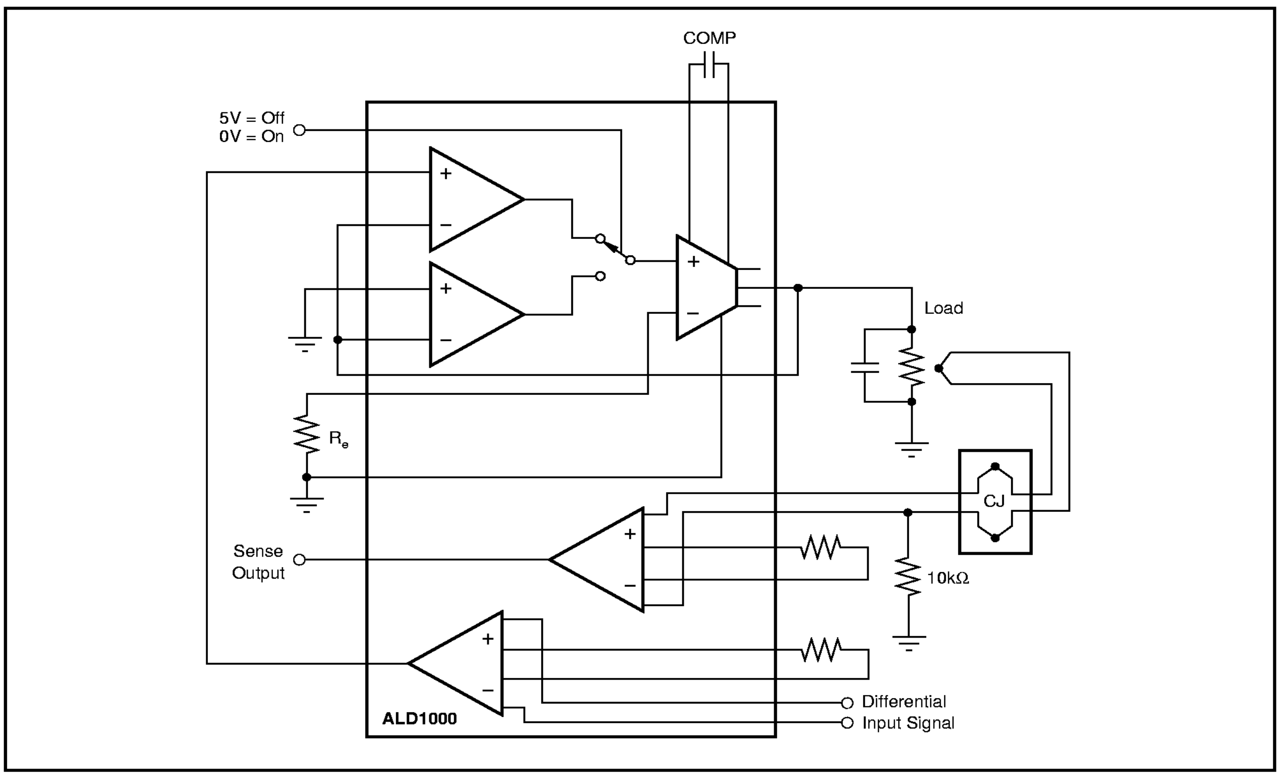


FIGURE 10. Showing Flexibility in Application: Using Direct Voltage Feedback to Free Both IAs; Using an IA as a Differential Input; Using a Grounded Input to Provide an Off State; Providing a Ground Path for Bias Current With a Thermocouple.




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