EVALUATION KIT FOR PA21 PIN-OUT

EK21

APEX MICROTECHNOLOGY CORPORATION • TUCSON, ARIZONA • APPLICATIONS HOTLINE (800) 546-APEX

INTRODUCTION

This easy-to-use kit provides a platform for the evaluation of power op amps that use the PA21 pin-out configuration. It can be used to analyze a multitude of standard or proprietary circuit configurations. In addition, it is flexible enough to do most standard amplifier test configurations.

The schematic for 1/2 of the PC board is shown in Figure 2. The schematic for the other half is identical except part reference designators are primed (i.e. R1 = R1'). Note that all of the components shown on the schematic will probably not be used for any single circuit. The component locations on the PC board (See Figure 3) provide maximum flexibility for a variety of configurations. Also included are loops for current probes as well as connection pads on the edge of the PC board for easy interconnects.

The hardware required to mount the PC board and the device under evaluation to the heatsink are included in the kit. Because of the limitless combination of configurations and component values that can be used, no other parts are included in this kit. However, generic formulas and guidelines are included in the APEX HYBRID & IC HANDBOOK and this evaluation kit documentation.

ASSEMBLY HINTS

The mating sockets included with this kit have recessed nut sockets for mounting the device under evaluation. This allows assembly from one side of the heatsink, making it easy to swap devices under evaluation. The sizes of the stand-offs were selected to allow proper spacing of the board-to-heatsink and allow enough height for components when the assembly is inverted.

PARTS LIST

Part #	Description	Quantity
HS11	Heatsink	1
EK21PC	PC Board	1
MS03	Mating Socket	2
HWRE01	Hardware Kit	1

HWRE01 contains the following:

4	#8 Panhead Screw	4	#6 x 1.25" Panhead Screw
4	#8 .375" Hex Spacer	4	#6 x 5/16" Hex Nut
4	#8 1.00" Hex Stand Off	2	#6 x 1/4" Hex Nut

ASSEMBLY

1. Insert a #6 x 5/16" hex nut in each of the nut socket recesses located on the bottom of the mating socket.
2. Insert the socket into the pc board until it is firmly pressed against the ground plane side of the pc board.
3. Solder the socket in place (see Figure 1). Be sure the nuts are in the recesses prior to soldering.
4. Mount the PC board assembly to the heatsink using the stand-offs and spacers included.
5. Apply thermal grease to the bottom of the device under evaluation. Insert into the mating socket through the heatsink.
6. Use the #6 x 1.25" panhead screws to mount the amplifier to the heat sink. Do not overtorque. Recommended mounting torque is 4-7 in-lbs (.45-.79 N•M).

Mounting precautions, general operating considerations, and heatsinking information may be found in the APEX HYBRID & IC HANDBOOK.

NOTE: Refer to HS11 Heatsink note on page 3.

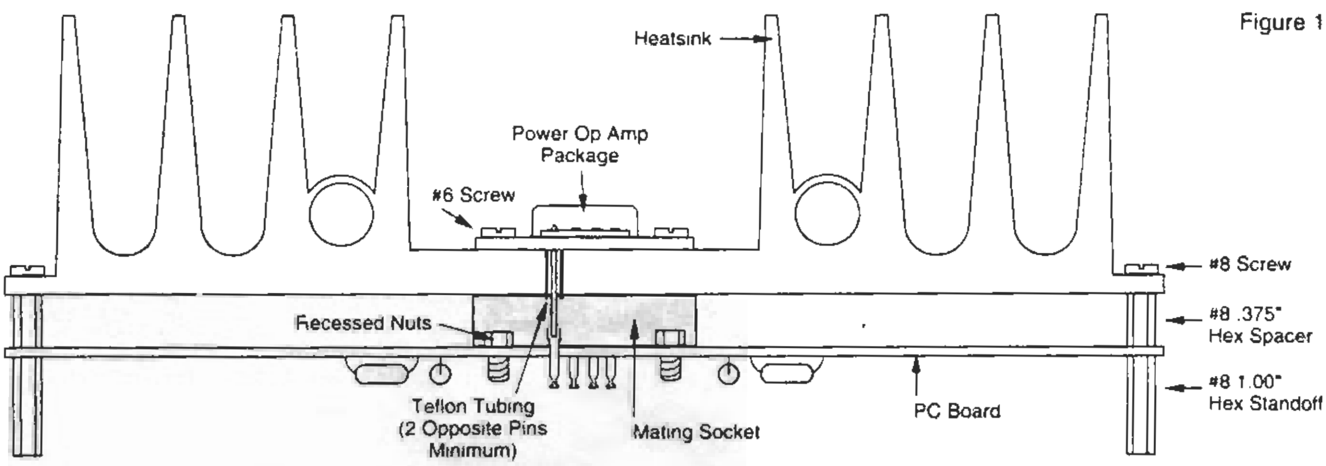


Figure 1

BEFORE YOU GET STARTED

- All Apex amplifiers should be handled using proper ESD precautions!
- Initially set all power supplies to the minimum operating levels allowed in the device data sheet.
- Check for oscillations.
- Always use the heatsink included in this kit with thermal grease and torque the part to the specified 4-7 in-lbs (.45-.79 N•M).
- Do not change connections while the circuit is under power.
- Never exceed any of the absolute maximums listed in the device data sheet.
- Always use adequate power supply bypassing.
- Remember that internal power does not equal load power.
- Do not count on internal diodes to protect the output against sustained, high frequency, high energy kickback pulses.

Figure 2

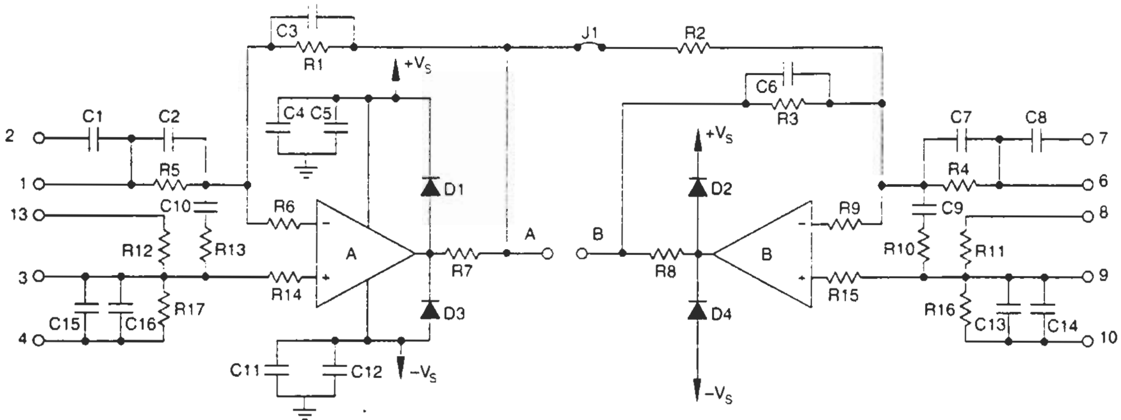
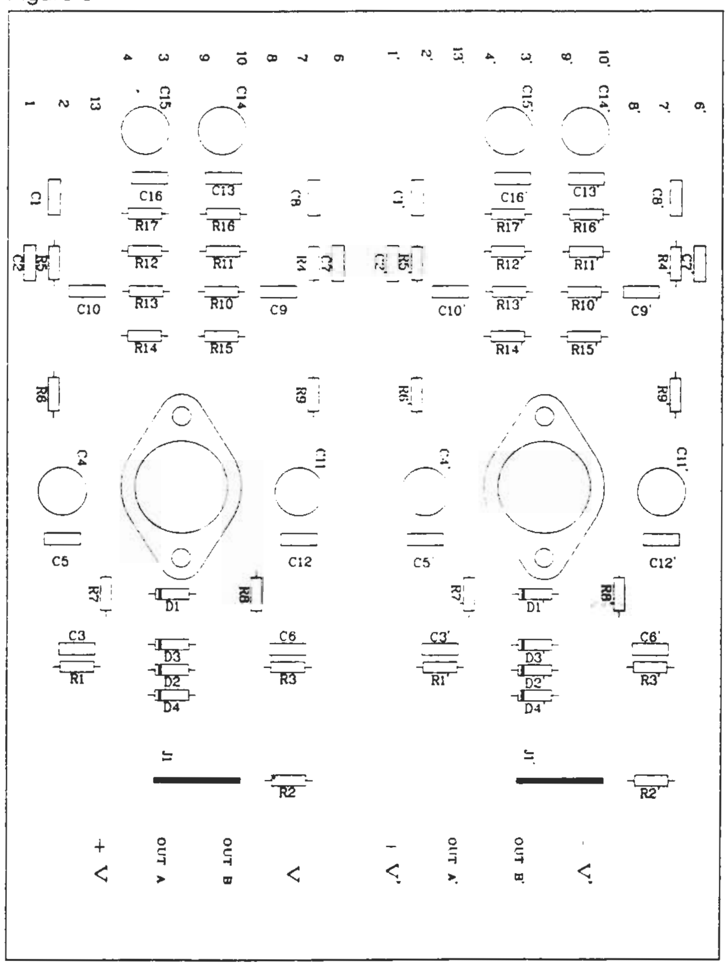


Figure 3



TYPICAL COMPONENT FUNCTIONS

COMPONENT	FUNCTION
R1	Feedback resistor, A side
R2	Input resistor, B side, bridge mode
R3	Feedback resistor, B side
R4	Input resistor, B side
R5	Input resistor, A side
R6	Input bias current measurement (Note 4)
R7	Output current sense resistor or loop for current probe
R8	Output current sense resistor or loop for current probe
R9	Input bias current measurement (Note 4)
R10	Noise gain compensation (Note 1)
R11	Resistor divider network for single supply bias (Note 2)
R12	Resistor divider network for single supply bias (Note 2)
R13	Noise gain compensation (Note 1)
R14	Input bias current measurement
R15	Input bias current measurement
R16	Resistor divider network for single supply bias (Note 2)
R17	Resistor divider network for single supply bias (Note 2)
C1	Input coupling
C2	AC gain set
C3	AC gain or stability (Note 1)
C4	Power supply bypass
C5	Power supply bypass
C6	AC gain or stability (Note 1)
C7	AC gain set
C8	Input coupling
C9	Noise gain compensation (Note 1)
C10	Noise gain compensation (Note 1)
C11	Power supply bypass (Note 3)
C12	Power supply bypass (Note 3)
D1,2,3,4	Flyback protection (Note 5)
C13-16	Bias node noise bypass (Note 2)

NOTES: Refer to the following sections of the APEX HYBRID & IC HANDBOOK as noted.

1. See Stability section of "General Operating Considerations."
2. See "Gen. Operating Considerations," and AN3 "Bridge Circuit Drives."
3. See Power Supplies section of "General Operating Considerations."
4. See "Parameter Definitions and Test Methods."
5. See Amplifier Protection section of "Gen. Operating Considerations."

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BRIDGE MODE OPERATION

There are two types of bridge mode operation that will be covered in this section: dual (or split) supply and single supply. The PA21 is well suited for both types of bridge mode operation. If another vendor's pin compatible part is to be compared to the PA21. a close look at output swing and input common mode range is in order. The features that make the PA21 an excellent choice for bridge operation are not included in most other amplifiers. A lack of common mode range may cause permanent damage to other pin compatible parts and the inability of other amplifiers to swing close to the supply rails may cause a lack of available output voltage at the load as well as increase internal dissipation.

The circuit shown in Figure 4 is a dual supply bridge using the "master-slave" configuration. Resistors R 6,7,8,9,14,15 and J1 should be shorts. The available output voltage swing is Vss–(2*Vsat). If operating a PA21A at 3 Amps and 30 Volts total supply this translates to:

$$V_{AB}(max) = 30-(2*3.5) = 23$$

Of course this 23 volts may be applied in either direction across the load. To set the gain of the circuit you must determine the desired voltage across the load at Vin = full scale. Inserting these values into the following equation will yield the ratio of R1 to R5.

$$(V_{AB}/(2*Vin)) = R1/R5$$

The values of R 1,2,3, and 5 should be chosen such that input bias current will not cause an error voltage that is unacceptable. Set R2

Figure 4
Dual Supply Bridge

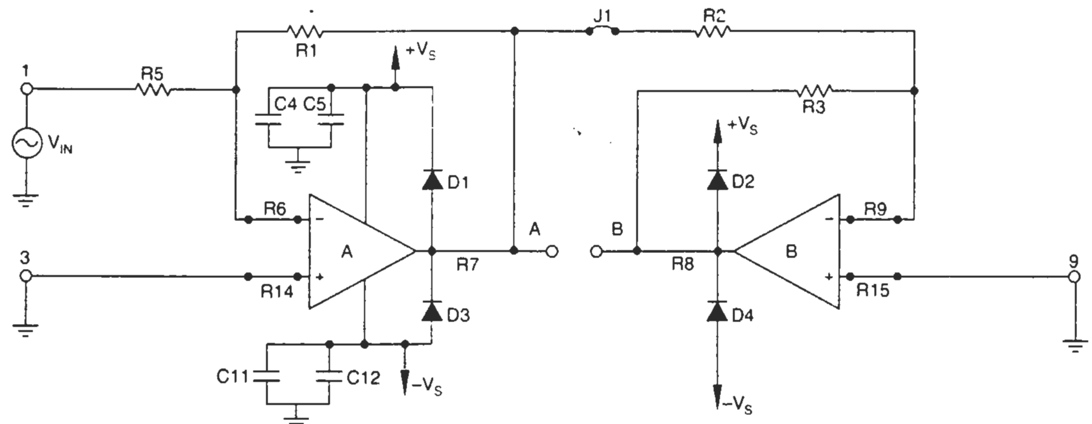
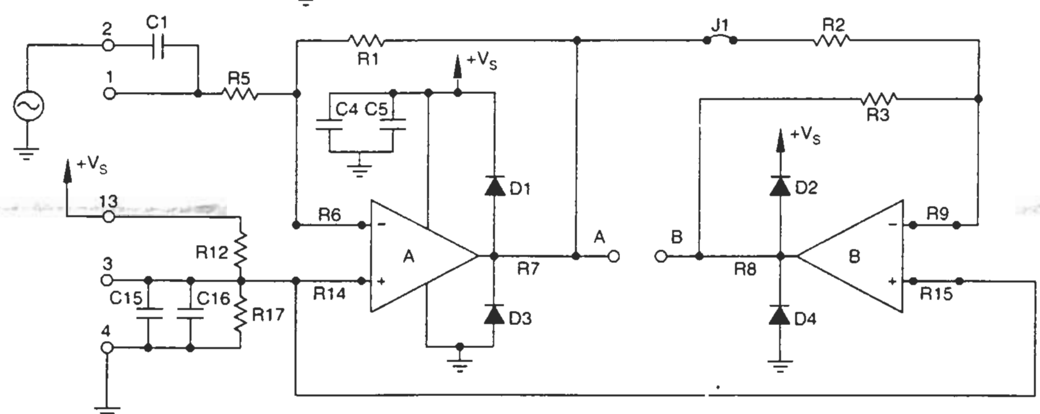


Figure 5
Single Supply Bridge



equal to R3 to configure the slave amplifier as a unity gain inverter.

Figure 5 shows a typical single supply bridge circuit for an AC coupled input signal. DC coupled inputs may require a different topology to accommodate proper gain and offset terms for a desired transfer function.

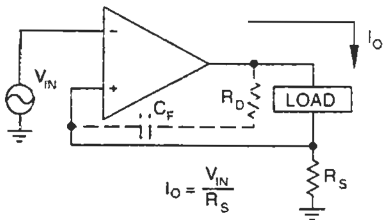
The gain and output voltage capability for the single supply bridge are determined the same way as the dual supply bridge (see AN#2). The difference is the bias requirement for the slave amplifier. The noninverting input of the slave amplifier should be biased at mid supply, and must be bypassed.

HS11 HEATSINK NOTE

The HS11 Heatsink is provided in this evaluation kit to **guarantee** adequate **thermal** design through heat removal from the part under evaluation. Once maximum power dissipation for the application is determined (refer to "General Operating Considerations" and Application Note 11 in the APEX HYBRID & IC HANDBOOK), the final mechanical design will probably require substantially less heatsinking.

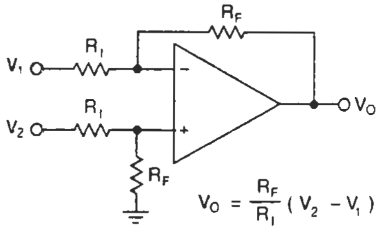
APEX MICROTECHNOLOGY makes no representation that the use or interconnection of the circuits described herein will not infringe on existing or future patent rights, nor do the descriptions contained herein imply the granting of licenses to make, use or sell equipment constructed in accordance therewith.

VOLTAGE-TO-CURRENT CONVERSION
NON-INVERTING CONFIGURATION



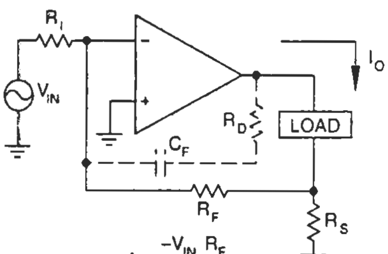
$I_O = \frac{V_{IN}}{R_S}$

DIFFERENCE AMPLIFIER



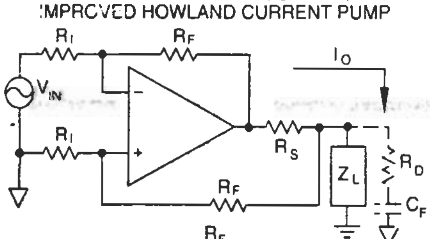
$V_O = \frac{R_F}{R_I}(V_2 - V_1)$

VOLTAGE-TO-CURRENT CONVERSION
INVERTING CONFIGURATION



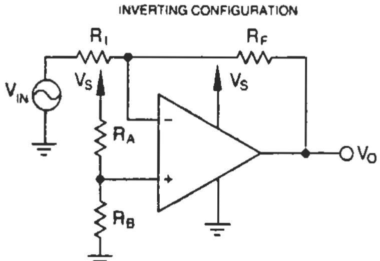
$I_O = \frac{-V_{IN} R_F}{R_S R_I}$

VOLTAGE-TO-CURRENT CONVERSION
IMPROVED HOWLAND CURRENT PUMP



$I_O = -V_{IN}\frac{R_F}{R_I R_S}$

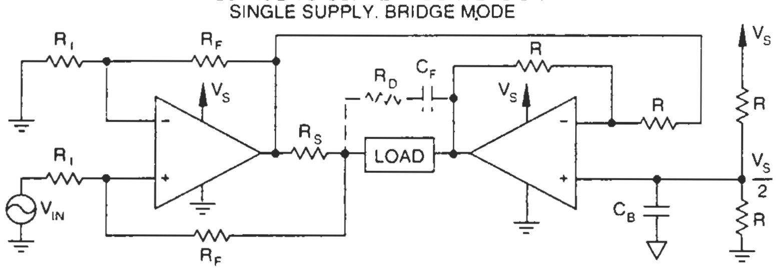
SINGLE SUPPLY OPERATION
INVERTING CONFIGURATION



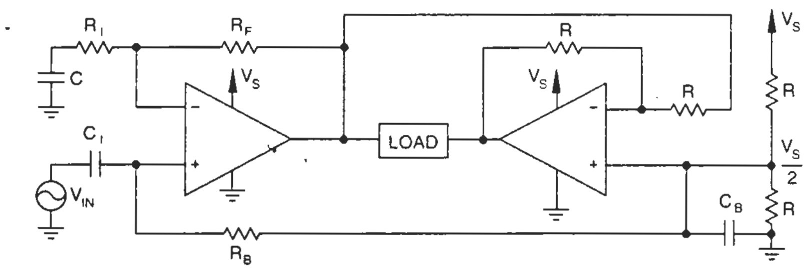
$V_O\ (\text{Bias}) = \left(\frac{V_S\ R_B}{R_A + R_B}\right)\left(1 + \frac{R_F}{R_I}\right)$

$V_O\ (\text{Signal}) = V_{IN}\left(-\frac{R_F}{R_I}\right)$

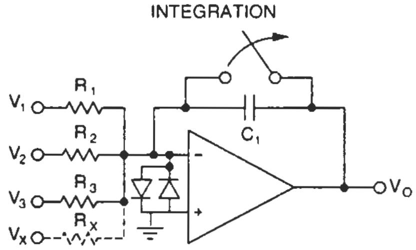
VOLTAGE-TO-CURRENT CONVERSION
SINGLE SUPPLY, BRIDGE MODE



VOLTAGE FOLLOWER WITH GAIN
SINGLE SUPPLY, BRIDGE MODE

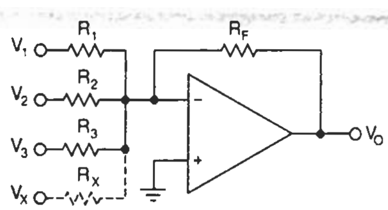


INTEGRATION



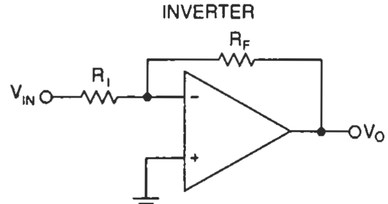
$V_O = \frac{T}{C_1}\int_0^T \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_X}{R_X}\right)dt$

SUMMING / SCALING



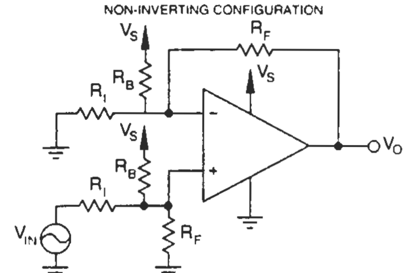
$V_O = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_X}{R_X}\right)$

INVERTER



$V_O = -\left(\frac{R_F}{R_I}\right)V_{IN}$

SINGLE SUPPLY
NON-INVERTING CONFIGURATION



i) $V_O = \frac{R_F}{R_I}$

ii) For $V_{IN} = 0$

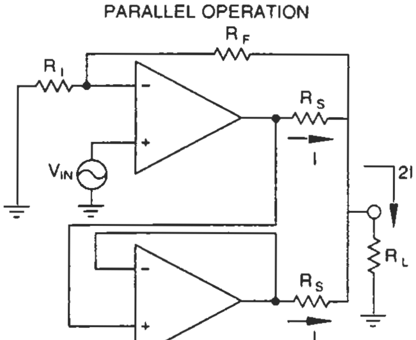
$V_{CM} = \frac{V_S\ (R_I // R_F)}{R_B + (R_I // R_F)}$

iii) $V_{CM\Delta} = \frac{V_{IN}\ (R_B // R_F)}{R_I + (R_B // R_F)}$

iv) For $V_{IN} > 0$

$V_{CM} = V_{CM}\ @\ V_{IN} = 0 + V_{CM\Delta}$

PARALLEL OPERATION



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APEX® μtech

POWER DUAL OPERATIONAL AMPLIFIERS

PA21/25/26 • PA21A/25A

APEX MICROTECHNOLOGY CORPORATION • APPLICATIONS HOTLINE 800 546-APEX (800-546-2739)

FEATURES

- LOW COST
- WIDE COMMON MODE RANGE — Includes negative supply
- WIDE SUPPLY VOLTAGE RANGE
  - Single supply: 5V to 40V
  - Split supplies: ±2.5V to ±20V
- HIGH EFFICIENCY — $|V_s - 2.2V|$ at 2.5A typ
- HIGH OUTPUT CURRENT — 3A min (PA21A)
- INTERNAL CURRENT LIMIT
- LOW DISTORTION

APPLICATIONS

- HALF & FULL BRIDGE MOTOR DRIVERS
- AUDIO POWER AMPLIFIER
  - STEREO — 30W RMS per channel
  - BRIDGE — 60W RMS per package
- IDEAL FOR SINGLE SUPPLY SYSTEMS
  - 5V — Peripherals
  - 12V — Automotive
  - 28V — Avionic

DESCRIPTION

The amplifiers consist of a monolithic dual power op amp in a 8-pin hermetic TO-3 package (PA21 and PA25) and a 12-pin SIP package (PA26). Putting two power op amps in one package and on one die results in an extremely cost effective solution for applications requiring multiple amplifiers per board or bridge mode configurations.

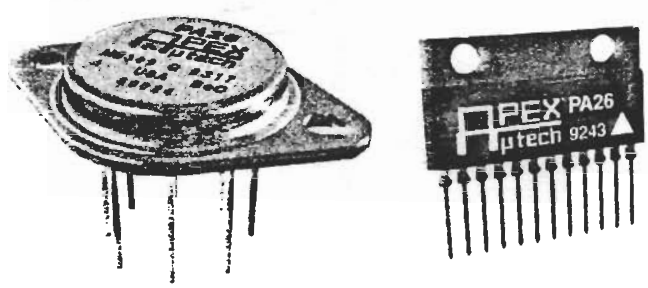
The wide common mode input range includes the negative rail, facilitating single supply applications. It is possible to have a "ground based" input driving a single supply amplifier with ground acting as the "second" or "bottom" supply of the amplifier.

The output stages are also well protected. They possess internal current limit circuits. While the device is well protected, the Safe Operating Area (SOA) curve must be observed. Proper heatsinking is required for maximum reliability.

This hybrid integrated circuit utilizes thick film (cermet) resistors, ceramic capacitors and semiconductor chips to maximize reliability, minimize size and give top performance. Ultrasonically bonded aluminum wires provide reliable interconnections at all operating temperatures. The 8-pin TO-3 package is hermetically sealed and electrically isolated. The use of compressible isolation washers voids the warranty. The tab of the SIP12 plastic package is tied to $-V_S$.

TYPICAL APPLICATION

R1 and R2 set up amplifier A in a non-inverting gain of 2.8. Amp B is set up as a unity gain inverter driven from the output of amp A. Note that amp B inverts signals about the reference node, which is set at mid-supply (14V) by R5 and R6. When the command input is 5V, the output of amp A is 14V. Since this is equal to the reference node voltage, the output of amp B is also 14V, resulting in 0V across the motor. Inputs more positive than 5V result in motor current flow from left to right (see Figure 1). Inputs less positive than 5V drive the motor in the opposite direction.



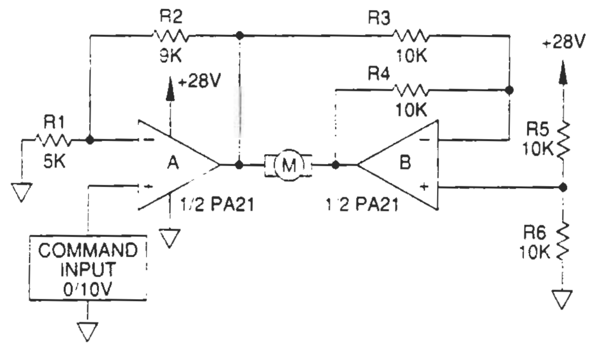


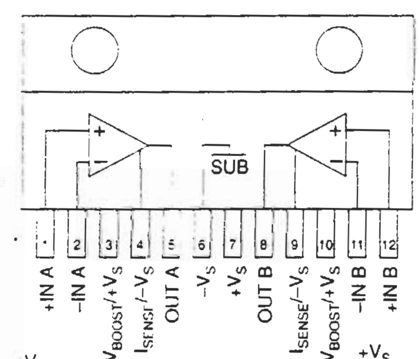
FIGURE 1: BIDIRECTIONAL SPEED CONTROL FROM A SINGLE SUPPLY

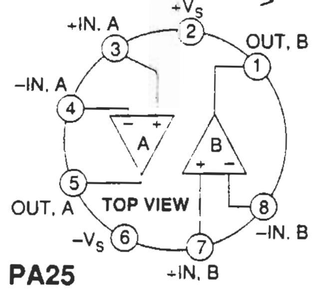
The amplifiers are especially well-suited for this application. The extended common mode range allows command inputs as low as 0V. Its superior output swing abilities let it drive within 2V of supply at an output current of 2A. This means that a command input that ranges from 0V to 10V will drive a 24V motor from full scale CCW to full scale CW at up to ±2A. A single power op amp with an output swing capability of Vs –6 would require ±30V supplies and would be required to swing 48V p-p at twice the speed to deliver an equivalent drive.

EXTERNAL CONNECTIONS

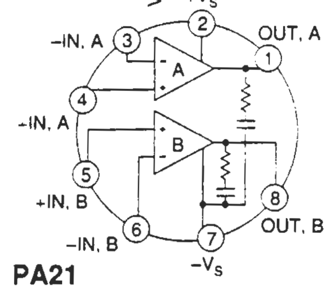
PA26

Connect pins 3 and 10 to pin 7 and connect pins 4 and 9 to pin 6 unless special functions are required.





PA25



PA21

ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, total	5V to 40V
OUTPUT CURRENT	SOA
POWER DISSIPATION, internal (per amplifier)	25W
POWER DISSIPATION, internal (both amplifiers)	36W
INPUT VOLTAGE, differential	$\pm V_S$
INPUT VOLTAGE, common mode	$+V_S$, $-V_S-.5V$
JUNCTION TEMPERATURE, max[1]	150°C
TEMPERATURE, pin solder—10 sec max	300°C
TEMPERATURE RANGE, storage	–65°C to 150°C
OPERATING TEMPERATURE RANGE, case	–55°C to 125°C

SPECIFICATIONS

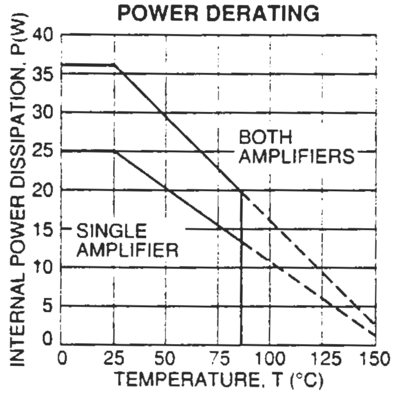
PARAMETER	TEST CONDITIONS[2]	PA21/25/26 MIN	PA21/25/26 TYP	PA21/25/26 MAX	PA21A/PA25A MIN	PA21A/PA25A TYP	PA21A/PA25A MAX	UNITS
INPUT								
OFFSET VOLTAGE, initial			1.5	10		.5	4	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		15			10		µV/°C
BIAS CURRENT, initial			35	1000		•	250	nA
COMMON MODE RANGE	Full temperature range	$-V_S-.3$		$+V_S-2$	•		•	V
COMMON MODE REJECTION, DC	Full temperature range	60	85		•	•		dB
POWER SUPPLY REJECTION	Full temperature range	60	80		•	•		dB
CHANNEL SEPARATION	I_{OUT} = 1A, F = 1kHz	50	68		•	•		dB
GAIN								
OPEN LOOP GAIN	Full temperature range	80	100		•	•		dB
GAIN BANDWIDTH PRODUCT	A_V = 40dB		600			•		kHz
PHASE MARGIN	Full temperature range		65			•		°
POWER BANDWIDTH	$V_{O(P-P)}$ = 28V		13.6			•		kHz
OUTPUT								
CURRENT, peak		2.5			3			A
CURRENT, limit			3.0			4.0		A
SLEW RATE		.5	1.2		•	•		V/µs
CAPACITIVE LOAD DRIVE	A_V = 1		.22			•		µF
VOLTAGE SWING	Full temp. range, I_O = 100mA	$\|V_S\|-1.0$	$\|V_S\|-0.8$		•	•		V
VOLTAGE SWING	Full temp. range, I_O = 1A	$\|V_S\|-1.8$	$\|V_S\|-1.3$		•	•		V
VOLTAGE SWING	I_O = 2.5A (PA21, 25)	$\|V_S\|-3.0$	$\|V_S\|-2.2$					V
VOLTAGE SWING	I_O = 3.0A (PA21A, PA25A)				$\|V_S\|-3.5$	$\|V_S\|-3$		V
POWER SUPPLY								
VOLTAGE, V_{SS}[3]		5[4]	30	40	•	•	•	V
CURRENT, quiescent, total			45	90		•	•	mA
THERMAL								
RESISTANCE, junction to case								
DC, single amplifier			5.0			•		°C/W
DC, both amplifiers[5]			3.4			•		°C/W
AC, single amplifier			3.7					°C/W
AC, both amplifiers[5]			2.4					°C/W
RESISTANCE, junction to air			30			•		°C/W
TEMPERATURE RANGE, case	Meets full range specifications	–25		85	–25		85	°C

NOTES:
- • The specification of PA21A/PA25A is identical to the specification for PA21/PA25 in applicable column to the left.
1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.
2. Unless otherwise noted, the following conditions apply: $\pm V_S = \pm 15V$, $T_C = 25°C$.
3. $+V_S$ and $-V_S$ denote the positive and negative supply rail respectively. V_{SS} denotes the total rail-to-rail supply voltage.
4. Current limit may not function properly below V_{SS} = 6V, however SOA violations are unlikely in this area.
5. Rating applies when power dissipation is equal in the two amplifiers.

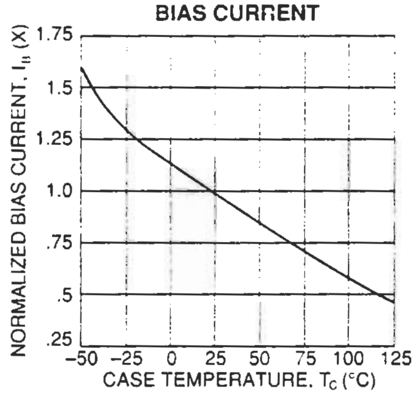
CAUTION The internal substrate contains beryllia (BeO). Do not break the seal. If accidentally broken, do not crush, machine, or subject to temperatures in excess of 850°C to avoid generating toxic fumes. (PA21 and PA25 only. PA26 does not contain BeO).

PA21/25/26 • PA21A/25A

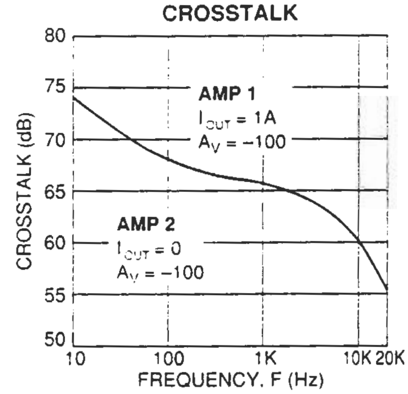
POWER DERATING



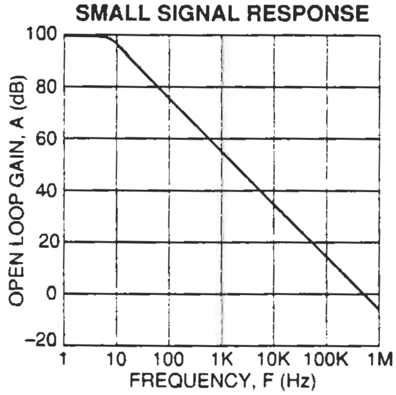
BIAS CURRENT



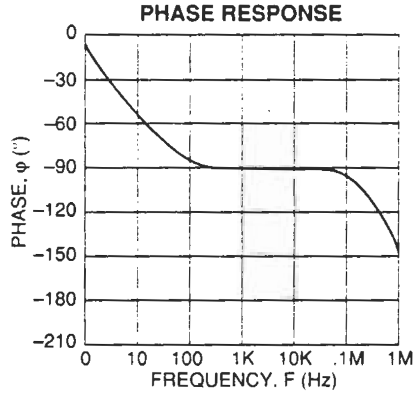
CROSSTALK



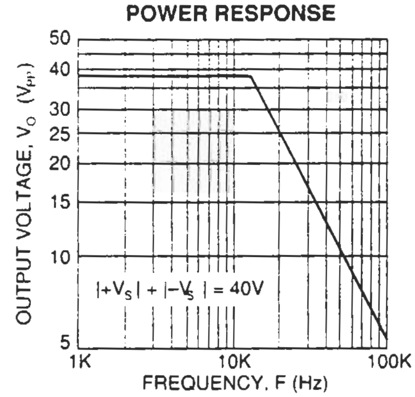
SMALL SIGNAL RESPONSE



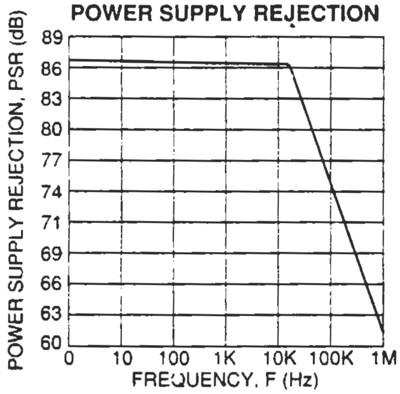
PHASE RESPONSE



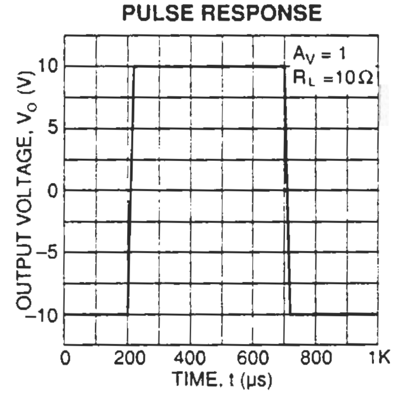
POWER RESPONSE



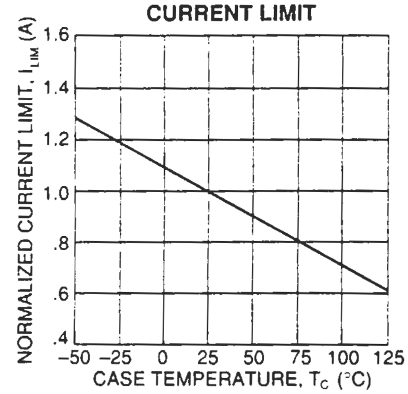
POWER SUPPLY REJECTION



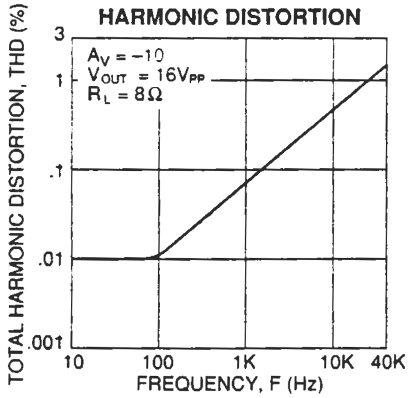
PULSE RESPONSE



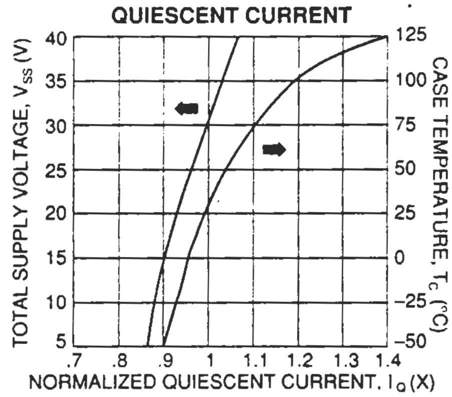
CURRENT LIMIT



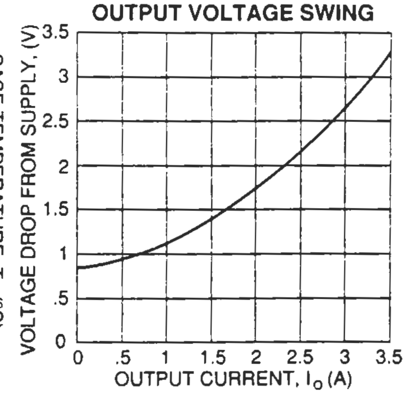
HARMONIC DISTORTION



QUIESCENT CURRENT



OUTPUT VOLTAGE SWING



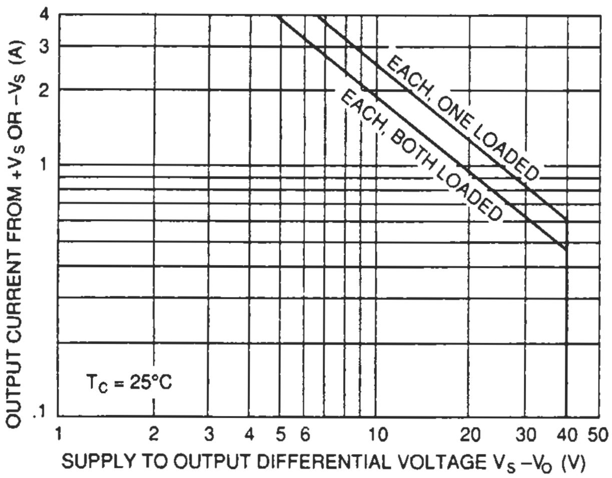
GENERAL

Please read the "General Operating Considerations" section, which covers stability, supplies, heatsinking, mounting, current limit, SOA interpretation, and specification interpretation. Additional information can be found in the application notes. For information on the package outline, heatsinks, and mounting hardware, consult the "Accessory and Package Mechanical Data" section of the handbook.

CURRENT LIMIT

Current limit is internal to the amplifier, the typical value is shown in the current limit specification.

SAFE OPERATING AREA (SOA)



The SOA curves combine the effect of all limits for this power op amp. For a given application, the direction and magnitude of the output current should be calculated or measured and checked against the SOA curves. This is simple for resistive loads but more complex for reactive and EMF generating loads. The following guidelines may save extensive analytical efforts.

Under transient conditions, capacitive and dynamic* inductive loads up to the following maximum are safe:

±Vs	CAPACITIVE LOAD	INDUCTIVE LOAD
20V	200µF	7.5mH
15V	500µF	25mH
10V	5mF	35mH
5V	50mF	150mH

* If the inductive load is driven near steady state conditions, allowing the output voltage to drop more than 6V below the supply rail while the amplifier is current limiting, the inductor should be capacitively coupled or the supply voltage must be lowered to meet SOA criteria.

NOTE: For protection against sustained, high energy flyback, external fast-recovery diodes should be used.

MONOLITHIC AMPLIFIER STABILITY CONSIDERATIONS

All monolithic power op amps use output stage topologies that present special stability problems. This is primarily due to non-complementary (both devices are NPN) output stages with a mismatch in gain and phase response for different polarities of output current. It is difficult for the op amp manufacturer to optimize compensation for all operating conditions.

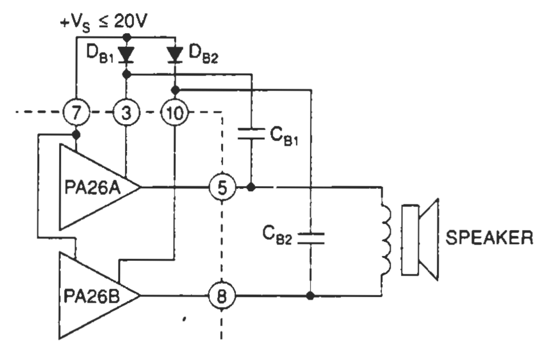
The recommended R-C network of 1 ohm in series with 0.1µF from output to AC common (ground or a supply rail, with adequate bypass capacitors) will prevent local output stage oscillations.

This network is provided internally on the PA21 but must be supplied externally on the PA25 and PA26. The amplifiers are internally compensated for unity gain stability, no additional compensation is required.

THERMAL CONSIDERATIONS

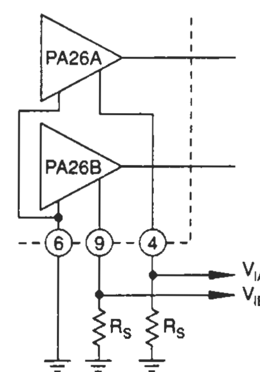
Although $R_{\theta JC}$ is the same for PA21/25/26 there are differences in the thermal interface between case and heatsink which will limit power dissipation capability. Thermal grease or an Apex TW03 thermal washer, $R_{\theta CS}$ = .1-.2°C/W, is the only recommended interface for the PA21/25. The PA26 will require a thermal washer which is electrically insulating since the tab is tied to $-V_S$. This can result in thermal impedances for $R_{\theta CS}$ of up to 1°C/W or greater.

ADDITIONAL PA26 PIN FUNCTIONS



Simple bootstrapping improves positive output swing. Connect pins 3 and 10 to V_S if not used. Typical currents are 12mA each.

Typical connection for current sense resistors. Connect pins 9 and 4 to pin 6 if not used.



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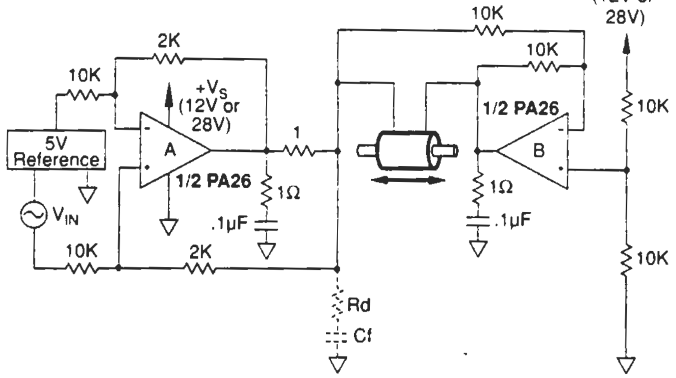
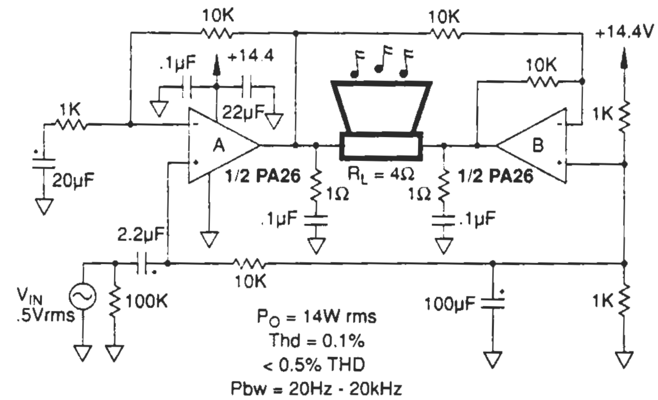
POWER DUAL OPERATIONAL AMPLIFIERS
PA21/25/26 DESIGN IDEAS

By Jerry Steele, Applications Engineer

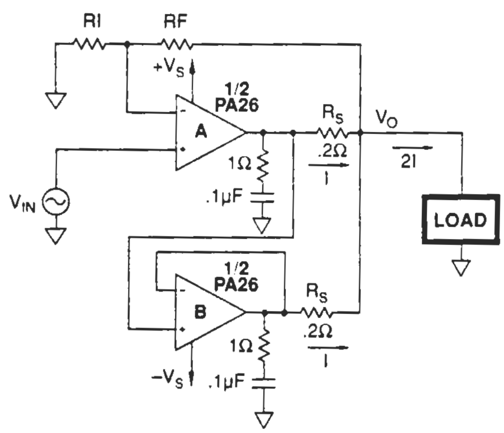
TYPICAL CIRCUITS:



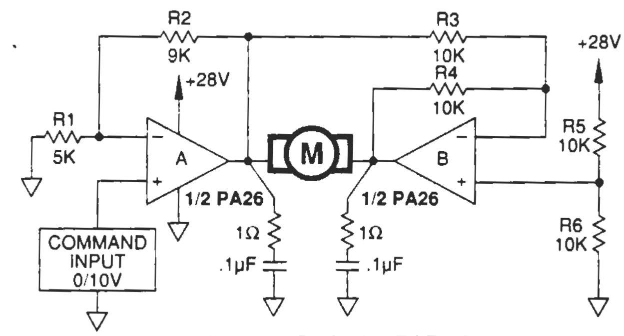
CURRENT CONTROL SOLENOID OR LINEAR ACTUATOR DRIVE
±200mA/V current output



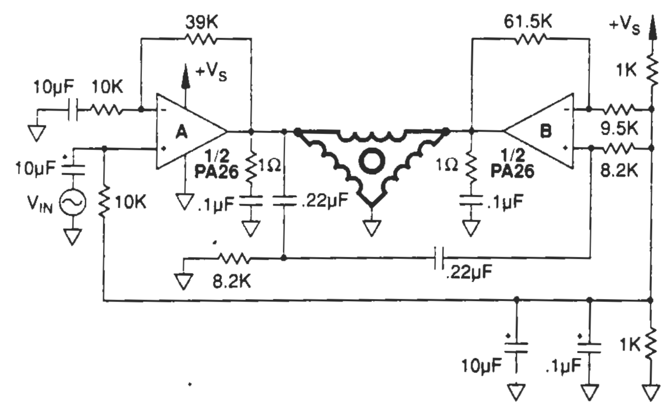
AUDIO BRIDGE



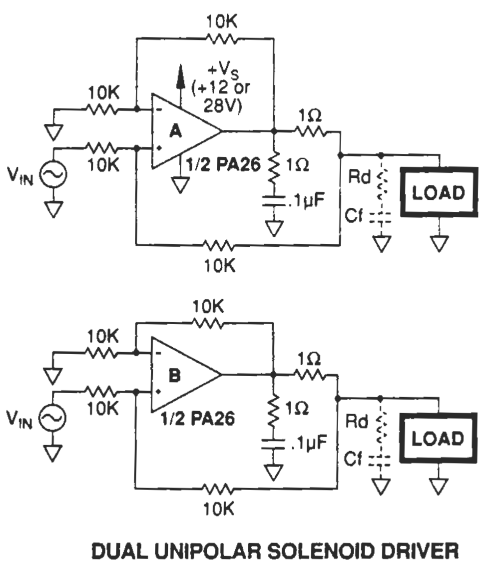
PARALLEL CONNECTION
yields single 6A amplifier



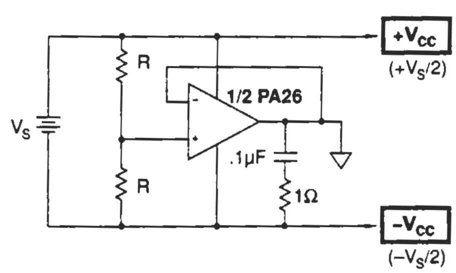
BIDIRECTIONAL MOTOR DRIVE



60Hz 3 PHASE MOTOR DRIVE
Single Supply



DUAL UNIPOLAR SOLENOID DRIVER
1A/V current output



ARTIFICIAL GROUND (SUPPLY SPLITTER)