●新特器件应用

功率放大器 PA34 及其应用

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Power Amplifier PA34 and Its Application

Jia Ailian

摘要: PA34 是 APEX 公司新推出的大功率运算放大器，它具有输入共模范围宽、电源电压范围大、效率高、失真小等特点，可用来完成音响功放以及半桥式全桥电机的驱动。文中介绍了 PA34 的特点、性能以及在双向电机驱动电路中的应用。给出了利用 PA34 设计的双向电机驱动电路。同时指出了安装 PA34 时应当注意的几点注意事项。

关键词: PA34;　SOA;　双向电机驱动

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1　概述

PA34 是 APEX 公司推出的 7 脚 TO220 封装的大功率运算放器，它的输入共模范围很宽，且内含输出限流保护功能，同时具有很宽的电源电压范围。其中单电源时电源电压范围为 5V～40V；双电源时电源电压范围为 ±2.5V～±20V。PA34 的效率很高，其输出电流最小值为 2.5A，且失真很小。

PA34 功率放大器可广泛应用于半桥或全桥电机驱动、音响功放以及众多的单电源系统，如 5V 外部电路系统、12V 自动化系统及 28V 航空航天系统等领域。

2　引脚排列和主要参数

图 1 所示是 PA34 的外形封装和引脚排列示意图。其主要参数如下：

●电源电压：5V～40V；

●输出电流：PA34 的输出电流与电源到输出间的电压值有关，具体参数可参见图 2 的 SOA 曲线；

●内部功耗：18.5W；

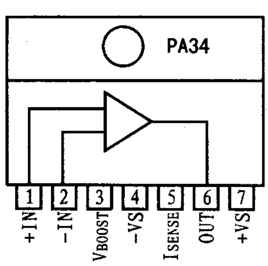

图 1　PA34 的外形封装

●差模输入电压：±Vs，

●共模输入电压：+Vs～-Vs-0.5V；

●最大结温：150℃；

●焊接温度(10s)：300℃；

●贮存温度范围：-65～150℃；

●工作温度范围：-55～125℃。

3　主要管脚功能

PA34 除了具有输入、输出和电源输入引脚外，还具有两个较为特殊的引脚 V_{BOOST} 和 I_{SENSE}。

3.1　V_{BOOST} 管脚

V_{BOOST} 管脚是 PA34 运放的第二级负载正端，当这个管脚连接到高于 $+V_S$ 的 5V 电源时，它将对上面的晶体管(连接成射极跟随器的达林顿管)提供更大的驱动，因而可使输出晶体管更好地饱和。

V_{BOOST} 管脚大约需要 10～12mA 的电流，动态时具有 1kΩ 的阻抗。应用到 V_{BOOST} 的最大电压为 40V(相对于 -Vs)。+Vs 和 V_{BOOST} 间的电压差是没有限制的。

图 3 给出了一个自举电路，该电路的耦合输出

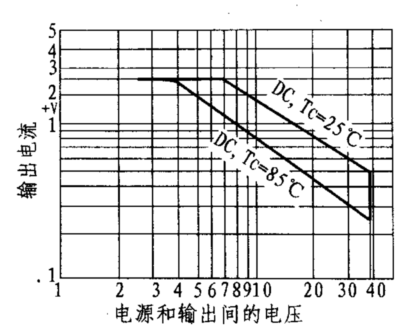

图 2　SOA 曲线

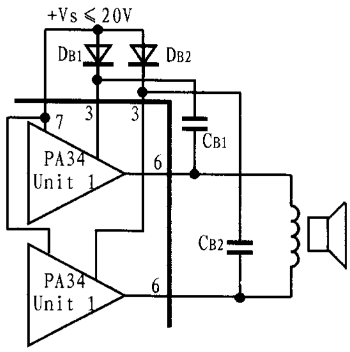

图3 自举电路

波形将在 V_{BOOST}管脚输出。而这将会引起 V_{BOOST}电压从它的初始值向正电压摆动，其摆动值为 +Vs-0.7V(二极管管压降)，初始值和摆动的总和为 V_{BOOST}的输出。换句话说，如果 V_{BOOST}初始值为 19.3V，输出摆动正向电压为 18V，那么 V_{BOOST}上的电压应为 19.3-0.7+18 等于 36.6V。

3.2 I_{SENSE} 管脚

I_{SENSE} 管脚可用来和输出级的负半边串联。只有当负电流输出时，电流才流过这个管脚，此时流过这个管脚的电流和流过输出端的电流值相同。也就是说，如果有 -1A 的电流流过输出，则 I_{SENSE} 管脚将有 1A 的电流流过，而如果 +1A 流过输出，则 I_{SENSE} 管脚的电流应当为零。

4 应用说明

4.1 安全工作区(SOA)

PA34 的 SOA 曲线可参见图 2，该安全工作曲线考虑了所有限制的影响，当电路中具有足够的输出电流，对于电阻性负载来说，这种情况比较简单，而对于感性负载和具有反向电动势(EMF)的负载来说这一问题就变得相对比较复杂。

在瞬态条件下，容性和感性负载只有满足表 1 给出的条件值时才是安全的。但对于持续的、高能量的回馈，还必须外接快速恢复二极管。

4.2 稳定性

为了保证电路的稳定性，几乎所有的非互补型输出运放都采取输出级拓扑电路，对于不同的输出电流极性，由于其在增益和相位上的响应不匹配，因此，要使制造商考虑到所有工作条件下的最佳补偿是很困难的。

表1 PA34 的容性和感性负载安全值

±Vs	容性负载	感性负载
20V	200μF	7.5mH
15V	500μF	25mH
10V	5mF	35mH
5V	50mF	150mH

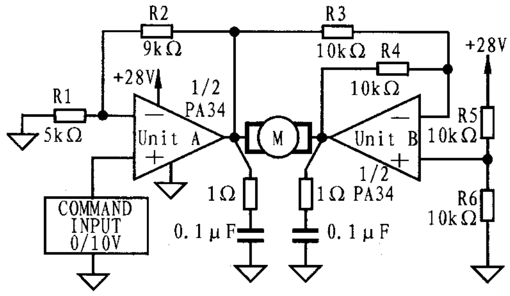

图4 双向电机驱动

使用时，可以在 PA34 的输出端到地之间接一个 1Ω 的电阻并并联一个 0.1μF 的电容(电源和地必须有合适的旁路电容)，这样可以避免 PA34 在应用电路中产生局部输出振荡。

5 应用电路

图 4 是利用两个 PA34 设计的双向电机驱动电路，图中，R1 和 R2 将运放 A 的同相增益设定为 2.8，而运放 B 是运放 A 的输出驱动的一个单位增益反相器。需注意的是：运放 B 反相端的参考节点电压应通过电阻 R5 和 R6 设置为电源的中点电压(14V)。当输入为 5V 时，A 的输出为 14V，这等于参考节点电压。由于运放 B 的输出也是 14V，这样，穿过电机的电压为 0V。当输入电压高于 5V 时，流过电机的电流从左到右。而当输入电压低于 5V 时，流过电机的电流方向与之相反，从而使电机做反向转动。

6 安装注意事项

在安装 PA34 时，应注意以下几点：

(1) 必须用散热器，因为即使在空载情况下，PA34 内部功耗也在 3.6W 左右，因而必须使用散热垫圈或导热胶。

(2) 尽量避免折弯引脚，否则会损坏运放的内部电路结构。

(3) 在管脚焊到固定端前，必须使衬底尽可能贴紧散热器。

(4) 无论对管脚有何种方向的挤压，都必须提供必要的应力释放。

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PA34

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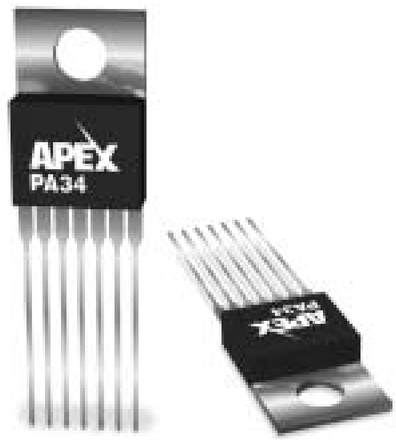


FEATURES

- 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 — |Vs–2.8V| at 2.5A typ
- HIGH OUTPUT CURRENT — 2.5A min
- INTERNAL CURRENT LIMIT
- LOW DISTORTION

APPLICATIONS

- HALF & FULL BRIDGE MOTOR DRIVERS
- AUDIO POWER AMPLIFIER
- IDEAL FOR SINGLE SUPPLY SYSTEMS
  5V — Peripherals
  12V — Automotive
  28V — Avionic

DESCRIPTION

The PA34 consists of a monolithic power op amp in a 7-pin TO220 package.

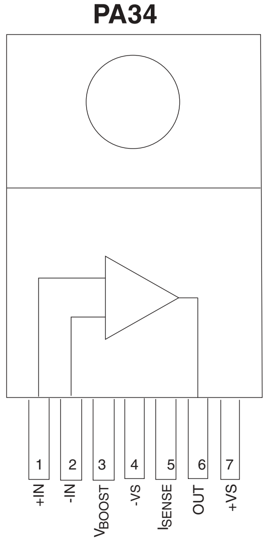
The wide common mode input range includes the negative rail, facilitating single supply applications. It is possible to have a "ground based" input driving a single supply amplifier with ground acting as the "second" or "bottom" supply of the amplifier.

The output stage is 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.

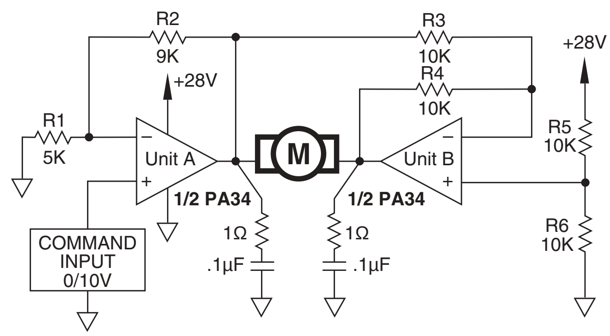
The tab of the 7 pin plastic package is tied to $-V_S$.

EXTERNAL CONNECTIONS

PA34



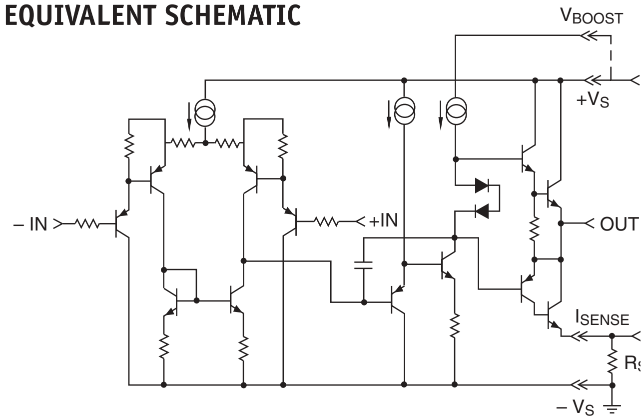
TYPICAL APPLICATION



BIDIRECTIONAL MOTOR DRIVE

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. Inputs less positive than 5V drive the motor in the opposite direction. (See PA21/25/26 Datasheet for additional application description.)

EQUIVALENT SCHEMATIC



ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, total	5V to 40V
OUTPUT CURRENT	SOA
POWER DISSIPATION, internal	18.5W
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

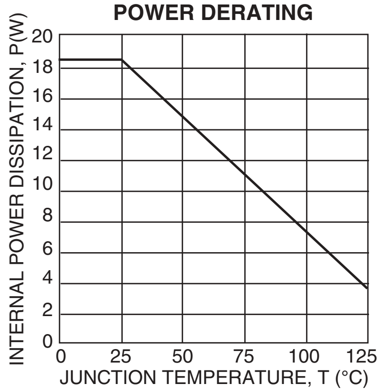
SPECIFICATIONS

PARAMETER	TEST CONDITIONS[2]	PA34 MIN	PA34 TYP	PA34 MAX	UNITS
INPUT					
OFFSET VOLTAGE, initial			1.5	10	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		15		μV/°C
BIAS CURRENT, initial		35	1000	nA	
COMMON MODE RANGE	Full temperature range	$-V_S-.3$		$+V_S-2$	dB
COMMON MODE REJECTION, DC	Full temperature range	60	85		dB
POWER SUPPLY REJECTION	Full temperature range	60	80		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			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	$\|V_S\|$ –1.4		V
VOLTAGE SWING	I_O = 2.5A	$\|V_S\|$ –3.0	$\|V_S\|$ –2.8		V
POWER SUPPLY					
VOLTAGE, V_{SS}[3]		5[4]	30	40	V
CURRENT, quiescent, total			45	90	mA
THERMAL					
RESISTANCE, DC junction to case			5.44	6.8	°C/W
RESISTANCE, AC junction to case			4.08	5.1	°C/W
RESISTANCE, junction to air			60		°C/W
TEMPERATURE RANGE, case	Meets full range specifications	–25		85	°C

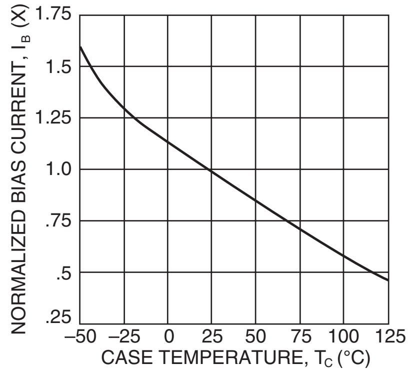
NOTES:

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.

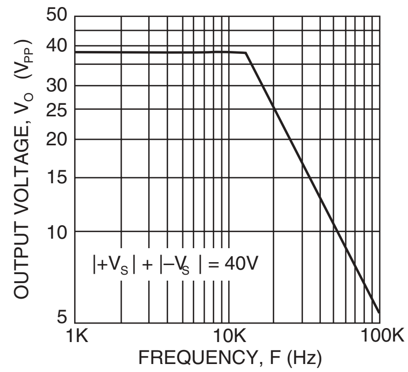
POWER DERATING



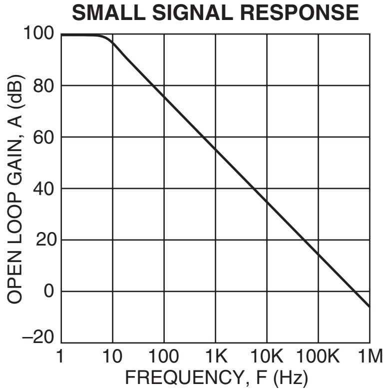
BIAS CURRENT



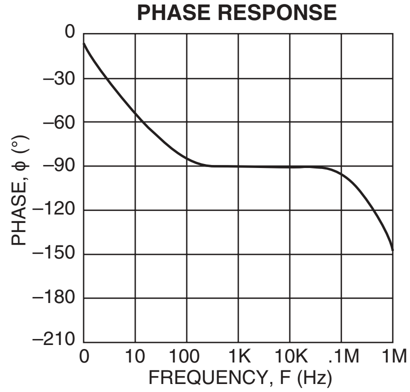
POWER RESPONSE



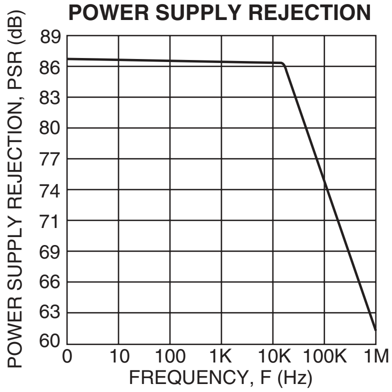
SMALL SIGNAL RESPONSE



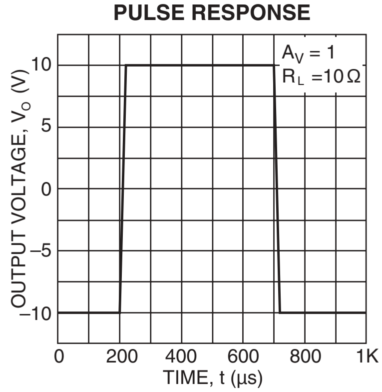
PHASE RESPONSE



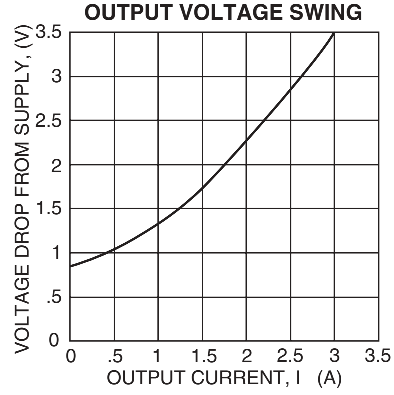
POWER SUPPLY REJECTION



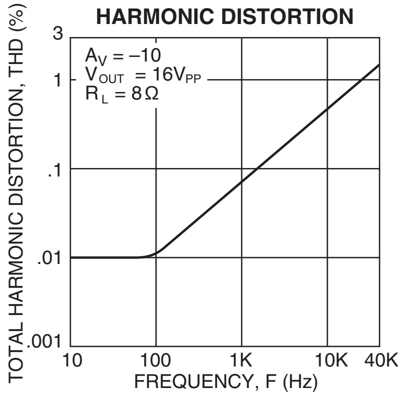
PULSE RESPONSE



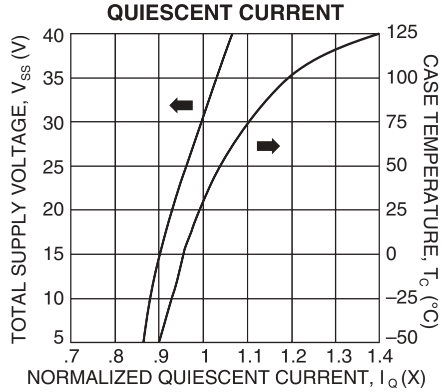
OUTPUT VOLTAGE SWING



HARMONIC DISTORTION

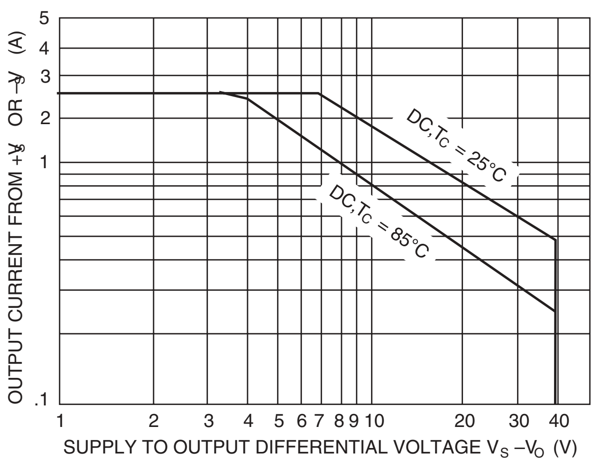


QUIESCENT CURRENT



GENERAL

Please read Application Note 1 "General Operating Considerations" which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.apexmicrotech.com for design tools that help automate tasks such as calculations for stability, internal power dissipation, current limit and heat sink selection. The "Application Notes" and "Technical Seminar" sections contain a wealth of information on specific types of applications. Package outlines, heat sinks, mounting hardware and other accessories are located in the "Packages and Accessories" section. Evaluation Kits are available for most Apex product models. Consult the "Evaluation Kit" section for details. For the most current version of all Apex product data sheets, visit www.apexmicrotech.com.



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.

The amplifiers are internally compensated for unity gain stability, no additional compensation is required.

THERMAL CONSIDERATIONS

The PA34 may 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.

MOUNTING PRECAUTIONS

1. Always use a heat sink. Even unloaded, the PA34 can dissipate up to 3.6 watts. A thermal washer or thermal grease should always be used.
2. Avoid bending the leads. Such action can lead to internal damage.
3. Always fasten the tab to the heat sink before the leads are soldered to fixed terminals.
4. Strain relief must be provided if there is any probability of axial stress to the leads.

ADDITIONAL PA34 PIN FUNCTIONS

V_{BOOST}

The V_{BOOST} pin is the positive terminal for the load of the second stage of the amplifier. When that terminal is connected to a voltage greater than $+V_S$ it will provide more drive to the upper output transistor, which is a darlington connected emitter follower. This will better saturate the output transistor.

When V_{BOOST} is about 5 Volts greater than $+V_S$ the positive output can swing 0.5 Volts closer to the rail. This is as much improvement as is possible.

V_{BOOST} pin requires approximately 10–12mA of current. Dynamically it represents 1K Ω impedance. The maximum voltage that can be applied to V_{BOOST} is 40 volts with respect to $-V_S$. There is no limit to the difference between $+V_S$ and V_{BOOST}.

Figure 1 shows a bootstrap which dynamically couples the output waveform onto the V_{BOOST} pin. This causes V_{BOOST} to swing positive from it's initial value, which is equal to $+V_S$ -0.7 V (one diode drop), an amount equal to the output. In other words, if V_{BOOST} was initially 19.3, and the output swings positive 18 Volts, the voltage on the V_{BOOST} pin will swing to 19.3 -0.7 + 18 or 36.6. The capacitor needs to be sized based on a 1K Ω impedance and the lowest frequency required by the circuit. For example, 20Hz will require > 8uF.

I_{SENSE}

The I_{SENSE} pin is in series with the negative half of the output stage only. Current will flow through this pin only when negative current is being outputted. The current that flows in this pin is the same current that flows in the output (if –1A flows in the output, the I_{SENSE} pin will have 1A of current flow, if +1A flows in the output the I_{SENSE} pin will have 0 current flow).

The resistor choice is arbitrary and is selected to provide whatever voltage drop the engineer desires, up to a maximum of 1.0 volt. However, any voltage dropped across the resistor will subract from the swing to rail. For instance, assume a +/–12 volt power supply and a load that requires +/–1A. With no current sense resistor the output could swing +/–10.2 volts. If a 1 Ω resistor is used for current sense (which will drop 1 Volt at 1 Amp) then the output could swing +10.2, –9.2 Volts.

Figure 2 shows the PA34 I_{SENSE} feature being used to obtain a Transconductance function. In this example, amplifier "A" is the master and amplifier "B" is the slave. Feedback from sensing resistors R_S is applied to the summing network and scaled to the inverting input of amplifier "A" where it is compared to the input voltage. The current sensing feedback imparts a Transconductance feature to the amplifiers transfer function. In other words, the voltage developed across the sensing resistors is directly proportional to the output current. Using this voltage as a feedback source allows expressing the gain of the circuit in amperes vs input voltage. The transfer funcion is approximately:

$$I_L = (V_{IN} - V_{REF}) * R_{IN} / R_{FB} / R_s$$

In the illustration, resistors R_{IN}, R_{FB} and R_S determine gain.

V_{BIAS} should be set midway between $+V_s$ and $-V_s$, Vref is usually ground in dual supply systems or used for level translation in single supply systems.

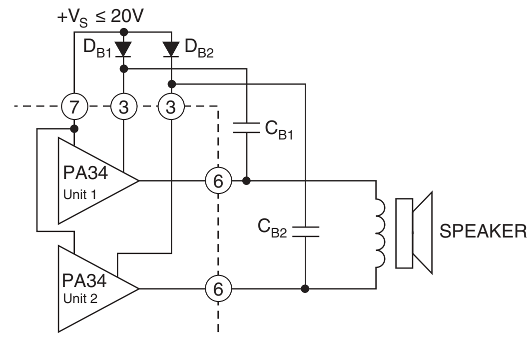


FIGURE 1. SIMPLE BOOTSTRAPPING IMPROVES POSITIVE OUTPUT SWING. TYPICAL CURRENTS ARE 12mA EACH.

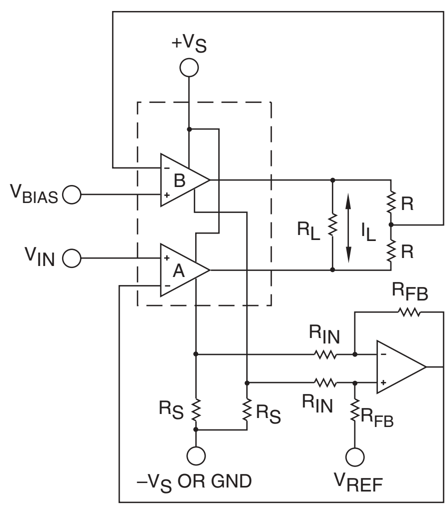


FIGURE 2. I_{SENSE} TRANSCONDUCTANCE BRIDGING AMPLIFIER

PA34

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PRELIMINARY

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 — |Vs–2.2V| at 2.5A typ
- HIGH OUTPUT CURRENT — 2.5A min
- INTERNAL CURRENT LIMIT
- LOW DISTORTION

APPLICATIONS

- HALF & FULL BRIDGE MOTOR DRIVERS
- AUDIO POWER AMPLIFIER
  - STEREO — 18W RMS per channel
  - BRIDGE — 36W RMS per package
- IDEAL FOR SINGLE SUPPLY SYSTEMS
  - 5V — Peripherals
  - 12V — Automotive
  - 28V — Avionic

DESCRIPTION

The PA34 consist of a monolithic power op amp in a 7-pin T0220 package.

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.

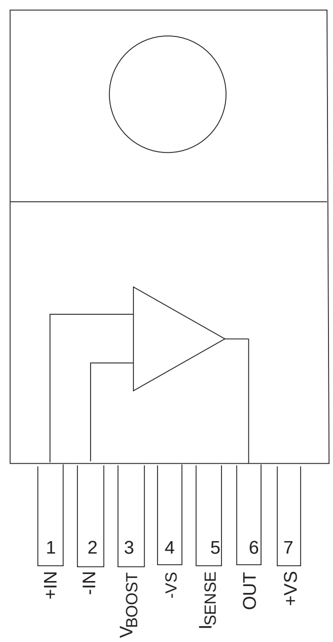
The output stage is also well protected. They possess internal current limit circuits. While the device is well protected, the Safe Operating Area (SOA) curve must be observed. Proper heatsinking is required for maximum reliability.

The tab of the 7 pin plastic package is tied to $-V_S$.

Graphic for PA34
Here

EXTERNAL CONNECTIONS

PA34



ABSOLUTE MAXIMUM RATINGS

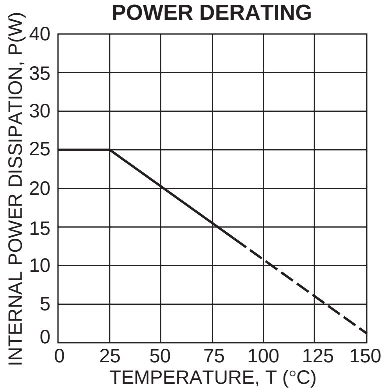
SUPPLY VOLTAGE, total	5V to 40V
OUTPUT CURRENT	SOA
POWER DISSIPATION, internal (per amplifier)	25W
INPUT VOLTAGE, differential	$\pm V_S$
INPUT VOLTAGE, common mode	$+V_S$, $-V_S$–.5V
JUNCTION TEMPERATURE, max[1]	150°C
TEMPERATURE, pin solder—10 sec max	300°C
TEMPERATURE RANGE, storage	–65°C to 150°C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

SPECIFICATIONS

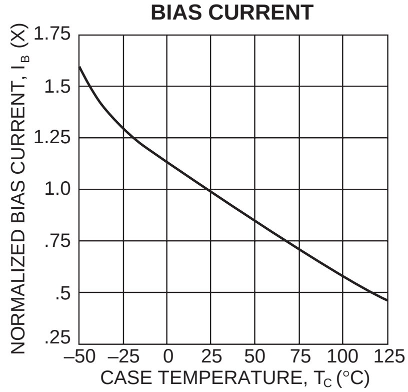
PARAMETER	TEST CONDITIONS[2]	PA34 MIN	TYP	MAX	UNITS
INPUT					
OFFSET VOLTAGE, initial			1.5	10	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		15		µV/°C
BIAS CURRENT, initial		35	1000	nA	
COMMON MODE RANGE	Full temperature range	$-V_S$–.3		$+V_S$–2	dB
COMMON MODE REJECTION, DC	Full temperature range	60	85		dB
POWER SUPPLY REJECTION	Full temperature range	60	80		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			A
CURRENT, limit			3.0		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	$\|V_S\|$ –1.4		V
VOLTAGE SWING	I_O = 2.5A	$\|V_S\|$ –3.0	$\|V_S\|$ –2.8		V
VOLTAGE SWING	I_O = 3.0A				V
POWER SUPPLY					
VOLTAGE, V_{SS}[3]		5[4]	30	40	V
CURRENT, quiescent, total			45	90	mA
THERMAL					
RESISTANCE, DC junction to case			5.0		°C/W
RESISTENCE,AC junction to case			3.7		°C/W
RESISTANCE, junction to air			30		°C/W
TEMPERATURE RANGE, case	Meets full range specifications	–25		85	°C

NOTES:
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.

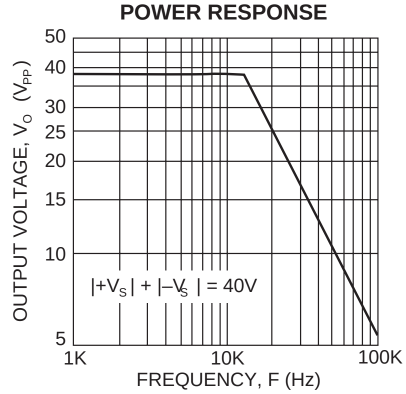
POWER DERATING



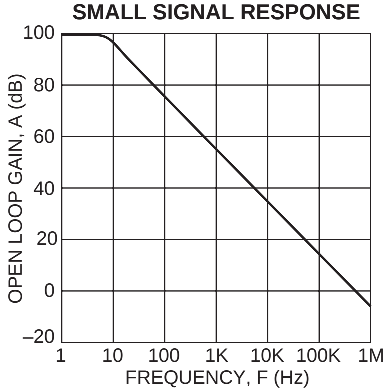
BIAS CURRENT



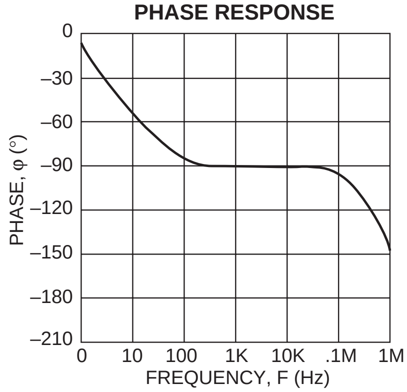
POWER RESPONSE



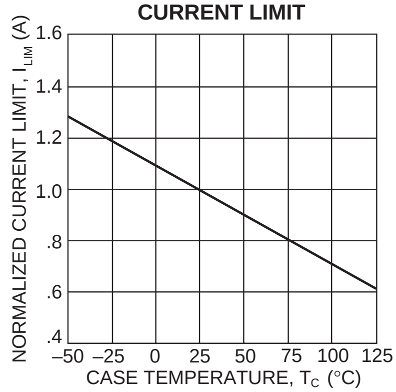
SMALL SIGNAL RESPONSE



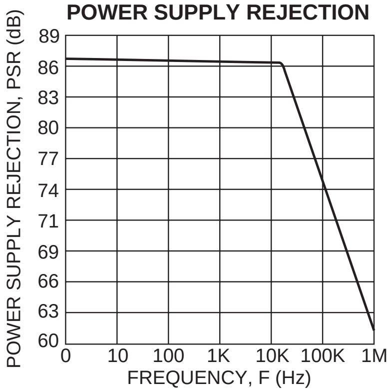
PHASE RESPONSE



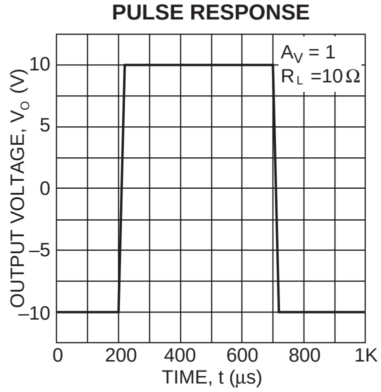
CURRENT LIMIT



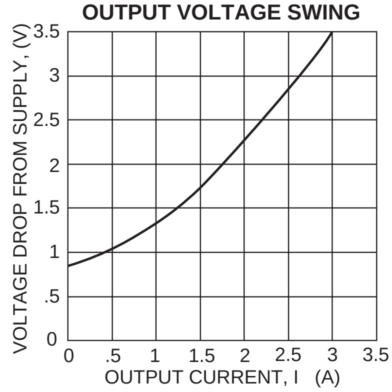
POWER SUPPLY REJECTION



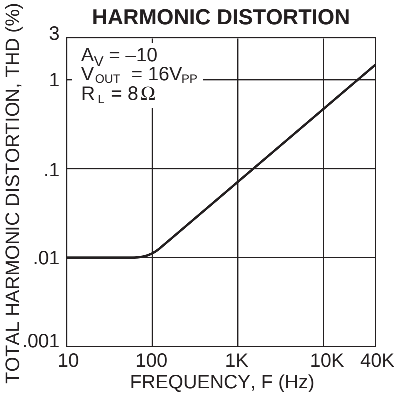
PULSE RESPONSE



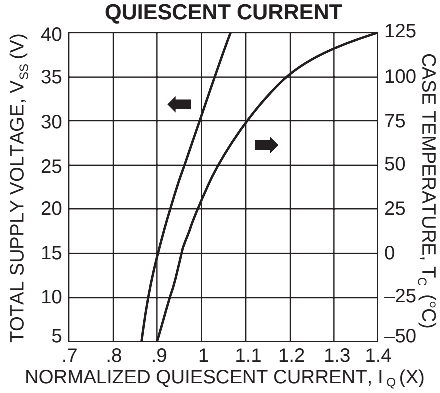
OUTPUT VOLTAGE SWING



HARMONIC DISTORTION



QUIESCENT CURRENT

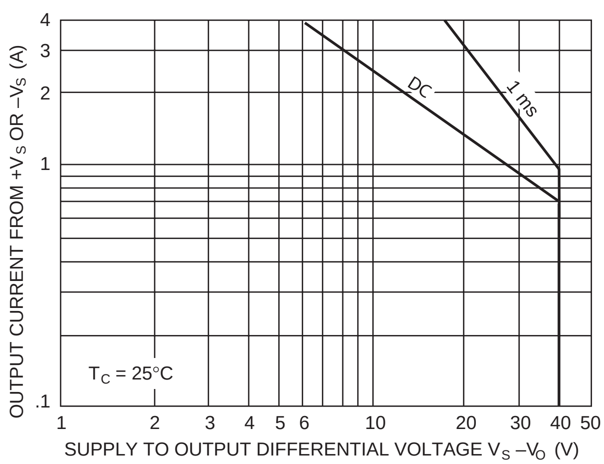


GENERAL

Please read Application Note 1 "General Operating Considerations" which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.apexmicrotech.com for design tools that help automate tasks such as calculations for stability, internal power dissipation, current limit and heat sink selection. The "Application Notes" and "Technical Seminar" sections contain a wealth of information on specific types of applications. Package outlines, heat sinks, mounting hardware and other accessories are located in the "Packages and Accessories" section. Evaluation Kits are available for most Apex product models, consult the "Evaluation Kit" section for details. For the most current version of all Apex product data sheets, visit www.apexmicrotech.com.

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.

The amplifiers are internally compensated for unity gain stability, no additional compensation is required.

THERMAL CONSIDERATIONS

The PA34 may 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.

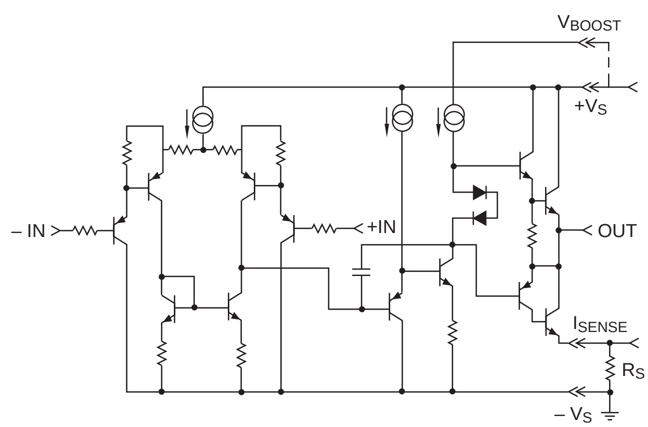


FIGURE 2. EQUIVALENT SCHEMATIC

ADDITIONAL PA34 PIN FUNCTIONS

V_{BOOST}

The V_{BOOST} pin is the positive terminal for the load of the second stage of the amplifier. When that terminal is connected to a voltage greater than $+V_S$ it will provide more drive to the upper output transistor, which is a darlington connected emitter follower. This will better saturate the output transistor.

When V_{BOOST} is about 5 Volts greater than $+V_S$ the positive output can swing 0.5 Volts closer to the rail. This is as much improvement as is possible.

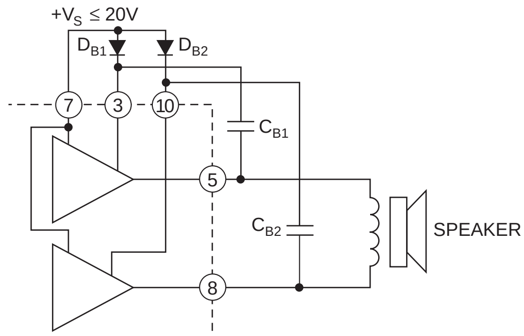


FIGURE 3. SIMPLE BOOTSTRAPPING IMPROVES POSITIVE OUTPUT SWING. CONNECT PINS 3 AND 10 TO V_S IF NOT USED. TYPICAL CURRENTS ARE 12mA EACH.

V_{BOOST} pin requires approximately 10–12mA of current. Dynamically it represents 1K Ω impedance. The maximum voltage that can be applied to V_{BOOST} is 40 volts with respect to $-V_S$. There is no limit to the difference between $+V_S$ and V_{BOOST}.

Figure 3 shows a bootstrap which dynamically couples the output waveform onto the V_{BOOST} pin. This causes V_{BOOST} to swing positive from it's initial value, which is equal to $+V_S$ -0.7 V (one diode drop), an amount equal to the output. In other words, if V_{BOOST} was initially 19.3, and the output swings positive 18 Volts, the voltage on the V_{BOOST} pin will swing to 19.3 -0.7 + 18 or 36.6. The capacitor needs to be sized based on a 1K Ω impedance and the lowest frequency required by the circuit. For example, 20Hz will require > 8uF.

I_{SENSE}

The I_{SENSE} pin is in series with the negative half of the output stage only. Current will flow through this pin only when negative current is being outputted. The current that flows in this pin is the same current that flows in the output (if –1A flows in the output, the I_{SENSE} pin will have 1A of current flow, if +1A flows in the output the I_{SENSE} pin will have 0 current flow).

The resistor choice is arbitrary and is selected to provide whatever voltage drop the engineer desires, up to a maximum of 1.0 volt. However, any voltage dropped across the resistor will subract from the swing to rail. For instance, assume a +/–12 volt power supply and a load that requires +/–1A. With no current sense resistor the output could swing +/–10.2 volts. If a 1 Ω resistor is used for current sense (which will drop 1 Volt at 1 Amp) then the output could swing +10.2, –9.2 Volts.

Figure 4 shows the PA34 I_{SENSE} feature being used to obtain a Transconductance function. In this example, amplifier "A" is the master and amplifier "B" is the slave. Feedback from sensing resistors R_S is applied to the summing network and scaled to the inverting input of amplifier "A" where it is compared to the input voltage. The current sensing feedback imparts a Transconductance feature to the amplifiers transfer function. In other words, the voltage developed across the sensing resistors is directly proportional to the output current. Using this voltage as a feedback source allows expressing the gain of the circuit in amperes vs input voltage. The transfer funcion is approximately:

$$I_L = (V_{IN} - V_{REF}) * R_{IN} / R_{FB} / R_s$$

In the illustration, resistors R_{IN}, R_{FB} and R_S determine gain.

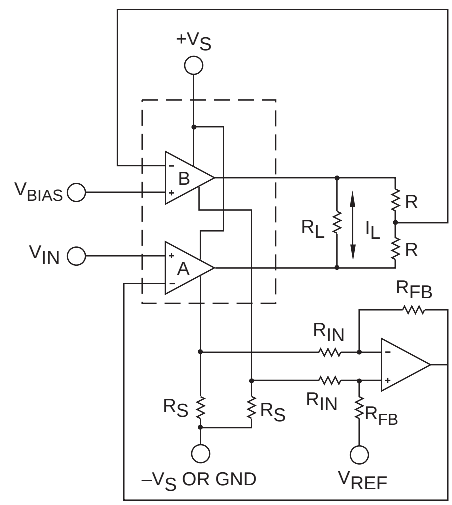


FIGURE 4. I_{SENSE} TRANSCONDUCTANCE BRIDGING AMPLIFIER

V_{BIAS} should be set midway between $+V_S$ and $-V_S$, Vref is usually ground in dual supply systems or used for level translation in single supply systems.

MOUNTING PRECAUTIONS

1. Always use a heat sink. Even unloaded, the PA34 can dissipate up to 3.6 watts. A thermal washer or thermal grease should always be used.
2. Avoid bending the leads. Such action can lead to internal damage.
3. Always fasten the tab to the heat sink before the leads are soldered to fixed terminals.
4. Strain relief must be provided if there is any probability of axial stress to the leads.

POWER OPERATIONAL AMPLIFIER

PA34

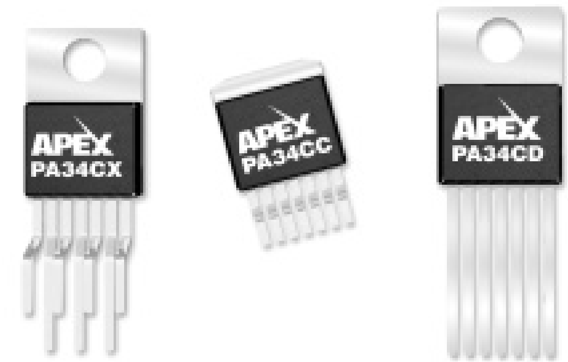
APEX MICROTECHNOLOGY

HTTP://WWW.APEXMICROTECH.COM (800) 546-APEX (800) 546-2739

Not recommended for new design in.

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 — |Vs–2.8V| at 2.5A typ
- HIGH OUTPUT CURRENT — 2.5A min
- INTERNAL CURRENT LIMIT
- LOW DISTORTION
- PACKAGING OPTIONS
  - 7 TO-220 Plastic Package (PA34CD)
  - 7 TO-220 with Staggered Lead Form (PA34CX)
  - 7 DDPAK Surface Mount Package (PA34CC)



APPLICATIONS

- HALF & FULL BRIDGE MOTOR DRIVERS
- AUDIO POWER AMPLIFIER
- IDEAL FOR SINGLE SUPPLY SYSTEMS
  5V Peripherals, 12V Automotive, 28V Avionic

DESCRIPTION

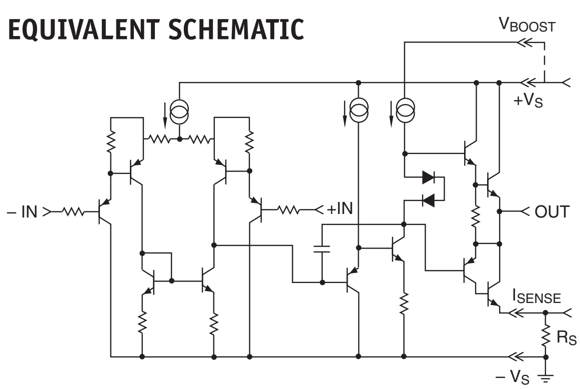
The PA34 consists of a monolithic power operational amplifier in three standard package designs. The surface mount version of the PA34, the PA34CC, is an industry standard non-hermetic plastic 7-pin DDPAK. The through hole versions of the PA34, the PA34CD and PA34CX, are industry standard non-heremetic plastic 7-pin TO-220 packages. The PA34CX is a staggered lead formed PA34CD and offers industry standard 100 mil spacing. This allows for easier PC board layout. (Please reference to the lead form datasheet drawing LF005 for package dimensions of the PA34CX.

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 stage is 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.

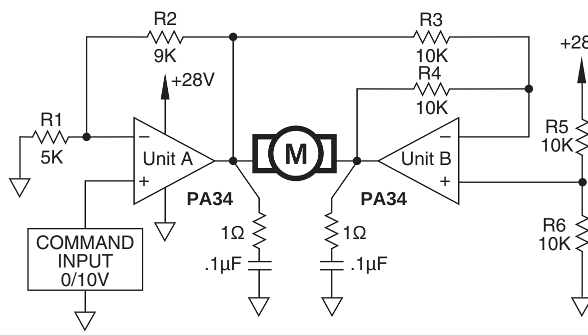
The monolithic amplifier is directly attached to the metal tabs of the PA34CC, PA34CD, and PA34CX. The metal tabs are directly tied to -Vs.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATION

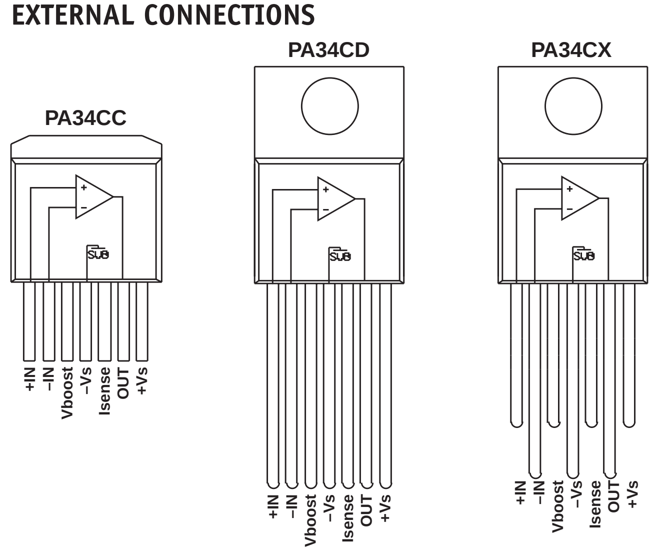
Ref: APPLICATION NOTE 20: "Bridge Mode Operation of Power Amplifiers"



BIDIRECTIONAL MOTOR DRIVE

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. Inputs less positive than 5V drive the motor in the opposite direction. (See PA21/25/26/37 Datasheet for additional application description.)

EXTERNAL CONNECTIONS



ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, total	5V to 40V
OUTPUT CURRENT	SOA
POWER DISSIPATION, internal	18.5W
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	220°C
TEMPERATURE RANGE, storage	–65°C to 150°C
OPERATING TEMPERATURE RANGE, case	–40°C to 125°C

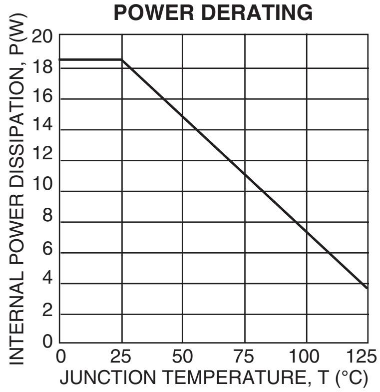
SPECIFICATIONS

PARAMETER	TEST CONDITIONS[2]	PA34 MIN	TYP	MAX	UNITS
INPUT					
OFFSET VOLTAGE, initial			1.5	10	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		15		μV/°C
BIAS CURRENT, initial		35	1000		nA
COMMON MODE RANGE	Full temperature range	$-V_S-.3$		$+V_S-2$	dB
COMMON MODE REJECTION, DC	Full temperature range	60	85		dB
POWER SUPPLY REJECTION	Full temperature range	60	80		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			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	$\|V_S\|$ –1.4		V
VOLTAGE SWING	I_O = 2.5A	$\|V_S\|$ –3.0	$\|V_S\|$ –2.8		V
POWER SUPPLY					
VOLTAGE, V_{SS}[3]		5	30	40	V
CURRENT, quiescent, total			45	90	mA
THERMAL					
RESISTANCE, DC junction to case			5.44	6.8	°C/W
RESISTANCE, AC junction to case			4.08	5.1	°C/W
RESISTANCE, junction to air (CD,CX)			60		°C/W
RESISTANCE, junction to air (CC)[4]			27		°C/W
TEMPERATURE RANGE, case	Meets full range specifications	–25		85	°C

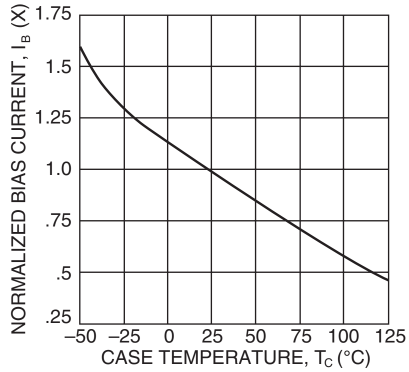
NOTES:

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. Heat tab attached to 3/32" FR-4 board with 2oz. copper. Topside copper area (heat tab directly attached) = 1000 sq. mm, backside copper area = 2500 sq. mm, board area = 2500 sq. mm.

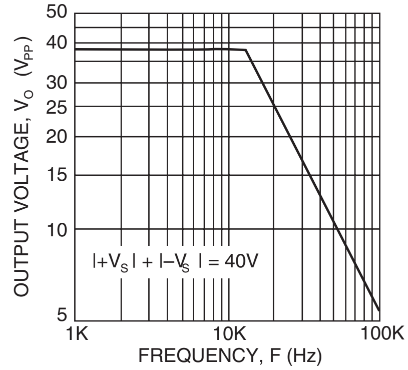
POWER DERATING



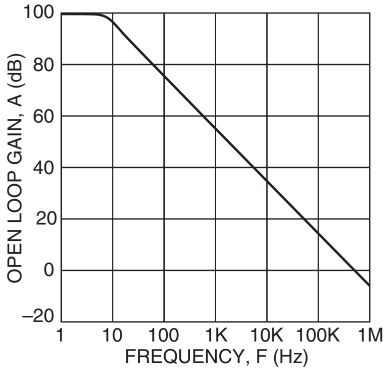
BIAS CURRENT



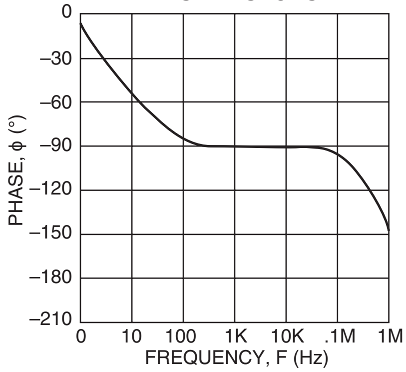
POWER RESPONSE



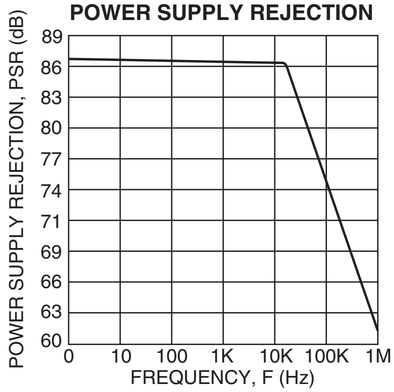
SMALL SIGNAL RESPONSE



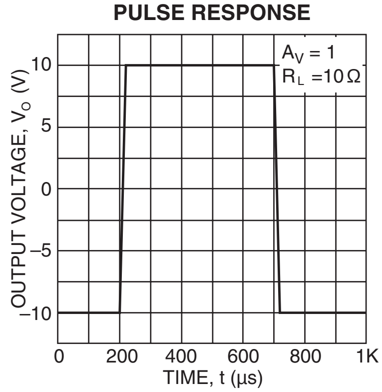
PHASE RESPONSE



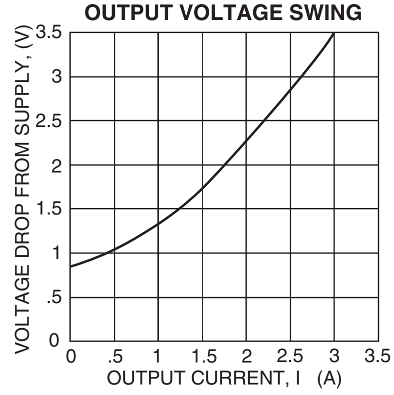
POWER SUPPLY REJECTION



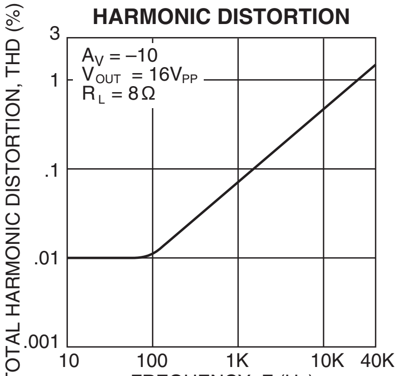
PULSE RESPONSE



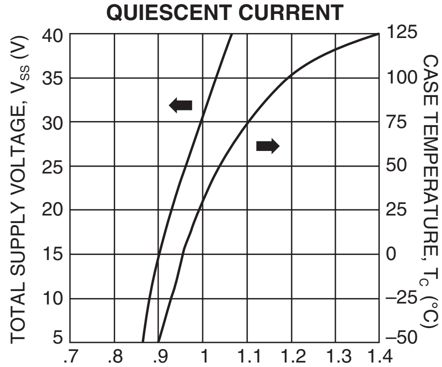
OUTPUT VOLTAGE SWING



HARMONIC DISTORTION

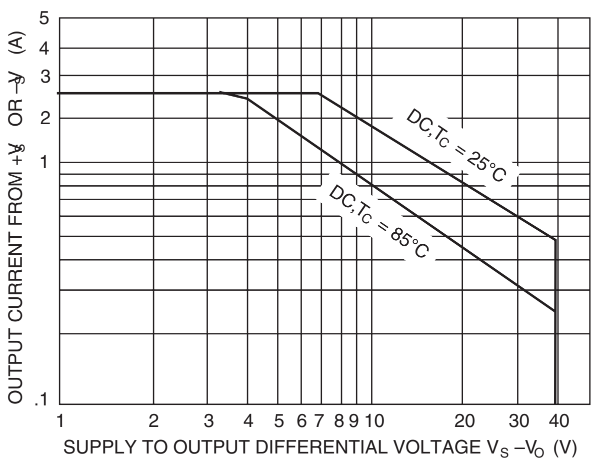


QUIESCENT CURRENT



GENERAL

Please read Application Note 1 "General Operating Considerations" which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.apexmicrotech.com for design tools that help automate tasks such as calculations for stability, internal power dissipation, current limit and heat sink selection. The "Application Notes" and "Technical Seminar" sections contain a wealth of information on specific types of applications. Package outlines, heat sinks, mounting hardware and other accessories are located in the "Packages and Accessories" section. Evaluation Kits are available for most Apex product models. Consult the "Evaluation Kit" section for details. For the most current version of all Apex product data sheets, visit www.apexmicrotech.com.



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.

The amplifiers are internally compensated for unity gain stability, no additional compensation is required.

THERMAL CONSIDERATIONS

The PA34 may 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.

The PA34CC 7-pin DDPAK surface mountable package has a large exposed integrated copper heatslug to which the monolithic amplifier is directly attached. The PA34CC requires surface mount techniques of heatsinking. A solder connection to an area of 1 to 2 square inches of foil is recommended for circuit board layouts. This may be adequate heatsinking but the large number of variables involved suggests temperature measurements to be made on the top of the package. Surface mount techniques include the use of a surface mount fan in combination with a surface mount heatsink on the backside of the FR4/PC board. Do not allow the temperature to exceed 85°C.

MOUNTING PRECAUTIONS

1. Always use a heat sink. Even unloaded, the PA34 can dissipate up to 3.6 watts. A thermal washer or thermal grease should always be used.
2. Avoid bending the leads. Such action can lead to internal damage.
3. Always fasten the tab to the heat sink before the leads are soldered to fixed terminals.
4. Strain relief must be provided if there is any probability of axial stress to the leads.

ADDITIONAL PA34 PIN FUNCTIONS

V_{BOOST}

The V_{BOOST} pin is the positive terminal for the load of the second stage of the amplifier. When that terminal is connected to a voltage greater than $+V_S$ it will provide more drive to the upper output transistor, which is a darlington connected emitter follower. This will better saturate the output transistor.

When V_{BOOST} is about 5 Volts greater than $+V_S$ the positive output can swing 0.5 Volts closer to the rail. This is as much improvement as is possible.

V_{BOOST} pin requires approximately 10–12mA of current. Dynamically it represents 1K Ω impedance. The maximum voltage that can be applied to V_{BOOST} is 40 volts with respect to $-V_S$. There is no limit to the difference between $+V_S$ and V_{BOOST}.

Figure 1 shows a bootstrap which dynamically couples the output waveform onto the V_{BOOST} pin. This causes V_{BOOST} to swing positive from it's initial value, which is equal to $+V_S$ -0.7 V (one diode drop), an amount equal to the output. In other words, if V_{BOOST} was initially 19.3, and the output swings positive 18 Volts, the voltage on the V_{BOOST} pin will swing to 19.3 -0.7 + 18 or 36.6. The capacitor needs to be sized based on a 1K Ω impedance and the lowest frequency required by the circuit. For example, 20Hz will require > 8uF.

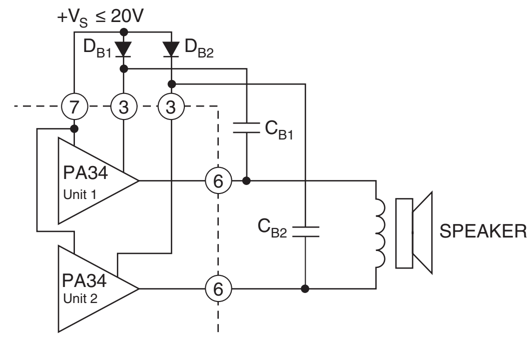


FIGURE 1. SIMPLE BOOTSTRAPPING IMPROVES POSITIVE OUTPUT SWING. TYPICAL CURRENTS ARE 12mA EACH.

I_{SENSE}

The I_{SENSE} pin is in series with the negative half of the output stage only. Current will flow through this pin only when negative current is being outputted. The current that flows in this pin is the same current that flows in the output (if –1A flows in the output, the I_{SENSE} pin will have 1A of current flow, if +1A flows in the output the I_{SENSE} pin will have 0 current flow).

The resistor choice is arbitrary and is selected to provide whatever voltage drop the engineer desires, up to a maximum of 1.0 volt. However, any voltage dropped across the resistor will subract from the swing to rail. For instance, assume a +/–12 volt power supply and a load that requires +/–1A. With no current sense resistor the output could swing +/–10.2 volts. If a 1 Ω resistor is used for current sense (which will drop 1 Volt at 1 Amp) then the output could swing +10.2, –9.2 Volts.

Figure 2 shows the PA34 I_{SENSE} feature being used to obtain a Transconductance function. In this example, amplifier "A" is the master and amplifier "B" is the slave. Feedback from sensing resistors R_S is applied to the summing network and scaled to the inverting input of amplifier "A" where it is compared to the input voltage. The current sensing feedback imparts a Transconductance feature to the amplifiers transfer function. In other words, the voltage developed across the sensing resistors is directly proportional to the output current. Using this voltage as a feedback source allows expressing the gain of the circuit in amperes vs input voltage. The transfer funcion is approximately:

$$I_L = (V_{IN} - V_{REF}) * R_{IN} / R_{FB} / R_s$$

In the illustration, resistors R_{IN}, R_{FB} and R_S determine gain.

V_{BIAS} should be set midway between $+V_S$ and $-V_S$, Vref is usually ground in dual supply systems or used for level translation in single supply systems.

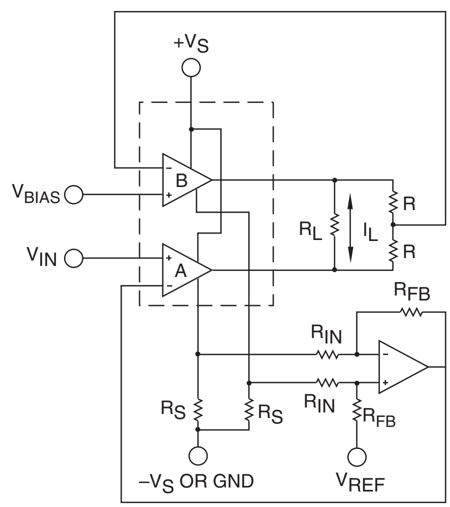


FIGURE 2. I_{SENSE} TRANSCONDUCTANCE BRIDGING AMPLIFIER

APPLICATION REFERENCES:

For additional technical information please refer to the following Application Notes:

AN 1: General Operating Considerations
AN 3: Bridge Circuit Drives
AN 21: Single Supply Operation of Power Amplifiers
AN 24: Brush Type DC Motor Drive