



# TPA12/ TPA12A Power Operational Amplifier



THALER CORPORATION • 2015 N. FORBES BOULEVARD • TUCSON, AZ. 85745 • (520) 882-4000

## FEATURES

- HIGH OUTPUT CURRENT -  $\pm 15A$  PEAK
- HIGH VOLTAGE RATING -  $\pm 50V$
- LOW THERMAL RESISTANCE -  $1.4$  °C/W
- CURRENT FOLDOVER PROTECTION
- EXCELLENT LINEARITY - CLASS A/B OUTPUT

## APPLICATIONS

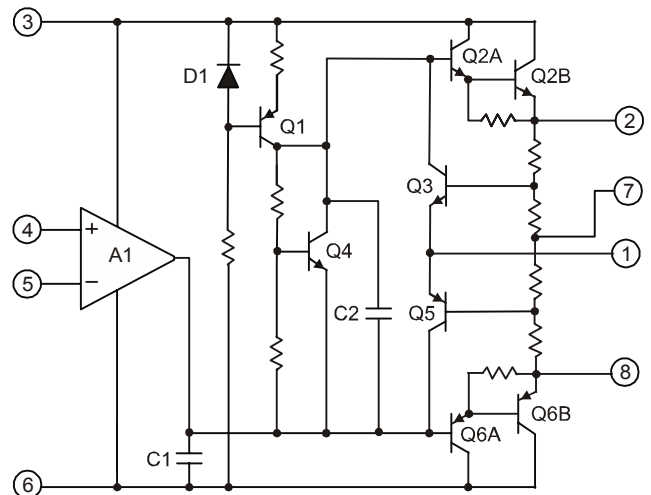
- MOTOR, VALVE AND ACTUATOR CONTROL
- MAGNETIC DEFLECTION CIRCUITS UP TO 10A
- POWER TRANSDUCERS UP TO 100 kHz
- AUDIO AMPLIFIERS UP TO 120W RMS

## DESCRIPTION

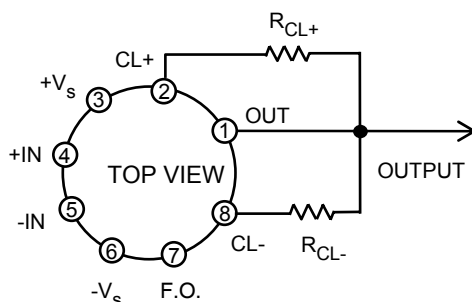
The TPA12 and TPA12A are designed for high voltage and high current applications. They can deliver up to 600 Watts of power to a load. The safe operating area (SOA) at the output stage can be guaranteed for all operating conditions by properly selecting the external current limiting resistor.

The class A/B output stage delivers power with remarkably low distortion (see graph page 3). In order to maintain stable bias current and low distortion over the operating temperature range a resistor/thermistor network in the  $V_{BE}$  multiplier is used to closely match the  $V_{BE}$  of the output transistors.

## EQUIVALENT SCHEMATIC



## EXTERNAL CONNECTIONS AND PIN CONFIGURATIONS



# TPA12/TPA12A

## ABSOLUTE MAXIMUM RATINGS

|                             |                     |                                    |               |
|-----------------------------|---------------------|------------------------------------|---------------|
| Supply Voltage              | 100V                | Temperature, pin solder – 10s      | 300°C         |
| Output Current, within SOA  | 15A                 | Temperature, junction <sup>1</sup> | 200°C         |
| Power Dissipation, internal | 125W                | Temperature range, storage         | -65 to +150°C |
| Input Voltage, differential | ±V <sub>S</sub> -3V | Operating temperature range, case  | -55 to +125°C |
| Input Voltage, common mode  | ±V <sub>S</sub>     |                                    |               |

## Electrical Specifications

### TPA12

### TPA12A

| PARAMETER                                    | CONDITIONS <sup>2,5</sup>                             | MIN                | TYP                | MAX  | MIN | TYP | MAX  | UNITS |
|--|---|--------------------|--------------------|------|-----|-----|------|-------|
| <b>INPUT</b>                                 |   |                    |                    |      |     |     |      |       |
| Offset Voltage, initial                      | T <sub>c</sub> = 25°C                                 |                    | ±2                 | ±6   |     | ±1  | ±4   | mV    |
| Offset Voltage, vs. temp.                    | full temperature range                                |                    | ±10                | ±65  |     | *   | ±40  | µV/°C |
| Offset Voltage, vs. supply                   | T <sub>c</sub> = 25°C                                 |                    | ±30                | ±200 |     | *   | *    | µV/V  |
| Offset Voltage, vs. power                    | T <sub>c</sub> = 25°C                                 |                    | ±20                |      |     | *   |      | µV/W  |
| Bias Current, initial                        | T <sub>c</sub> = 25°C                                 |                    | ±12                | ±30  |     | 10  | 20   | nA    |
| Bias Current, vs. temp.                      | full temperature range                                |                    | ±50                | ±500 |     | *   | *    | pA/°C |
| Bias Current, vs. supply                     | T <sub>c</sub> = 25°C                                 |                    | ±10                |      |     | *   |      | pA/V  |
| Offset Current, initial                      | T <sub>c</sub> = 25°C                                 |                    | ±12                | ±30  |     | ±5  | ±20  | nA    |
| Offset Current, vs. temp.                    | full temperature range                                |                    | ±50                |      |     | *   |      | pA/°C |
| Input Impedance, DC                          | T <sub>c</sub> = 25°C                                 |                    | 200                |      |     | *   |      | MΩ    |
| Input Capacitance                            | T <sub>c</sub> = 25°C                                 |                    | 3                  |      |     | *   |      | pF    |
| Common Mode Volt. Range <sup>3</sup>         | full temperature range                                | ±V <sub>S</sub> -5 | ±V <sub>S</sub> -3 |      | *   | *   |      | V     |
| Common Mode Rejection, DC                    | full temp. range V <sub>CM</sub> = ±V <sub>S</sub> -5 | 74                 | 100                |      | *   | *   |      | db    |
| <b>GAIN</b>                                  |   |                    |                    |      |     |     |      |       |
| Open Loop Gain at 10Hz                       | T <sub>c</sub> = 25°C, 1kΩ load                       |                    | 110                |      |     | *   |      | db    |
| Open Loop Gain at 10Hz                       | Full temp range, 8Ω load                              | 96                 | 108                |      | *   | *   |      | db    |
| Gain Bandwidth Product (1MHz)                | T <sub>c</sub> = 25°C, 8Ω load                        |                    | 4                  |      |     | *   |      | MHz   |
| Power Bandwidth                              | T <sub>c</sub> = 25°C, 8Ω load                        | 13                 | 20                 |      | *   | *   |      | kHz   |
| Phase Margin A <sub>v</sub> = +4             | Full temp range, 8Ω load                              |                    | 20                 |      |     | *   |      | o     |
| <b>OUTPUT</b>                                |   |                    |                    |      |     |     |      |       |
| Voltage Swing <sup>3</sup>                   | T <sub>c</sub> =25°C, TPA12 =10A, TPA12A=15A          | ±V <sub>S</sub> -6 |                    |      | *   |     |      | V     |
| Voltage Swing <sup>3</sup>                   | T <sub>c</sub> = 25°C, I <sub>o</sub> = 5A            | ±V <sub>S</sub> -5 |                    |      | *   |     |      | V     |
| Voltage Swing <sup>3</sup>                   | full temp range, I <sub>o</sub> = 80mA                | ±V <sub>S</sub> -5 |                    |      | *   |     |      | V     |
| Current, peak                                | T <sub>c</sub> = 25°C                                 | 10                 |                    |      | 15  |     |      | A     |
| Settling Time to .1%,                        | T <sub>c</sub> = 25°C, 2V step                        |                    | 2                  |      |     | *   |      | µs    |
| Slew Rate                                    | T <sub>c</sub> = 25°C                                 | 2.5                | 4                  |      | *   | *   |      | V/µs  |
| Capacitive Load                              | full temp range, A <sub>v</sub> = 4                   |                    |                    | 1.5  |     |     | *    | nF    |
| Capacitive Load                              | full temp range, A <sub>v</sub> >10                   |                    |                    | SOA  |     |     | *    |       |
| <b>POWER SUPPLY</b>                          |   |                    |                    |      |     |     |      |       |
| Voltage                                      | full temp range                                       | ±10                | ±40                | ±45  | *   | *   | ±50  | V     |
| Current, quiescent                           | T <sub>c</sub> = 25°C                                 |                    | 25                 | 50   |     | *   | *    | mA    |
| <b>THERMAL</b>                               |   |                    |                    |      |     |     |      |       |
| Resistance, AC junction to case <sup>4</sup> | T <sub>c</sub> = -55 to +125°C, F>60Hz                |                    | 0.8                | 0.9  |     | *   | *    | °C/W  |
| Resistance, DC junction to case              | T <sub>c</sub> = -55 to +125°C                        |                    | 1.25               | 1.4  |     | *   | *    | °C/W  |
| Resistance, junction to air                  | T <sub>c</sub> = -55 to +125°C                        |                    | 30                 |      |     | *   |      | °C/W  |
| Temperature Range, case                      | Meets full range specifications                       | -25                |                    | +85  | -55 |     | +125 | °C    |

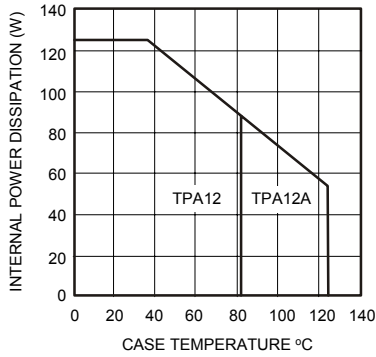
Notes: \*Same as previous Model.

1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.
2. The power supply voltage for all specifications is ±40V unless otherwise noted as a test condition.
3. +Vs and -Vs denote the positive and negative supply rail respectively. Total Vs is measured from +Vs to -Vs.
4. Rating applies if the output current alternates between both output transistors at a rate faster than 60Hz.
5. Exceeding CMV range can cause the output to latch.

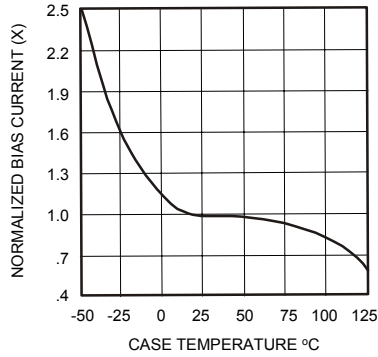
*Caution: The internal substrate contains beryllia (BeO). Do not crush, break, machine or subject the substrate to temperatures in excess of 850C.*

# TYPICAL PERFORMANCE CURVES

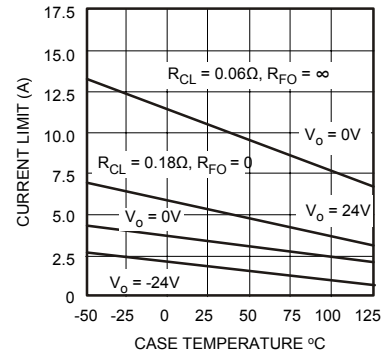
**POWER DERATING**



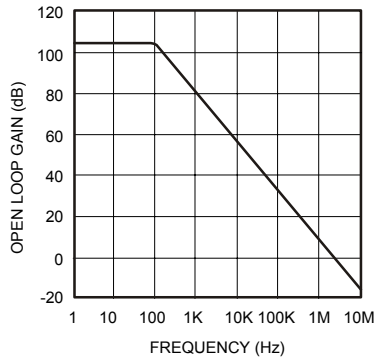
**BIAS CURRENT**



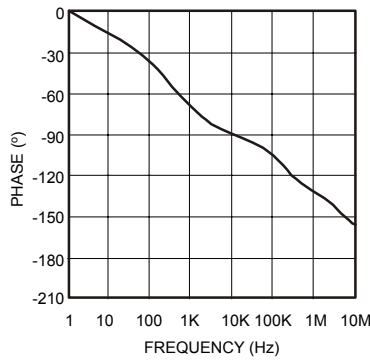
**CURRENT LIMIT**



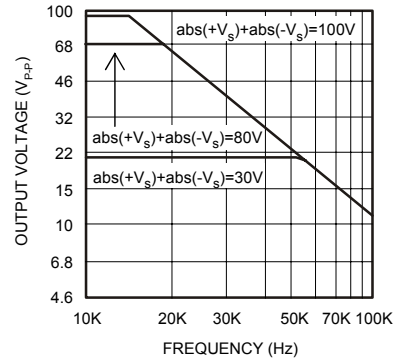
**SMALL SIGNAL RESPONSE**



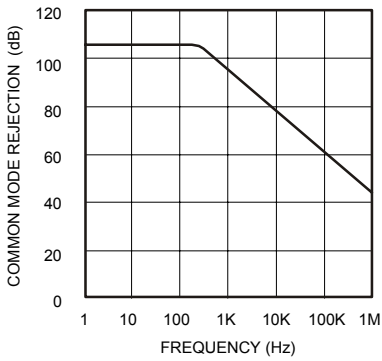
**PHASE RESPONSE**



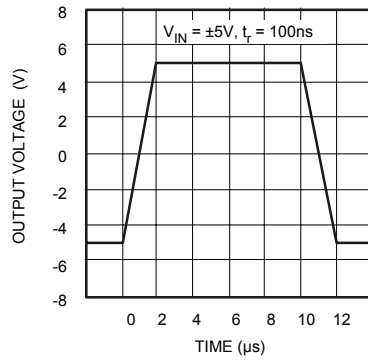
**POWER RESPONSE**



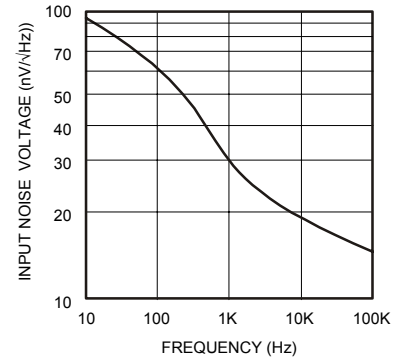
**COMMON MODE REJECTION**



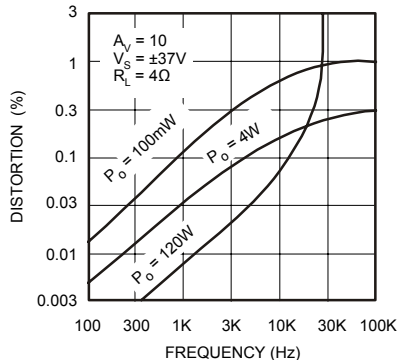
**PULSE RESPONSE**



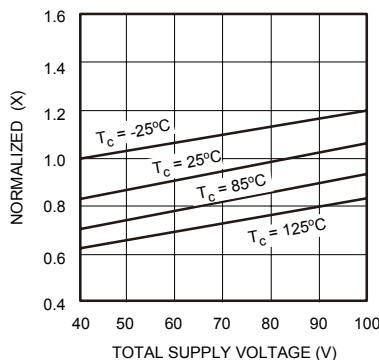
**INPUT NOISE**



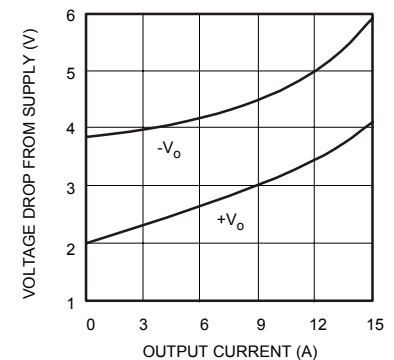
**HARMONIC DISTORTION**



**QUIESCENT CURRENT**



**OUTPUT VOLTAGE SWING**

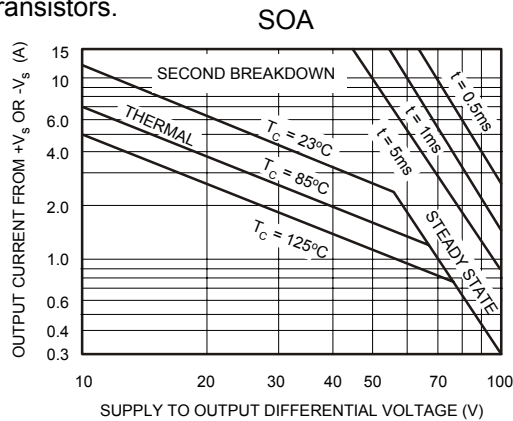


# DISCUSSION OF PERFORMANCE

## SAFE OPERATING AREA (SOA)

The output stage of most power amplifiers has three distinct limitations:

- 1) The current handling capability of the transistor geometry and the wire bonds.
- 2) The second breakdown effect which occurs whenever the simultaneous collector current and collector-emitter voltage exceeds specified limits.
- 3) The junction temperature of the output resistors.



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.

1. Capacitive and dynamic\* loads up to the following maximums are safe with the current limits set as specified.

| $\pm V_s$ | Capacitive Load |                 | Inductive Load |                 |
|-----------|-----------------|-----------------|----------------|-----------------|
|           | $I_{LIM} = 5A$  | $I_{LIM} = 10A$ | $I_{LIM} = 5A$ | $I_{LIM} = 10A$ |
| 50V       | 200 $\mu$ F     | 125 $\mu$ F     | 5mH            | 2.0mH           |
| 40V       | 500 $\mu$ F     | 350 $\mu$ F     | 15mH           | 3.0mH           |
| 35V       | 2.0mF           | 850 $\mu$ F     | 50mH           | 5.0mH           |
| 30V       | 7.0mF           | 2.5mF           | 150mH          | 10mH            |
| 25V       | 25mF            | 10mF            | 500mH          | 20mH            |
| 20V       | 60mF            | 20mF            | 1,000mH        | 30mH            |
| 15V       | 150mF           | 60mF            | 2,500mH        | 50mH            |

2. The amplifier can handle any EMF generating or reactive load and short circuits to the supply rail or common if the current limits are set as follows at  $T_c = 25^\circ C$ .

\* If the inductive load is driven near steady state conditions, allowing the output voltage to drop more than 8V below the supply rail with  $I_{LIM} = 15A$  or 25V below the supply rail with  $I_{LIM} = 5A$  while the amplifier is current limiting, the inductor must be capacitively coupled or the current limit must be lowered to meet SOA criteria.

| $\pm V_s$ | Short to $\pm V_s$<br>C,L or EMF Load | Short to<br>Common |
|-----------|---------------------------------------|--------------------|
| 50V       | 0.30A                                 | 2.4A               |
| 40V       | 0.58A                                 | 2.9A               |
| 35V       | 0.87A                                 | 3.7A               |
| 30V       | 1.50A                                 | 4.1A               |
| 25V       | 2.40A                                 | 4.9A               |
| 20V       | 2.90A                                 | 6.3A               |
| 15V       | 4.20A                                 | 8.0A               |

These simplified limits may be exceeded with further analysis using the operating conditions for a specific application.

## CURRENT LIMIT

For fixed current limit, leave pin 7 open and use the equations in 1 and 2.

$$R_{CL} = 0.65/I_{CL} \quad (1)$$

$$I_{CL} = 0.65/R_{CL} \quad (2)$$

Where:

$I_{CL}$  is the current limit in amperes.

$R_{CL}$  is the current limit resistor in ohms.

For certain applications the foldover current limit adds a slope to the current limit which allows more power to be delivered to the load without violating the SOA. For maximum foldover slope, ground pin 7 and use equations 3 and 4.

$$I_{CL} = (0.65 + (V_o * 0.014)) / R_{CL} \quad (3)$$

$$R_{CL} = (0.65 + (V_o * 0.014)) / I_{CL} \quad (4)$$

Where  $V_o$  is the output voltage in volts.

Most designers start with either equation 1 to set  $R_{CL}$  for the desired output current at 0V out or with equation 4 set to  $R_{CL}$  at the maximum output voltage. Equation 3 should then be used to plot the resulting foldover limits on the SOA graph. If equation 3 results in a negative current limit, foldover slope must be reduced. This can happen when the output voltage is the opposite polarity of the supply conducting the current.

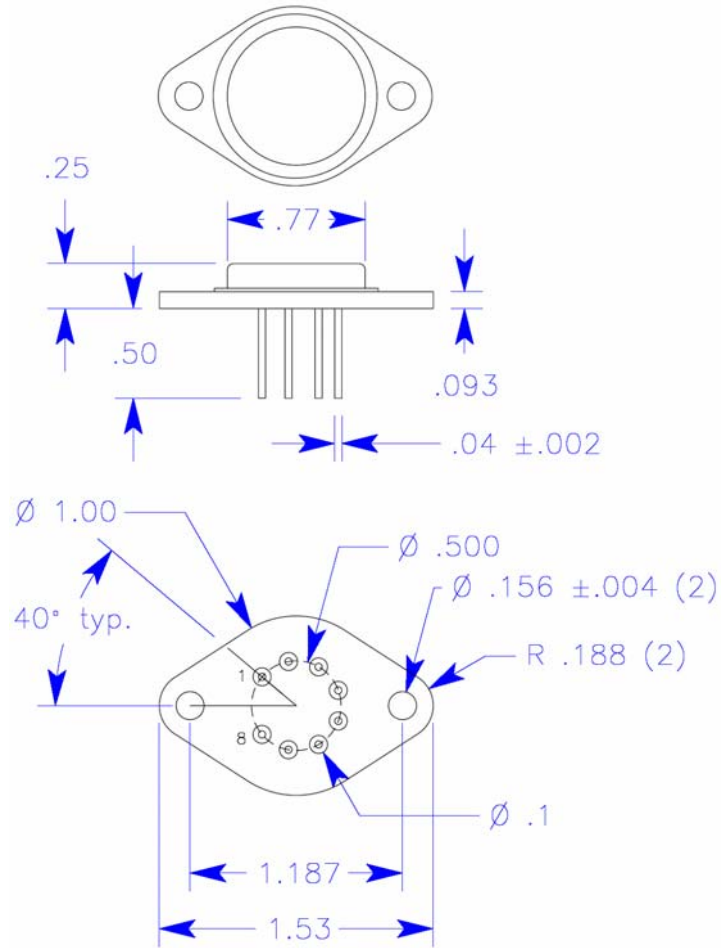
In applications where a reduced foldover slope is desired, this can be achieved by adding a resistor ( $R_{FO}$ ) between pin 7 and ground. Use equations 5 and 6 with this new resistor in the circuit.

$$I_{CL} = ((0.65 + (V_o * 0.014)) / (10.14 + R_{FO})) / R_{CL} \quad (5)$$

$$R_{CL} = ((0.65 + (V_o * 0.014)) / (10.14 + R_{FO})) / I_{CL} \quad (6)$$

Where  $R_{FO}$  is in K ohms.

# MECHANICAL



TO3-8 Package