

LM2005 20 Watt Automotive Power Amplifier

General Description

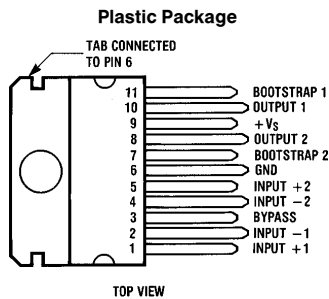
The LM2005 is a dual high power amplifier, designed to deliver optimum performance and reliability for automotive applications. High current capability (3.5A) enables the device to deliver 10W/channel into 2 Ω (LM2005T-S), or 20W bridged monaural (LM2005T-M) into 4 Ω , with low distortion.

Features

- Wide supply range (8V–18V)
- Externally programmable gain
- With or without bootstrap
- Low distortion
- Low noise

- High peak current capability
- $P_O = 20W$ bridge
- High voltage protection
- AC and DC output short circuit protection to ground or across load
- Thermal protection
- Inductive load protection
- Accidental open ground protection
- Immunity to 40V power supply transients
- 3°C/W device dissipation
- Pin for pin compatible with TDA2005

Connection Diagram



Order Number LM2005T-S
or LM2005T-M
See NS Package Number TA11A

Typical Application

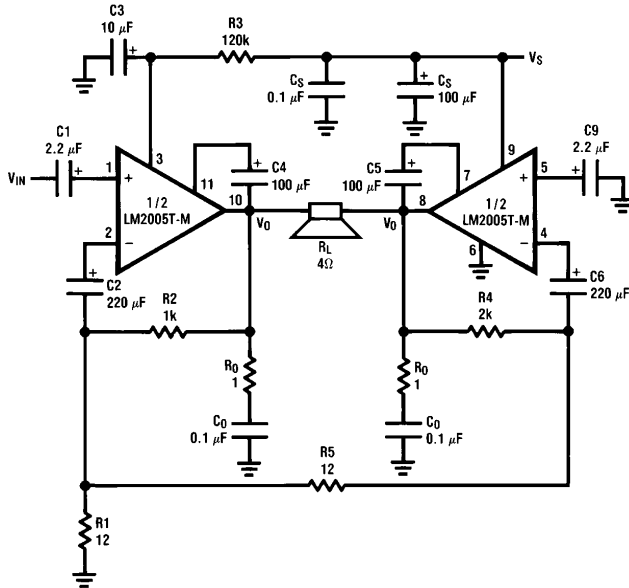


FIGURE 1. 20W Bridge Amplifier Application and Test Circuit

LM2005T-M and LM2005T-S

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

| | |
|-----------------------------|-----|
| Operating Supply Voltage | 18V |
| DC Supply Voltage (Note 1) | 28V |
| Peak Supply Voltage (50 ms) | 40V |

| | |
|------------------------------------|-----------------|
| Output Current | |
| Repetitive (Note 2) | 3.5A |
| Non-Repetitive | 4.5A |
| Power Dissipation | 30W |
| Operating Temperature | −40°C to +85°C |
| Storage Temperature | −60°C to +150°C |
| Lead Temp. (Soldering, 10 seconds) | 260°C |

LM2005T-M

Electrical Characteristics Refer to the **bridge** application circuit, *Figure 1*, $T_{amb} = 25^{\circ}\text{C}$, $A_V = 50\text{ dB}$, $R_{th}(\text{heatsink}) = 4^{\circ}\text{C/W}$, unless otherwise specified

| Parameter | Test Conditions | Min | Typ | Max | Units |
|---|--|----------------|----------------|------------------------|---------------|
| Supply Voltage | | 8 | | 18 | V |
| Output Offset Voltage (Note 3) (between Pin 8 and 10) | $V_S = 14.4\text{V}$ $V_S = 13.2\text{V}$ | | ± 20 | ± 150 ± 150 | mV mV |
| Total Quiescent Drain Current Includes Current in Feedback Resistors | $V_S = 14.4\text{V}$ $R_L = 4\Omega$ $V_S = 13.2\text{V}$ $R_L = 3.2\Omega$ | | 75 70 | 150 160 | mA mA |
| Output Power | $d = 10\%$ $f = 1\text{ kHz}$ $V_S = 14.4\text{V}$ $R_L = 4\Omega$ $R_L = 3.2\Omega$ $V_S = 13.2\text{V}$ $R_L = 3.2\Omega$ | 18 20 17 | 20 22 19 | | W W W |
| THD | $f = 1\text{ kHz}$ $V_S = 14.4\text{V}$ $R_L = 4\Omega$ $P_O = 50\text{ mW to }15\text{W}$ $V_S = 13.2\text{V}$ $R_L = 3.2\Omega$ $P_O = 50\text{ mW to }13\text{W}$ | | | 1 1 | % % |
| Input Sensitivity | $f = 1\text{ kHz}$ $P_O = 2\text{W}$ $R_L = 4\Omega$ $P_O = 2\text{W}$ $R_L = 3.2\Omega$ | | 9 8 | | mV mV |
| Input Resistance | $f = 1\text{ kHz}$ | 70 | | | k Ω |
| Low Frequency Roll Off (−3 dB) | $R_L = 3.2\Omega$ | | | 40 | Hz |
| High Frequency Roll Off (−3 dB) | $R_L = 3.2\Omega$ | 20 | | | kHz |
| Closed Loop Voltage Gain | $f = 1\text{ kHz}$ | 45 | 50 | | dB |
| Total Input Noise Voltage | $R_g = 10\text{ k}\Omega$ (Note 4) | | 3 | 10 | μV |
| Supply Voltage Rejection | $R_g = 10\text{ k}\Omega$ $f_{\text{ripple}} = 100\text{ Hz}$ $C_4 = 10\text{ }\mu\text{F}$ $V_{\text{ripple}} = 0.5\text{V}$ | 45 | 55 | | dB |
| Efficiency | $V_S = 14.4\text{V}$ $f = 1\text{ kHz}$ $P_O = 20\text{W}$ $R_L = 4\Omega$ $P_O = 22\text{W}$ $R_L = 3.2\Omega$ $V_S = 13.2\text{V}$ $f = 1\text{ kHz}$ $P_O = 19\text{W}$ $R_L = 3.2\Omega$ | | 60 60 58 | | % % % |
| Output Voltage with One Side of the Speaker Shorted to Ground | $V_S = 14.4\text{V}$ $R_L = 4\Omega$ $V_S = 13.2\text{V}$ $R_L = 3.2\Omega$ | | | 2 | V |

Note 1: Internal voltage limit. Shuts down above 20V.

Note 2: Internal current limit.

Note 3: For LM2005T-M only.

Note 4: Bandwidth filter: 22 Hz to 22 kHz.

LM2005T-S

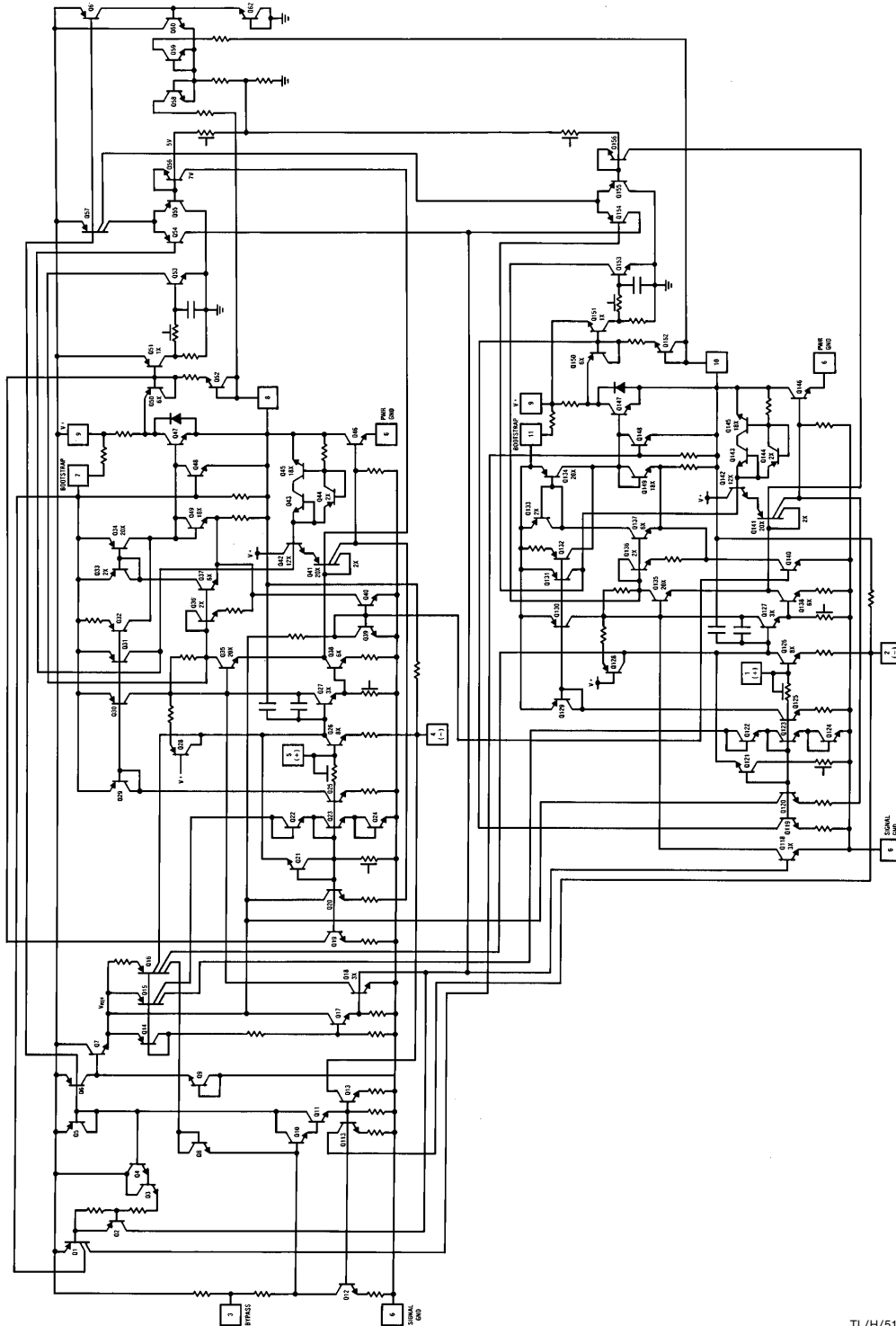
Electrical Characteristics Refer to the **stereo** application circuit, *Figure 2*, $T_{amb} = 25^{\circ}\text{C}$, $G_v = 50\text{ dB}$, $R_{th}(\text{heatsink}) = 4^{\circ}\text{C/W}$, unless otherwise specified

| Parameter | Test Conditions | Min | Typ | Max | Units |
|---|--|-----|-----|-----|---------------|
| Supply Voltage | | 8 | | 18 | V |
| Quiescent Output Voltage | $V_S = 14.4\text{V}$ | 6.6 | 7.2 | 7.8 | V |
| | $V_S = 13.2\text{V}$ | 6 | 6.6 | 7.2 | V |
| Total Quiescent Drain Current Includes Current in Feedback Resistors | $V_S = 14.4\text{V}$ | | 65 | 120 | mA |
| | $V_S = 13.2\text{V}$ | | 62 | 120 | mA |
| Output Power (Each Channel) | $f = 1\text{ kHz}$ $d = 10\%$ | | | | |
| | $V_S = 14.4\text{V}$ $R_L = 4\Omega$ | 6 | 6.5 | | W |
| | $R_L = 3.2\Omega$ | 7 | 8 | | W |
| | $R_L = 2\Omega$ | 9 | 10 | | W |
| | $R_L = 1.6\Omega$ | 10 | 11 | | W |
| | $V_S = 13.2\text{V}$ $R_L = 3.2\Omega$ | 6 | 6.5 | | W |
| | $R_L = 1.6\Omega$ | 9 | 10 | | W |
| | $V_S = 16\text{V}$ $R_L = 2\Omega$ | | 12 | | W |
| THD (Each Channel) | $f = 1\text{ kHz}$ $R_L = 4\Omega$ | | | | |
| | $V_S = 14.4\text{V}$ $P_O = 50\text{ mW to }4\text{W}$ | | 0.2 | 1 | % |
| | $V_S = 14.4\text{V}$ $R_L = 2\Omega$ | | | | |
| | $P_O = 50\text{ mW to }6\text{W}$ | | 0.3 | 1 | % |
| | $V_S = 13.2\text{V}$ $R_L = 3.2\Omega$ | | | | |
| | $P_O = 50\text{ mW to }3\text{W}$ | | 0.2 | 1 | % |
| Cross Talk (Note 5) | $V_S = 14.4\text{V}$ $f = 1\text{ kHz}$ | 40 | 60 | | dB |
| | $R_L = 4\Omega$ | | | | |
| | $V_O = 4 V_{rms}$ $f = 10\text{ kHz}$ | | 40 | | dB |
| | $R_g = 5\text{ k}\Omega$ | | | | |
| Input Saturation Voltage | | 300 | | | mV |
| Input Sensitivity | $f = 1\text{ kHz}$ $P_O = 1\text{W}$ | | 6 | | |
| | $R_L = 4\Omega$ | | 5.5 | | mV |
| Input Resistance | $f = 1\text{ kHz}$ Non-Inverting Input | 70 | 200 | | k Ω |
| | Inverting Input | | 10 | | k Ω |
| Low Frequency Roll Off (-3 dB) | $R_L = 2\Omega$ | | | 50 | Hz |
| High Frequency Roll Off (-3 dB) | $R_L = 2\Omega$ | 15 | | | kHz |
| Voltage Gain (Open Loop) | $f = 1\text{ kHz}$ | | 90 | | dB |
| Voltage Gain (Closed Loop) | $f = 1\text{ kHz}$ | 48 | 50 | 51 | dB |
| Closed Loop Gain Matching | | | 0.5 | | dB |
| Total Input Noise Voltage | $R_g = 10\text{ k}\Omega$ (Note 6) | | 1.5 | 5 | μV |
| Supply Voltage Rejection | $R_g = 10\text{ k}\Omega$ $f_{ripple} = 100\text{ Hz}$ $C_3 = 10\text{ }\mu\text{F}$ $V_{ripple} = 0.5\text{V}$ | 35 | 45 | | dB |
| Efficiency | $V_S = 14.4\text{V}$ $f = 1\text{ kHz}$ | | | | |
| | $R_L = 4\Omega$ $P_O = 6.5\text{W}$ | | 70 | | % |
| | $R_L = 2\Omega$ $P_O = 10\text{W}$ | | 60 | | % |
| | $V_S = 13.2\text{V}$ $f = 1\text{ kHz}$ | | | | |
| | $R_L = 3.2\Omega$ $P_O = 6.5\text{W}$ | | 70 | | % |
| | $R_L = 1.6\Omega$ $P_O = 10\text{W}$ | | 60 | | % |

Note 5: For LM2005T-S only.

Note 6: Bandwidth filter: 22 Hz to 22 kHz.

Equivalent Schematic



TL/H/5129-3

External Components (Figure 2)

| Components | Comments | Components | Comments |
|------------------------------------|--|---------------------------------|--|
| 1. R1, R2 R5, R4 | Sets voltage gain, $A_V \cong 1 + \frac{R'}{R1}$ $A_V = 1 + \frac{R'}{R5}$ for one channel, for the other. Where R' is the equivalent resistance of R2 in parallel with an internal 10k resistor: $R' = \frac{10k \cdot R2}{R2 + 10k}$ If $R2 \ll 10k$, then $A_V \cong 1 + \frac{R2}{R1}$ | 5. C4, C5 6. C3 7. C2, C6 | Bootstrap capacitors, used to increase drive to output stage. Improves power supply rejection. Increasing C3 increases turn-on delay (approximately 2 ms per μF). Inverting input DC decouple. Low frequency pole: $F_{L2} = \frac{1}{2\pi Z(\text{inverting})C2}$ $Z(\text{inverting}) \approx 10 k\Omega$ |
| 2. R3 | Adjusts output symmetry for maximum power output. | 8. C _C | Output coupling capacitor. Isolates pins 10 and 8 from load. Low frequency pole; $F_{L3} = \frac{1}{2\pi R_L C_C}$ |
| 3. R _O , C _O | Works to stabilize internal output stage. Necessary for stability. C _O should be ceramic disc or equivalently good high frequency capacitor. | 9. C _S | Power supply filtering. |
| 4. C1, C9 | Input coupling capacitor. Low frequency pole set by $F_{L1} = \frac{1}{2\pi Z(\text{non-inverting})C1}$ Decreasing capacitor value will also increase noise. | | |

Typical Applications (Continued)

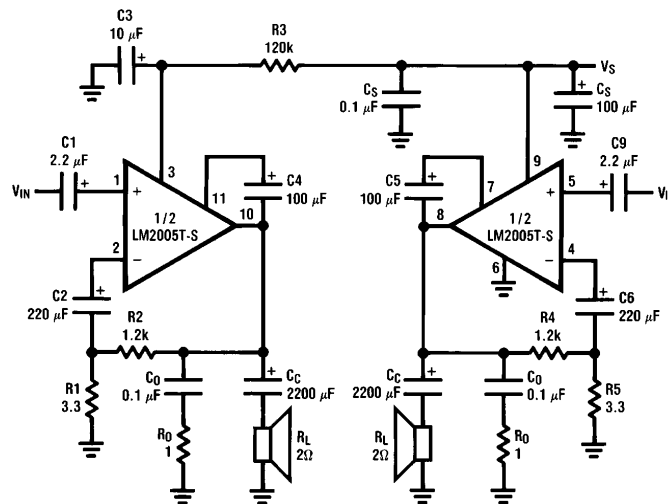
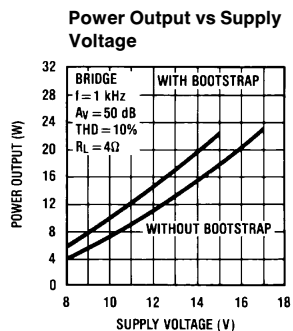
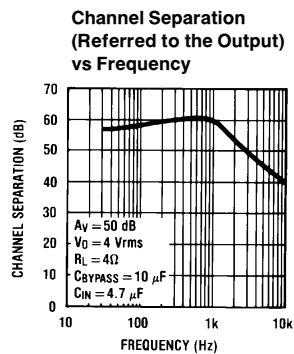
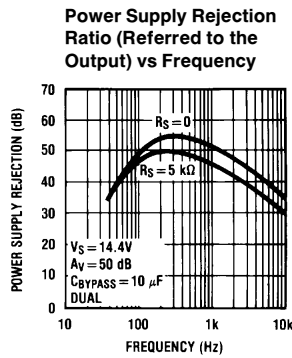
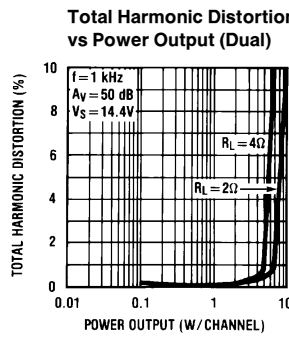
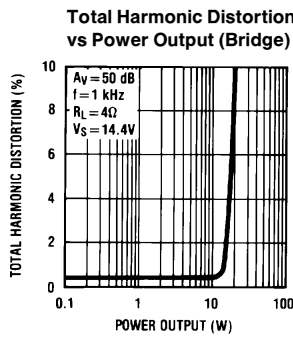
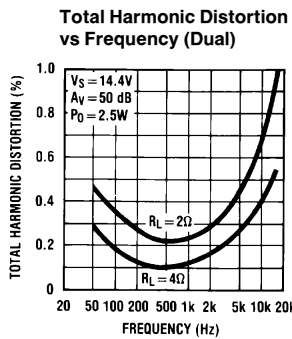
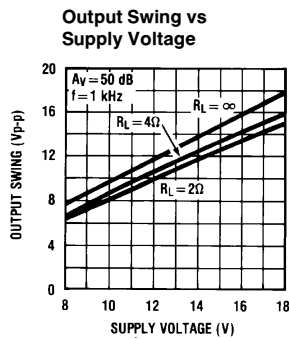
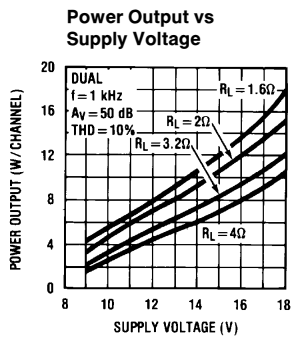
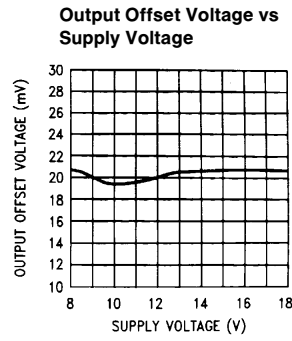
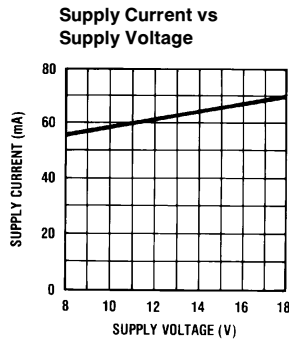
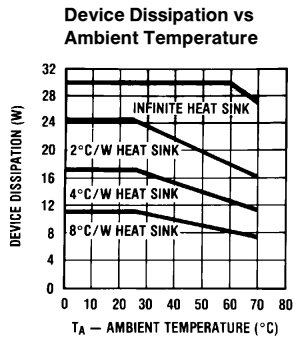


FIGURE 2. 10W/Channel Stereo Amplifier Application and Test Circuit

TL/H/5129-4

Typical Performance Characteristics



TL/H/5129-5

Application Hints

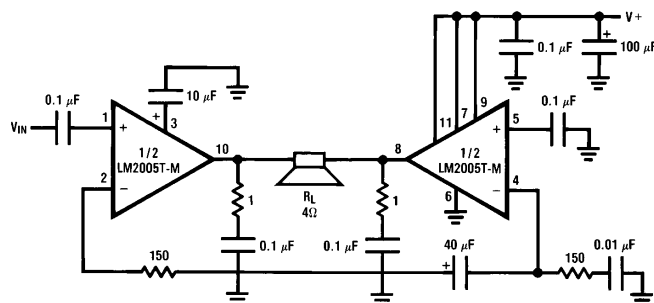
The high current capability of the LM2005 allows it to continuously endure either AC or DC short circuit of the output with a maximum supply voltage of 16V. This will protect the loudspeaker in a bridge mode, when a DC short of the output occurs on one side of the speaker. The device will prevent the speaker from destruction by reducing the DC across the load (bridge mode) to typically less than 2 V_{DC} (V_S=14.4V, R_L=4Ω), by an internal current pullback method.

The LM2005 can withstand a constant 28 V_{DC} on the supply with no damage (maximum operating voltage is 18V). The device is also protected from load dump or dangerous transients up to 40V for 50 ms (every 1000 ms) on the supply with no damage.

Protection diodes protect the device driving inductive loads, during which the load can generate voltages greater than

supply or less than ground levels. The protection diodes will clamp these transients to a safe V_{BE} above and below the rails.

The bridge configuration in *Figure 3* is designed for applications requiring minimal printed circuit board area and maximum cost effectiveness. The circuit will function with the elimination of bootstrap components R3, C4 and C5 (refer to *Figure 1*). This will result in less output power by decreasing output voltage swing to the load. By using internal feedback resistors (typically 10 kΩ), feedback components R2, R3 and C2 (*Figure 1*) may be omitted where closed loop voltage gain accuracy is not critical. The net result is a stable, cost effective circuit that will satisfy many application needs.

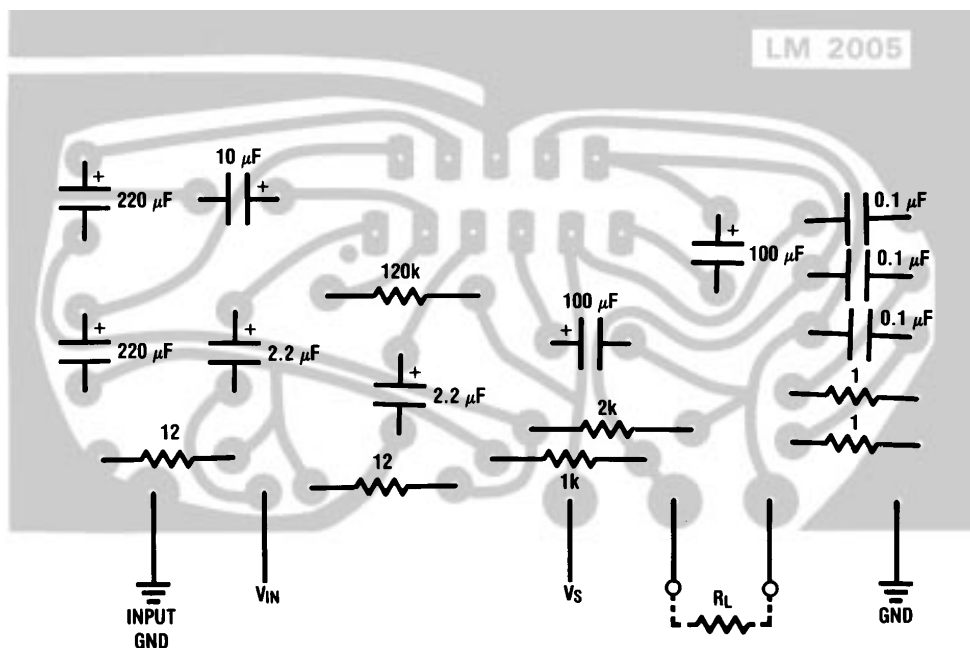


TL/H/5129-6

A_V = 41.5 dB @ 1 kHz

FIGURE 3. Minimal Component Application Circuit

Component Side (Scale 2:1)

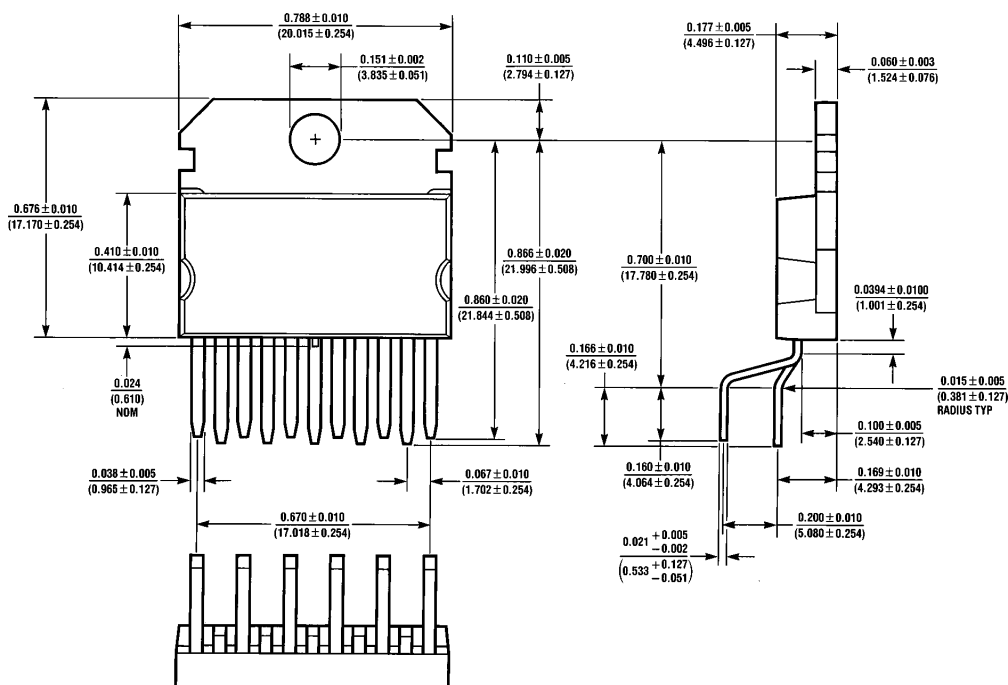


TL/H/5129-7

FIGURE 4. Printed Circuit Board Layout for LM2005

Physical Dimensions inches (millimeters)

Lit. # 107847



T11A (REV B)

11-Lead TO-220 Power Package (T)
Order Number LM2005T-S or LM2005T-M
NS Package Number T11A

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