National Semiconductor

April 1989

LM2005 20 Watt Automotive Power Amplifier

General Description

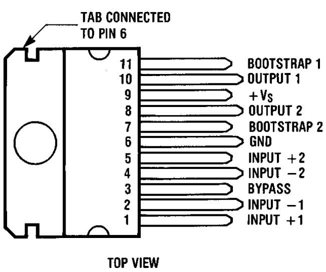
The LM2005 is a dual high power amplifier, designed to deliver optimum performance and reliability for automotive applications. High current capability (3.5A) enables the device to deliver 10W/channel into 2Ω (LM2005T-S), or 20W bridged monaural (LM2005T-M) into 4Ω, with low distortion.

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

Plastic Package



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

Typical Application

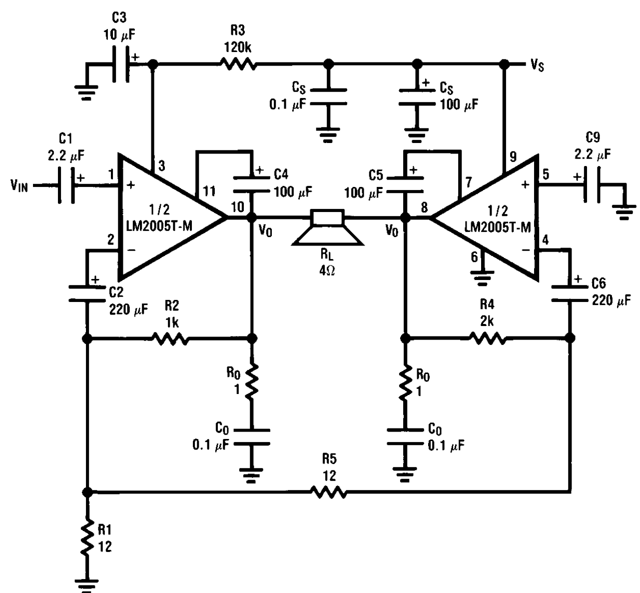

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FIGURE 1. 20W Bridge Amplifier Application and Test Circuit

 RRD-B30M115/Printed in U. S. A.

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*, $T_{amb} = 25°C$, $A_V = 50$ dB, $R_{th\ (heatsink)} = 4°C/W$, 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)	$V_S = 14.4V$ $V_S = 13.2V$			±20	±150 ±150	mV mV
Total Quiescent Drain Current Includes Current in Feedback Resistors	$V_S = 14.4V$ $V_S = 13.2V$	$R_L = 4\Omega$ $R_L = 3.2\Omega$		75 70	150 160	mA mA
Output Power	$d = 10\%$ $V_S = 14.4V$ $V_S = 13.2V$	$f = 1$ kHz $R_L = 4\Omega$ $R_L = 3.2\Omega$ $R_L = 3.2\Omega$	 18 20 17	 20 22 19		 W W W
THD	$f = 1$ kHz $V_S = 14.4V$ $P_O = 50$ mW to 15W $V_S = 13.2V$ $P_O = 50$ mW to 13W	 $R_L = 4\Omega$ $R_L = 3.2\Omega$ 			 1 1	 % %
Input Sensitivity	$f = 1$ kHz $P_O = 2W$ $P_O = 2W$	 $R_L = 4\Omega$ $R_L = 3.2\Omega$		 9 8		 mV mV
Input Resistance	$f = 1$ kHz		70			kΩ
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	$f = 1$ kHz		45	50		dB
Total Input Noise Voltage	$R_g = 10$ kΩ (Note 4)			3	10	μV
Supply Voltage Rejection	$R_g = 10$ kΩ $C_4 = 10\ \mu F$	$f_{ripple} = 100$ Hz $V_{ripple} = 0.5V$	45	55		dB
Efficiency	$V_S = 14.4V$ $P_O = 20W$ $P_O = 22W$ $V_S = 13.2V$ $P_O = 19W$	$f = 1$ kHz $R_L = 4\Omega$ $R_L = 3.2\Omega$ $f = 1$ kHz $R_L = 3.2\Omega$		 60 60 58		 % % %
Output Voltage with One Side of the Speaker Shorted to Ground	$V_S = 14.4V$ $V_S = 13.2V$	$R_L = 4\Omega$ $R_L = 3.2V$			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

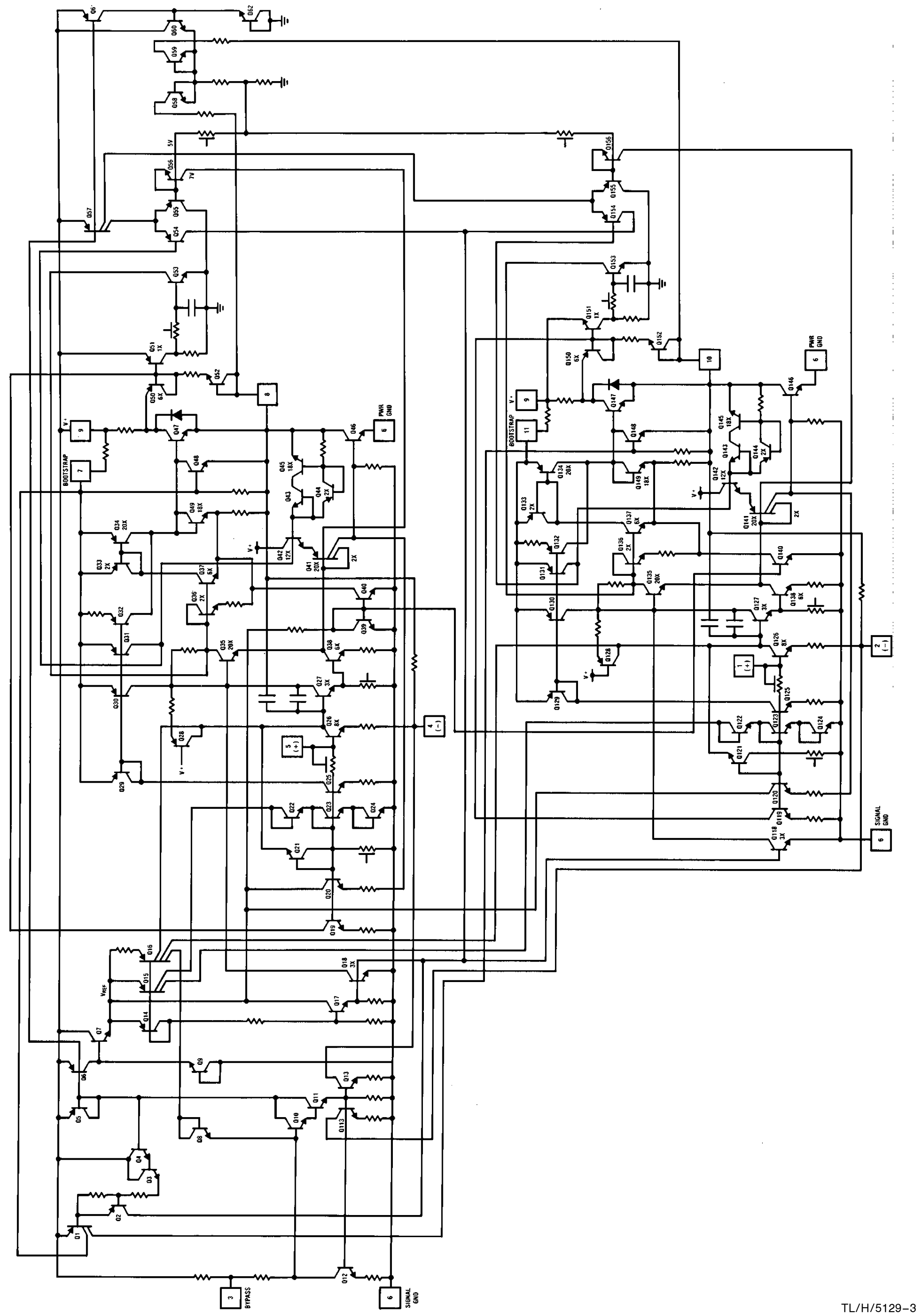
Electrical Characteristics Refer to the **stereo** application circuit, *Figure 2,* $T_{amb} = 25°C$, $G_v = 50$ dB, $R_{th\ (heatsink)} = 4°C/W$, unless otherwise specified

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

Note 5: For LM2005T-S only.

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

Equivalent Schematic



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External Components *(Figure 2)*

Components	Comments
1. R1, R2 R5, R4	Sets voltage gain, $A_V \cong 1 + \frac{R'}{R1}$ for one channel, $A_V = 1 + \frac{R'}{R5}$ for the other. Where R' is the equivalent resistance of R2 in parallel with an internal 10k resistor: $R' = \frac{10k \bullet R2}{R2 + 10k}$. If R2 $\ll$ 10k, then $A_V \cong 1 + \frac{R2}{R1}$.
2. R3	Adjusts output symmetry for maximum power output.
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.
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.
5. C4, C5	Bootstrap capacitors, used to increase drive to output stage.
6. C3	Improves power supply rejection. Increasing C3 increases turn-on delay (approximately 2 ms per μF).
7. C2, C6	Inverting input DC decouple. Low frequency pole: $F_L2 = \frac{1}{2\pi Z\text{(inverting)}C2}$. Z (inverting) $\approx$ 10 kΩ.
8. C_C	Output coupling capacitor. Isolates pins 10 and 8 from load. Low frequency pole; $F_L3 = \frac{1}{2\pi R_L C_C}$.
9. C_S	Power supply filtering.

Typical Applications (Continued)

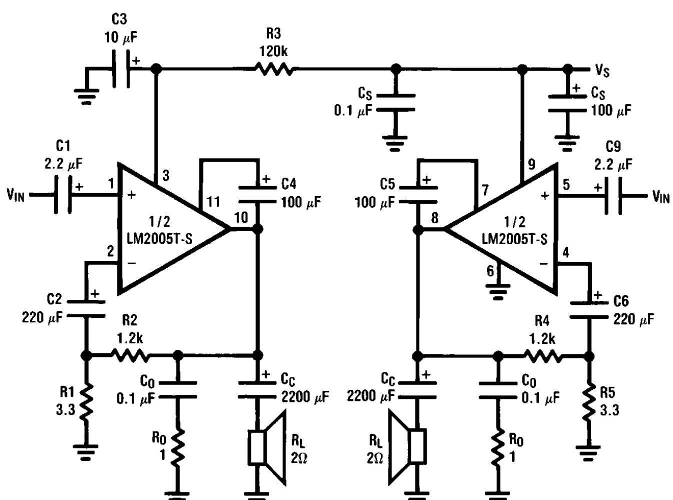

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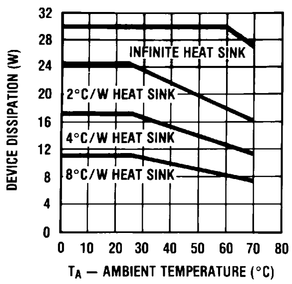
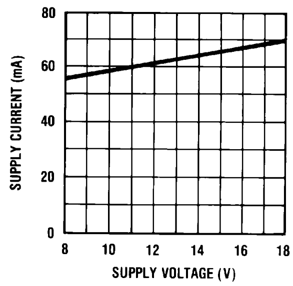
FIGURE 2. 10W/Channel Stereo Amplifier Application and Test Circuit

Typical Performance Characteristics

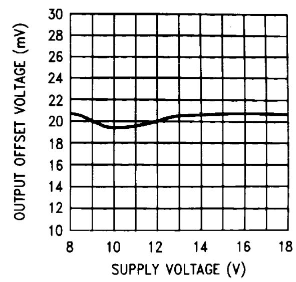
Device Dissipation vs Ambient Temperature



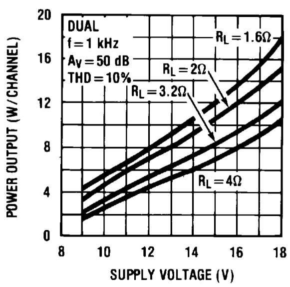
Supply Current vs Supply Voltage



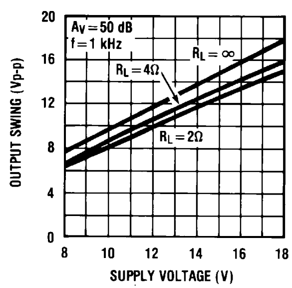
Output Offset Voltage vs Supply Voltage



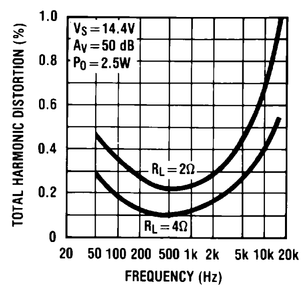
Power Output vs Supply Voltage



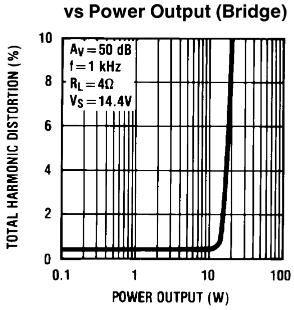
Output Swing vs Supply Voltage



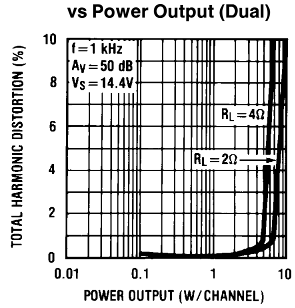
Total Harmonic Distortion vs Frequency (Dual)



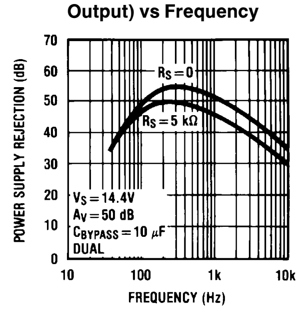
Total Harmonic Distortion vs Power Output (Bridge)



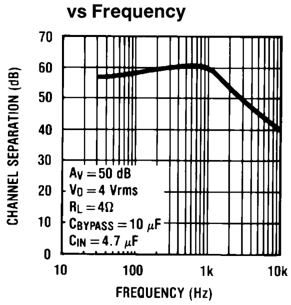
Total Harmonic Distortion vs Power Output (Dual)



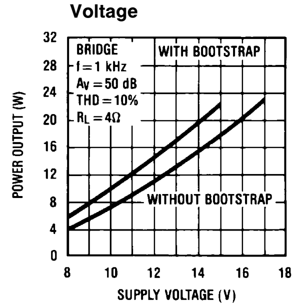
Power Supply Rejection Ratio (Referred to the Output) vs Frequency



Channel Separation (Referred to the Output) vs Frequency



Power Output vs Supply Voltage



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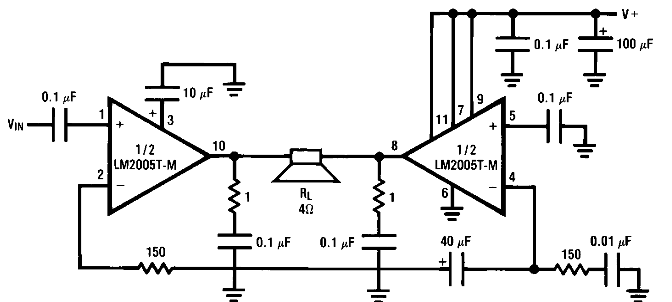
Application Hints

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.



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A_V = 41.5 dB @ 1 kHz

FIGURE 3. Minimal Component Application Circuit

Component Side (Scale 2:1)

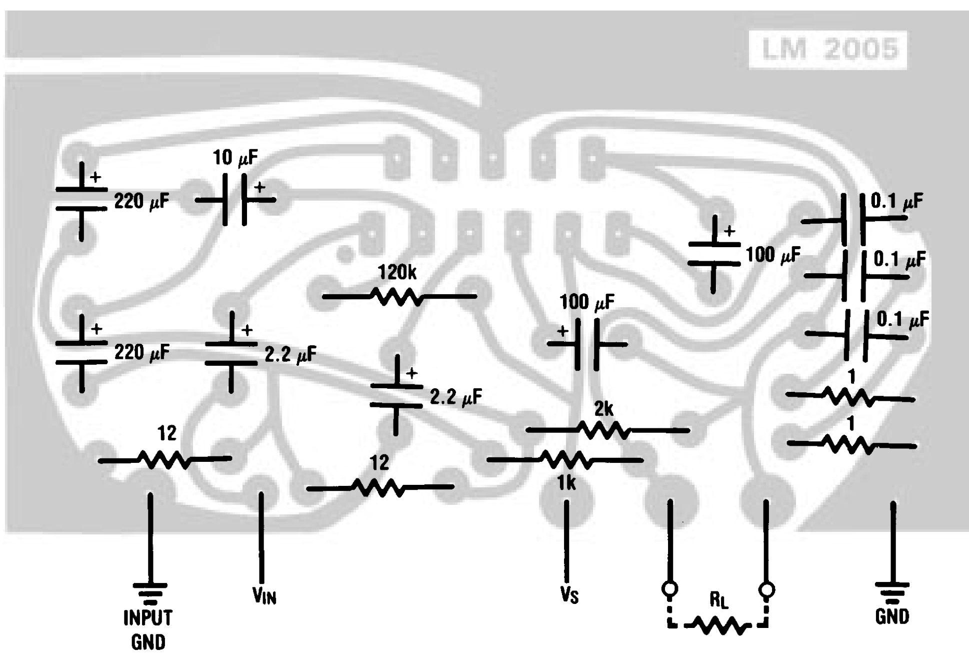

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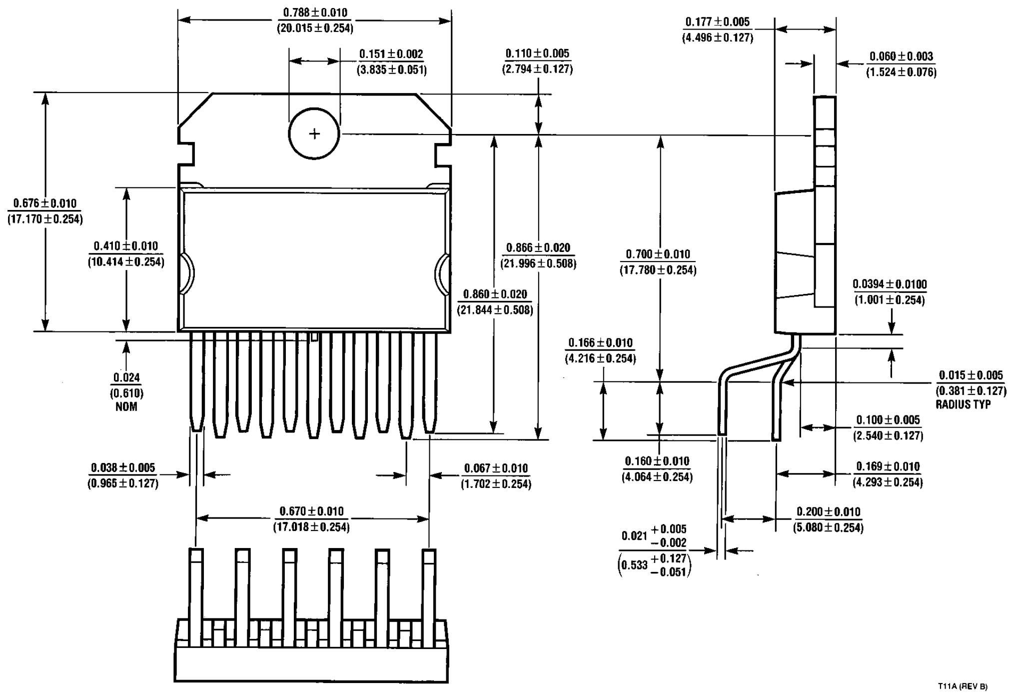
FIGURE 4. Printed Circuit Board Layout for LM2005

Physical Dimensions inches (millimeters)

Lit. # 107847



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

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