# LM1875 20W Audio Power Amplifier

**Check for Samples: LM1875**

## FEATURES

- **Up to 30 Watts Output Power**
- **$A_{VO}$ Typically 90 dB**
- **Low Distortion: 0.015%, 1 kHz, 20 W**
- **Wide Power Bandwidth: 70 kHz**
- **Protection for AC and DC Short Circuits to Ground**
- **Thermal Protection with Parole Circuit**
- **High Current Capability: 4A**
- **Wide Supply Range 16V-60V**
- **Internal Output Protection Diodes**
- **94 dB Ripple Rejection**
- **Plastic Power Package TO-220**

## APPLICATIONS

- **High Performance Audio Systems**
- **Bridge Amplifiers**
- **Stereo Phonographs**
- **Servo Amplifiers**
- **Instrument Systems**

## DESCRIPTION

The LM1875 is a monolithic power amplifier offering very low distortion and high quality performance for consumer audio applications.

The LM1875 delivers 20 watts into a 4Ω or 8Ω load on ±25V supplies. Using an 8Ω load and ±30V supplies, over 30 watts of power may be delivered. The amplifier is designed to operate with a minimum of external components. Device overload protection consists of both internal current limit and thermal shutdown.

The LM1875 design takes advantage of advanced circuit techniques and processing to achieve extremely low distortion levels even at high output power levels. Other outstanding features include high gain, fast slew rate and a wide power bandwidth, large output voltage swing, high current capability, and a very wide supply range. The amplifier is internally compensated and stable for gains of 10 or greater.

### Connection Diagram

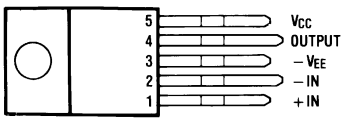


**Figure 1. NDH0005D, KC0005A, NEB0005E, NEB0005B, Front View**

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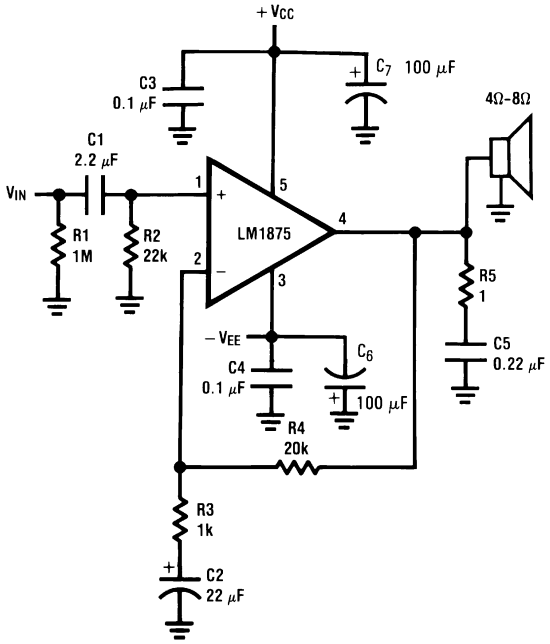
## Typical Applications




These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings(1)

| | | |
|---|---|---|
| Supply Voltage | | 60V |
| Input Voltage | | $-V_{EE}$ to $V_{CC}$ |
| Storage Temperature | | −65°C to + 150°C |
| Junction Temperature | | 150°C |
| Lead Temperature | (Soldering, 10 seconds) | 260°C |
| | $\theta_{JC}$ | 3°C |
| | $\theta_{JA}$ | 73°C |

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits.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## Electrical Characteristics

$V_{CC}$=+25V, $-V_{EE}$=−25V, $T_{AMBIENT}$=25°C, $R_L$=8Ω, $A_V$=20 (26 dB), $f_o$=1 kHz, unless otherwise specified.

| Parameter | Conditions | Typical | Tested Limits | Units |
|---|---|---|---|---|
| Supply Current | $P_{OUT}$=0W | 70 | 100 | mA |
| Output Power(1) | THD=1% | 25 | | W |
| THD(1) | $P_{OUT}$=20W, $f_o$=1 kHz | 0.015 | | % |
| | $P_{OUT}$=20W, $f_o$=20 kHz | 0.05 | 0.4 | % |
| | $P_{OUT}$=20W, $R_L$=4Ω, $f_o$=1 kHz | 0.022 | | % |
| | $P_{OUT}$=20W, $R_L$=4Ω, $f_o$=20 kHz | 0.07 | 0.6 | % |
| Offset Voltage | | ±1 | ±15 | mV |
| Input Bias Current | | ±0.2 | ±2 | µA |
| Input Offset Current | | 0 | ±0.5 | µA |
| Gain-Bandwidth Product | $f_o$=20 kHz | 5.5 | | MHz |
| Open Loop Gain | DC | 90 | | dB |
| PSRR | $V_{CC}$, 1 kHz, 1 Vrms | 95 | 52 | dB |
| | $V_{EE}$, 1 kHz, 1 Vrms | 83 | 52 | dB |
| Max Slew Rate | 20W, 8Ω, 70 kHz BW | 8 | | V/µs |
| Current Limit | $V_{OUT}$ = $V_{SUPPLY}$ −10V | 4 | 3 | A |
| Equivalent Input Noise Voltage | $R_S$=600Ω, CCIR | 3 | | µVrms |

(1) Assumes the use of a heat sink having a thermal resistance of 1°C/W and no insulator with an ambient temperature of 25°C. Because the output limiting circuitry has a negative temperature coefficient, the maximum output power delivered to a 4Ω load may be slightly reduced when the tab temperature exceeds 55°C.

## Typical Applications For Single Supply Operation

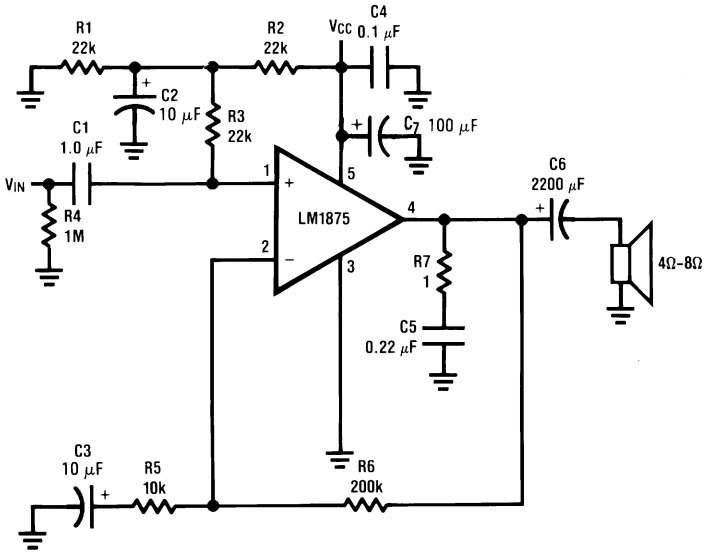


**Figure 2.**

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## Typical Performance Characteristics

**THD vs Power Output**

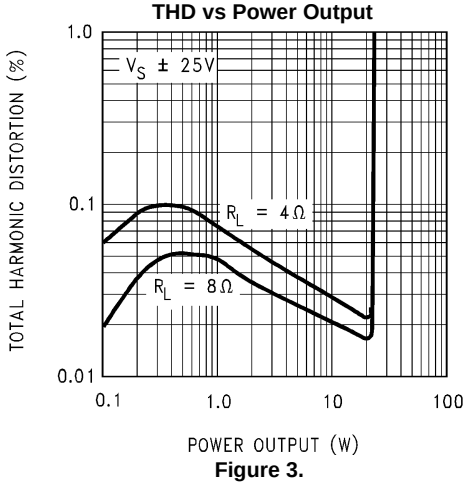



**Figure 3.**

**THD vs Frequency**

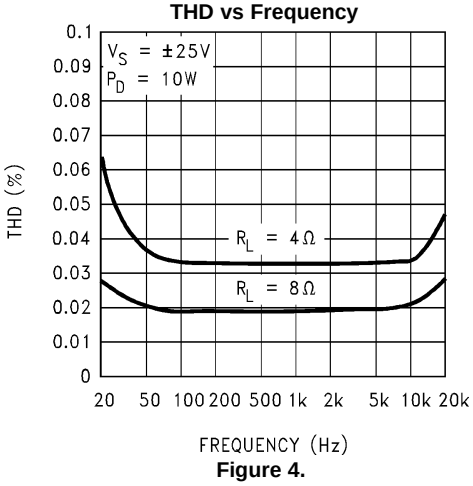



**Figure 4.**

**Power Output vs Supply Voltage**

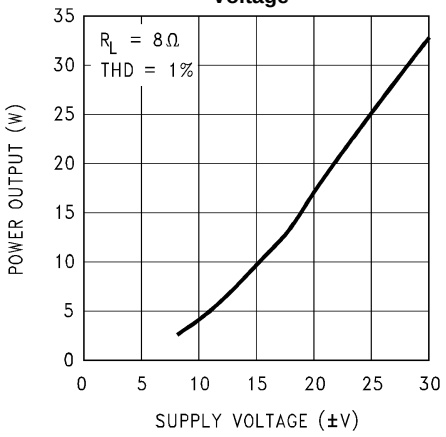



**Figure 5.**

**Supply Current vs Supply Voltage**

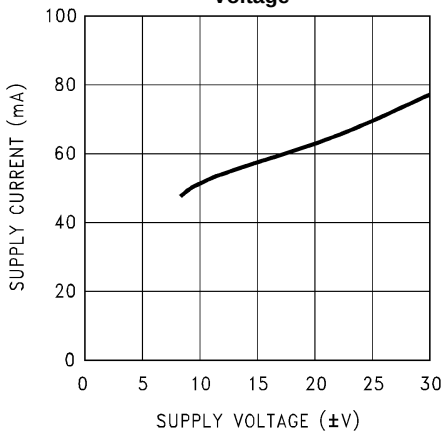



**Figure 6.**

**PSRR vs Frequency**

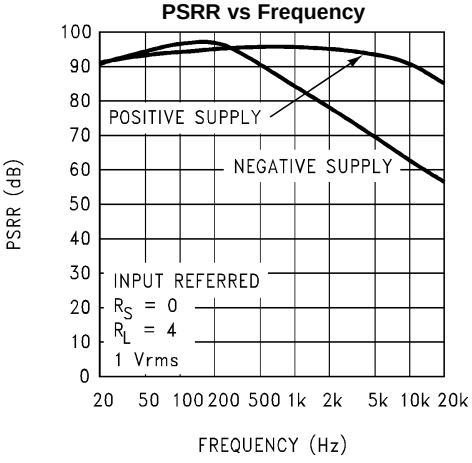
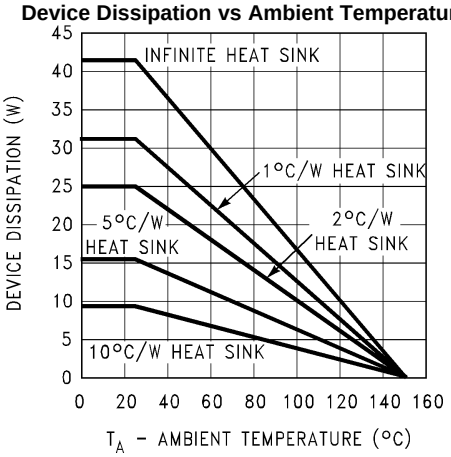



**Figure 7.**

**Device Dissipation vs Ambient Temperature†**




†φINTERFACE = 1°C/W.
See Application Hints.

**Figure 8.**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## Typical Performance Characteristics (continued)

**Power Dissipation vs Power Output**

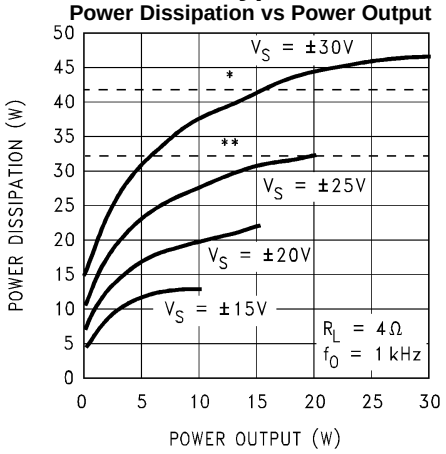


**Figure 9.**

**Power Dissipation vs Power Output**

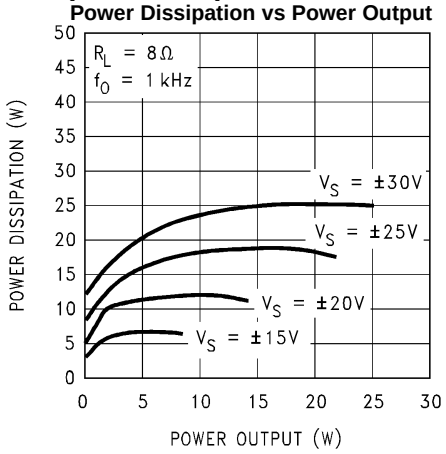


**Figure 10.**

**$I_{OUT}$ vs $V_{OUT}$-Current Limit/ Safe Operating Area Boundary**

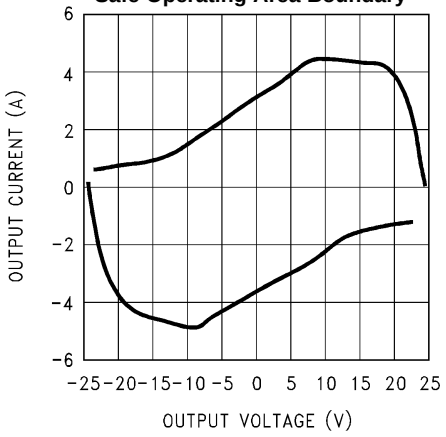


**Figure 11.**

**Open Loop Gain and Phase vs Frequency**

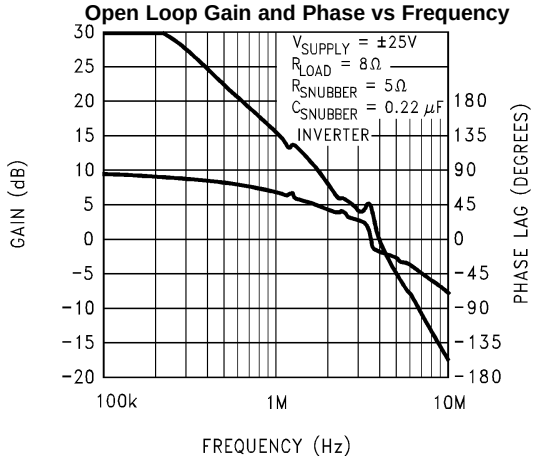


**Figure 12.**

Thermal shutdown with infinite heat sink

Thermal shutdown with 1°C/W heat sink

**Input Bias Current vs Supply Voltage**

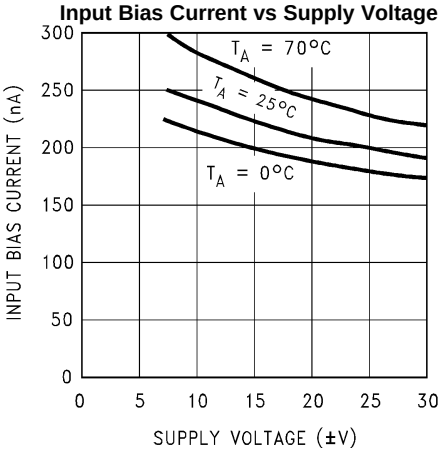


**Figure 13.**

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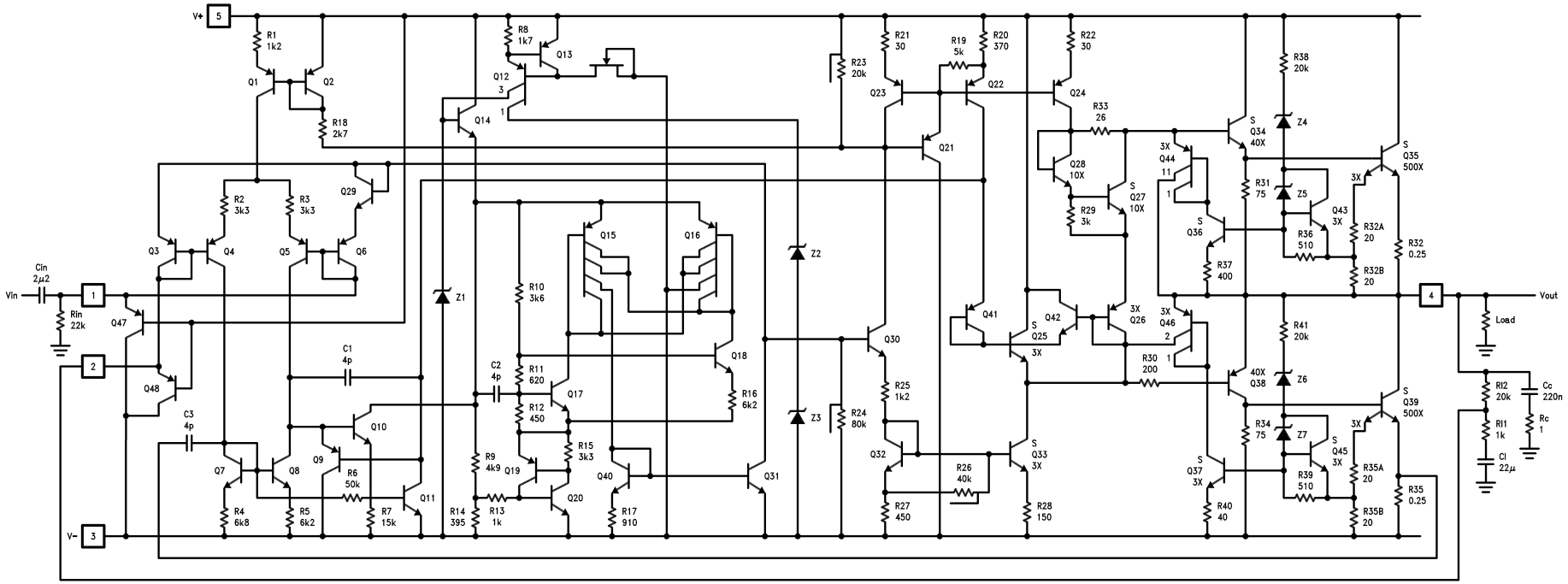
## Schematic Diagram





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# APPLICATION HINTS

## STABILITY

The LM1875 is designed to be stable when operated at a closed-loop gain of 10 or greater, but, as with any other high-current amplifier, the LM1875 can be made to oscillate under certain conditions. These usually involve printed circuit board layout or output/input coupling.

Proper layout of the printed circuit board is very important. While the LM1875 will be stable when installed in a board similar to the ones shown in this data sheet, it is sometimes necessary to modify the layout somewhat to suit the physical requirements of a particular application. When designing a different layout, it is important to return the load ground, the output compensation ground, and the low level (feedback and input) grounds to the circuit board ground point through separate paths. Otherwise, large currents flowing along a ground conductor will generate voltages on the conductor which can effectively act as signals at the input, resulting in high frequency oscillation or excessive distortion. It is advisable to keep the output compensation components and the 0.1 µF supply decoupling capacitors as close as possible to the LM1875 to reduce the effects of PCB trace resistance and inductance. For the same reason, the ground return paths for these components should be as short as possible.

Occasionally, current in the output leads (which function as antennas) can be coupled through the air to the amplifier input, resulting in high-frequency oscillation. This normally happens when the source impedance is high or the input leads are long. The problem can be eliminated by placing a small capacitor (on the order of 50 pF to 500 pF) across the circuit input.

Most power amplifiers do not drive highly capacitive loads well, and the LM1875 is no exception. If the output of the LM1875 is connected directly to a capacitor with no series resistance, the square wave response will exhibit ringing if the capacitance is greater than about 0.1 µF. The amplifier can typically drive load capacitances up to 2 µF or so without oscillating, but this is not recommended. If highly capacitive loads are expected, a resistor (at least 1Ω) should be placed in series with the output of the LM1875. A method commonly employed to protect amplifiers from low impedances at high frequencies is to couple to the load through a 10Ω resistor in parallel with a 5 µH inductor.

## DISTORTION

The preceding suggestions regarding circuit board grounding techniques will also help to prevent excessive distortion levels in audio applications. For low THD, it is also necessary to keep the power supply traces and wires separated from the traces and wires connected to the inputs of the LM1875. This prevents the power supply currents, which are large and nonlinear, from inductively coupling to the LM1875 inputs. Power supply wires should be twisted together and separated from the circuit board. Where these wires are soldered to the board, they should be perpendicular to the plane of the board at least to a distance of a couple of inches. With a proper physical layout, THD levels at 20 kHz with 10W output to an 8Ω load should be less than 0.05%, and less than 0.02% at 1 kHz.

## CURRENT LIMIT AND SAFE OPERATING AREA (SOA) PROTECTION

A power amplifier's output transistors can be damaged by excessive applied voltage, current flow, or power dissipation. The voltage applied to the amplifier is limited by the design of the external power supply, while the maximum current passed by the output devices is usually limited by internal circuitry to some fixed value. Short-term power dissipation is usually not limited in monolithic audio power amplifiers, and this can be a problem when driving reactive loads, which may draw large currents while high voltages appear on the output transistors. The LM1875 not only limits current to around 4A, but also reduces the value of the limit current when an output transistor has a high voltage across it.

When driving nonlinear reactive loads such as motors or loudspeakers with built-in protection relays, there is a possibility that an amplifier output will be connected to a load whose terminal voltage may attempt to swing beyond the power supply voltages applied to the amplifier. This can cause degradation of the output transistors or catastrophic failure of the whole circuit. The standard protection for this type of failure mechanism is a pair of diodes connected between the output of the amplifier and the supply rails. These are part of the internal circuitry of the LM1875, and needn't be added externally when standard reactive loads are driven.

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## THERMAL PROTECTION

The LM1875 has a sophisticated thermal protection scheme to prevent long-term thermal stress to the device. When the temperature on the die reaches 170°C, the LM1875 shuts down. It starts operating again when the die temperature drops to about 145°C, but if the temperature again begins to rise, shutdown will occur at only 150°C. Therefore, the device is allowed to heat up to a relatively high temperature if the fault condition is temporary, but a sustained fault will limit the maximum die temperature to a lower value. This greatly reduces the stresses imposed on the IC by thermal cycling, which in turn improves its reliability under sustained fault conditions.

Since the die temperature is directly dependent upon the heat sink, the heat sink should be chosen for thermal resistance low enough that thermal shutdown will not be reached during normal operation. Using the best heat sink possible within the cost and space constraints of the system will improve the long-term reliability of any power semiconductor device.

## POWER DISSIPATION AND HEAT SINKING

The LM1875 must always be operated with a heat sink, even when it is not required to drive a load. The maximum idling current of the device is 100 mA, so that on a 60V power supply an unloaded LM1875 must dissipate 6W of power. The 54°C/W junction-to-ambient thermal resistance of a TO-220 package would cause the die temperature to rise 324°C above ambient, so the thermal protection circuitry will shut the amplifier down if operation without a heat sink is attempted.

In order to determine the appropriate heat sink for a given application, the power dissipation of the LM1875 in that application must be known. When the load is resistive, the maximum average power that the IC will be required to dissipate is approximately:

$$P_{D(MAX)} \approx \frac{V_S^2}{2\pi^2 R_L} + P_Q$$

where

- $V_S$ is the total power supply voltage across the LM1875
- $R_L$ is the load resistance
- $P_Q$ is the quiescent power dissipation of the amplifier

The above equation is only an approximation which assumes an “ideal” class B output stage and constant power dissipation in all other parts of the circuit. The curves of “Power Dissipation vs Power Output” give a better representation of the behavior of the LM1875 with various power supply voltages and resistive loads. As an example, if the LM1875 is operated on a 50V power supply with a resistive load of 8Ω, it can develop up to 19W of internal power dissipation. If the die temperature is to remain below 150°C for ambient temperatures up to 70°C, the total junction-to-ambient thermal resistance must be less than

$$\frac{150°C - 70°C}{19W} = 4.2°C/W.$$

Using $\theta_{JC}$=2°C/W, the sum of the case-to-heat-sink interface thermal resistance and the heat-sink-to-ambient thermal resistance must be less than 2.2°C/W. The case-to-heat-sink thermal resistance of the TO-220 package varies with the mounting method used. A metal-to-metal interface will be about 1°C/W if lubricated, and about 1.2°C/W if dry.

If a mica insulator is used, the thermal resistance will be about 1.6°C/W lubricated and 3.4°C/W dry. For this example, we assume a lubricated mica insulator between the LM1875 and the heat sink. The heat sink thermal resistance must then be less than

4.2°C/W−2°C/W−1.6°C/W=0.6°C/W.

This is a rather large heat sink and may not be practical in some applications. If a smaller heat sink is required for reasons of size or cost, there are two alternatives. [EM00001]The maximum ambient operating temperature can be reduced to 50°C (122°F), resulting in a 1.6°C/W heat sink, or the heat sink can be isolated from the chassis so the mica washer is not needed. This will change the required heat sink to a 1.2°C/W unit if the case-to-heat-sink interface is lubricated.


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**NOTE**

When using a single supply, maximum transfer of heat away from the LM1875 can be achieved by mounting the device directly to the heat sink (tab is at ground potential); this avoids the use of a mica or other type insulator.

The thermal requirements can become more difficult when an amplifier is driving a reactive load. For a given magnitude of load impedance, a higher degree of reactance will cause a higher level of power dissipation within the amplifier. As a general rule, the power dissipation of an amplifier driving a 60° reactive load (usually considered to be a worst-case loudspeaker load) will be roughly that of the same amplifier driving the resistive part of that load. For example, a loudspeaker may at some frequency have an impedance with a magnitude of 8Ω and a phase angle of 60°. The real part of this load will then be 4Ω, and the amplifier power dissipation will roughly follow the curve of power dissipation with a 4Ω load.

## Component Layouts

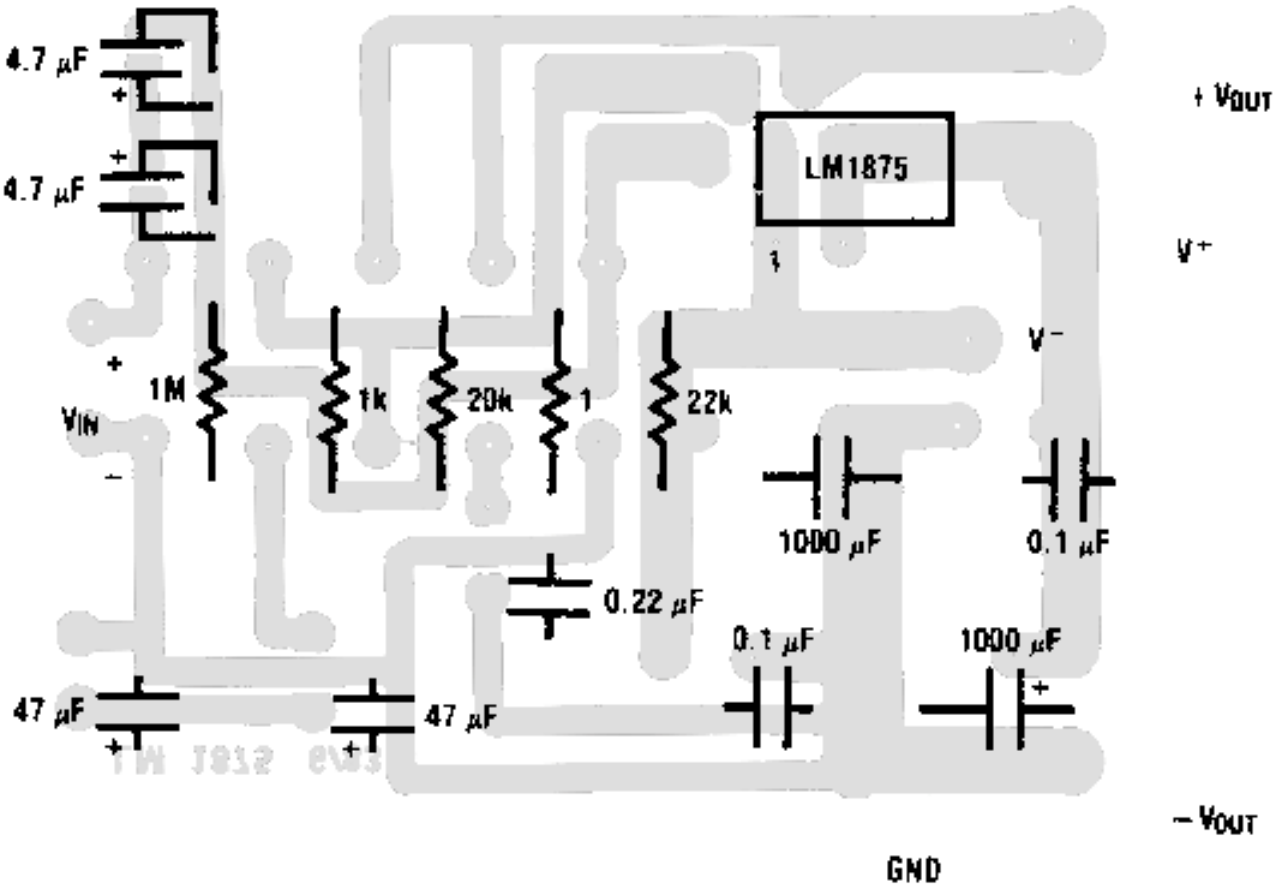


**Figure 14. Split Supply**

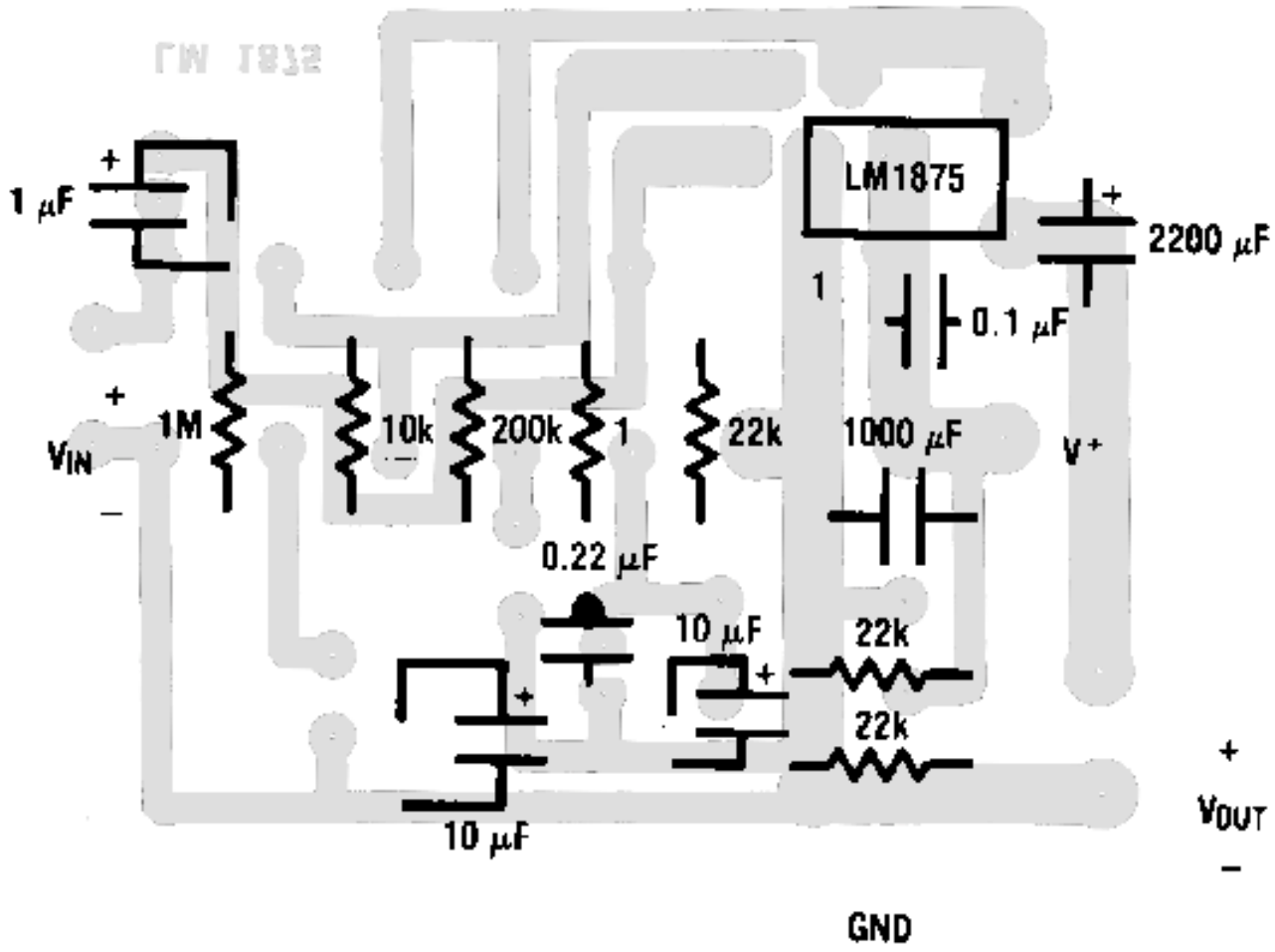


**Figure 15. Single Supply**


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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM1875T/LF02 | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/LF02.B | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/LF05 | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/LF05.B | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/NOPB | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |
| LM1875T/NOPB.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 70 | LM1875T |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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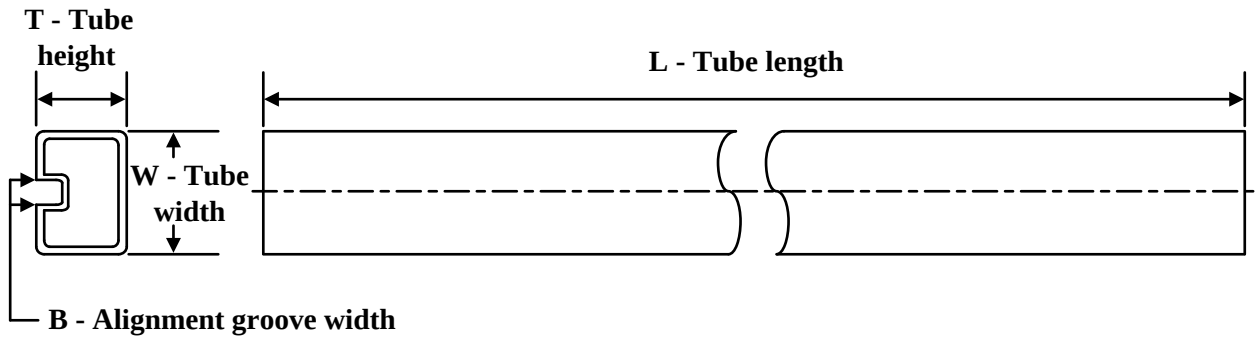
## TUBE




*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM1875T/LF02 | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/LF02.B | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/LF05 | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/LF05.B | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/NOPB | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM1875T/NOPB.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |

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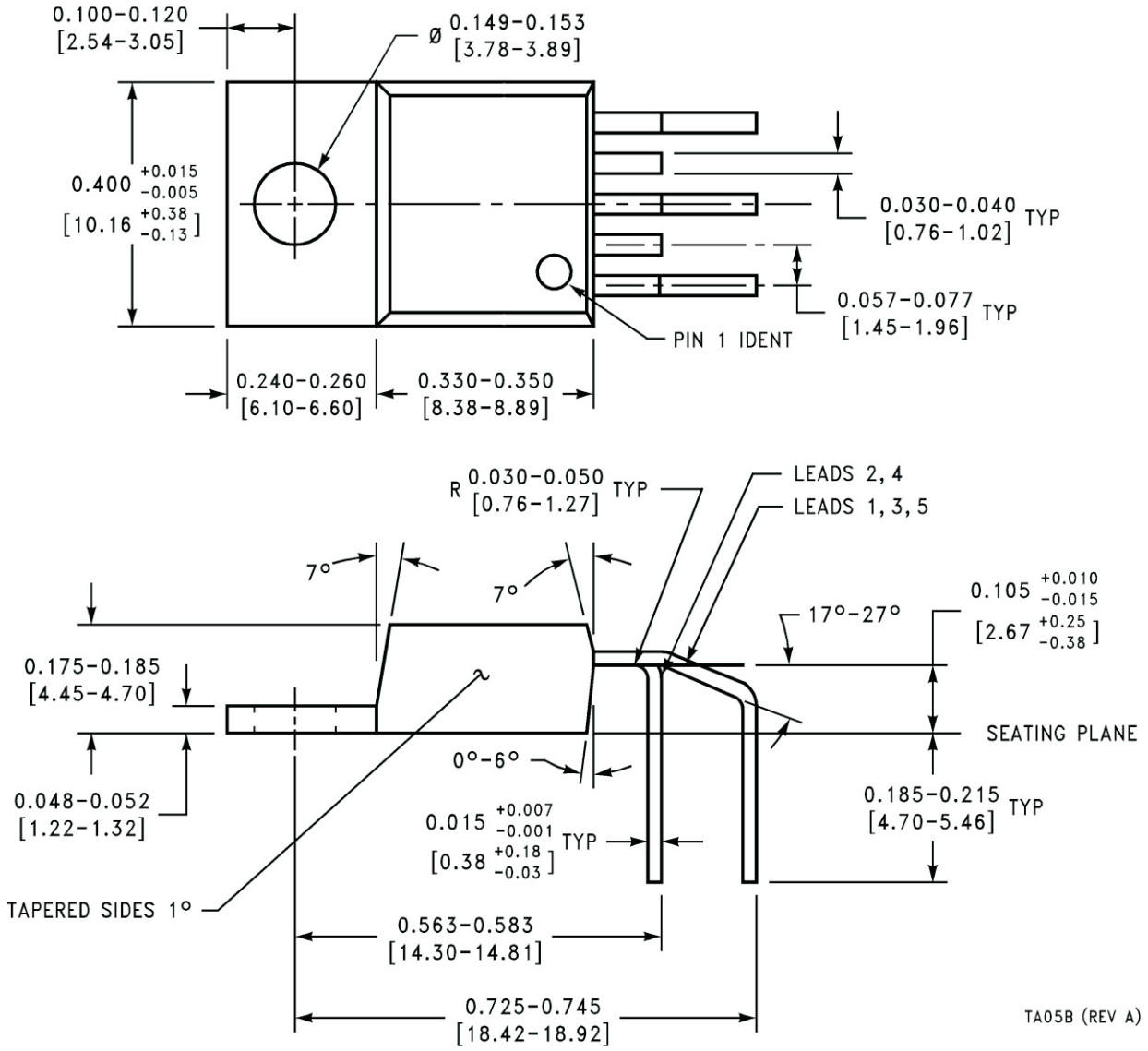
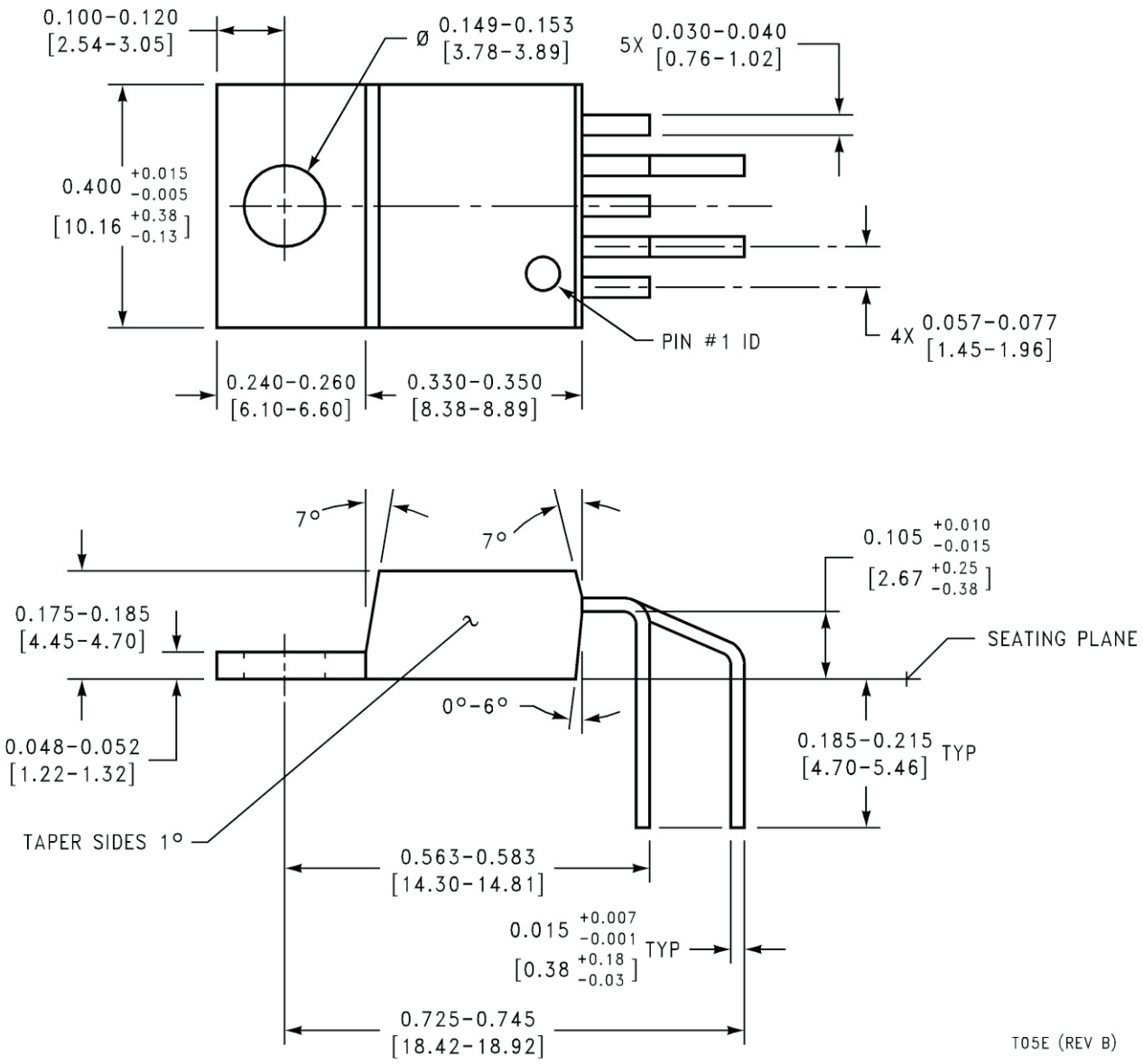
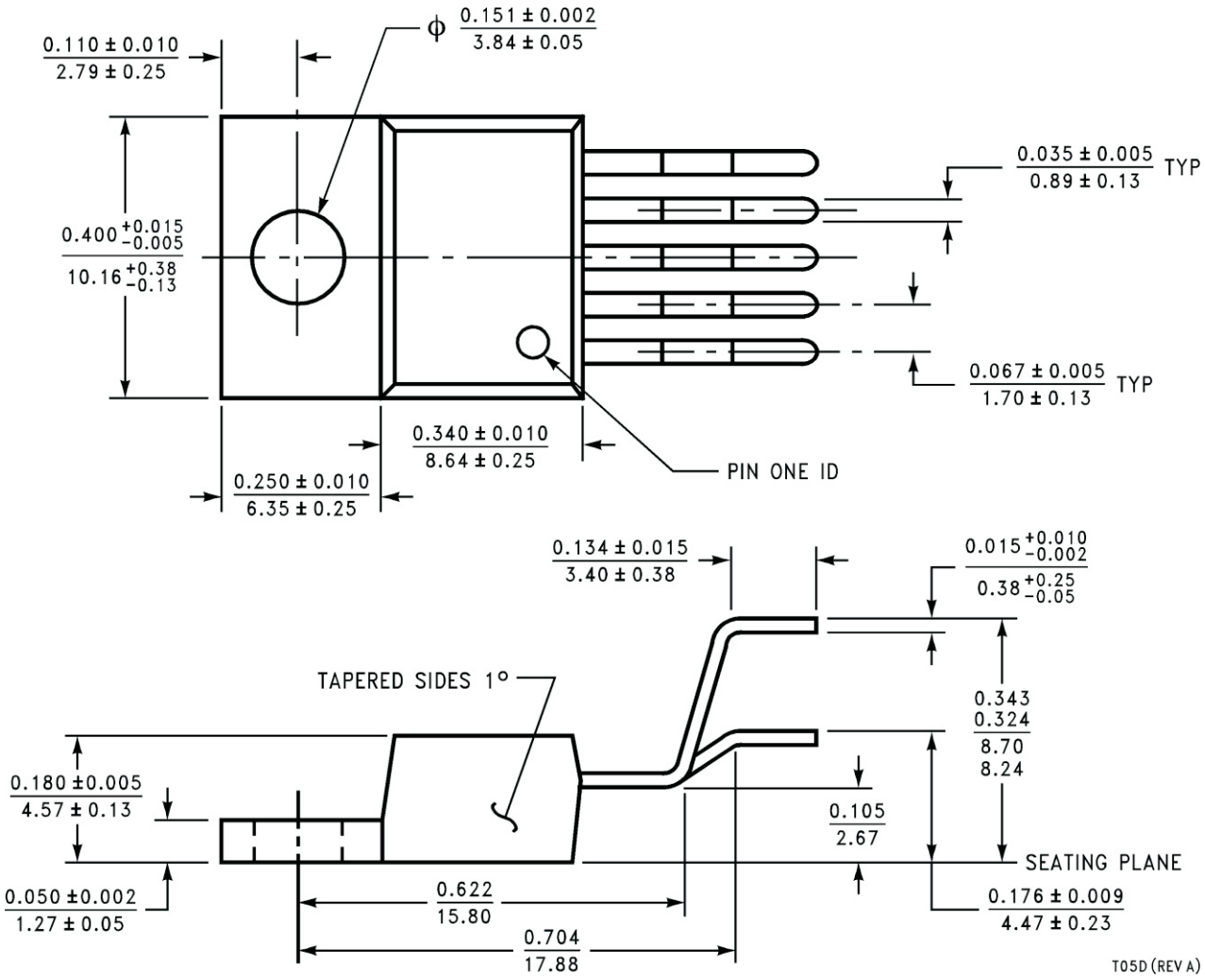

0.100–0.120
[2.54–3.05]
Ø 0.149–0.153
[3.78–3.89]
0.400 +0.015 −0.005
[10.16 +0.38 −0.13]
0.030–0.040 TYP
[0.76–1.02]
0.057–0.077 TYP
[1.45–1.96]
PIN 1 IDENT
0.240–0.260
[6.10–6.60]
0.330–0.350
[8.38–8.89]
R 0.030–0.050 TYP
[0.76–1.27]
LEADS 2, 4
LEADS 1, 3, 5
7°
7°
17°–27°
0.105 +0.010 −0.015
[2.67 +0.25 −0.38]
0.175–0.185
[4.45–4.70]
SEATING PLANE
0°–6°
0.048–0.052
[1.22–1.32]
0.185–0.215 TYP
[4.70–5.46]
0.015 +0.007 −0.001 TYP
[0.38 +0.18 −0.03]
TAPERED SIDES 1°
0.563–0.583
[14.30–14.81]
0.725–0.745
[18.42–18.92]
TA05B (REV A)

NEB0005E


0.100-0.120
[2.54-3.05]
Ø 0.149-0.153
[3.78-3.89]
5X 0.030-0.040
[0.76-1.02]
0.400 +0.015 -0.005
[10.16 +0.38 -0.13]
PIN #1 ID
4X 0.057-0.077
[1.45-1.96]
0.240-0.260
[6.10-6.60]
0.330-0.350
[8.38-8.89]
7°
7°
0.105 +0.010 -0.015
[2.67 +0.25 -0.38]
0.175-0.185
[4.45-4.70]
SEATING PLANE
0°-6°
0.048-0.052
[1.22-1.32]
0.185-0.215 TYP
[4.70-5.46]
TAPER SIDES 1°
0.563-0.583
[14.30-14.81]
0.015 +0.007 -0.001 TYP
[0.38 +0.18 -0.03]
0.725-0.745
[18.42-18.92]
T05E (REV B)

NDH0005D


0.110 ± 0.010
2.79 ± 0.25
ϕ 0.151 ± 0.002
3.84 ± 0.05
0.035 ± 0.005
0.89 ± 0.13
TYP
0.400 +0.015 −0.005
10.16 +0.38 −0.13
0.067 ± 0.005
1.70 ± 0.13
TYP
0.340 ± 0.010
8.64 ± 0.25
PIN ONE ID
0.250 ± 0.010
6.35 ± 0.25
0.134 ± 0.015
3.40 ± 0.38
0.015 +0.010 −0.002
0.38 +0.25 −0.05
TAPERED SIDES 1°
0.343
0.324
8.70
8.24
0.180 ±0.005
4.57 ± 0.13
0.105
2.67
SEATING PLANE
0.050 ±0.002
1.27 ± 0.05
0.622
15.80
0.176 ± 0.009
4.47 ± 0.23
0.704
17.88
T05D (REV A)

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