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AND8196/D

ThermalTrak™ Audio Output Transistors

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APPLICATION NOTE

One of the major design concerns in the output section of a typical class AB audio amplifier is output bias and stability over the operating temperature range. In the past, this was typically accomplished through the use of a single bias transistor mounted on the amplifier's heatsink in close proximity to the output devices. When this is done, there is a period of time that must pass before thermal equilibrium or stability has been reached. This period may last as long as 30 minutes. This is known as warmup time. Most designers have to slightly underbias the amplifier output devices so that thermal runaway does not occur. These tradeoffs take away from true high fidelity performance of the amplifier.

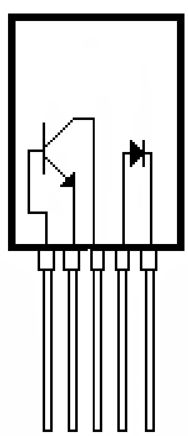
The ThermalTrak devices were developed so the design engineer could more accurately control the bias of the output stage of an audio amplifier. The most efficient and straightforward solution to the problem is to incorporate a temperature sensing device into the output transistor. This will improve amplifier performance and offer instant bias regulation in the power output stage.

Another benefit of integrating the diode with the power transistor is that actual real time protection from thermal runaway can be implemented into an audio output section through temperature sensing between the active elements.

Each of the ThermalTrak audio output devices incorporates Ultrafast diode technology as the temperature sensing device along with the audio output transistor.

Although many circuit variations exist, the amplifier circuit in Figure 1 is typical of most used in the industry today. Modifications were made to improve stability and performance with low impedance loads.

The bias circuit consists of a small signal transistor (TO−92) mounted on the heat sink between the (TO−220) power output drivers. Bias stability in this design requires that the bias level be set to a point at which thermal runaway does not occur, yet high enough to prohibit crossover distortion. In this design, the actual voltage drop across the bias transistor was set to 3.2 volts between emitter and collector. Any more bias voltage than that and a small amount of thermal runaway would occur when the amplifier is driven hard into a low impedance load.



ThermalTrak™ Device TO−264 Package

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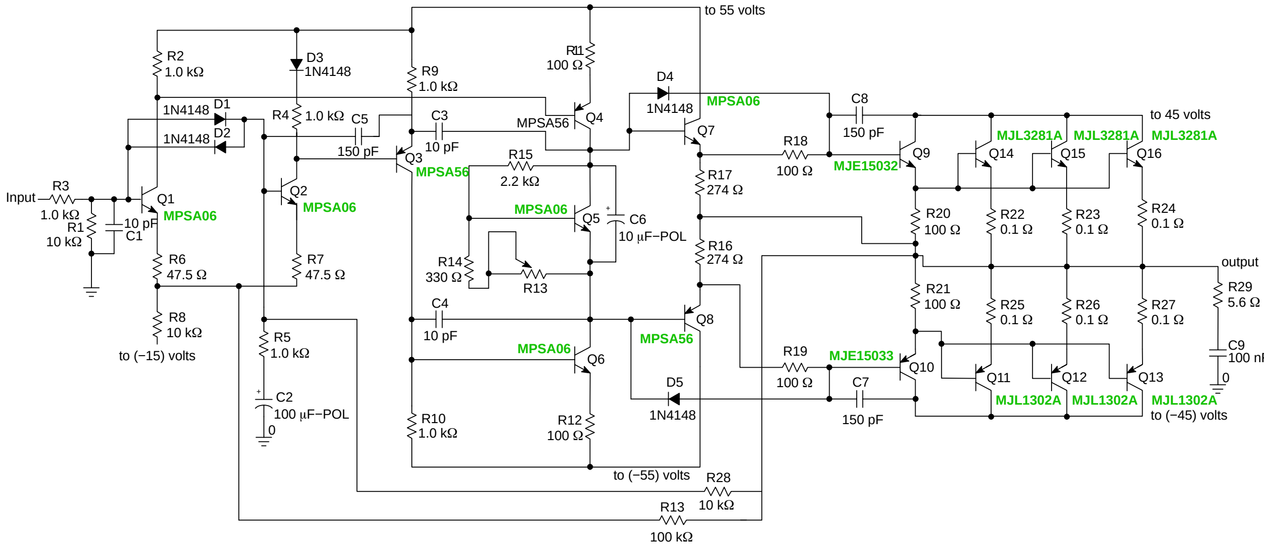

Figure 1.

The thermal runaway is caused by a small amount of thermal lag in the heatsink. In order to improve the small signal distortion of the amplifier due to this thermal lag slightly more bias is required. A trim potentiometer, as shown in Figure 1, is used with an active bias transistor to facilitate biasing.

With minimal emitter resistors, (0.1 Ω) on the output devices, this biasing becomes very delicate and time consuming in a production environment. Many circuit variations have been implemented to help reduce this effect. Each of them incurs an increase in the system cost.

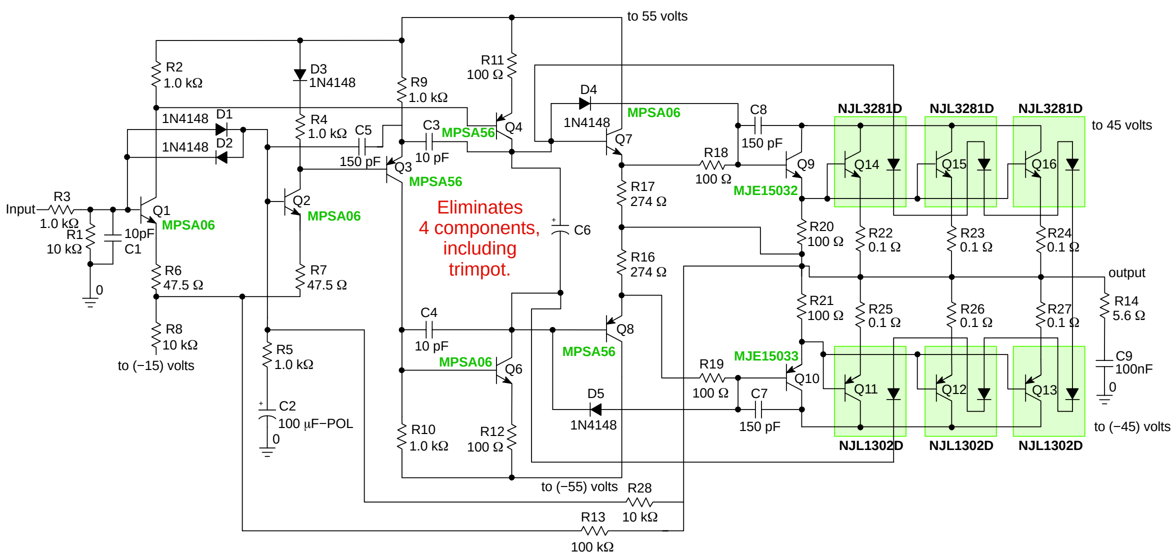

Figure 2.

By thermally integrating bias diodes into the output transistors, the actual die temperature can be precisely monitored in real−time. When this is done, the bias is now controlled internally and changes are compensated for on a real time basis. The result is an instantly trimmed bias current that does not allow any thermal runaway or thermal lag due to the mass of the heatsink. Another benefit of the modified circuit is the fact that it can be implemented without the use of a bias trimming potentiometer. This also eliminates a production step and guarantees that a quiescent bias point has been reached.

In Figure 2, the active bias transistor and all the passive components have been removed and replaced by the integrated power output transistor and diode solution (ThermalTrak). The result is a stabilized bias current providing a very accurate quiescent current that adjusts to loading and signal levels almost instantaneously. Distortion levels at lower output voltages will improve dramatically, as will full power THD performance. The noise floor of the amplifier will also improve through the elimination of the oscillation at the zero volt crossing caused by the slightly underbiased condition created by the original circuitry.

Amplifier settling time and bias stabilization will also demonstrate improvement with a slightly lower output impedance to work with. The amplifier will also work better over temperature since the bias current is now monitored by the actual die temperature within the output transistors instead of using the heatsink temperature. These improvements are shown in Figure 3.

An Audio Precision analyzer was used to measure the THD performance. With bias diodes integrated into the output transistors, the new quiescent bias voltage has been raised to 3.4 volts and lower distortion performance is achieved without any thermal lag issues. The amplifier circuit also is completely stable with a 2 Ω load without any bias current creep typically caused by temperature differences between power components or thermal shock.

As shown in the distortion curves in Figure 3, a large improvement in distortion performance is achieved using the ThermalTrak transistor technology. Most of the improvements are in the region of lower power output voltages where the majority of the lower level musical content exists. It should also be noted that bias control is active over a much wider range. There is virtually no warmup time.

Along with bias control, there are a number of other applications that can be derived from this type of component configuration such as individual driver control for current sharing in the output devices, or temperature sensing for a protection circuit.

In this application we have shown how to increase the reliability of an audio power amplifier and improve performance where it counts the most, the ability to build something without the need for additional manual adjustments to make it function correctly. We have also reduced manufacturing cost and eliminated the thermal lag associated with big bulky heatsinks. Along with this, also note that a bias adjustment will not be required for a reasonable performance power amplifier.

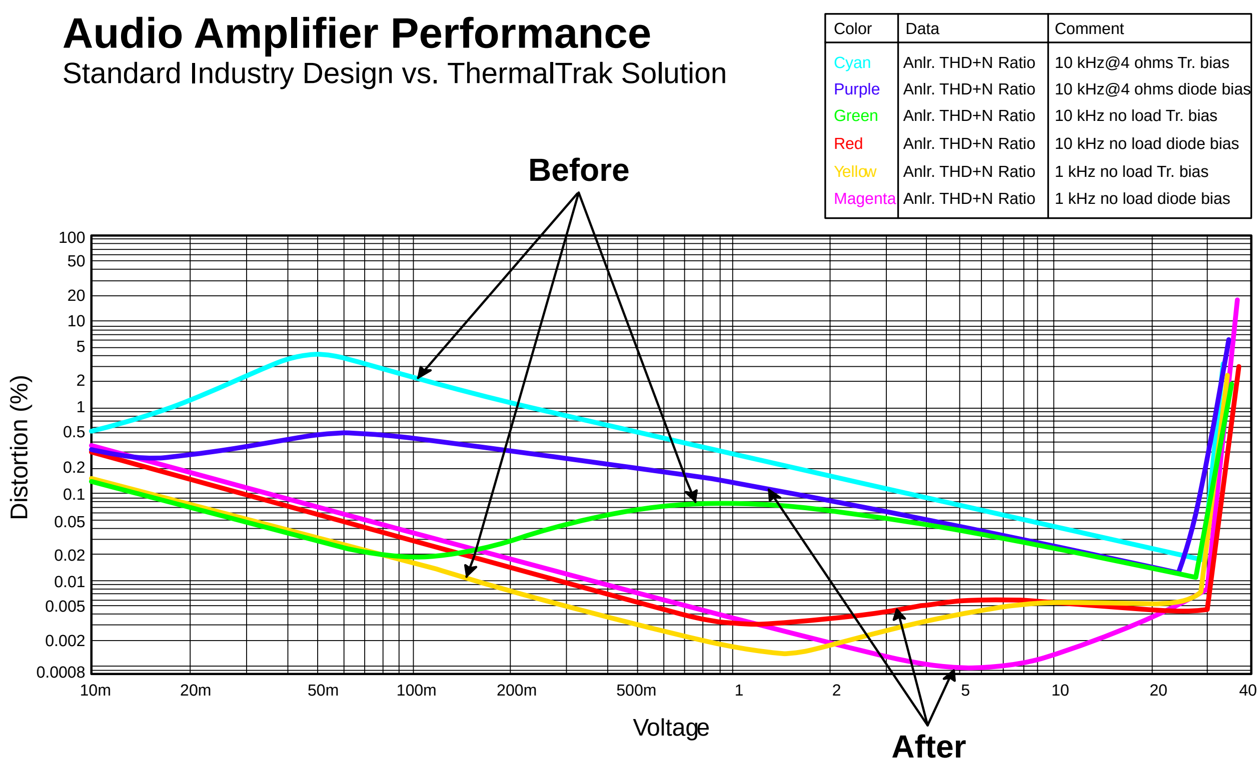

Figure 3. Load Conditions: 4 Ω non−inductive resistor for sweep 1. No load for sweeps 2 and 3.

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