Crown's ODEP Circuit

Crown® has been building power amplifiers for over 30 years. In that time Crown has made numerous contributions to not only the audio industry, but to technical advancement in general. In the middle 1970's Crown introduced the first amplifier to employ a new output topology called the grounded bridge. This new technology allowed for more power to be generated from a smaller, lighter package with lower distortion than other high excursion topologies. By 1984 other technological developments were made which, when added to the grounded bridge, resulted in a highly efficient and economical package for the professional audio industry. One of these key developments was ODEP (Output Device Emulation Protection). ODEP is a thermal management system which safely allows an amplifier to produce more power than an equivalent amplifier with conventional VI limiting.

ODEP CONCEPT

The most critical components in a power amplifier are the transistors in the output stage that drive the high voltage and current to the speakers. ODEP is a form of protection that ensures long term safe operation of these key transistors.

There are only two things that usually kill transistors. The first is voltage, the second is heat. Power supply voltages are known, and the voltage limits of a given transistor are known. Good design usually eliminates any possibility of failure due to over-voltage.

In a power amplifier the output stage is the major source of heat inside the chassis, and heat is the real concern during operation. As electrical current passes through a transistor, the transistor must dissipate power. The only way for a transistor to dissipate power is in the form of heat. Figure 1 shows the heat output of an output transistor driving a simulated speaker load.

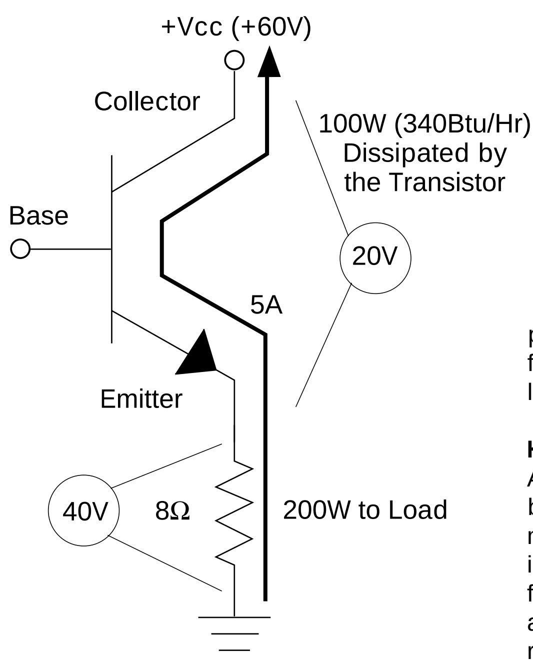


Figure 1. Transistor Power Dissipation

Heat Dissipation

The heat is generated at the heart of the output transistors' chip, in what is called the die. The die is the junction area of the actual semiconductor materials. The heat generated at the die is transferred directly to the metal case of the transistors; then from case to heat sink; then from heat sink to the atmosphere. Figure 2 shows an "exploded view" of an output transistor device on a heat sink. It also shows the electrical equivalent to both steady-state (DC Model) and dynamic (AC Model) conditions.

Physical Designs

Many other manufacturers use a "wind tunnel" effect in forced cooling designs. Wind tunnels are excellent for testing the aerodynamics of a new car, but the concept is flawed when used to cool high power electronics. When air is blown a long distance through a narrow passage, the air warms as is flows through the passage. By the time the air reaches the transistors in the rear, it has already warmed up. The warmer the air, the less heat it can remove. Finally, the rear transistors are not cooled as well as the front transistors, resulting in uneven and less efficient cooling.

Crown has employed the most advanced techniques available for heat dissipation. The case of the metal TO-3 package transistors is connected directly to the collector material at the transistor's die. The heat sinks are energized with high voltage. This eliminates the need for a layer of insulation between device and heat sink. Crown heat sink technology is also very advanced. The most efficient way to transfer heat from a piece of metal to the air is to have the highest surface to volume ratio possible. Crown uses convoluted fin stock on its heat sinks to obtain this high ratio. The concept is like that used to build air conditioners and automobile radiators. To obtain the most even heat transfer possible, air is forced a short distance across wide heat sinks.

Nature of Musical Signals

Musical waveforms are not very much like pure sine waves. Music is comprised of many frequencies, occasional high peaks, and a good deal of smaller waves. Music is based on timing of beats, with rest between beats. For this reason, musical waveforms contain a lot of empty space between high and low pulses. It is the variation in frequency and amplitude that makes music enjoyable. Let it suffice to say that musical waveforms are very complex, with occasional peaks typically five to ten times higher than average levels, with occasional rests.

Heat Vs. Time

An amplifier's power rating is typically based on its maximum output. This maximum represents the highest peak in the audio which the amplifier can faithfully reproduce. If you push an amplifier to its limits (audio peaks reaching the maximum capability of the amplifier), most of the time the amplifier's output is still only a fraction of its limits. With that in mind, remember that the heat produced in the output device must transfer across the die to case boundary, through the case, through the case to heat sink boundary, and dissipate into and finally out of the heat sink.

If the transistor sees a continuous waveform, it would eventually reach a steady state condition where the thermal sensor on the heat sink would see a temperature representing the actual transistor temperature. With musical waveforms, however, the sensor cannot respond quickly to short duration extremely high power (thermal) output from the transistor. By the same token, once a heat sink is warmed up, the transistor cannot handle as much power because its ambient condition is already close to its thermal limits. The reduction is power handling capability per degree rise in temperature is called thermal derating.

Since the thermal switch cannot detect the dynamics of audio and its effect on the actual transistors (the heat transfer process takes a long time), it cannot effectively respond to dangerous thermal conditions.

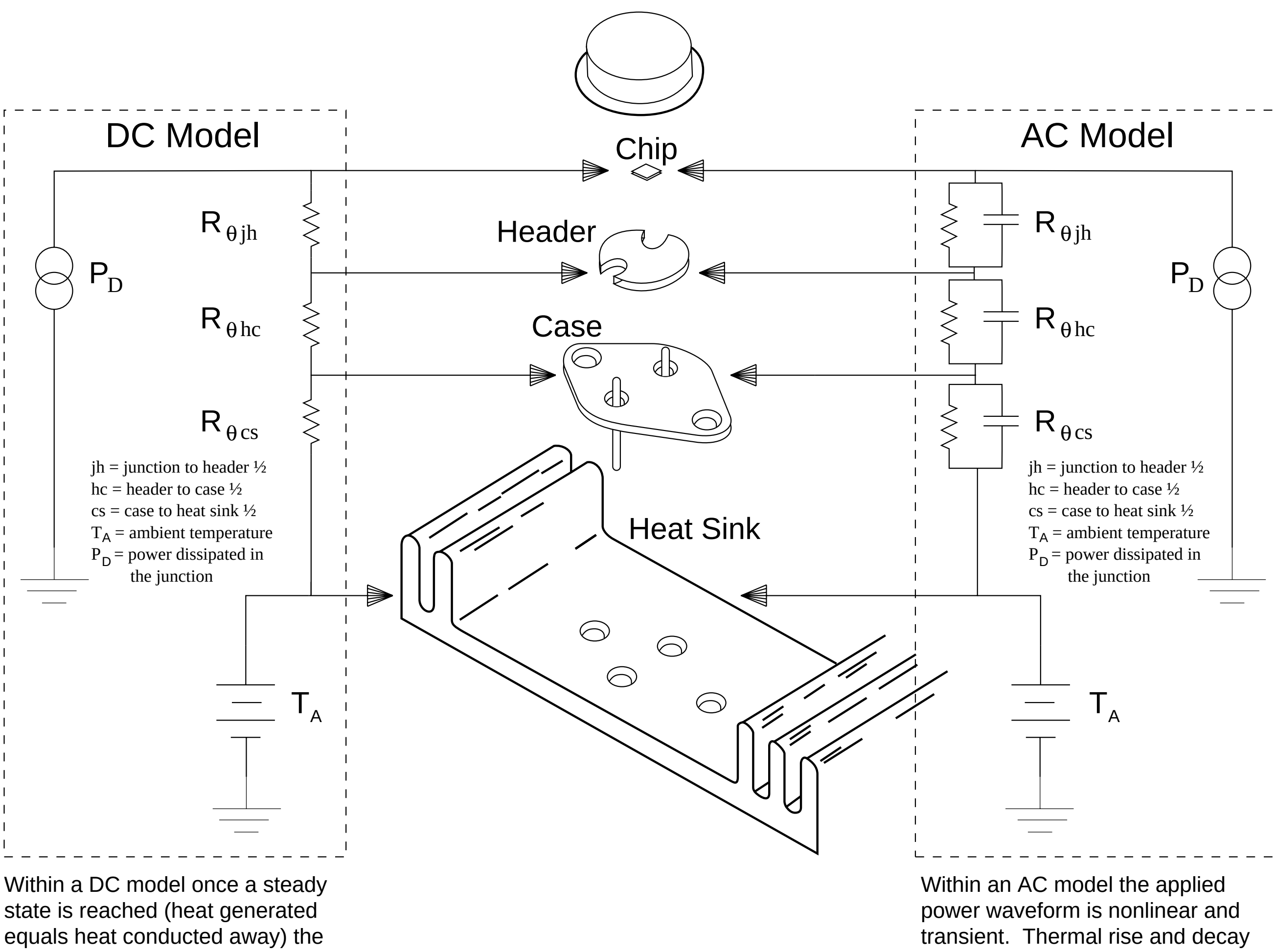
Conventional Thermal Protection

As for thermal protection, most other manufacturers use a thermal sensor mounted on the heat sinks. When the heat sink gets hot enough, the sensor causes amplifier shutdown. The effect, to the user, is potentially catastrophic: complete loss of audio. As described above, the basic thermal switch is also less effective as a means of protection.

Crown's Thermal Protection

Crown first addressed this problem with the innovation of VI limiting, introduced with the DC-300® (1966). As technologies improved and Crown continued to learn more about these thermal processes, and the unique situations involving audio waveforms, Crown developed the circuit now known as ODEP.

ODEP is, essentially, an analog computer which calculates the temperature at the die of the transistor. It senses output voltage and current, combining these to calculate output power. Heat sink temperature is also monitored. Temperature information is factored in for determining the amount of thermal derating. Analog circuits measure the rate of change of temperature. Power and thermal information are used to build a model of the heat transfer process, store of history of operation, and ultimately determine the actual temperature at the die of the devices. Figure 3 shows a simplified block diagram of the ODEP system.



Within a DC model once a steady state is reached (heat generated equals heat conducted away) the thermal increase is linear.

Within an AC model the applied power waveform is nonlinear and transient. Thermal rise and decay take on a logarithmic form. Thermal modeling, therefore, must be done with RC networks.

Figure 2. Heat Sink Simulations

If the ODEP circuitry determines that the audio is about to cause a dangerous thermal condition in the amplifier, it will limit the audio enough to prevent damage. ODEP does not shut down the amplifier, although if conditions are extremely severe it can almost completely limit the audio to prevent damage. With ODEP, the amplifier is protected at all times, and the show always goes on!

ODEP's output also supplies display circuitry on selected models with information about the amplifier's thermal headroom reserve. Crown holds the patent on ODEP, and is the only amplifier manufacturer to use this type of circuitry to calculate real thermal conditions.

ODEP AND THE IQ SYSTEM

The IQ System® is a product line of computerized audio equipment. Several types of Crown amplifiers are IQ compatible and may be equipped with an IQ System P.I.P. module (there are several models available). The IQ System allows an amplifier to be remotely monitored and controlled. ODEP, along with several other parameters, can be monitored on a remote PC via IQ. Selected IQ System P.I.P. modules offer a thermally driven compressor to keep the amp from reaching a point of protection and the ability to reach a safe continuous operating equilibrium with even a shorted load.

Since only Crown has ODEP, this information is unique to Crown's IQ System. No other computerized audio control system has the ability to tell you the actual thermal headroom conditions present in their amplifiers. Regardless of whether the amplifier offers computer control compatibility or even front panel indication, the ODEP circuit is always present and always keeping your amplifier safe.

ADVANCED CROWN TECHNOLOGIES

Crown has been an innovative company in the audio industry since its founding back in the 1940's. Today there are a number of technologies employed in Crown amplifiers that truly set Crown apart from the competition. Some of these include the grounded bridge™ output topology, IOC® thermal management, VZ® power supply technology, and a host of other feature benefit technology. ODEP is a powerful tool, but it stands on an impressive list of technology breakthroughs.

AMPLIFIER REFERENCE

Crown amplifiers equipped with the ODEP indication circuitry include: Micro-Tech® Series, Macro-Tech® Series, Com-Tech® Series, and the Reference Series.

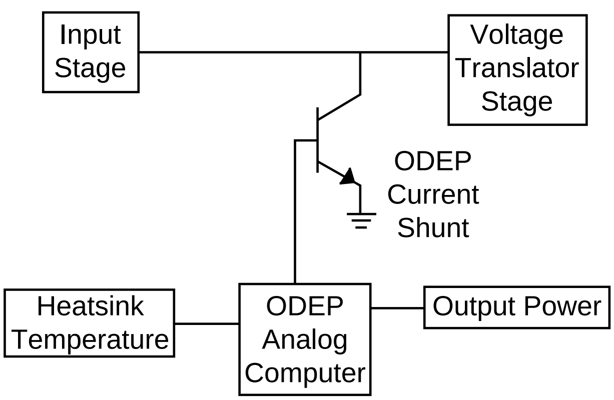


Figure 3. Simplified ODEP Block Diagram

Crown

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