Precautions for connecting APA outputs to other devices

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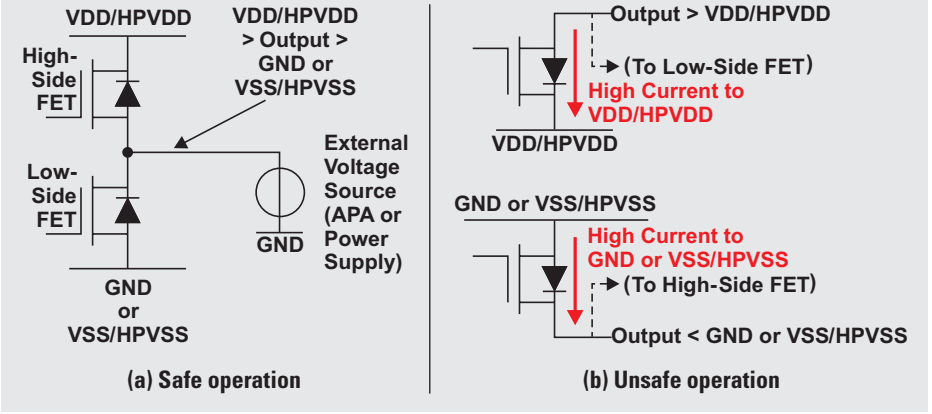
Multiple audio power amplifiers (APAs) may be connected to one output circuit by design, to multiplex different sources or to connect an external amplifier to save battery life. Also, one amplifier output may be connected to another or to a power supply by mistake. Any of these connections can force APA outputs to abnormal voltages, and this can damage an APA. This article explains limits that must be observed to avoid such damage.

Damage can occur whether an APA is active or shut down. The output of most APAs is protected with short-circuit protection (SCP) or overcurrent protection (OCP) when the APA is active, but the range of voltages the APA can tolerate is still the same. Generally, voltage forced into an APA output must be limited as follows to avoid APA damage:

- An APA output should not be forced more than 0.3 V above the APA's positive power-supply voltage (VDD or VCC), or more than –0.3 V below its negative power-supply voltage (ground or VSS).
- An APA output must never be forced beyond the Absolute Maximum Ratings for supply voltages given in the APA's data sheet.

Figure 1. Current conduction in forward-biased body diodes



How APAs respond to voltages forced into their outputs

When shut down, APAs have different resistances at their outputs, ranging from a few ohms to several kilohms to high impedance. If an external audio source connected to an APA output can drive the resistance there, it will force its voltage at the APA output.

When active, most class-AB devices have continuous-current limiting for SCP. This kind of APA holds its output at its intended output voltage until it is forced into SCP or OCP by the other source. Then it continues to draw its limit current, but its output voltage is controlled by the other source. If the APA continues to draw its limit current, it may overheat and go into thermal shutdown. Then its output voltage is controlled entirely by the other source. When the APA cools down enough, it will turn on again, and this cycle will continue as long as the external source is connected.

A typical Class-D APA holds its output at its intended output voltage until it is forced into SCP or OCP. Then it shuts down and its output voltage is controlled by the other source, without drawing significant current, as long as proper voltage limits are observed. A class-D APA with cycle-by-cycle OCP generally behaves like a continuous-current limiter until it shuts down.

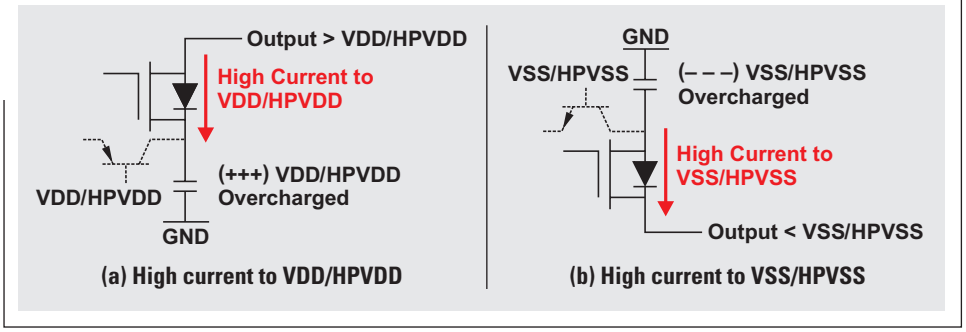
How damage occurs

If another source is connected to an APA output when it is shut down, it will force the APA output to follow its voltage. If the APA is active and the other source can supply enough current to force the APA into SCP or OCP, the other source will then force the APA output to follow its voltage. There are several different ways in which damage can be done.

Forward-biased body diode

Single-supply APAs operate between a positive power supply, usually called VDD or VCC, and ground. Output devices are FETs with body diodes that are reverse-biased in normal operation. Body diodes that are reverse-biased in normal operation (see Figure 1) can be damaged if one of the diodes becomes forward-biased and conducts excessive current. This can happen if an output of a single-supply APA is forced more than 0.3 V above VDD (or VCC) or more than –0.3 V below ground.

Figure 2. Pushing APA supply voltages beyond their limits



Texas Instruments (TI) DirectPath™ APAs operate between a positive power supply, usually called VDD, and a negative rail, usually called VSS, often generated from VDD with a switching circuit. The magnitude of VSS is generally less than the magnitude of VDD. Some DirectPath APAs regulate primary VDD to a lower level for their outputs, HPVDD, and generate a negative rail, HPVSS, from HPVDD, to control maximum output power. If an output of a DirectPath APA is forced more than 0.3 V above VDD/HPVDD or more than –0.3 V below VSS/HPVSS, one of the body diodes may become forward-biased and conduct excessive current, which can damage the diode.

Power-supply overvoltage

Even if external source currents do not damage a body diode, they may flow to VDD/HPVDD or VSS/HPVSS (see Figure 2). VDD/HPVDD and VSS/HPVSS typically only source current, so the diode currents may charge the supply voltages beyond their absolute maximum ratings and in turn may damage the APA and/or the supply components.

Table 1 may be helpful in understanding the different supplies for various DirectPath APAs. Supplies for devices not included here can be determined by comparing their data-sheet information to this table. Supply labels may be different from the labels shown in the table.

Related Web sites

www.ti.com/audio

www.ti.com/sc/device/*partnumber*

Replace *partnumber* with TPA4411, TPA6130A2, TPA6132A2, or TPA6136A2

Table 1. Comparison of supply-voltage limits for APA devices*

DEVICE	TPA4411	TPA6130A2	TPA6132A2	TPA6136A2
Positive Supply Voltage	SVDD = 1.8 to 4.5	VDD = 2.5 to 5.5	HPVDD = 1.8	HPVDD = 1.8
Negative Supply Voltage	SVSS ≈ –SVDD	CPVSS ≈ –VDD when VDD < 2.8 V** CPVSS ≈ –2.8 V when VDD ≥ 2.8 V	HPVSS = –1.8	HPVSS = –1.8

* APA outputs must never be forced beyond absolute maximum ratings for supply voltages.
- For single-supply APAs, this includes VDD (or VCC).
- For DirectPath APAs like TPA4411, this includes SVDD and SVSS.
- For DirectPath APAs like TPA6132A2, this includes HPVDD and HPVSS.
- Sometimes no absolute maximum rating is given for VSS/HPVSS. In these cases, the negative of the maximum recommended operating voltage for VDD/HPVDD should be used.

** When VDD < 2.8 V, CPVSS falls as VDD falls.

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