Implement a clip-detection circuit for BTL Class D amplifiers

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Clip detection is a convenient feature in Class AB amplifiers. It produces a signal from a clip-detection pin that drives an automatic volume control, which reduces gain compression and distortion when the amplifier is overdriven. Class AB amplifiers, such as the STMicroelectronics TDA7293, TDA7396, STA7360, and STA540 and the Toshiba TA8275 and TB29xx, have on-chip clip-detection circuits. Newer Class D automotive amplifiers, such as the four-channel STMicroelectronics TDA7454 and the Texas Instruments TAS5414/5424, have on-chip clip-detection circuits, but these ICs use a common clip-detection pin, comprising hardware ORed inside the IC, for all four channels. Other Class D amplifiers lack the clip-detection feature altogether, but you can implement it with external components.

An analog-input Class D amplifier comprises PWM (pulse-width-modulation) logic, gate-drive circuits, and a power stage. The PWM logic transforms the analog-input signal into a PWM signal. The power stage with the gate drivers transforms the low-power PWM signal into a high-voltage, high-current PWM sequence. A BTL (bridge-tied-load) amplifier basically comprises two gate-drive circuits and two power stages, which the same PWM signal drives. The signal directly drives one gate-drive circuit and phase-inverts the other. In theory, a BTL amplifier can produce four times more power into the same load than a single-ended amplifier.

Figure 1 illustrates the implementation of an external clip-detection circuit to a BTL-Class D-amplifier IC. The voltage swing on each output is symmetrical and is within the range of voltage drop on the on-resistance of MOSFET Q_6 to the common-collector voltage, V_{CC}, minus the voltage drop on the on-resistance of MOSFET Q_3. When the output voltage reaches a certain threshold, Q_1 turns off. The component values of R_1, R_2, and R_3 and the voltage drop across diodes D_1 through D_4 set this threshold, which is 0.5V with respect to power ground, P_{GND}, for the given component values. A positive-going pulse appears on the collector of Q_1 whenever the output voltage is below the threshold with respect to power ground. This pulse alerts the host microcontroller to the existence of clipping (Figure 2). Capacitor C_1 filters the residual of the switching- and high-frequency content of the audio signal.

A simple application involves filtering and integrating the pulses with further automatic reduction and restoration of the volume setting using the microcontroller's driven-volume control to counteract the clipping distortion. You can also implement more sophisticated algorithms (Reference 1). A suitable peak detector comprising Q_2, R_5, and C_2 allows the circuit to hold the short clipping pulses for a longer time. You can add LED circuitry to provide a visual clipping indication.

Reference

1. Person, Andrew P, and James P Muccioli, "Adjustable Clip Detection System," US Patent, 5,453,716, Sept 26, 1995, US Patent Office.

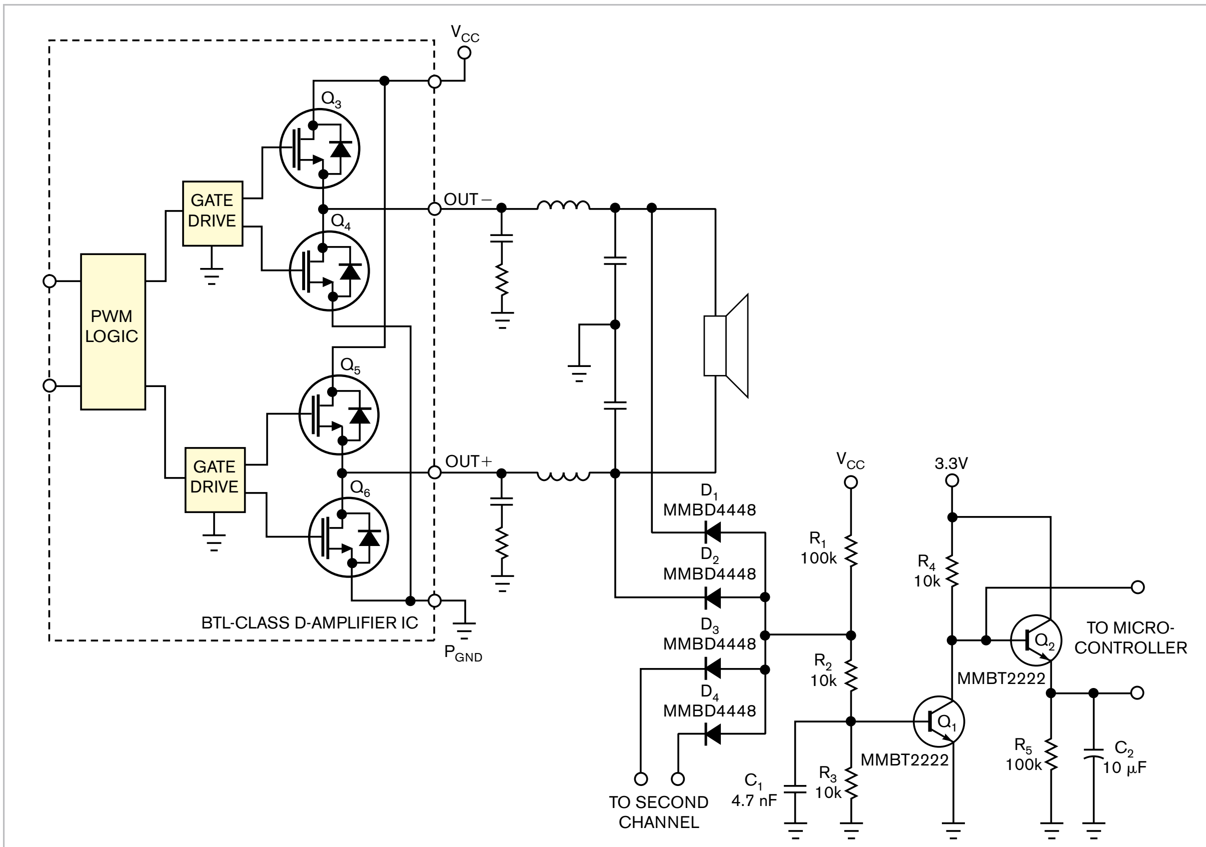

Figure 1 Adding several components to the BTL-Class D-amplifier IC provides a clip-detection function. A peak detector, comprising Q_2, R_5, and C_2, is optional.

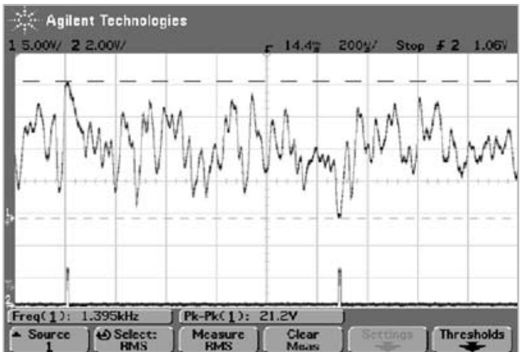

Figure 2 A positive-going pulse appears on the collector of Q_1 whenever the output voltage is below the threshold with respect to power ground.