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# Isolated Output for Class-D DC Amplifiers

NASA TECH BRIEF

Marshall Space Flight Center

### The problem:

High-efficiency switching mode (class-D) power amplifiers are limited in output amplitude to the power supply voltage and also are referenced to supply ground. It is often desirable to isolate the amplifier output so that load ground may be independent of supply ground.

### The solution:

A transformer-coupled output stage has been developed for use with pulse-width modulated class-D dc amplifiers.

## How it's done:

The transformer-coupled output circuit is comprised of two channels corresponding to negative and positive input signals. The schematic shows only the output stage of the complete amplifier which requires positive base drive for both  $(Q_1 \text{ and } Q_2)$  drive transistors.

Since the two channels are similar, only the negative channel will be discussed in detail. Assume that the channel associated with  $Q_2$  is operating, that the pulse-

width-modulated driving signal (a train of constantamplitude, positive pulses) has remained unchanged for several cycles, and that the time constant of the filter capacitor  $C_1$  and load  $R_L$  is large enough that the output voltage, e<sub>0</sub>, approximates some positive dc level. At time "zero", a pulse drives  $Q_2$  into saturation. Since the voltage drop across  $Q_2$  is quite small, almost the entire supply voltage is applied across the associated primary windings of transformer  $T_2$ . The polarity of the voltage across diode D<sub>2</sub> and the phasing of the transformer secondary is such that current will not flow in the secondary while Q<sub>2</sub> remains saturated and current is flowing in the primary. During this time, Q<sub>4</sub>, one of the clamping transistors, is reverse-biased by the voltage from the base-drive winding. Assuming that the current in all of the transformer windings is initially zero, the primary current waveform describes a ramp. As current flows in the primary winding, energy is stored in the core of the transformer, because current flow may not occur at this time in either the secondary or Q<sub>4</sub> basedriven windings.



Transformer-Coupled Output Circuit Schematic

#### (continued overleaf)

This document was prepared under the sponsorship of the National Aeronautics and Space Administration. Neither the United States Government nor any person acting on behalf of the United States Government assumes any liability resulting from the use of the information contained in this document, or warrants that such use will be free from privately owned rights. At time  $\pi$ ,  $Q_2$  is driven to cut-off by the driver. As current flow ceases in  $Q_2$ , the voltage across the primary reverses polarity in response to the change in current. At the same moment, the secondary and the  $Q_4$  base-drive winding voltage polarities also reverse, driving  $Q_4$  on and forward-biasing  $D_2$ . As the magnetic field begins to collapse, current flows in the secondary, removing the stored energy from the core of  $T_2$ . The secondary current waveform is a ramp of negative slope.

During this sequence of events, the role of  $Q_3$ , the other clamping transistor, is to prevent the positive output voltage from being short-circuited by  $D_1$  and the secondary of  $T_1$ . If an output voltage of only one polarity is desired, then just one channel of the output circuit is required.

The amplitude of the secondary-current triangular pulse is a function of the duration of the driving pulse. Therefore, this output circuit converts the pulsewidth modulated driving signal to a pulse-amplitude modulated signal. The output capacitor  $C_1$  serves as a filter to remove carrier frequency components. A more elaborate low-pass filter may be connected between  $C_1$ and the load  $R_L$  for improved carrier filtering.

#### Note:

Requests for further information may be directed to: Technology Utilization Officer Marshall Space Flight Center Code A&PS-TU Marshall Space Flight Center, Alabama 35812 Reference: B73-10331

#### Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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