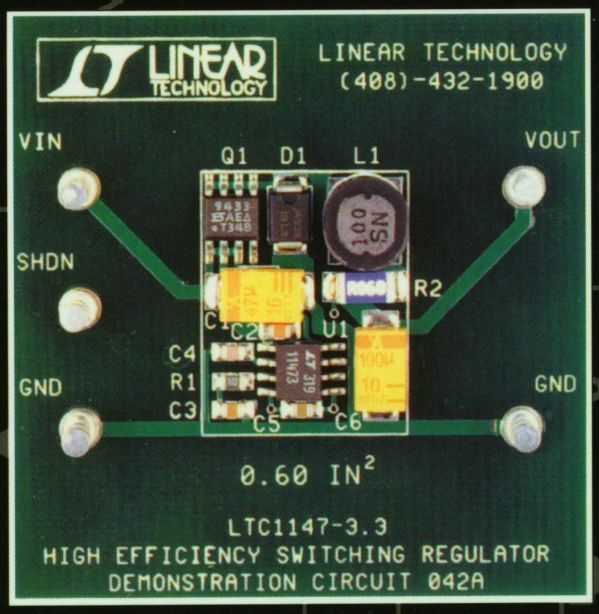
JOHN D. LENK

SIMPLIFIED DESIGN OF SWITCHING POWER SUPPLIES



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1.1.4 Transistor and Diode Characteristics

Switching regulators must use transistors with a gain-bandwidth product (fT) of at least 4 MHz to operate efficiently (an fT of 30 MHz is even better). Darlington transistors and MOSFETs are also used in switching regulators.

A fast-recovery rectifier, or a Schottky barrier diode, is used as a free-wheeling clamp diode to keep the switching-transistor load line within safe operating limits and to increase efficiency. Other solid-state devices used in some switching regulators include gates, flip-flops (FFs), op-amp comparators, timers, and rectifiers.

1.2 Typical Switching-Regulator Circuits

Figure 1–2 shows four typical PNP/NPN switching-regulator circuits. All of the circuits have the following common elements: switching transistor, clamp diode, LC filter, and a logic or control block. None of the circuits provide full isolation between the line and load, as would be the case if more than one series transistor is used. However, the one-transistor design is the simplest and most economical.

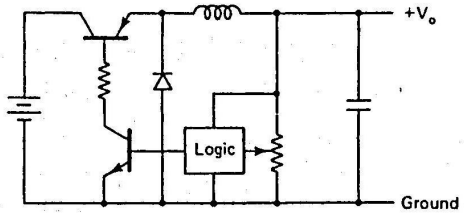
It is usually desirable to have at least one line in common with the input and output to reduce ground loops. The one-line approach also determines whether the output voltage is considered positive or negative. However, most circuits can operate from either supply because the input and output grounds are usually isolated. The one-transistor, one-line approach is the most popular switching-regulator design.

In the circuits of Figs. 1–2(a) and 1–2(b), the logic or control operates from the load voltage. Such circuits are not self-starting, and provisions must be made to operate from the line during start-up (and in the event of short circuits).

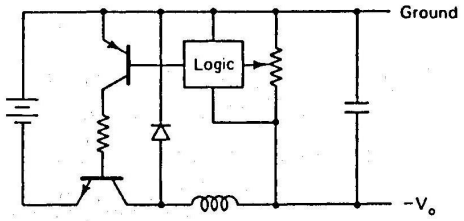
In the circuits of Figs. 1–2(c) and 1–2(d), the logic operates continuously from the line and is isolated from the load voltage. The sense and feedback elements must be electrically isolated (sometimes with an optocoupler).

The circuits of Figs. 1–2(b) and 1–2(d) are generally used in line-operated supplies because economical high-voltage NPN transistors are available whereas PNP types are not. Of the two, the circuit of Fig. 1–2(d) is most popular, because the logic is tied directly to the series switch and switching is more efficient. Driver transformers are used in some designs to interface between the logic and switching transistors. In such a case, the switching transistor may be either PNP or NPN.

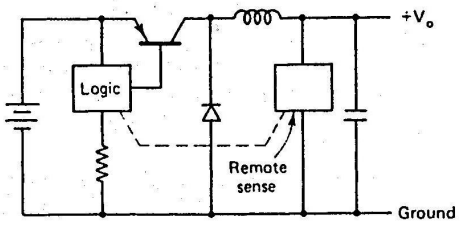
Figure 1–3 shows three typical MOSFET switching-regulator (or -converter) circuits, representing the three basic configurations: *buck, boost,* and *buck-boost* (all of which are described more fully in Section 1.5). In brief, each of the three configurations meets a particular need. When output voltage is greater than the input, the converter is usually operated in the positive *voltage-boost* circuit (also known as a *step-up* converter). The buck circuit is used when the input voltage is always greater than the desired output voltage (and is also known as a *step-down* converter). The



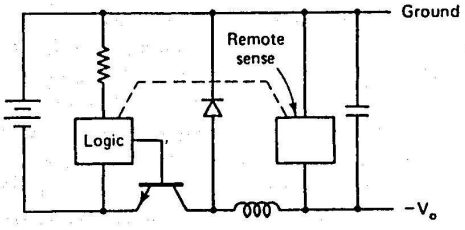
(a) Positive output, common logic and load



(b) Negative output, common logic and load



(c) Positive output, isolated logic and load



(d) Negative output, isolated logic and load

Figure 1–2. Four typical switching-regulator circuits

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