design ideas

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MOSFET switch provides efficient ac/dc conversion

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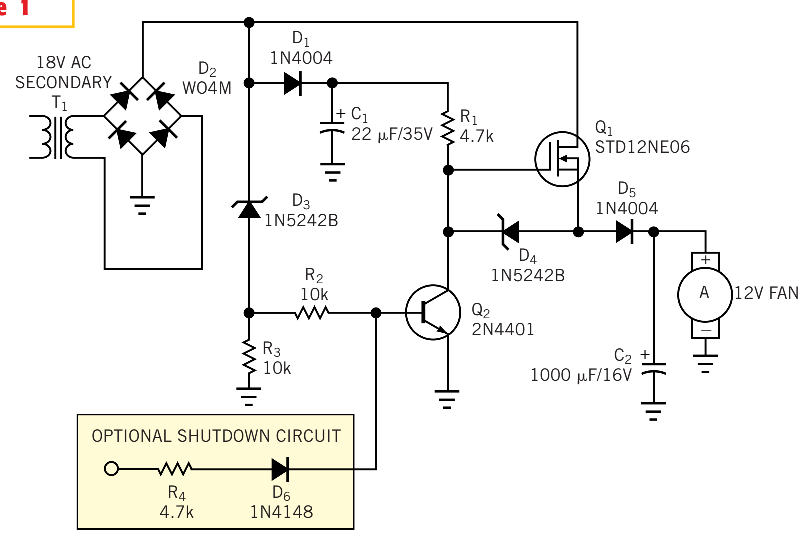
Occasionally, you have access to a transformer for powering a dc circuit, but its output voltage is much higher than that required for the dc voltage. The full-wave-rectified and filtered output of an ac input voltage V_X, is $V_{DC} = 1.414V_X - 2V_F$, where V_F is the forward drop in the rectifier (approximately 0.7V). For example, if you require 12V dc to power a small cooling fan drawing 100 mA and the ac voltage is 18V, a full-wave rectifier and filter results in a 24V-dc output. Although you can regulate the voltage down to 12V dc by using a simple three-terminal regulator (such a µA7812), the result is wasted power of approximately 1.3W. This waste means that you must provide for heat removal, somewhat defeating the purpose of including the cooling fan. If you use a typical 100×100-mm, 12V-dc fan rated at 0.45A, the typical heat loss is approximately 2.5W, increasing to 5W at full load. In many applications, this level of loss is unacceptable, so you'd have to use an extra transformer secondary, a dc/dc converter, or a switching regulator. The circuit in **Figure 1** uses a MOSFET switch and diode to effectively draw current from the transformer when the voltage is close to the desired level of 12V dc.

Figure 1



Using a MOSFET circuit, you can efficiently convert the too-high voltage of a leftover transformer to a lower dc level.

The full-wave bridge, D_2, rectifies the 18V-ac signal. The diode, D_1, and C_1 provide a gate bias voltage of approximately 24V dc. This voltage drives the gate of Q_1 through R_1, shunted by D_4, which maintains the gate voltage at a maximum of 12V relative to the source, even during transient conditions. As the bridge-rectifier output increases from 0V to the peak of approximately 24V each half-cycle, the bias voltage holds the MOSFET on until the input voltage reaches the breakdown voltage of D_3 (12V) plus the $V_{BE(ON)}$ of Q_2, or approximately 12.7V. At that point, Q_2 turns on, turning Q_1 off. The output filter capacitor, C_2, charges through D_5. As the rectifier output voltage decreases from 24 to 0V, Q_2 again turns off at approximately 12.7V, allowing Q_1 to turn on and provide another pulse of current to charge C_2. C_2 provides power for the load between the pulses, which occur at 240 Hz with a 60-Hz input. Thus, power drain from the transformer occurs in short pulses, much in the manner of a typical bridge-rectifier/output-filter arrangement but at double the frequency. If you want to turn the fan off with a logic signal, you can add R_4 and D_6. When you apply a logic-high signal to the input, Q_2 conducts, turning the MOSFET off. (DI #2484)

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MOSFET switch provides efficient ac/dc conversion **149**
Passive circuit monitors AES data **150**
µC multiplexes DIP switches to I/O port **150**
Switched-capacitor IC controls feedback loop **154**
Simple circuit disconnects load **158**
Follow the debouncing flip-flops **160**
Inductorless converter provides high efficiency **162**