Shunt regulator provides overvoltage protection

Robert N Buono, Mahwah, NJ

The circuit in **Figure 1** uses a typical technique for varying the output voltage of a power supply via a programmable control voltage. Although the topology and schematic details of the power supply are not critical, the protection technique is novel.

The control IC is a UC3843AN PWM controller. This IC applies 2.5V to the noninverting input of an internal error amplifier but does not bring this input out to a pin (node B). The inverting input of the error amplifier is available at an external pin (node A). To regulate V_{OUT}, the control IC must maintain the voltage at Node A equal to the 2.5V at Node B. The component values in the **figure** allow the dc output voltage of the power supply to vary between a minimum of 5V and a maximum of 75V, as a function of $V_{CONTROL}$, which can vary from 0 to 3V (corresponding to a V_{OUT} of 5V and 75V, respectively).

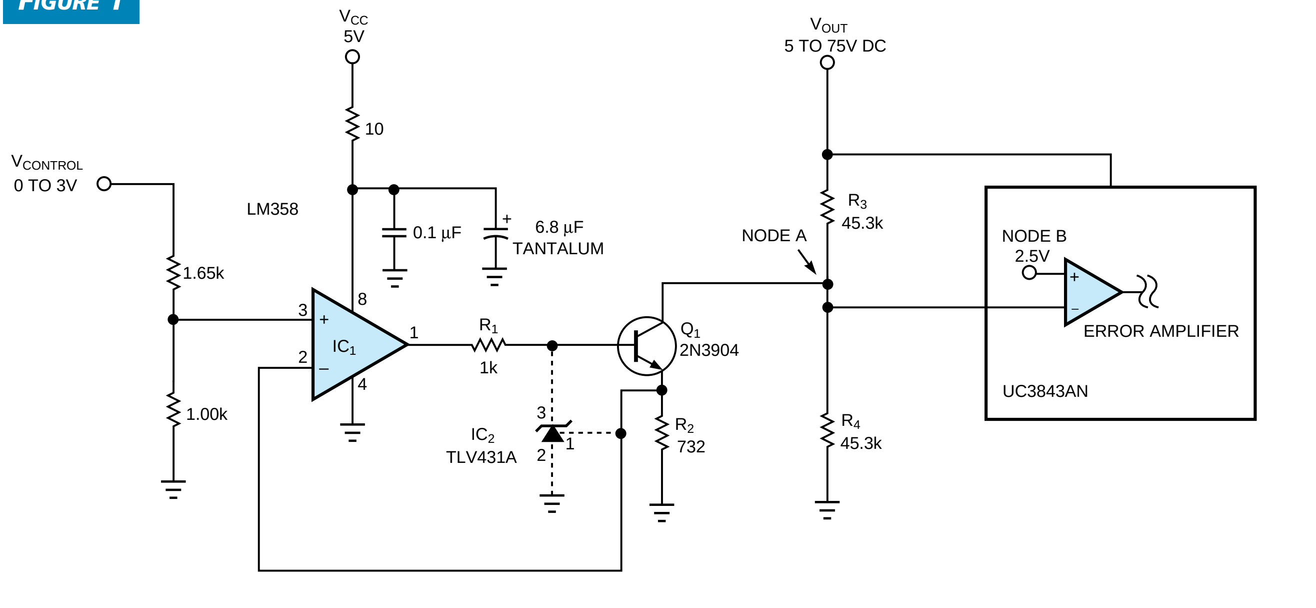
In the absence of Q_1, V_{OUT} and the voltage division of R_3 and R_4 determine the voltage at Node A. The circuit compares this voltage with the 2.5V at Node B. The power supply's output-voltage control loop keeps the voltage at Node A equal to Node B by appropriately controlling V_{OUT}.

The circuit provides programmability of V_{OUT} by sinking current from Node A. V_{OUT} must source any current that flows from this node. Also, the current must flow through R_3, which causes the voltage drop across R_3 to increase. V_{OUT} is then always equal to the voltage drop across R_3 plus a current set by $V_{CONTROL}$. IC_1's op amp forces the voltage across R_2 to equal the voltage at Pin 3 of IC_1.

The addition of just one component, IC_2, adds precise overvoltage protection to the variable-output power supply. IC_2 is a low-voltage shunt regulator that incorporates an internal 1.24V precision reference. This low reference voltage allows you to use this protection circuit with conventional power-supply control ICs for which 2.5V is a common internal reference voltage. Under normal operating conditions (for output voltages between 5 and 75V), IC_2 does nothing. The voltage at IC_2's reference (Pin 1) is less than its internal 1.24V reference, so its cathode (Pin 3) draws no current. In this case, IC_1 solely controls the voltage at the base of Q_1. For example, if $V_{CONTROL}$ is 3V, then the voltage across R_2 is 1.13V and V_{OUT} equals 75V. Note that, to simplify this example, the beta of Q_1 is assumed to be infinite.

However, in the event of any kind of fault that might cause the voltage across R_2 to rise above 1.24V (which corresponds to a maximum V_{OUT} of 81.7V), the shunt regulator begins to function. As the voltage at Pin 1 of IC_2 begins to exceed the internal 1.24 reference voltage, the cathode of IC_2 begins to conduct. The cathode of IC_2 then pulls down on the base of Q_1 to maintain 1.24V at Pin 1 of IC_2. As this happens, IC_2 through Q_1 controls the voltage across R_2. This con-

FIGURE 1



Adding one shunt regulator, IC_2, to an otherwise typical programmable power supply provides precise overvoltage protection.

trol causes the output of IC_1 to saturate at a positive voltage of approximately 3.7V because IC_1 can no longer keep the voltage across R_2 equal to the voltage at its input (Pin 3). The benefit to circuit operation is that IC_2 now operates with a constant-cathode current determined by the voltage across R_1, which equals 3.7–1.8V/1kΩ=1.9 mA. This level of cathode current ensures that IC_2 regulates properly.

This protection circuit is immune to any potential failure mode of IC_1's op amp or the programming voltage source, $V_{CONTROL}$. IC_1 operates only from 5V. If its output (Pin 1) shorts to ground, the minimum V_{OUT} results. If its output shorts to V_{CC}, IC_2 sinks 5–1.8V/1 kΩ=3.2 mA, and V_{OUT} clamps at the maximum of 81.7V. (DI #2146) EDN

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