Voltage regulator protects logic pull-up transistors

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A monolithic three-terminal voltage regulator and a Norton-type operational amplifier can provide excellent short-circuit protection—particularly for the transistor that's providing active pull-up at the output of a logic circuit.

All too often, transistors operated in this way are destroyed when the logic output is inadvertently shorted to ground. Sometimes, too, protecting these transistors is further complicated because the logic must be run at 28 volts. An easy solution would appear to be a current regulator. But most current limiters have one of two drawbacks—either they introduce an unacceptably large voltage drop, or they create excessive heat in biasing resistors.

A monolithic three-terminal voltage regulator, however, has neither defect. When the regulator is not overloaded, the voltage drop across the device is only about 1.5 v. When it is overloaded, the heat it creates remains within an acceptable range. Usually, the highest output voltage that one of these regulators can supply is 24 v. But, if the device's ground terminal is biased at 2 v (depending on the manufacturer's recommendations), the output of a 24-v regulator can be increased to 26.5 v.

When connected as shown, the regulator provides current limiting in two ways. Through its internal circuitry, it acts as a surge-current limiter of about 2 amperes. It also operates as a thermal-current limiter that reduces that output voltage when the current demand becomes excessive. This keeps the power dissipated in the regulator from exceeding the maximum allowable limit. Here, the thermal-current limiting will start at around 400 milliamperes.

Limiting the current available for the active-pull-up transistor will prevent the transistor from being destroyed as long as it is kept in saturation or in cutoff. A Norton amplifier allows both these conditions to be met—its current-sinking capability is greater than 30 mA, and it has an active pull-up in its output circuit. Because of the voltage drop across the regulator, this active pull-up creates a reverse bias on the transistor being protected, eliminating the need for the transistor's pull-up resistor. Also, a Norton amplifier will work reliably with a single-ended power supply at, as well as above, a supply voltage of 28 v.

The diode at the output of the circuit protects the transistor from overvoltages. For example, this diode will guard against an overvoltage caused by an inductive kickback that could forward-bias the base-collector junction of the transistor. □

Guarding against short circuits. An IC voltage regulator and a Norton amplifier keep this active-pull-up transistor from being permanently damaged if the input logic signal is mistakenly shorted to ground. The regulator provides both surge-current limiting and thermal-current limiting. The Norton amplifier keeps the transistor either fully saturated or fully cut off, and the output diode protects against overvoltages.