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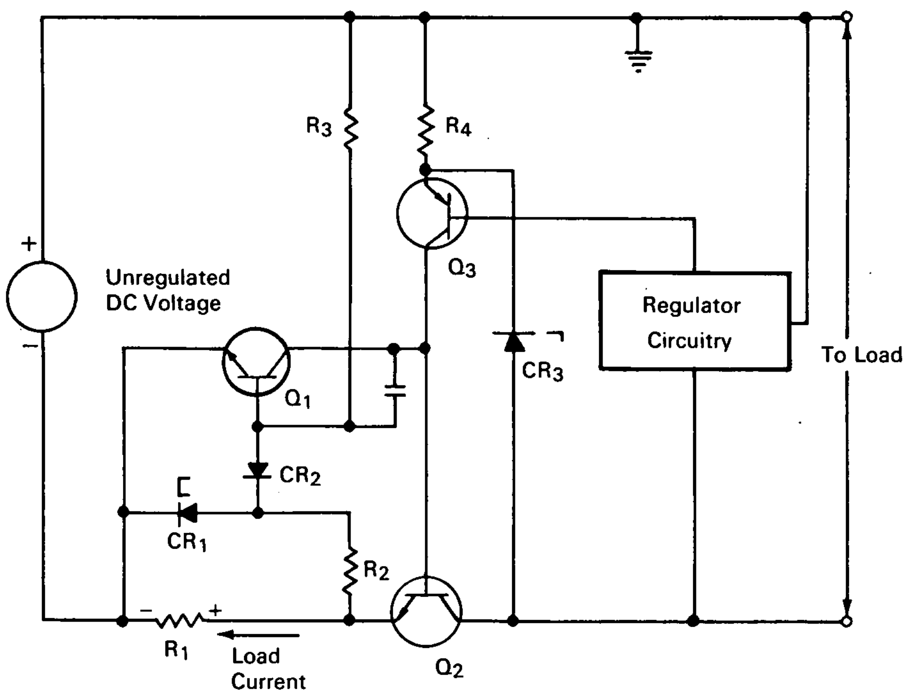
NASA TECH BRIEF

Circuit Protects Regulated Power Supply Against Overload Current



The problem:

To protect a low voltage transistorized dc regulator from damage by excessive load currents. In some applications, a single load fault can disable an entire system by disabling the regulators. Current threshold detectors have employed zener diodes and the voltage characteristics of transistor base–emitter junctions but these have not achieved sharp detection and current limiting.

The solution:

A sensing circuit in which a tunnel diode controls a series regulator transistor. When a fault occurs, the faulty circuit is limited to a preset percentage of the current when limiting first occurs.

How it's done:

R_4, Q_3, and CR_3 form the regulator series stage driver and Q_2 is the regulator series element. The overload circuit is composed of R_1, R_2, R_3, CR_1, CR_2, and Q_1, and functions by shunting the base current of Q_2 through Q_1 in case of overload, thereby shutting off Q_2 and limiting the fault current. The volt-ampere characteristics of CR_1 are used to provide the voltage threshold detection. The voltage across R_1 is used to detect the magnitude of the load current.

(continued overleaf)

When the load current is just below the limiting level, current through R_3 plus current through R_2 is just below the threshold point of CR_1. The base-to-emitter voltage of Q_1 is the sum of voltages across CR_1 and CR_2 and the current through R_3 is such that the voltage across CR_2 is about 400 mv. The voltage across CR_1 is at 50 mv and the base-emitter voltage of Q_1 is 450 mv which is not sufficient to turn on Q_1. This is the normal mode of overload curcuit/regulator function.

When the load current causes the peak-point current of CR_1 to be exceeded, it causes the base-emitter voltage of Q_1 to turn that transistor on. As a result, current through R_3 now flows into the base of Q_1 and the collector current of Q_3 flows into Q_1 rather than the base of Q_2 so that Q_2 turns off and limits the current to the regulator, the collector-emitter (saturated) voltage of Q_1 being less than the threshold base-emitter voltage of Q_2. The regulator series element being turned off, current through R_1 decreases, allowing current through CR_1 to decrease. When the current through CR_1 drops below its valley-point current, the overload circuit returns to its original state. If the overload is still present, the cycle is repeated, alternately cutting off Q_2 and continuing to limit overload current to the regulator until the fault in the load is corrected. Value of the capacitor controls frequency of the series stage cycle.

Notes:

1. Typical changes of the threshold detection current are ±10% over a range from 0° to +70°C. Any change with temperature in the base-emitter voltage threshold of Q_1 is compensated for by a like change in the threshold voltage of CR_2.
2. This circuit provides sharp detection of overload currents at very low voltage levels and has limited short circuit currents to less than 10% more than the detector (CR_1) threshold current.
3. The circuit shown uses a germanium tunnel diode but will perform satisfactorily with one of silicon.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10292

Patent status:

No patent action is contemplated by NASA.

Source: H. B. Airth
of Westinghouse Electric Corporation
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