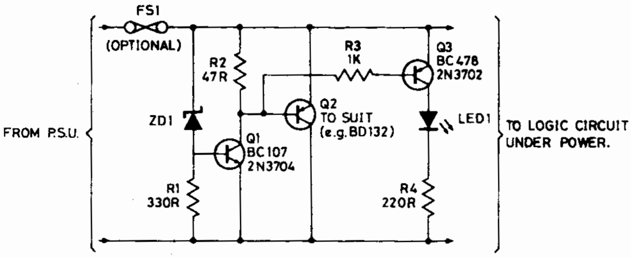


Overvoltage Protection for Logic

E. Parr

With the introduction of integrated circuit voltage regulators it is very easy to make power supplies for logic circuits. Unfortunately it is only easy to blast a board of TTL by letting the voltage rise above 7V as could happen if the common line came off a regulator IC or the sense lines came off a commercial power supply.

The described circuit was designed by the author as a "last ditch" defence after a disconnected sense line allowed a commercial 5V supply to rise to 9V and blast 50 TTL chips. The circuit is simple to add onto any power supply, and it is the author's intention to build it "on board" with any future system containing more than about 10 TTL chips.

Zener diode ZD1 senses the supply, and should the supply rise above 6V Q1 will turn on. In turn Q2 conducts clamping the rail.

Subsequent events depend on the source supply. It will either shut down, go into current limit or blow its supply fuse. None of these will damage the TTL chips.

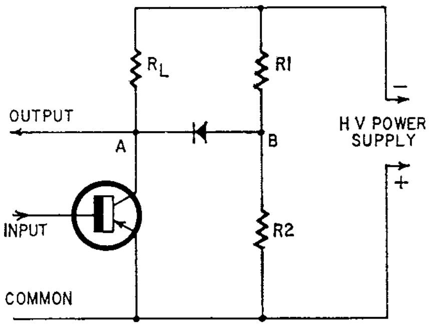
The rating Q2 depends on the source supply, and whether it will be required to operate continuously in the event of failure. Its current rating obviously has to be in excess of the source supply. If the source supply is likely to sit down, LED1 should be added to indicate the circuit has operated.

The circuit will operate in approximately 500 nS space, so it will also protect the logic from transient spikes which a normal regulator would not block.

HIGH-VOLTAGE PROTECTION FOR TRANSISTORS

When operating a transistor with a high-value collector load resistor, a power supply of 100 volts or more may be needed. This is OK as long as sufficient collector current flows to keep the collector-to-emitter voltage below the maximum rating.

The schematic shows a method of preventing this catastrophe. The bleeder current through R1 and R2 should be about ten times the normal collector current through the load resistor, R_L. The voltage between point "B" and the positive terminal of the power supply must be below the transistor's maximum collector-voltage rating. The transistor's base bias may

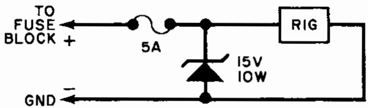


then be set to make the collector-to-emitter voltage about one-half this value. Under this condition, the diode is back-biased, and its resistance is so high as to have little effect on circuit operation. Should the transistor's base current go too far positive, the collector voltage rises until voltage at point "A" is equal to the voltage at point "B" (plus the diode's forward voltage drop). The diode conducts, the voltage at point "A" goes no higher. The transistor is protected. Reverse diode and power supply polarities for rpn transistors.—*Frank H. Tooker* **R-E**

MOBILE PROTECTION

Q. ***How can I protect my mobile transceiver from overvoltages?—Steve Hackett, Bangor, ME***

A. The circuit shown uses the "crowbar" technique. That is, if the voltage applied



to the rig reaches 15 volts, the zener diode starts conducting heavily and will blow the 5-Ampere (fast blow) fuse. The circuit will "crowbar" and remove power from the transceiver before it is damaged by the overvoltage. If you have a positive-ground electrical system, reverse the zener diode. The fuse can be inserted on either side of the dc supply.

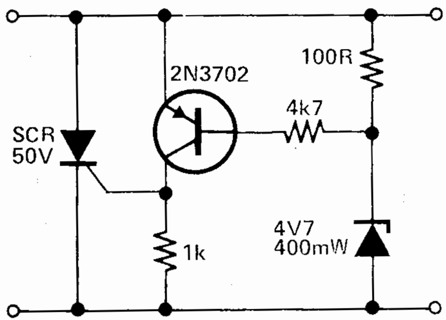


Fig. 1

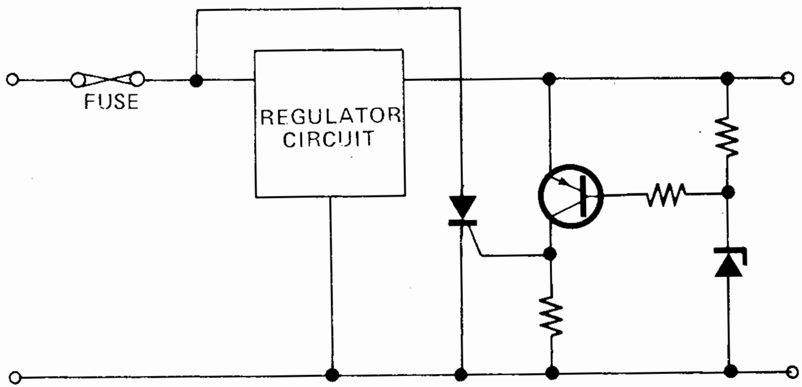


Fig. 2

SIMPLE CROWBAR CIRCUIT

This circuit provides overvoltage protection in case of voltage regulator failure or application of an external voltage. It is intended to be used with a supply offering some form of short circuit protection, either foldback, current limiting or simple fuse. The circuit is less effective in the latter case however, as a good deal of damage can be done in the time taken to blow a fuse.

The most likely application is a 5V logic supply, since TTL is easily damaged by excess voltage. The values chosen in Fig.1 are for a 5V supply, although any supply up to about 25V can be protected by simply choosing the appropriate zener diode. When the supply voltage exceeds the zener voltage +0.7V, the transistor turns on and fires the thyristor. This shorts out the supply, and prevents the voltage rising any further. In the case of a supply with only fuse protection, it is better to connect the thyristor across the unregulated supply as shown in Fig.2 to prevent damage to the regulator circuit when the crowbar operates.

The thyristor should have a current rating about twice the expected short circuit current and a maximum voltage greater than the supply voltage. The circuit can be reset by either switching off the supply, or by breaking the thyristor circuit with a switch.

Crowbar protection circuit senses load voltage directly

by Thomas E. Skopal
Acopian Corp., Easton, Pa.

The triggering point of the overvoltage-protection crowbar circuit for a power supply can be decreased without increasing the circuit's sensitivity to transients. The trick is to have the crowbar circuit sense the voltage across the load, rather than the output voltage of the power supply, as is usually done.

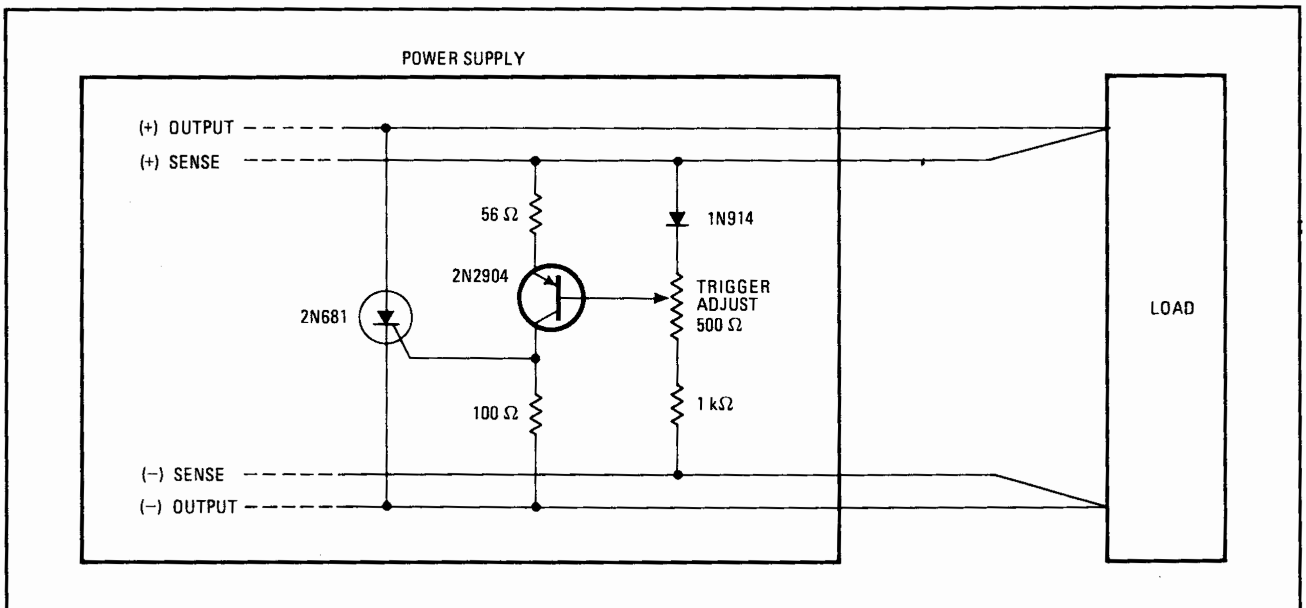
To provide maximum protection, a crowbar circuit is generally set reasonably close to the operating voltage required by the load. Typically, a compromise setting of about 15% above the load's operating voltage is chosen, because commonly encountered transients may cause spurious crowbar triggering and interfere with normal system operation if a tighter differential is used.

However, when voltage drops in the supply's output wiring exceed 2% or 3% of the output voltage—a common occurrence with low-voltage, high-current logic supplies—the system designer is faced with a dilemma. If he compensates for these drops with an increase in power-supply output voltage, the differential will be reduced and the crowbar's sensitivity to transients increased. And if crowbar setting is increased to maintain the same differential, load protection is degraded.

This conflict can be resolved by using the four-terminal crowbar circuit shown in the figure. It senses the voltage across the load, much as a supply's remote-sensing connections may be used to automatically compensate for voltage drops caused by long wires.

The crowbar's triggering point is a function of the voltage seen by the load, as opposed to the output voltage of the supply, and it is unaffected by the amplitude of the wiring voltage drops. Since the sensing connections of the crowbar share the sense lines of the supply's regulator, no additional system wiring is required.

The diode in the circuit provides temperature compensation for the transistor. The component values given are appropriate for power supplies having outputs of 4 to 10 volts and of up to 20 amperes. □



Better protection. Crowbar circuit protects a power supply from overvoltages by sensing the voltage across the load, instead of the supply's output voltage, which is the usual approach. This means that overvoltage sensing will not be affected by wiring voltage drops, nor will there be an increased sensitivity to voltage transients. The components shown here are for a power supply of 4 to 10 volts at up to 20 amperes.

SCR crowbar circuit fires quickly and surely

by Steve Summer
Hauppauge, N.Y.

A monolithic voltage regulator's presence in an SCR crowbar circuit makes the circuit fast-acting, dependable, and capable of producing fast-risetime drive currents as large as several amperes. The circuit shown in the diagram is simple yet effective, providing a drive current of 200 milliamperes with a risetime of 1 microsecond. The 723-type IC regulator is used as a comparator that contains its own stable reference voltage source. The setpoint of the comparator establishes the protection voltage level for the power-supply bus.

A satisfactory crowbar circuit for good power-supply protection generally asks a lot of the crowbar SCR. Typically, power supplies have large output capacitances that impose high surge currents and di/dt levels on the crowbar SCR when it is fired. These large current surges can cause SCR failure or degradation if the SCR drive current is inadequate or soft (has a slow risetime).

The gate drive required to attain the SCR's specified surge and di/dt capability may be many times greater than the worst-case gate drive needed for turn-on. In addition, for best di/dt resistance, the risetime of the gate drive should be quite short, preferably less than a microsecond.

Many simple crowbar circuits use such devices as zener diodes to fire the crowbar SCR. Although this results in a soft turn-on that will fire the SCR at least once, the dependability of such a scheme is questionable.

The circuit shown, however, is hard-firing. Resistors R_1 and R_2 make up a voltage divider that nominally sets the voltage at the inverting input of the comparator to 2 volts. Another voltage divider, consisting of resistors R_3 and R_4, samples the power-supply bus and drives the comparator's noninverting input. When the voltage on the power-supply bus exceeds the setpoint of the comparator, the output of the regulator rises. This voltage rise, which appears across resistor R_5, adds (in phase) to the voltage at the comparator's noninverting input, providing rapid regeneration, as well as a fast-rising pulse to drive the SCR.

Resistor R_6 limits the SCR drive current to about 200 milliamperes, a value that is adequate for sensitive-gate or amplifying-gate devices. To obtain larger drive currents of up to several amperes, an emitter-follower stage can be added at the output of the regulator. The capacitor acts as a filter to prevent the crowbar from firing in response to transient voltages. □

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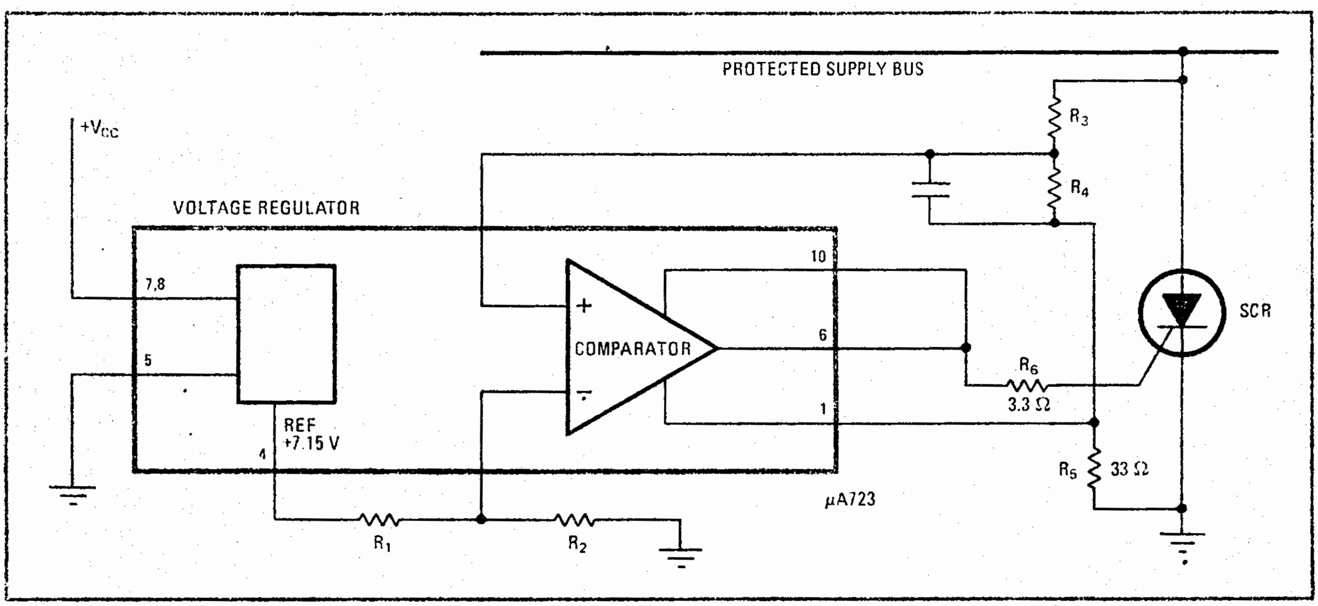


Hard-firing SCR. Crowbar protection circuit employs an IC voltage regulator to produce a fast-risetime large-value gate drive current for the SCR. The regulator, which is used as a comparator, has its own voltage reference source. When the voltage on the power-supply bus exceeds the set point of the comparator, the regulator's output voltage increases, producing a large fast-rising pulse that fires the SCR.

Diodes switch high power to protect sonar receiver

by F. E. Hinkle
Applied Research Laboratories, The University of Texas, Austin, Texas

A sonar system that uses the same transducer for both transmission and reception must include a transmit/receive (T/R) switch. This switch protects the sensitive receiving amplifiers from the high-power pulses applied to the transducer elements during the transmission phase. It also prevents the transmitter circuit from degrading the returned signal during the receiving phase.

In the solid-state switching network described here, pairs of diodes perform the transmit/receive switching automatically, without any extra driving or timing circuits. They are simply driven by high signal voltages into conduction during transmission and lapse into nonconduction during reception. This system transmits kilowatts of power efficiently and is adaptable to various numbers of transducer elements.

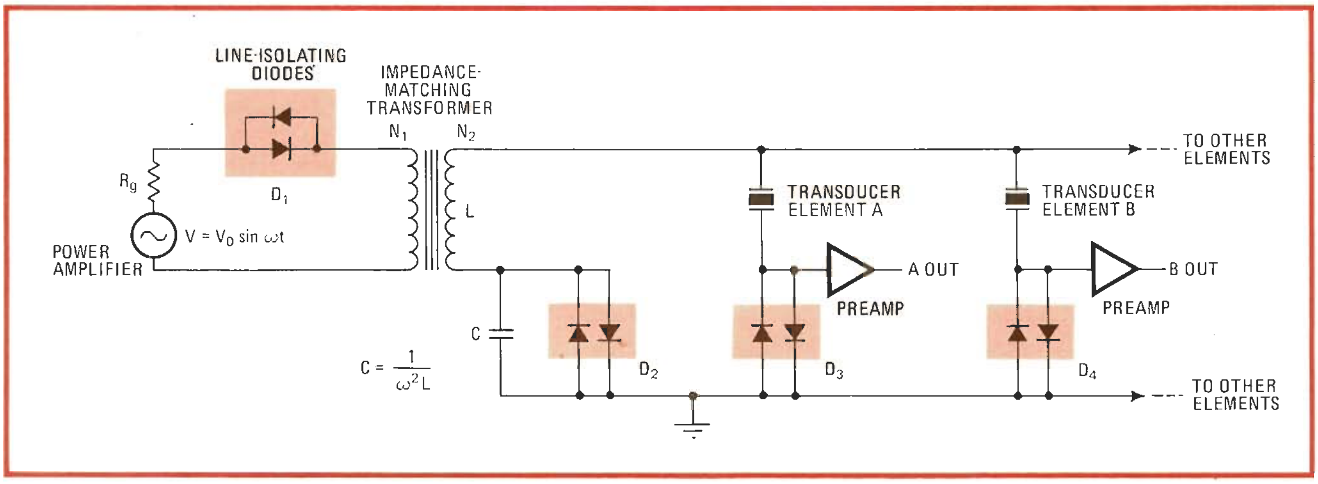
Figure 1 shows the circuit of the automatic solid-state transmit/receive switch. A transformer matches the impedance of the power amplifier to the impedance of the transducer load. Diode pairs D_1, D_2, D_3, and D_4 are placed in the circuit to pass the high currents and voltages that are present when the transducer is used for signal transmission. When the voltage is greater than 1 volt peak-to-peak, the diodes conduct and therefore appear to be short circuits.

Figure 2a shows the equivalent circuit during the transmission phase. Note that all transducer elements are in parallel, so that the same voltage is present across each one. Because diode pairs D_1 and D_2 are in series with the primary and secondary of the transformer, respectively, they must be able to carry the full source and load currents during transmissions. Diode pairs D_3 and D_4 need to carry only the currents that flow through transducer elements A and B, respectively. Diodes D_3 and D_4, acting as short circuits, protect the preamplifiers from the kilovolt-level voltages during the transmission phase.

At the end of the high-power transmitter pulse, all of the diodes stop conducting. Pulse echoes that return to the transducer elements generate only millivolt-level signals, so all of the diodes act as open circuits. (In reality, the diodes look like small capacitors—typically less than 100 picofarads.)

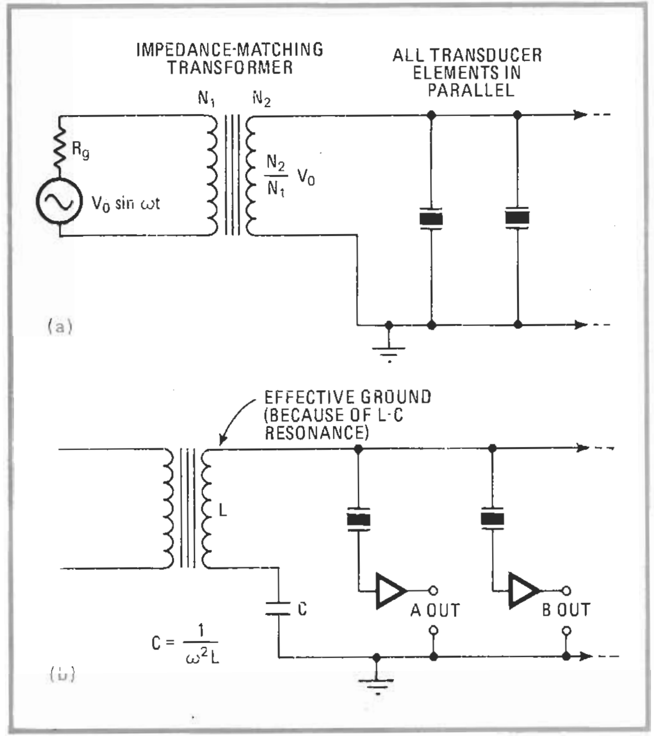
Figure 2b shows the ideal equivalent circuit of the system in this receiving condition. Note that capacitor C is made series-resonant with the secondary of the transformer, i.e., $C = 1/\omega^2 L$ where ω is the angular signal frequency and L is the inductance of the transformer secondary coil. This LC resonance, by creating an effective ground at the common side of all of the transducer elements, prevents crosstalk between them. The preamplifiers are connected to the other side of each element, and each amplifies only the signals from the element it is connected to. Because each element has its own amplifier channel, directional reception can easily be optimized by giving different gains, or weights, to each element. Diode pair D_1 open-circuits the primary side of the transformer to keep noise from entering the effective ground circuit from the power amplifier during the receive mode.

In the system, this transmit/receive technique is used to drive 5 kW into a transducer, which has 16 different elements that all have different gains during the receive mode. A directional receiving beam pattern is formed by summing the signals from all of the elements together after the preamplifier. If it is also necessary to



1. Self-controlled. Automatic solid-state transmit/receive switch uses pairs of diodes. High voltages during transmission drive diodes into conduction so that they appear as short circuits. Low voltages during reception leave diodes nonconducting so that they appear as open circuits. Capacitor C resonates L so that common sides of all transducer elements are grounded during receive mode.

2. T and R equivalents. With diodes short-circuited by high voltages that occur during the transmit phase (a), all transducer elements are in parallel and have equal voltages. During the receive phase (b), the diodes act as open circuits. Each element's signal is amplified separately, so that a directional beam-reception pattern can be formed by controlling the weight (i.e., amplifier gain) for each signal.



weight the elements separately during transmissions, several transformers can be employed to give different drive voltages across the elements.

The diodes used in the working circuit are the 1N3899 and the 1N3899R, which differ only in polarity. These 20-ampere units are stud-mounted for convenient installation and heat-sinking. For signal frequencies on the order of 10^4 hertz, the value of capacitor C is about 0.01 microfarad; because it is shunted by diode pair D_2, it does not need a high voltage rating and therefore can be mica or ceramic. The preamplifiers are type 739 operational amplifiers.

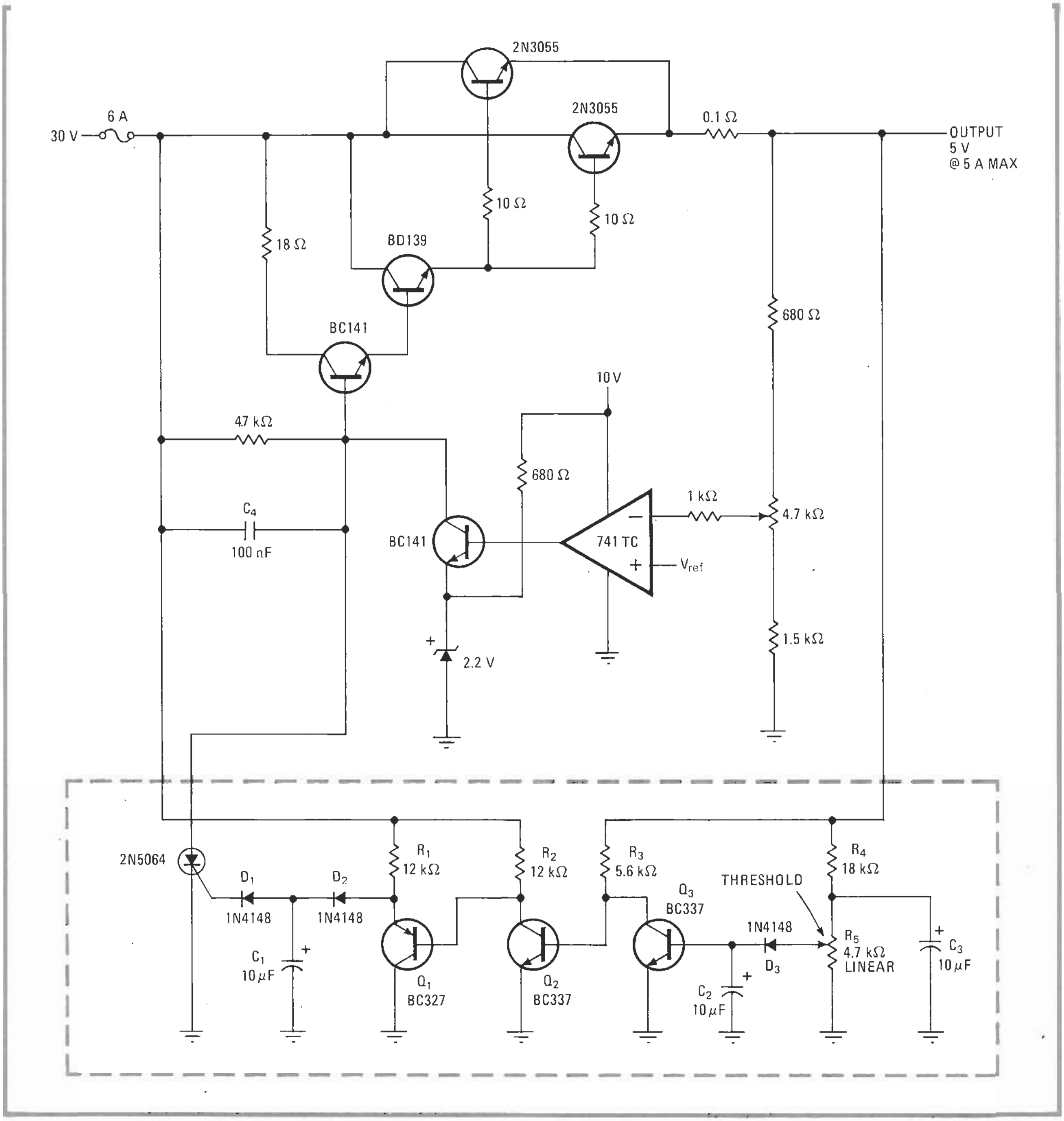
Since the transmit/receive switch does not use relays, no settling time is required prior to transmission. With no moving parts, this transmit/receive switch is quiet, efficient, and very reliable. Power limitations are defined largely by the current capabilities of diode pairs D_1 and D_2 together with the transformer. □

Fast-acting voltage detector protects high-current supplies

by Jorges S. Lucas
Engeletro, Belo Horizonte, Brazil

Protecting a regulated, nonswitching power supply against both short circuits and overvoltages can be difficult, especially if the supply is to deliver high currents. Should either condition occur, this circuit will act quickly to protect the supply, and its load as well, by deactivating the series or shunt pass element in the regulator and thus forcing the output current and voltage to zero.

A typical high-current power supply (5 volts at 5



Power guard. Transistors Q_1–Q_3 and SCR (within dotted lines) protect high-current power supply from short circuits and excessive output voltage. On occurrence of either event, Q_2 turns on, disabling Q_1 and enabling SCR to fire, shutting down supply's regulator.

amperes), which is modified slightly to accommodate the protection circuitry (dotted lines), is shown in the figure. When a short circuit occurs at the output, Q_2 turns on, which in turn disables Q_1. The voltage at the gate of the silicon controlled rectifier then rises at a rate determined by the time constant of elements R_1, D_1, D_2, and C_1. This delay prevents the SCR from triggering when power is first applied to the circuit. The SCR then fires, disabling the BC141/BC139 transistors in the power supply and shutting down the regulator.

Q_3, on the other hand, detects when the output voltage climbs above a user-set threshold. Once the threshold is exceeded, Q_3's base voltage rises at a rate determined by the time constant of elements C_2, R_4, D_3, and threshold potentiometer R_5 (delay must be provided for the reason discussed previously).

Q_3 then turns on. Q_2 and Q_1 react accordingly, and the SCR fires, as it did for the short circuit. Normal circuit operation may be restored simply by turning the power supply off and removing the abnormal condition, then switching on the supply again. □

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High-voltage regulator is immune to burnout

by Michael Maida
National Semiconductor Corp., Santa Clara, Calif.

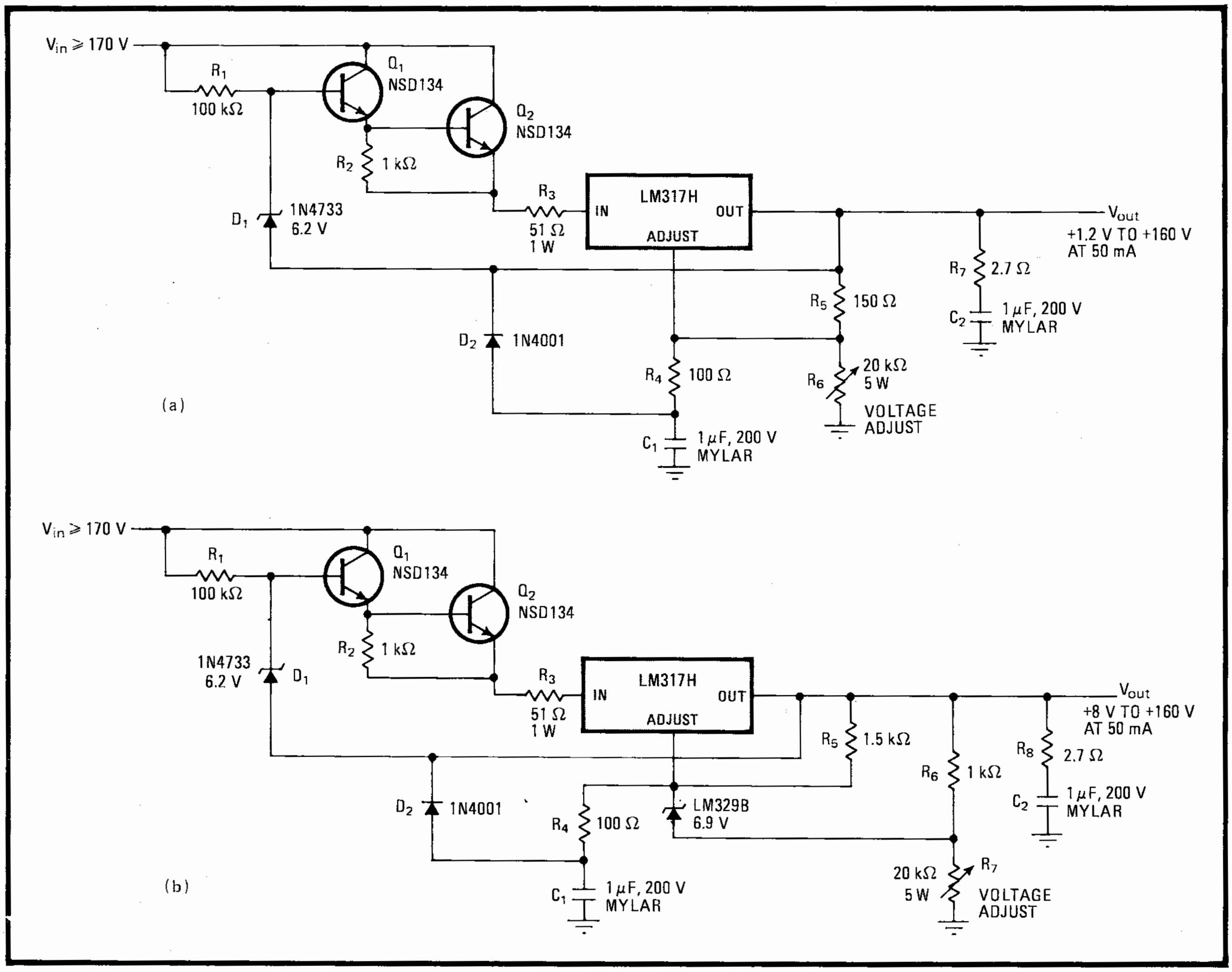
The floating-mode operation of adjustable three-terminal regulators in the LM117 family make them ideal for high-voltage service. Because the regulator sees only the input-output differential—40 volts for the LM117—its voltage rating will not be exceeded for outputs in the hundreds of volts. But the device may break down if the output is shorted unless a circuit can be developed for withstanding the high voltage typically encountered and the output current is limited to a safe value in the event of a dead short.

The circuit surrounding the regulator will serve to solve the problem. Zener diode D_1 maintains a 5-V input output differential over the entire range of output voltages from 1.2 to 160 V. Because high-voltage transistors inherently have a relatively low β, a Darlington arrangement is used to stand off the high input potentials.

The zener diode's impedance will be low, so that no bypass capacitor is required directly at the regulator's input. In fact, no capacitor should be used if the circuit is to survive a short at the output. Resistor R_3 limits the short-circuit current to 100 milliamperes. The RC network at the output improves the circuit's transient response, as does bypassing the adjustment pin. R_4 and D_2 protect the adjustment input from breakdown, if there should be a short circuit at the output.

The approach shown in (b) will serve well in precision regulator applications. Here a LM329B 6.9-V zener reference has been stacked in series with the LM317's internal reference to improve temperature stability and regulation.

These techniques can be employed for higher output voltages and/or currents by either using better high-voltage transistors or cascoded or paralleled transistors. In any event, the output short-circuit current determined by R_2 must be within Q_2's safe area of operations so that secondary breakdown cannot occur. □



Skirting shorts. Three-terminal regulator (a), configured for high-voltage duties as a consequence of operating in the floating mode, is protected by appropriate circuitry against burnout due to shorts. LM329B zener (b) and minor changes improve stability and regulation.

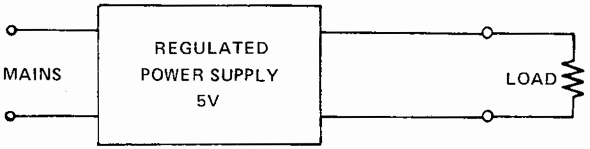


Fig.1

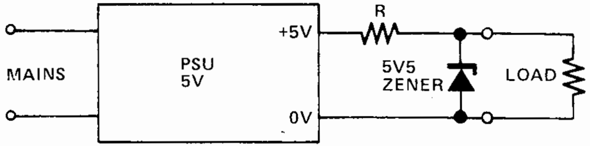


Fig.2

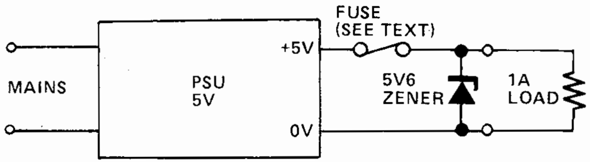


Fig.3

PROTECTION FROM TTL PSU FAILURE

With this circuit, a fault in the sophisticated PSU might cause the output voltage to rise above about 5.5V, (the maximum allowable) and thus cause damage to the ICs.

A simple zener regulator across the output as in Fig. 2 with a zener voltage of about 5.5V, means that at normal voltage, the zener is effectively open circuit. The effect of the load resistor R, would be to eliminate all the regulation of the main PSU.

In the circuit shown in Fig. 3, there is no load resistor to cause regulation problems, and the zener normally appears as an open circuit. But as soon as the voltage rises above about 5.5V the zener tries to draw a great deal of current and the fuse blows, cutting off the supply from the load.