

## 2

# Power Supplies—Fixed

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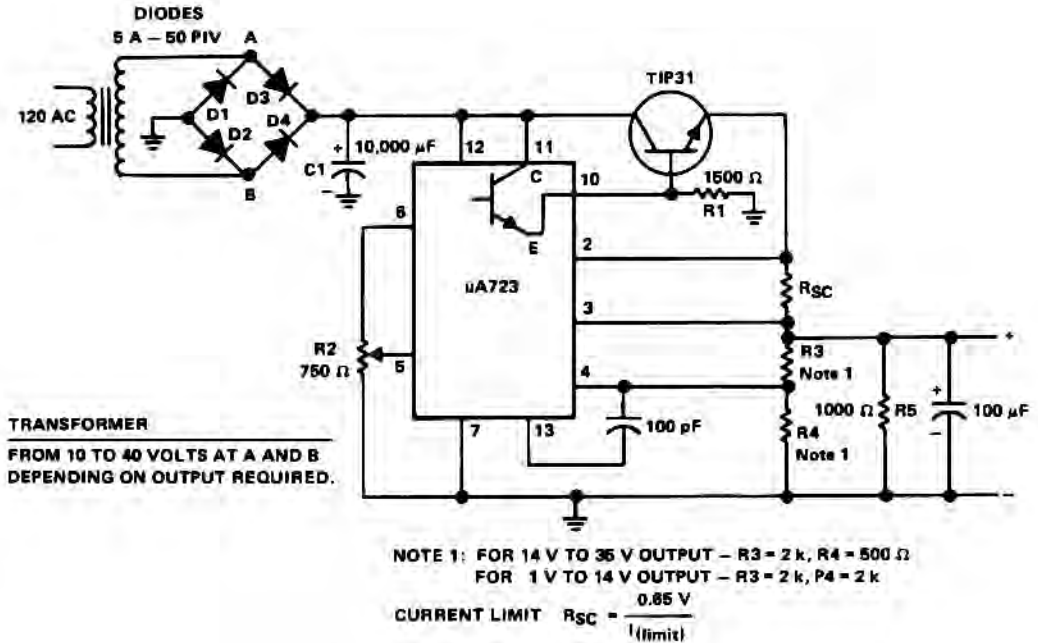
The sources of the following circuits are contained in the Sources section, which begins on page 125. The figure number in the box of each circuit correlates to the source entry in the Sources section.

General-Purpose Power Supply  
12-Vdc Battery-Operated 120-Vac Power Source  
Simple Power Supply  
Charge-Pool Power Supply  
Bilateral Current Source  
3- to 30-V Universal Power-Supply Module  
Regulator/Current Source  
Low-Power Switching Regulator  
Variable Voltage Regulator  
Switching Power Supply  
100-kHz Multiple-Output Switching Power Supply  
Isolated Feedback Power Supply  
Dual-Tracking Regulator  
+15-V 1-A Regulated Power Supply  
-15-V 1-A Regulated Power Supply  
Hand-Held Transceiver dc Adapter  
Low-Dropout 5-V Regulator  
Triac-Controlled Voltage Doubler  
High-Stability 10-V Regulator  
Voltage-Controlled Current Source

Low-Power Inverter  
Three-Rail Power Supply  
Programmable Power Supply  
Efficient Negative Voltage Regulator  
5 V-to-Isolated 5 V (at 20 mA) Converter  
Positive Regulator with npn and pnp Boost  
Tracking Preregulator  
Adjustable 10-A Regulator  
Low-Cost Low-Dropout Linear Regulator  
Voltage Doubler  
Safe Constant-Current Source  
Low-Cost 3-A Switching Regulator  
50-W Off-Line Switching Power Supply  
Positive Regulator with pnp Boost  
Low Forward-Drop Rectifier Circuit  
Low-Ripple Power Supply  
5.0-V/10-A Regulator  
5.0-V/3.0-A Regulator  
Bench-Top Power Supply  
Variable Current Source (100 mA to 2 A)

Basic Single-Supply Voltage Regulator  
 8-A Regulated Power Supply for Operating Mobile Equipment  
 Low-Voltage Regulators with Short-Circuit Protection  
 High-Stability 1-A Regulator  
 High-Current Inductorless Switching Regulator  
 200-kHz Switching Regulator  
 5-V 0.5-A Power Supply  
 3-W Switching-Regulator Circuit  
 Regulated Split Power Supplies from a Single Supply  
 Switching Step-Down Regulator  
 Single-Ended Regulator  
 $\pm 50$ -V Push-Pull Switched-Mode Converter  
 5-V/0.5-A Buck Converter  
 Slow Turn-On 15-V Regulator  
 ac Voltage Regulator  
 Uninterruptible  $+5$ -V Supply  
 Stand-By Power For Nonvolatile CMOS RAMs  
 5-V Supply With Stabilized Momentary Backup  
 Uninterruptible Power Supply for Personal Computers  
 90-Vrms Voltage Regulator Using a PUT  
 Switch-Mode Power Supply  
 Micropower Bandgap Reference Supply  
 $\pm 50$ -V Feed-Forward Switch-Mode Converter  
 Traveller's Shaver Adapter  
 100-V/0.25-A Switch-Mode Converter  
 Voltage Regulator  
 Dual-Polarity Power Supply  
 5.0-V/6.0-A/25-kHz Switching Regulator With Separate Ultra-Stable Reference  
 Mobile Voltage Regulator  
 Negative Switching Regulator  
 Positive Switching Regulator  
 Positive Floating Regulator  
 Negative Floating Regulator  
 Negative Voltage Regulator  
 $-15$ -V Negative Regulator  
 Slow Turn-On 15-V Regulator  
 High-Stability 10-V Regulator  
 5-V/1-A Switching Regulator  
 15-V/1-A Regulator with Remote Sense  
 Increasing the Power Rating of Zener Diodes  
 Voltage Regulator  
 Zener Diode Regulator  
 12- to 14-V Regulated 3-A Power Supply  
 dc-to-dc SMPS Variable (18 to 30 V Out at 0.2 A)  
 SCR Preregulator Fits Any Power Supply  
 Off-Line Flyback Regulator  
 500-kHz Switching Inverter for 12-V Systems  
 10-A Regulator with Current and Thermal Protection  
 Bipolar Power Supply For Battery Instruments  
 Power Supply for 25-W Arc Lamp  
 Power-Switching Circuit  
 100-V/0.25-A Switch Mode Converter  
 Radiation-Hardened 125-A Linear Regulator  
 Supply Voltage Splitter  
 3- to 5-V Regulated Output Converter  
 Memory-Save On Power-Down  
 100-Vrms Voltage Regulator

## GENERAL-PURPOSE POWER SUPPLY



TEXAS INSTRUMENTS

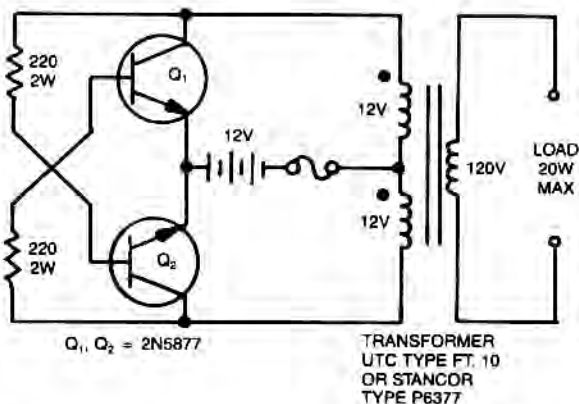
Fig. 2-1

The supply can be used for supply output voltages from 1 to 35 V. The line transformer should be selected to give about 1.4 times the desired output voltage from the positive side of filter capacitor C1 to ground. Potentiometer R2 sets the output voltage to the desired value by adjusting the reference input.  $R_{SC}$  is the current limit set resistor. Its value is calculated as:

$$R_{SC} = \frac{0.65 \text{ V}}{I_L}$$

For example, if the maximum current output is to be 1 A,  $R_{SC} = 0.65/1.0 = 0.65 \Omega$ . The 1-k $\Omega$  resistor,  $R_S$ , is a light-loaded resistor designed to improve the no-load stability of the supply.

## 12-Vdc BATTERY-OPERATED 120-Vac POWER SOURCE



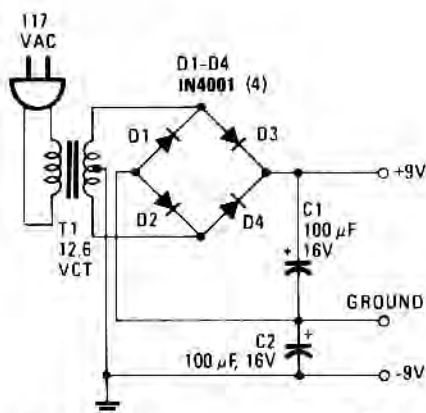
EDN

Fig. 2-2

A simple 120 V: 24 V, center-tapped control transformer and four additional components can do the job. This circuit outputs a clean 200-V pk-pk square wave at 60 Hz and can supply up to 20 W. The circuit is self-starting and free-running.

If Q1 is faster and has a higher gain than Q2, it will turn on first when you apply the input power and will hold Q2 off. Load current and transformer magnetizing current then flows in the upper half of the primary winding, and auto transformer action supplies the base drive until the transformer saturates. When that action occurs, Q1 loses its base drive. As it turns off, the transformer voltages reverse, turning Q2 on and repeating the cycle. The output frequency depends on the transformer iron and input voltage, but not on the load. The frequency will generally range between 50 to 60 Hz with a 60-Hz transformer and car battery or equivalent source. The output voltage depends on turns ratio and the difference between input voltage and transistor saturation voltage. For higher power, use larger transformers and transistors. This type of inverter normally is used in radios, phonographs, hand tools, shavers, and small fluorescent lamps. It will not work with reactive loads (motors) or loads with high inrush currents, such as coffee pots, frying pans, and heaters.

## SIMPLE POWER SUPPLY



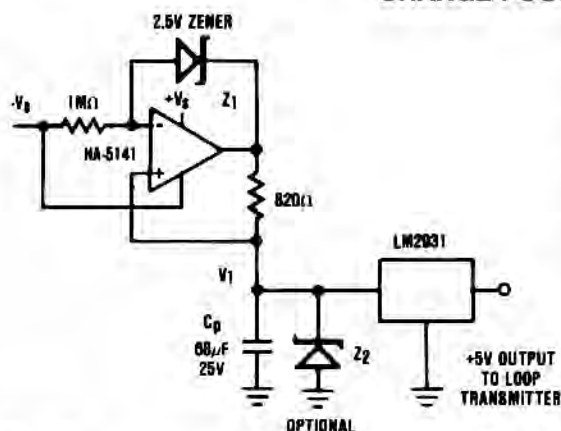
HANDS-ON ELECTRONICS

Fig. 2-3

This power supply delivers plus and minus 9 V to replace two 9-V batteries. The rectifier circuit is actually two separate full-wave rectifiers fed from the secondary of the transformer. One full-wave rectifier is composed of diodes D1 and D2, which develop +9 V, and the other is composed of D3 and D4, which develop -9 V.

Each diode from every pair rectifies 6.3 Vac, half the secondary voltage, and charges the associated filter capacitor to the peak value of the ac waveform,  $6.3 \times 1.414 = 8.9$  V. Each diode should have a PIV, Peak Inverse Voltage, rating that is at least twice the peak voltage from the transformer,  $2 \times 8.9 = 18$  V. The 1N4001 has a PIV of 50 V.

## CHARGE-POOL POWER SUPPLY



HARRIS

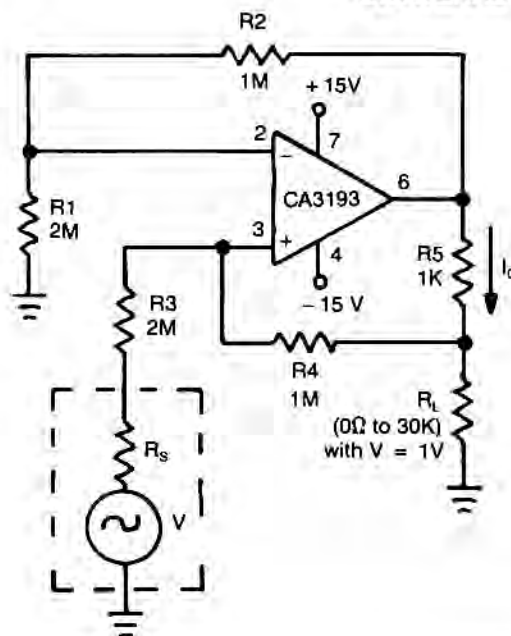
Fig. 2-4

It is usually desirable to have the remote transmitter of a 4- to 20-mA current loop system powered directly from the transmission line. In some cases, this is not possible because of the high-power requirements set by the remote sensor/transmitter system. In these cases, an alternative

to the separate power supply is still possible. If the remote transmitter can be operated in a pulsed mode where it is active only long enough to perform its function, then a charge pool power supply can still allow the transmitter to be powered directly by the current loop. In this circuit, constant current  $I_1$  is supplied to the charge pool capacitor, CP, by the HA-5141 (where  $I_1 = 3 \text{ mA}$ ). The voltage  $V_1$  continues to rise until the output of the HA-5141 approaches  $+V_s$  or the optional voltage limiting provided by Z2. The LM2931 voltage regulator supplies the transmitter with a stable +5-V supply from the charge collected by CP. Available power supply current is determined by the duration, allowable voltage drop on CP, and required repetition rate. For example, if  $V_1$  is allowed to drop 4.4 V and the duration of operation is 1 ms, the available power supply current is approximately:

$$= CP \frac{dV_1}{dt} = 68 \mu\text{F} \times \frac{4.4 \text{ V}}{1 \text{ ms}} = 30 \text{ mA}$$

## BILATERAL CURRENT SOURCE



This circuit uses a CA3193 precision op amp to deliver a current independent of variations in  $R_L$ . With  $R_1$  set equal to  $R_3$ , and  $R_2$  approximately equal to  $R_4 + R_5$ , the output current,  $I_L$ , is:  $V_{IN} (R_4)/(R_3) (R_5)$ . 500- $\mu\text{A}$  load current is constant for load values from 0 to 3  $\Omega$ .

ALL RESISTORS ARE 1%  
ALL RESISTANCE VALUES ARE IN OHMS  
IF  $R_1 = R_3$  AND  $R_2 \approx R_4 + R_5$  THEN

$I_L$  IS INDEPENDENT OF VARIATIONS IN  $R_L$   
FOR  $R_L$  VALUES OF  $0\Omega$  TO  $3K\Omega$  WITH  $V = 1\text{V}$

$$I_L = \frac{V R_4}{R_3 R_5} = \frac{V 1\text{M}}{(2\text{M})(1\text{K})} = \frac{V}{2\text{K}} = 500\mu\text{A}$$

GE/RCA

Fig. 2-5

### 3- to 30-V UNIVERSAL POWER-SUPPLY MODULE

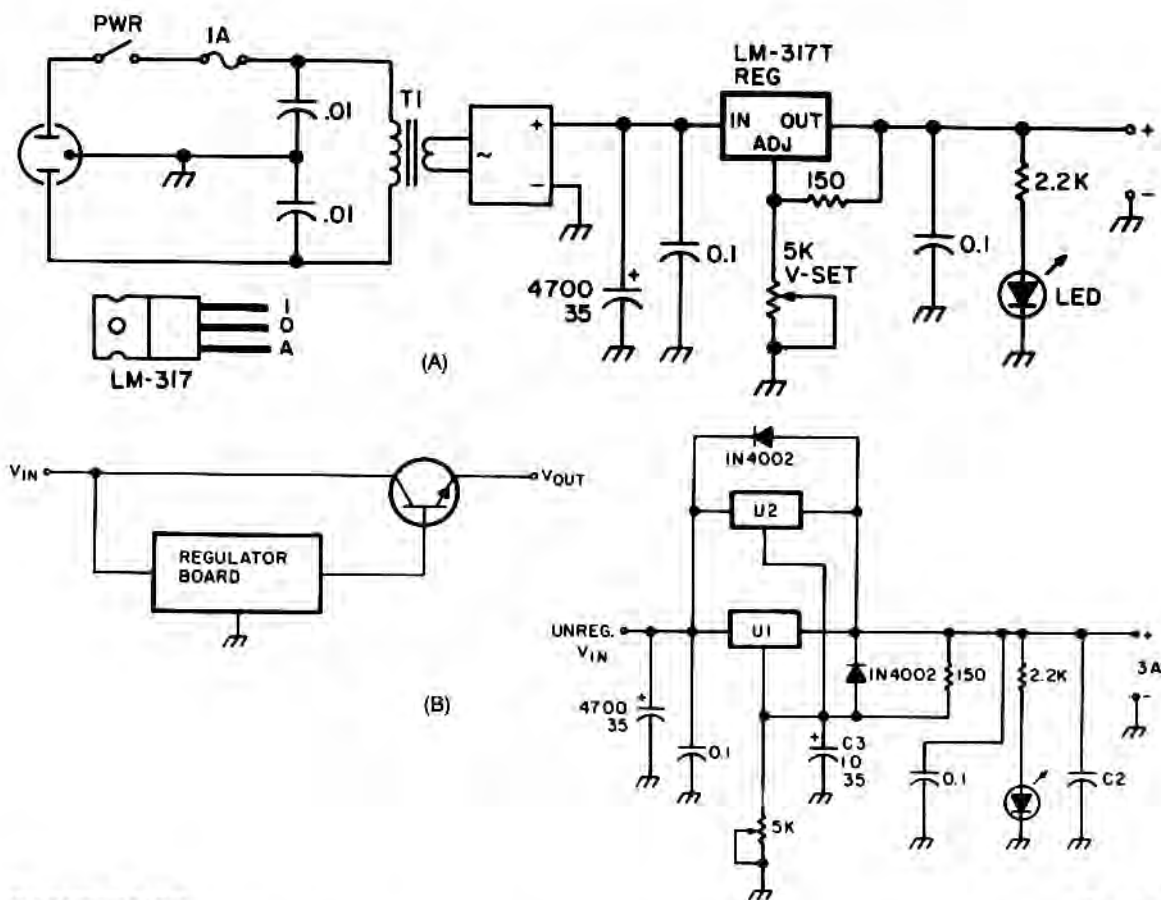
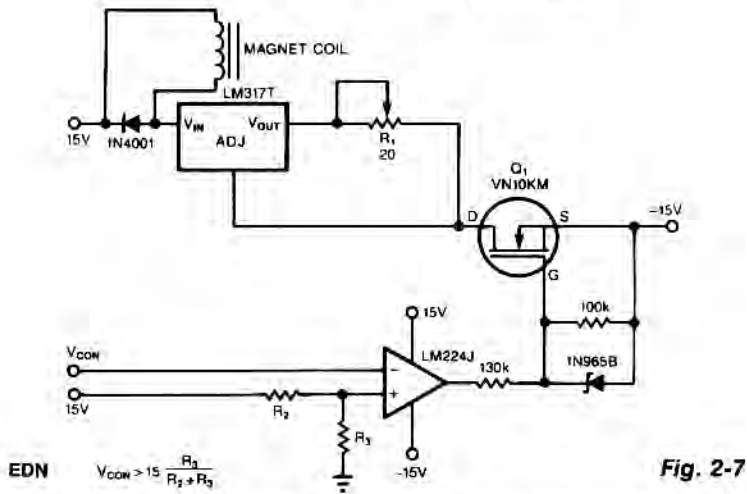


Fig. 2-6

U1, an LM317 adjustable regulator provides short-circuit protection and automatic current limiting at 1.5 A. The input voltage to the regulator is supplied by DB1, a 4-A 100 PIV full-wave bridge rectifier. Capacitor C1 provides initial filtering. U1 provides additional electronic filtering as part of the regulating function. The output level of the regulator is set by trim-pot R1. Bypass capacitors on the input and output of U1 prevent high-frequency oscillation. The current rating of the transformer must be at least 1.8 times the rated continuous-duty output of the supply. This means that a 1.5-A supply should use a 2.7-A transformer. For light or intermittent loads, a smaller 2.0-A transformer should suffice.

Wiring a second LM317, U2, in parallel with U1 is a quick and clean way to increase the current-limiting threshold to 3 A without sacrificing short-circuit protection. When more than 3 A is required, the regulator module can be used to drive the base of one or more pass-transistors (see Fig. 2-6B).

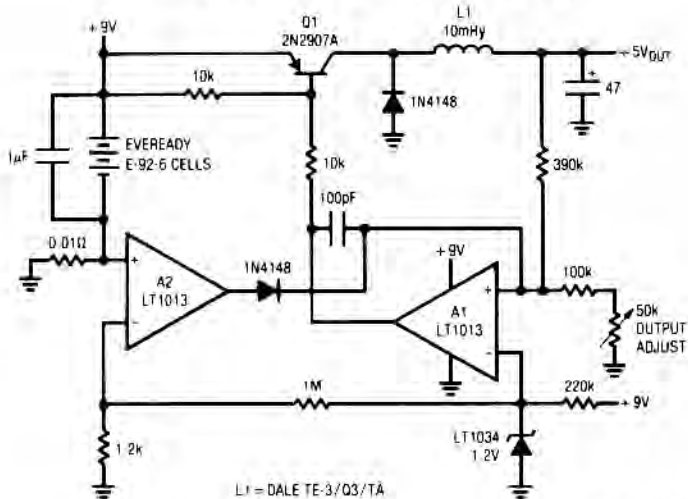
## REGULATOR/CURRENT SOURCE



**Fig. 2-7**

The circuit powers the load via the regulator's input instead of its output. Because the regulator's output sees constant dummy load R1, it tries to consume a constant amount of current, no matter what the voltage across the actual load really is. Hence, the regulator's input serves as a constant-current source for the actual load. Power the circuit with any one of the commonly available  $\pm 15$ - or  $\pm 12$ -V supplies. The voltage dropped across the regulator and dummy load decreased the total compliance voltage of the circuit. You set the load's current with R1. The current equals  $1.25 \text{ A}/\Omega \times R_1$ .

## LOW-POWER SWITCHING REGULATOR



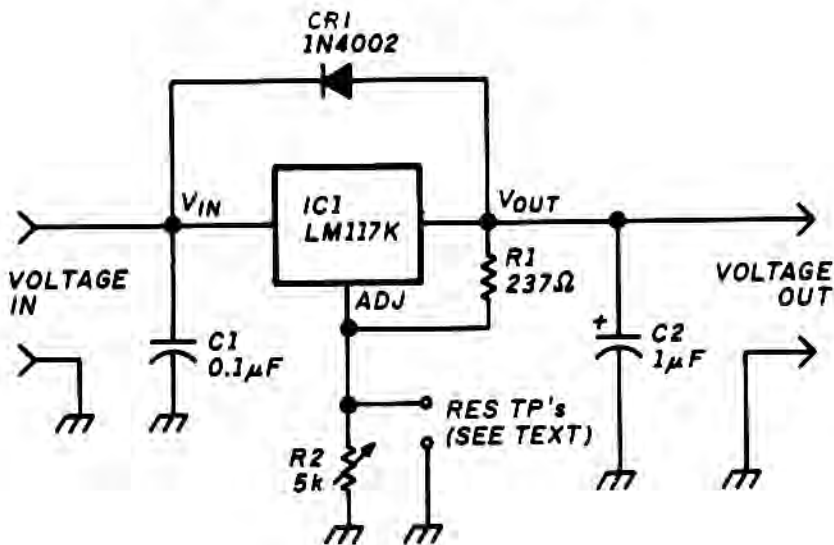
LINEAR TECHNOLOGY CORP.

**Fig. 2-8**

## LOW-POWER SWITCHING REGULATOR (cont.)

A simple battery-powered switching regulator provides 5 V out from a 9-V source with 80% efficiency and 50-mA output capability. When Q1 is on, its collector voltage rises, forcing current through the inductor. The output voltage rises, causing A1's output to rise. Q1 cuts off and the output drops low enough for A1 to turn on Q1. The 100-pF capacitor ensures clean switching. The cycle repeats when the output drops low enough for A1 to turn on Q1. The 1- $\mu$ F capacitor ensures low battery impedance at high frequencies, preventing *sag* during switching.

## VARIABLE VOLTAGE REGULATOR



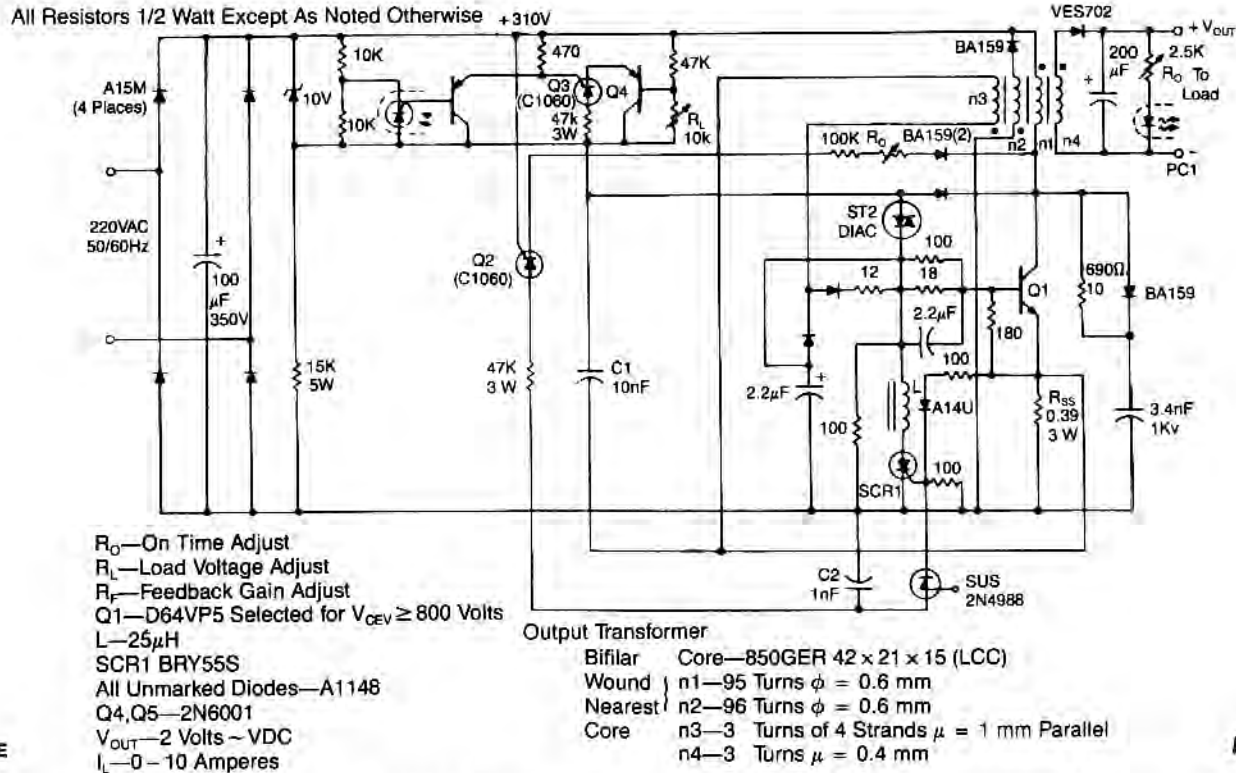
HAM RADIO

Fig. 2-9

The variable voltage regulator lets you adjust the output voltage of a fixed dc power supply between 1.2 and 37 Vdc, and will supply the output current in excess of 1.5 A. The circuit incorporates an LM117K three-terminal adjustable output positive voltage regulator in a TO-3 can. Thermal overload protection and short-circuit current-limiting constant with temperature are included in the package. Capacitor C1 reduces sensitivity to input line impedance, and C2 reduces excessive ringing. Diode CR1 prevents C2 from discharging through the IC during an output short.



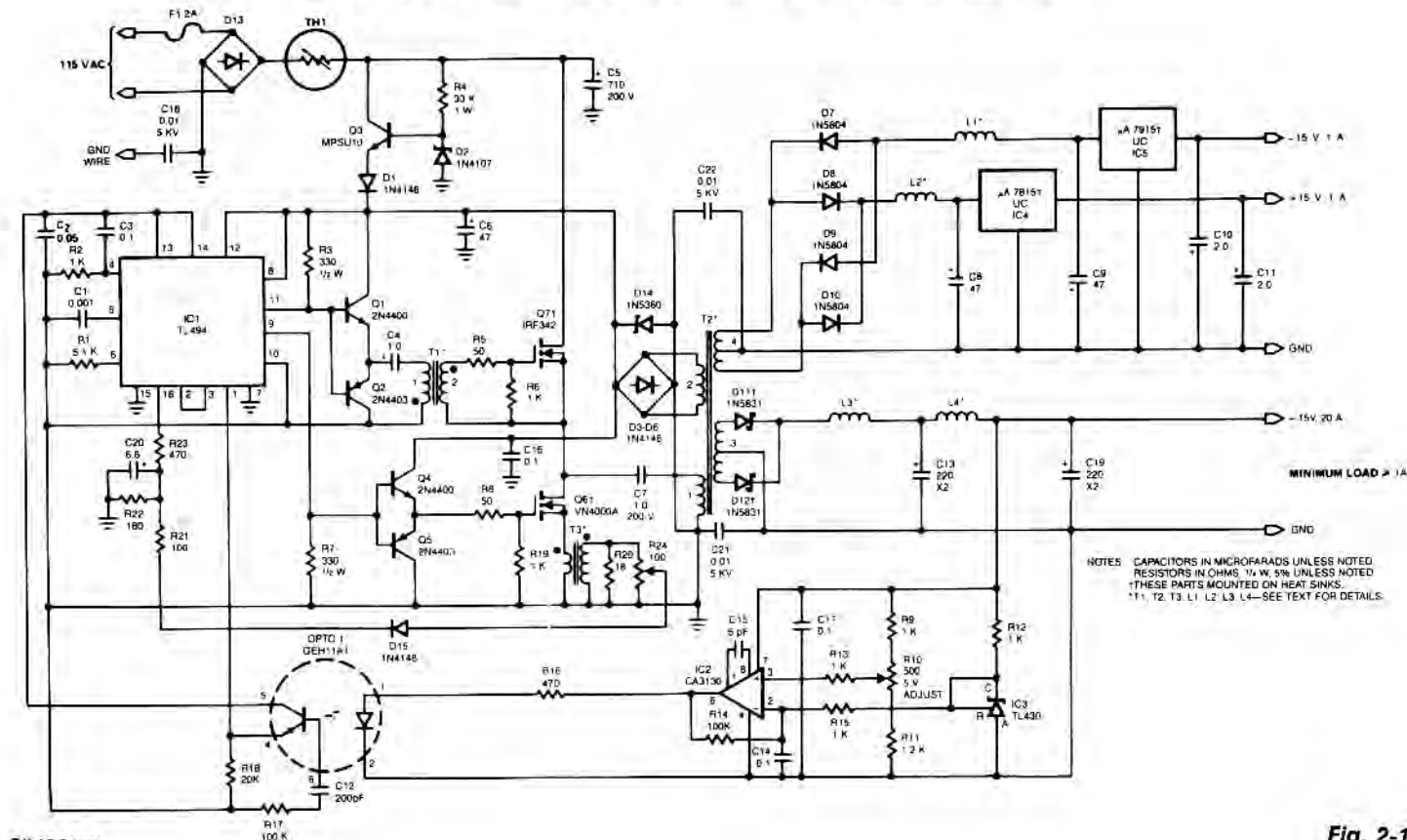
## SWITCHING POWER SUPPLY



**Fig. 2-10**

This low-voltage high-current output, switching dc power supply is running off the 220-Vac input. In this circuit, an ST2 diac relaxation oscillator, Q3, C1, and the diac, initiates conduction of the output switching transistor Q1, the on-time of which is maintained constant by a separate timing/commutation network consisting of Q2, C2, SUS, and SCR1. The output voltage, consequently, is dependent on the duty cycle. To compensate for unwanted variations of output voltage because of input voltage or load resistance fluctuations, an H11C wired as a linear-model unilateral pnp transistor in a stable differential amplifier configuration is connected into the galvanically isolated negative-feedback loop. The loop determines the duty cycle and hence the output voltage. Of further interest in this circuit is the use of several low-current, high-voltage, 400-V  $V_{DRM}$  thyristors (Q2, Q3), which are also used as pnp remote-base transistors. Short-circuit protection is assured by coupling Q1 collector-current feedback into the turn-off circuitry via  $R_{SS}$ .

## 100-kHz MULTIPLE-OUTPUT SWITCHING POWER SUPPLY

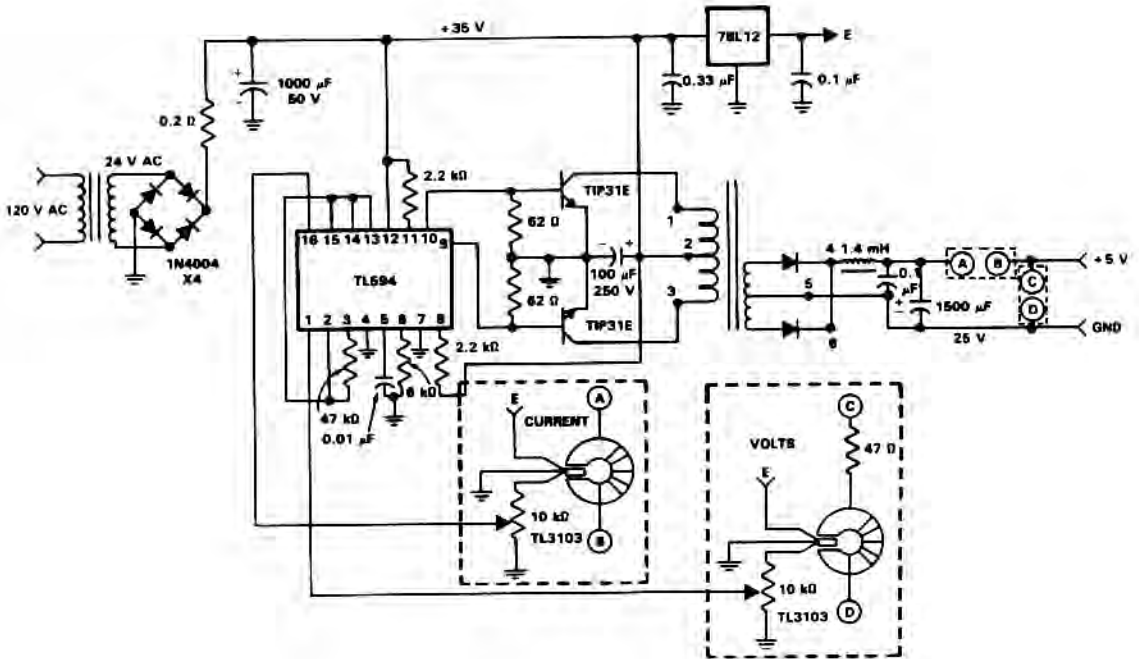


SILICONIX

Fig. 2-11

The power supply uses two VN4000A 400-V MOSPOWER FETs in a half-bridge power switch configuration. Outputs available are +5 V at 20 A and  $\pm 15$  V (or  $\pm 12$  V) at 1 A. Since linear three-terminal regulators are used for the low-current outputs, either  $\pm 12$  V or  $\pm 15$  V can be made available with a simple change in the transformer secondary windings. A TL494 switching regulator IC provides pulse-width modulation control and drive signals for the power supply. The upper MOSPOWER FET, Q7, in the power switch stage is driven by a simple transformer drive circuit. The lower MOS, Q6, since it is ground referenced, is directly driven from the control IC.

## ISOLATED FEEDBACK POWER SUPPLY



TEXAS INSTRUMENTS

Fig. 2-12

Figure 2-12 is a power supply circuit using the isolated feedback capabilities of the TL3103 for both current and voltage sensing. This supply is powered from the ac power line and has an output of 5 V at 1.5 A. Both output voltage and current are sensed and the error voltages are applied to the error amplifiers of the TL594 PWM control IC. The 24-V transformer produces about 35 V at the 1000- $\mu$ F filter capacitor. The 20-kHz switching frequency is set by the 6-k $\Omega$  resistor and the 0.01- $\mu$ F capacitor on pins 6 and 5, respectively. The TL594 is set for push-pull operation by tying pin 13 high. The 5-V reference on pin 14 is tied to pin 15, which is the reference or the current error amplifier. The 5-V reference is also tied to pin 2 which is the reference for the output voltage error amplifier. The output voltage and current limit are set by adjustment of the 10-k $\Omega$  pots in the TL3103 error-sensing circuits. A pair of TIP31E npn transistors are used as switching transistors in a push-pull circuit.

## DUAL-TRACKING REGULATOR

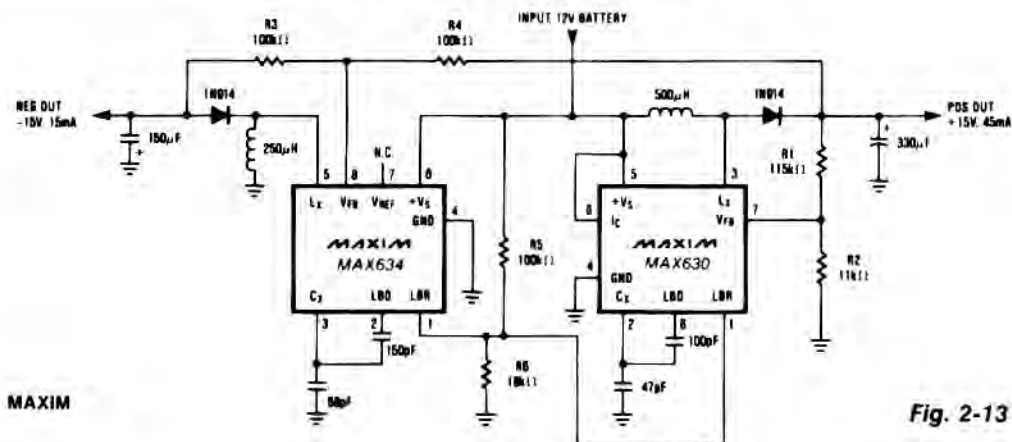


Fig. 2-13

A MAX634 inverting regulator is combined with a MAX630 to provide a dual tracking  $\pm 15\text{-V}$  output from a 12-V battery. The reference for the  $-15\text{-V}$  output is derived from the positive output via R3 and R4. Both regulators are set to maximize output power at low battery voltages by reducing the oscillator frequency, via LBR, when  $V_{\text{BATT}}$  falls to 8.5 V.

## +15-V 1-A REGULATED POWER SUPPLY

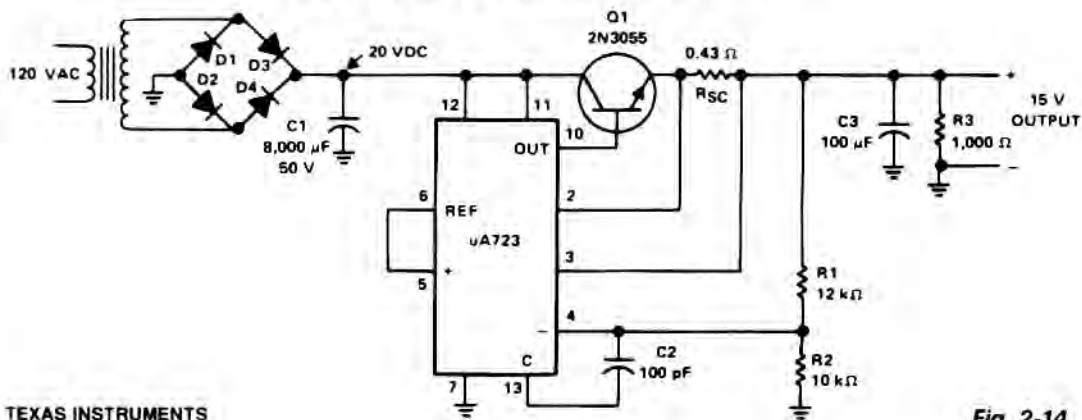


Fig. 2-14

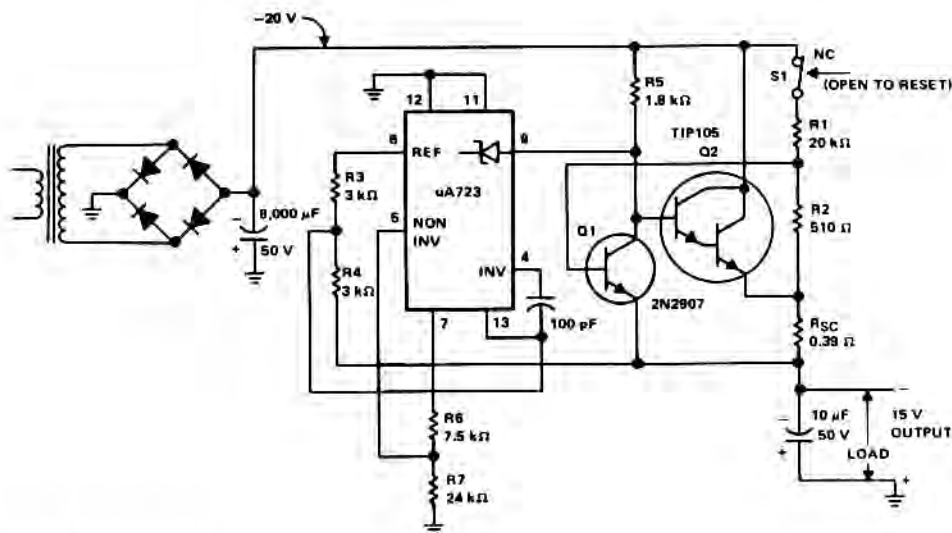
The supply receives +20 Vdc from the rectifier/filter section. This is applied to pins 11 and 12 of the uA723, as well as to the collector of the 2N3055 series-pass transistor. The output voltage is sampled through R1 and R2, providing about 7 V with respect to ground at pin 4. The reference terminal at pin 6 is tied directly to pin 5, the noninverting input of the error amplifier. For fine trimming the output voltage, a potentiometer can be installed between R1 and R2. A 100-pF capacitor from pin 13 to pin 4 furnishes gain compensation for the amplifier.

## + 15-V 1-A REGULATED POWER SUPPLY (cont.)

Base drive to the 2N3055 pass transistor is furnished by pin 10 of the  $\mu$ A723. Since the desired output of the supply is 1 A, maximum current limit is set to 1.5 A by resistor  $R_{SC}$  whose value is  $0.433 \Omega$ .

A  $100\text{-}\mu\text{F}$  electrolytic capacitor is used for ripple voltage reduction at the output. A  $1\text{-k}\Omega$  output resistor provides stability for the power supply under no-load conditions. The 2N3055 pass transistor must be mounted on an adequate heatsink.

## - 15-V 1-A REGULATED POWER SUPPLY

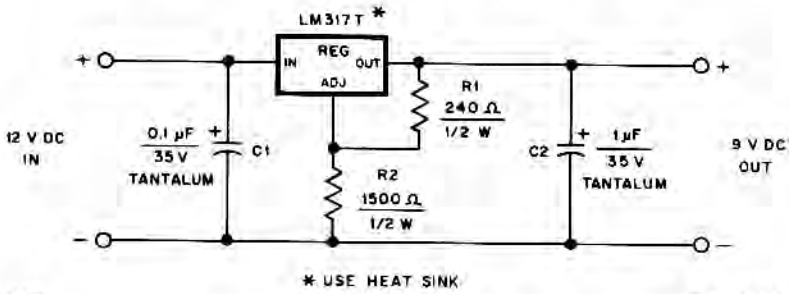


TEXAS INSTRUMENTS

Fig. 2-15

The supply receives  $-20\text{ V}$  from the rectifier/filter which is fed to the collector of the Darlington pnp pass transistor, a TIP105. The base drive to the TIP105 is supplied through resistor  $R_5$ . The base of the TIP105 is driven from  $V_Z$  terminal at pin 9, which is the anode of a  $6.2\text{-V}$  zener diode that connects to the emitter of the  $\mu$ A723 output control transistor. The method of providing the positive feedback required for foldback action is shown. This technique introduces positive feedback by increased current flow through resistors  $R_1$  and  $R_2$  under short-circuit conditions. This forward biases the base-emitter junction of the 2N2907 sensing transistor, which reduces base drive to the TIP105.

## HAND-HELD TRANSCEIVER dc ADAPTER

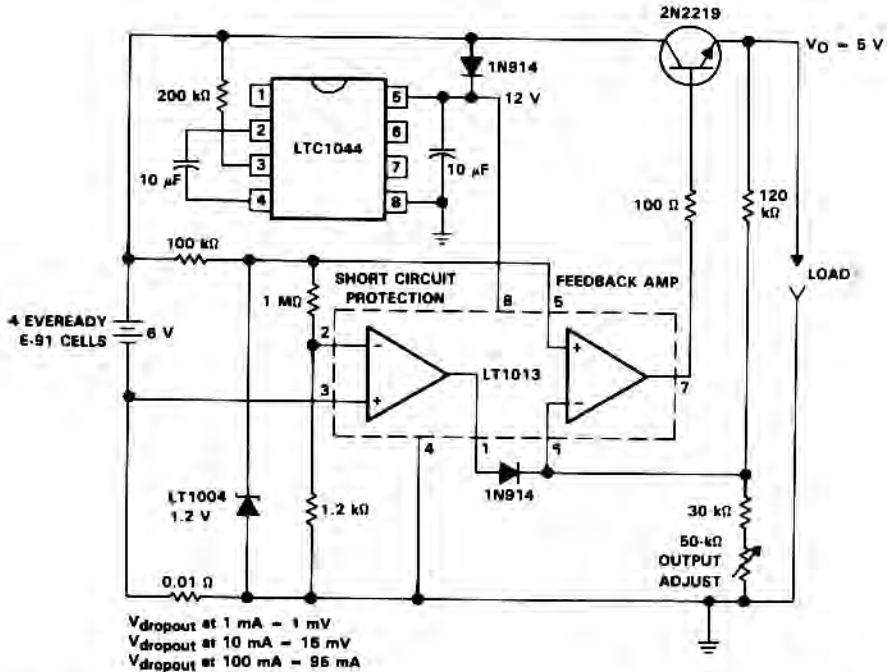


QST

Fig. 2-16

This dc adapter provides a regulated 9-V source for operating a Kenwood TR-2500 hand-held transceiver in the car. The LM317T's mounting tab is electrically connected to its output pin, so take this into account as you construct your version of the adapter. The LM317T regulator dissipates 2 or 3 W in this application, so mount it on a 1-x-2-inch piece of 1/8-inch-thick aluminum heatsink.

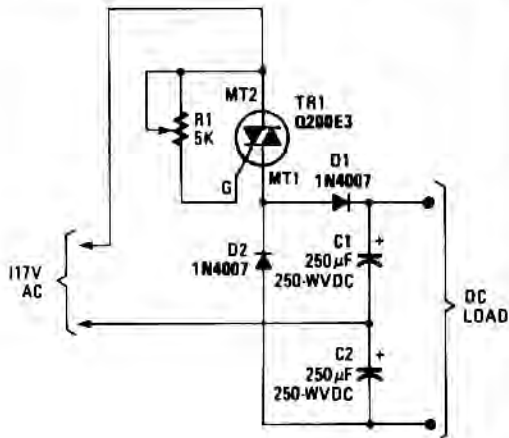
## LOW-DROPOUT 5-V REGULATOR



TEXAS INSTRUMENTS

Fig. 2-17

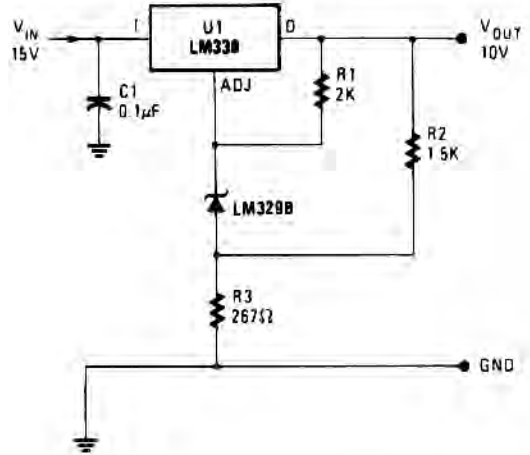
## TRIAC-CONTROLLED VOLTAGE DOUBLER



HANDS-ON ELECTRONICS

Fig. 2-18

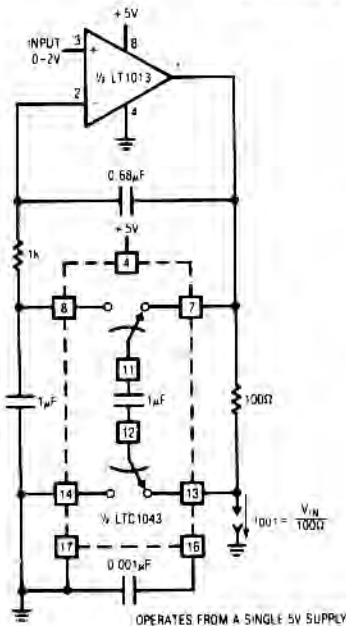
## HIGH-STABILITY 10-V REGULATOR



POPULAR ELECTRONICS

Fig. 2-19

## VOLTAGE-CONTROLLED CURRENT SOURCE

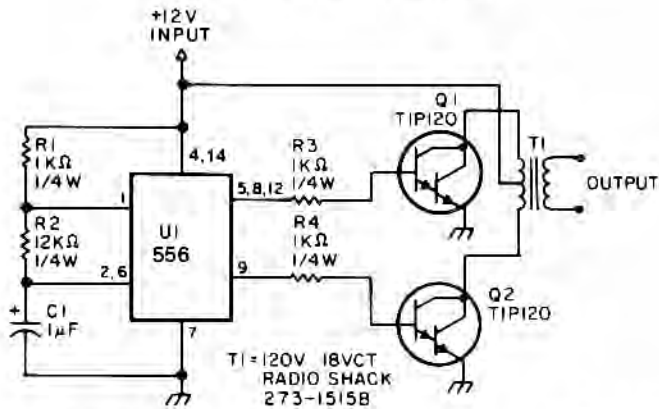


This is a simple, precise voltage-controlled current source. Bipolar supplies will permit bipolar output. Configurations featuring a grounded voltage-control source and a grounded load are usually more complex and depend upon several components for stability. In this circuit, accuracy and stability almost entirely depend upon the 100-Ω shunt.

LINEAR TECHNOLOGY CORP.

Fig. 7-20

## LOW-POWER INVERTER



73 AMATEUR RADIO

Fig. 2-21

This low-power inverter uses only 9 parts and turns 10 to 16 Vdc into 60-Hz, 115-V square-wave power to operate ac equipment up to 25 W. The first section of the 556 timer chip is wired as an astable oscillator with R2 and C1 setting the frequency. The output is available at pin 5. The second section is wired as a phase inverter. That output is available at pin 9. Resistors R3 and R4 keep output transistors Q1 and Q2 from loading down the oscillator. The two transistors drive the transformer push-pull fashion. When one transistor is biased-on, the other is cut-off. The transformer is a 120 V/18 VCT unit that is connected backwards, so that it steps the voltage up rather than down. Oscillator circuit U1, R1, R2, and C1 operates from about 4 to 16 V with a very stable output.

## THREE-RAIL POWER SUPPLY

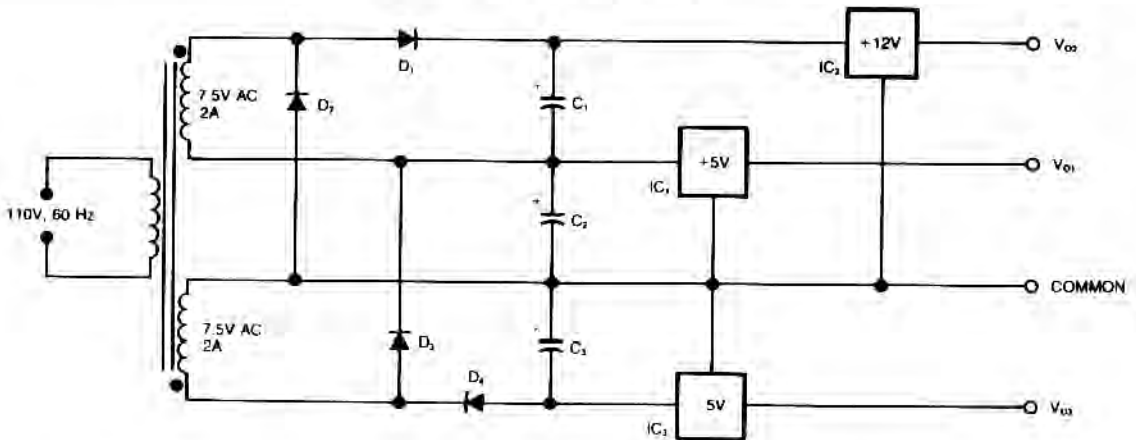


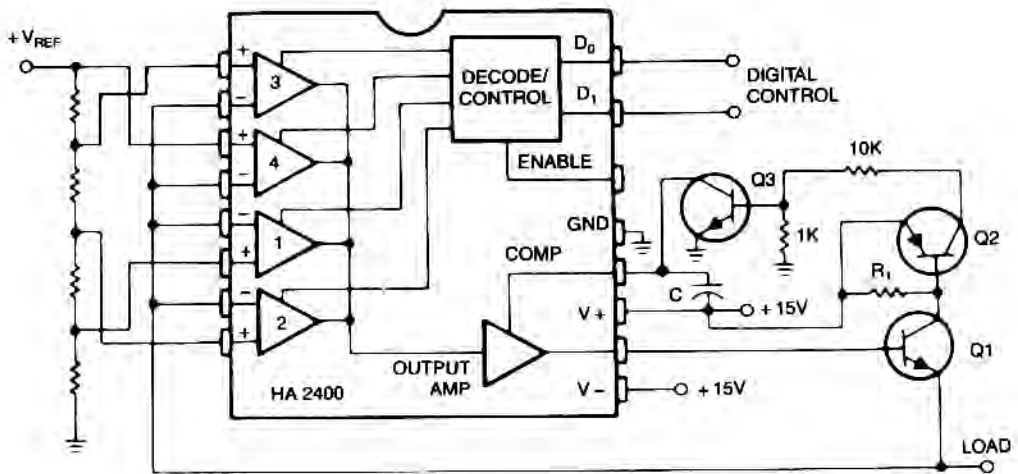
Fig. 2-22



## THREE-RAIL POWER SUPPLY (cont.)

This circuit generates three supply voltages using a minimum of components. Diodes D2 and D3 perform full-wave rectification, alternately charging capacitor C2 on both halves of the ac cycle. On the other hand, diode D1 with capacitor C1, and diode D4 with capacitor C3 each perform half-wave rectification. The full- and half-wave rectification arrangement is satisfactory for modest supply currents drawn from  $-5$  and  $+12$ -V regulators IC3 and IC2. You can use this circuit as an auxiliary supply in an up-based instrument, for example, and avoid the less attractive alternatives of buying a custom-wound transformer, building a more complex supply, or using a secondary winding, say 18 Vac, and wasting power in the 5-V regulators.

## PROGRAMMABLE POWER SUPPLY

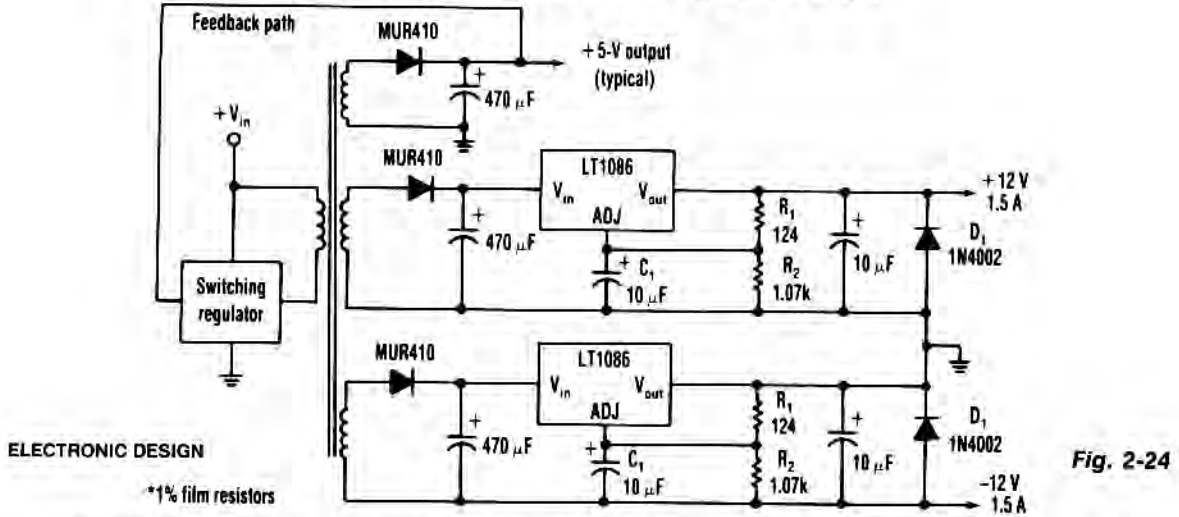


HARRIS

Fig. 2-23

Many systems require one or more relatively low-current voltage sources which can be programmed to a few predetermined levels. The circuit shown above produces positive output levels, but could be modified for negative or bipolar outputs. Q1 is the series regulator transistor, selected for the required current and power capability. R1, Q2, and Q3 form an optional short circuit protection circuit, with R1 chosen to drop about 0.7 V at the maximum output current. The compensation capacitor, C, should be chosen to keep the overshoot, when switching, to an acceptable level.

## EFFICIENT NEGATIVE VOLTAGE REGULATOR

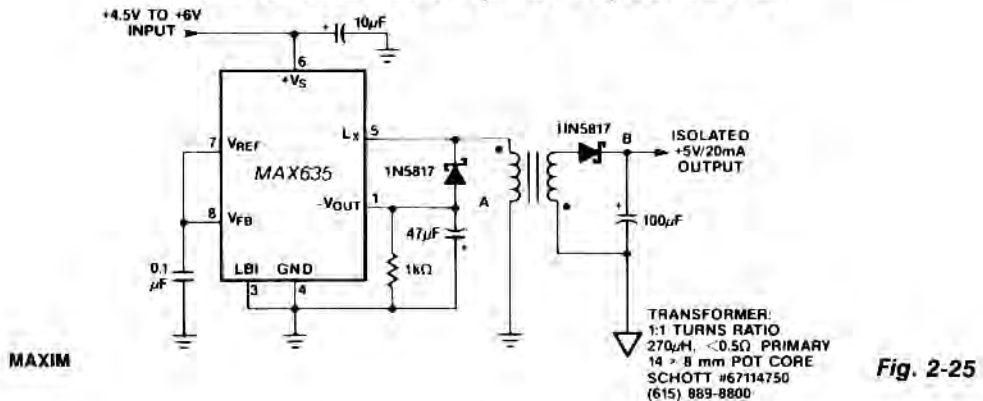


One way to provide good negative-voltage regulation is with a low-dropout positive-voltage regulator operating from a well-isolated secondary winding of a switch-mode circuit transformer. The technique works with any positive-voltage regulator, although highest efficiency occurs with low-dropout types.

Under all loading conditions, the minimum voltage difference between the regulator  $V_{IN}$  and  $V_{OUT}$  pins must be at least 1.5 V, the LT1086's low-dropout voltage. If this requirement isn't met, the output falls out of regulation. Two programming resistors,  $R_1$  and  $R_2$ , set the output voltage to 12 V, and the LT1086's servo the voltage between the output and its adjusting (ADJ) terminals to 1.25 V. Capacitor  $C_1$  improves ripple rejection, and protection diode  $D_1$  eliminates common-load problems.

Since a secondary winding is galvanically isolated, a regulator's 12 V output can be referenced to ground. Therefore, in the case of a negative-voltage output, the positive-voltage terminal of the regulator connects to ground, and the -12 V output comes off the anode of  $D_1$ . The  $V_{IN}$  terminal floats at 1.5 V or more above ground.

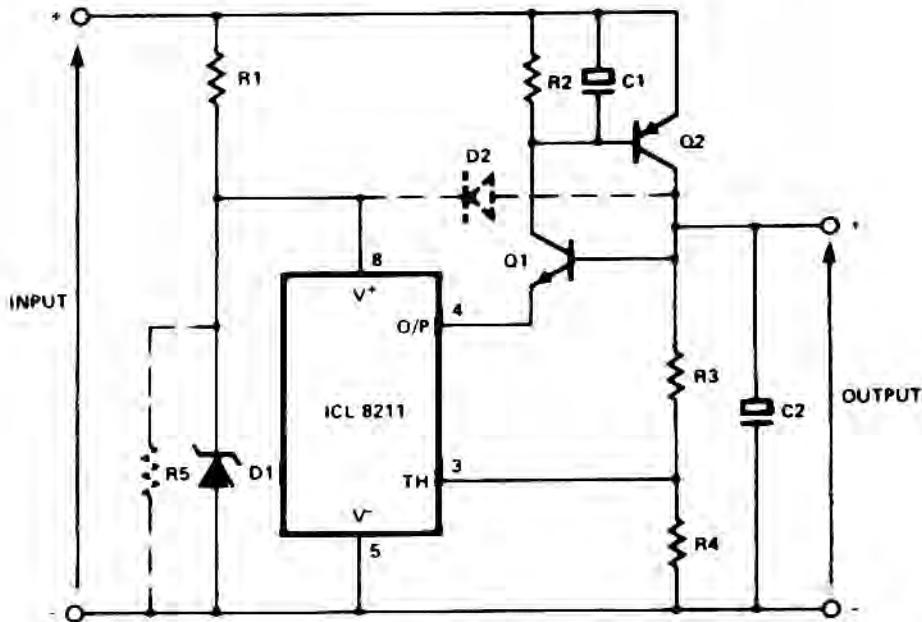
## 5 V-TO-ISOLATED 5 V (AT 20 mA) CONVERTER



## 5 V-TO-ISOLATED 5 V (AT 20 mA) CONVERTER (cont.)

In this circuit, a negative output voltage dc-dc converter generates a  $-5\text{ V}$  output at pin A. In order to generate  $-5\text{ V}$  at point A, the primary of the transformer must fly back to a diode drop more negative than  $-5\text{ V}$ . If the transformer has a tightly coupled 1:1 turns ratio, there will be a  $5\text{ V}$  plus a diode drop across the secondary. The 1N5817 rectifies this secondary voltage to generate an isolated  $5\text{ V}$  output. The isolated output is not fully regulated since only the  $-5\text{ V}$  at point A is sensed by the MAX635.

## POSITIVE REGULATOR WITH npn AND pnp BOOST

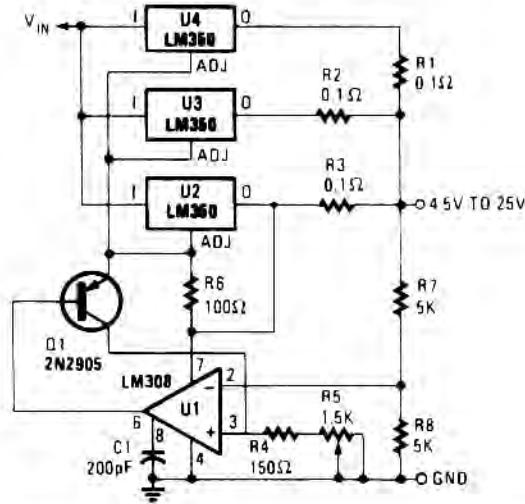


INTERSIL

Fig. 2-26

In the circuit, Q1 and Q2 are connected in the classic SCR or thyristor configuration. Where higher input voltages or minimum component count are required, the circuit for thyristor boost can be used. The thyristor is running in a linear mode with its cathode as the control terminal and its gate as the output terminal. This is known as the remote base configuration.

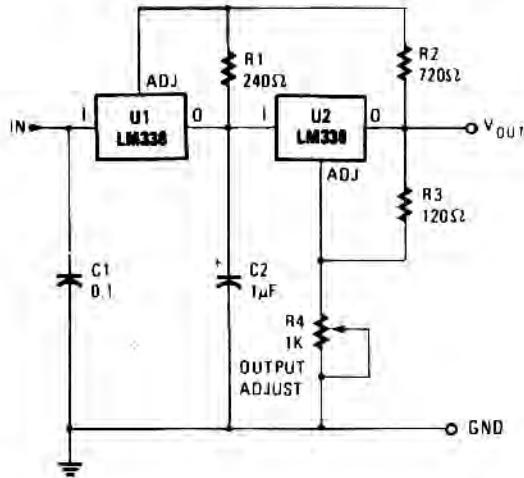
## TRACKING PREREGULATOR



POPULAR ELECTRONICS

Fig. 2-27

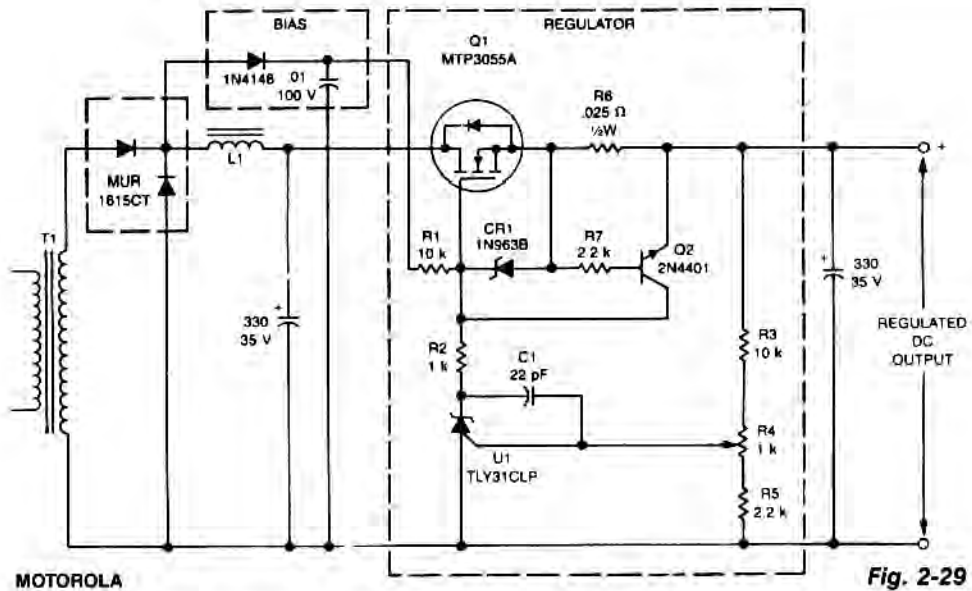
## ADJUSTABLE 10-A REGULATOR



POPULAR ELECTRONICS

Fig. 2-28

## LOW-COST LOW-DROPOUT LINEAR REGULATOR

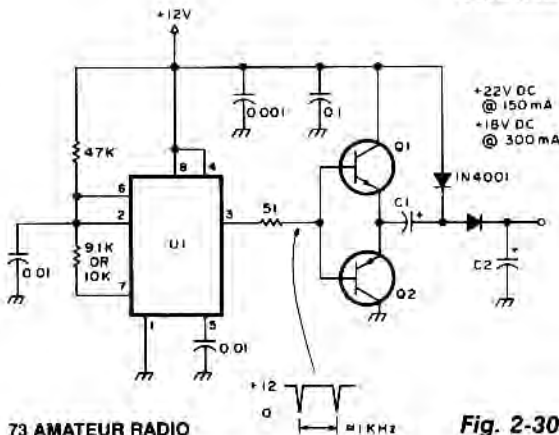


This linear post regulator provides 12 V at 3 A. It employs TL431 reference U1 which, without additional amplification, drives TMOS MTP3055A gate Q1 series pass regulator. Bias voltage is applied through R1 to Q1's gate, which is protected against overvoltage by diode CR1. Frequency compensation for closed-loop stability is provided by C1.

Key performance features are:

|                             |                            |
|-----------------------------|----------------------------|
| Dropout voltage: 0.6 V      | Load regulation: 10 mV     |
| Line regulation: $\pm 5$ mV | Output ripple: 10 mV pk-pk |

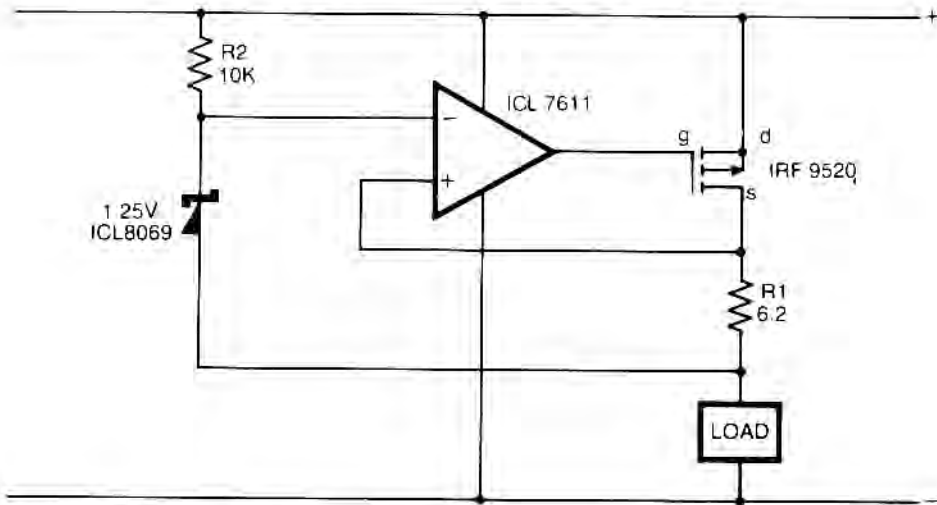
## VOLTAGE DOUBLER



This circuit drives relays of 24 and 18 Vdc from a 12-V power supply. Use this circuit with almost any pnp or npn power transistor.

**Parts:** U1: NE 555 timer. C1 and C2: 50  $\mu$ F/25 Vdc. Q1: TIP29, TIP120, 2N4922, TIP61, TIP110, or 2N4921. Q2: TIP30, TIP125, 2N4919, TIP62, TIP115, or 2N4918.

## SAFE CONSTANT-CURRENT SOURCE

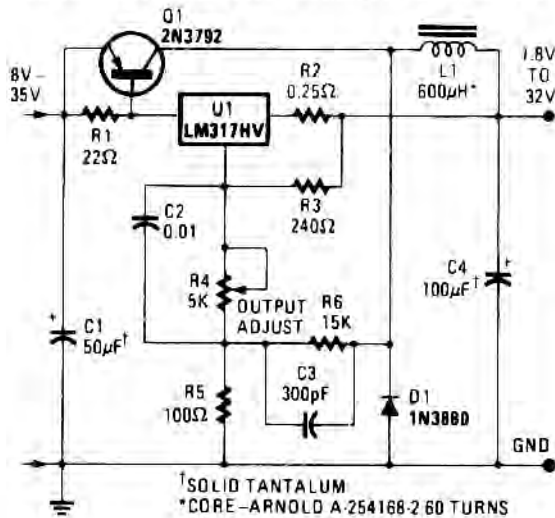


ELECTRONIC ENGINEERING

Fig. 2-31

In the circuit shown, a CMOS op amp controls the current through a p-channel HEXFET power transistor to maintain a constant voltage across R1. The current is given by:  $I = V_{REF}/R_1$ . The advantages of this configuration are: (a) in the event of a component failure, the load current is limited by R1; and (b) the overhead voltage needed by the op amp and the HEXFET is extremely low.

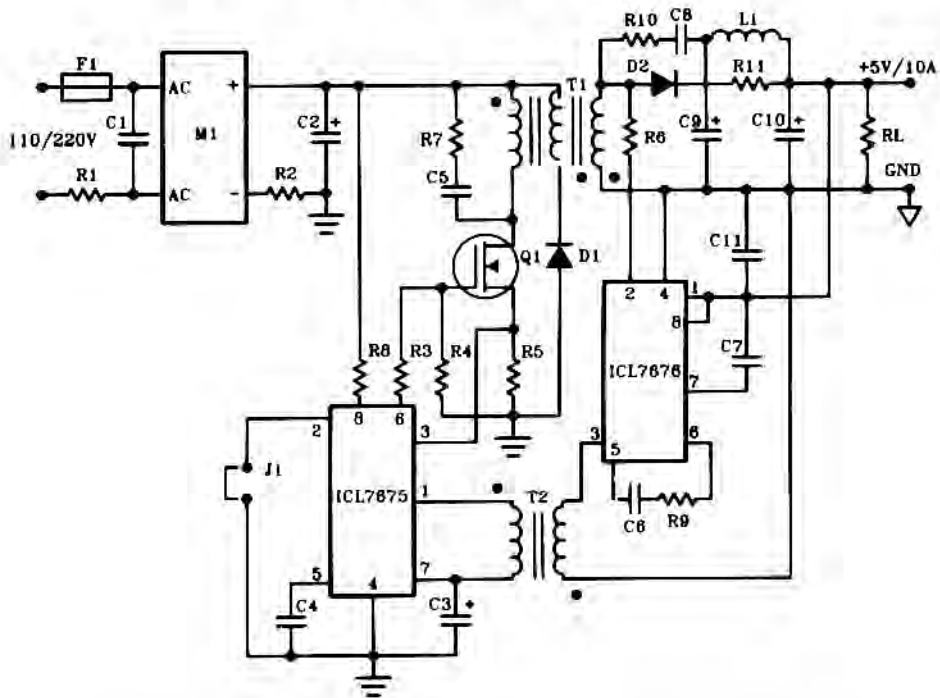
## LOW-COST 3-A SWITCHING REGULATOR



POPULAR ELECTRONICS

Fig. 2-32

## 50-W OFF-LINE SWITCHING POWER SUPPLY



**Component Values Table**

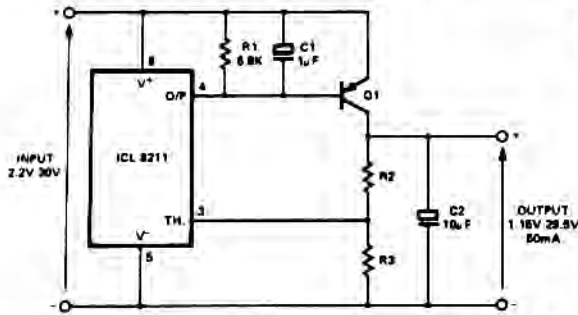
|     |                     |     |                       |    |                             |
|-----|---------------------|-----|-----------------------|----|-----------------------------|
| C1  | 0.022 $\mu$ F/400V  | R1  | 100 $\Omega$ at 25°C  | L1 | 25 $\mu$ H                  |
| C2  | 470 $\mu$ F/250V    | R2  | 1 $\Omega$ /1W        | D1 | 1N4937                      |
| C3  | 470 $\mu$ F/16V     | R3  | 10 $\Omega$ /0.25W    | D2 | MBR1035                     |
| C4  | 220 pF/100V         | R4  | 100 k $\Omega$ /0.25W | T1 | $L_p = 9$ mH, $n = 1:15$    |
| C5  | 470 pF/500V         | R5  | 0.33 $\Omega$ /1W     | T2 | 50 $\mu$ H, $n = 1:3$       |
| C6  | 2200 pF/500V        | R6  | 10 k $\Omega$ /0.25W  | F1 | Fuse 1 A/5B                 |
| C7  | 270 pF/500V         | R7  | 390 $\Omega$ /2W      | M1 | Diode Bridge                |
| C8  | 39 pF/500V          | R8  | 22 k $\Omega$ /10W    | Q1 | BUZ80A/IXTP4N80<br>(220VAC) |
| C9  | 11,000 $\mu$ F/6.3V | R9  | 68 $\Omega$ /0.25W    | Q1 | GE IRF823<br>(110VAC)       |
| C10 | 10 $\mu$ F/16V      | R10 | 10 $\Omega$ /0.5W     |    |                             |
| C11 | 0.047 $\mu$ F/10V   | R11 | 3.3 $\Omega$ /0.5W    |    |                             |
|     |                     | RL  | 5 $\Omega$ /10W       |    |                             |

INTERSIL

Fig. 2-33

The schematic shows a 50-W power supply with a 5-V 10-A output. It is a flyback converter operating in the continuous mode. The circuit features a primary side and secondary side controller with full-protection from fault conditions such as overcurrent. After the fault condition has been removed, the power supply will enter the soft-start cycle before recommencing normal operation.

## POSITIVE REGULATOR WITH pnp BOOST



INTERSIL

Fig. 2-34

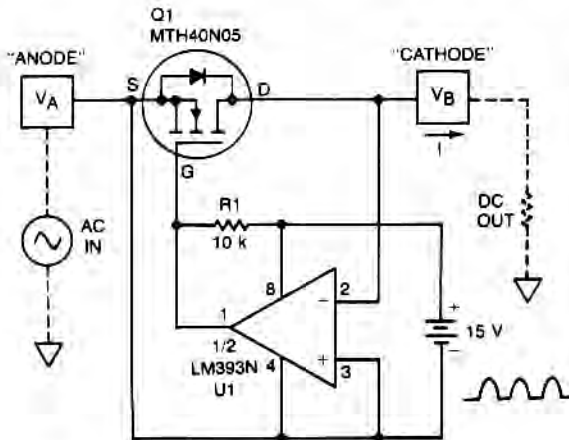
The IC8211 provides the voltage reference and regulator amplifier, while Q1 is the series pass transistor. R1 defines the output current of the IC8211, while C1 and C2 provide loop stability and also act to suppress feedthrough of input transients to the

output supply. R2 and R3 determine the output voltage as follows:

$$V_{OUT} = 1.5 \times \frac{R_2 + R_3}{R_3}$$

In addition, the values of R2 and R3 are chosen to provide a small amount of standing current in Q1, which gives additional stability margin to the circuit. Where accurate setting of the output voltage is required, either R2 or R3 can be made adjustable. If R2 is made adjustable, the output voltage will vary linearly with the shaft angle; however, if the potentiometer wiper was to open the circuit, the output voltage would rise. In general, therefore, it is better to make R3 adjustable, since this gives fail-safe operation.

## LOW FORWARD-DROP RECTIFIER CIRCUIT



MOTOROLA

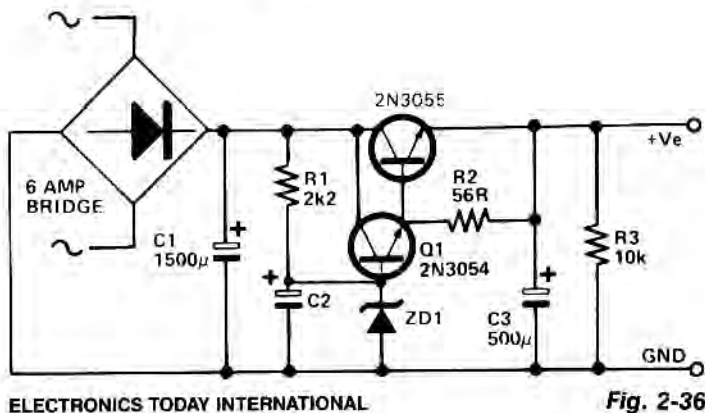
Fig. 2-35

A TMOS power FET, Q1, and an LM393 comparator provide a high-efficiency rectifier circuit. When  $V_A$  exceeds  $V_B$ , U1's output becomes high and Q1 conducts. Conversely, when  $V_B$  exceeds  $V_A$ , the comparator output becomes low and Q1 does not conduct.

The forward drop is determined by Q1's on resistance and current  $I$ . The MTH40N05 has an ON resistance of  $0.028 \Omega$ ; for  $I = 10 \text{ A}$ , the forward drop is less than  $0.3 \text{ V}$ . Typically, the best Schottky diodes do not even begin conducting below a few hundred mV.

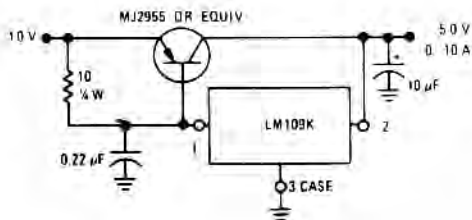


## LOW-RIPPLE POWER SUPPLY



This circuit can be used where a high current is required with a low-ripple voltage (such as in a high-powered class AB amplifier when high-quality reproduction is necessary). Q1, Q2, and R2 can be regarded as a power-Darlington transistor. ZD1 and R1 provide a reference voltage at the base of Q1. ZD1 should be chosen thus:  $ZD_1 = V_{out} - 1.2$ . C2 can be chosen for the degree of smoothness as its value is effectively multiplied by the combined gains of Q1/Q2, if 100  $\mu\text{F}$  is chosen for C2, assuming minimum hfe for Q1 and Q2,  $C = 100 \times 15(Q1) \times 25(Q2) = 37,000 \mu\text{F}$ .

### 5.0-V/10-A REGULATOR



### 5.0-V/3.0-A REGULATOR

