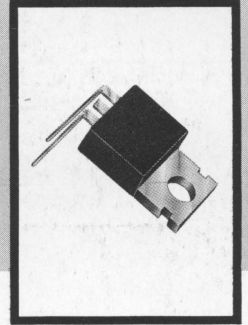


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RCA Silicon Power Plastic Transistors In a Regulated DC-to-DC Converter

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The RCA-2N5034 and RCA-2N5295 — key devices in the WB2EGZ converter circuit — belong to a family of the industry's most powerful plastic power transistors.

The 2N5034 offers an exceptional power-dissipation capability of 83 watts (P_{Max}), while the newly announced 2N5295 features a power-dissipation capability of 36 watts.

A unique, molded silicone-plastic package and ingenious lead design employed by this family of silicon n-p-n power transistors provide for simple mounting procedure. Transistor types are available either in "vertical-lead" configurations, which will fit standard sockets, or "horizontal-lead" versions for mounting on circuit boards. The 2N5034 is designed to fit a standard TO-3 socket, while the 2N5295 is easily accommodated by a TO-66 socket.

More than two years of rigorous field testing of these plastic devices in all types of applications have demonstrated product reliability and thermal characteristics approximating those of premium-quality non-plastic devices. "Hometaxial-base" construction of this new product family provides users with the industry's answer for freedom from transistor "second breakdown."

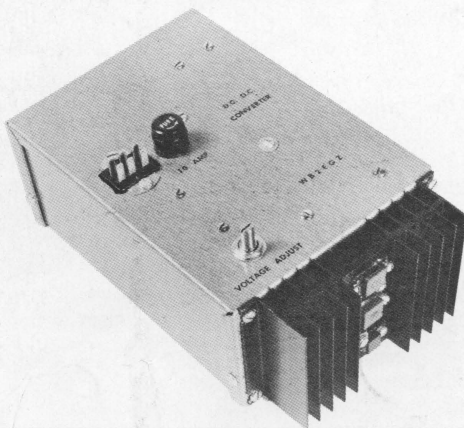
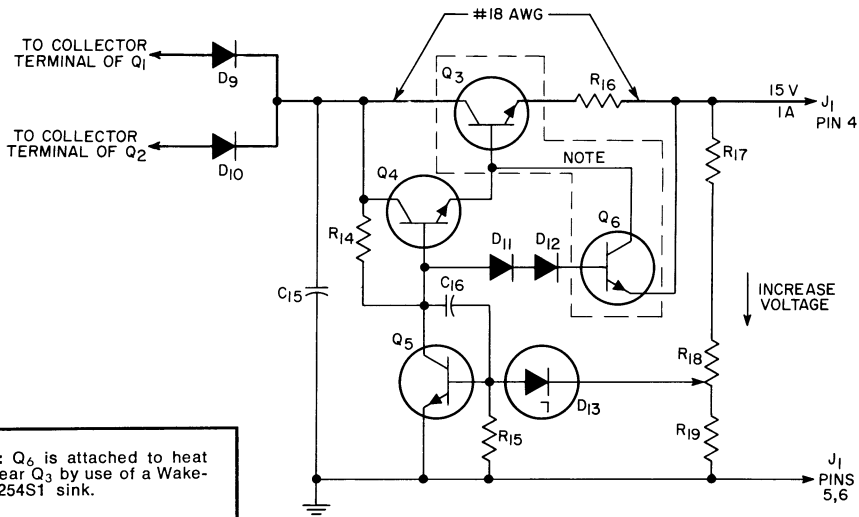
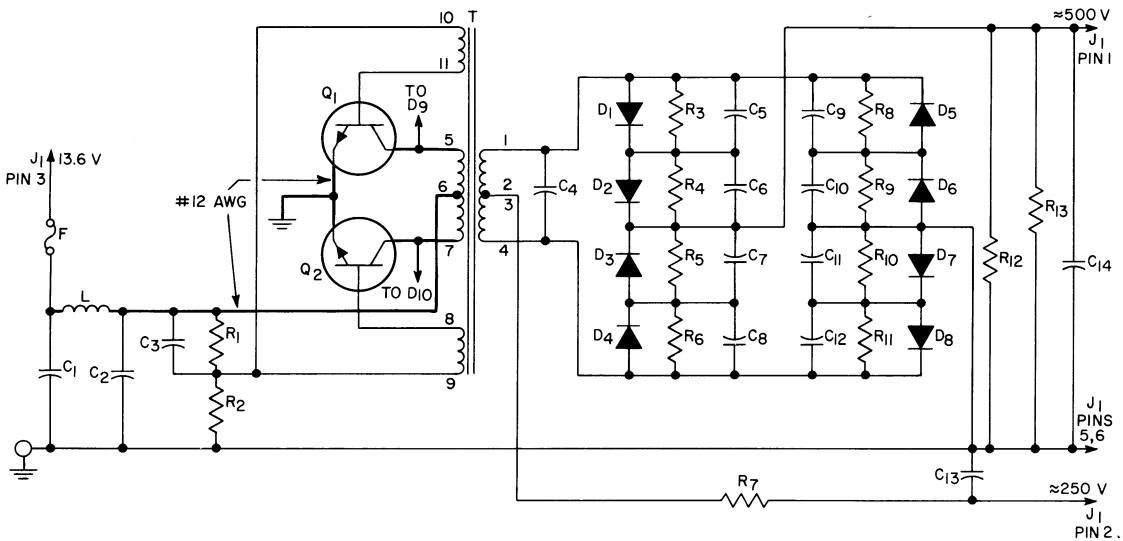


Figure 1: Exterior view of WB2EGZ DC-to-DC converter shows three silicon power plastic transistors mounted in center portion of heat sink. Two RCA-2N5034's are employed in the basic multivibrator circuit and one RCA-2N5295 in the series-regulator circuit. Unit is contained in a 3-by-5-by-7-inch minibox but circuitry can be compressed into even smaller space by experimenters seeking converter of minimal size.



NOTE: Q₆ is attached to heat sink near Q₃ by use of a Wakefield 254S1 sink.

- C₁ — 50 μ f, 25 volt, electrolytic
- C₂ — 1.0 μ f, 50 volt, Mylar
- C₃ — 100 μ f, 25 volt, electrolytic
- C₄ — 0.001 μ f, 1,600 volt, paper
- C₅ through C₁₂ — 0.001 μ f, 600 volt, ceramic disc
- C₁₃ — 10 μ f, 450 volt, electrolytic
- C₁₄ — 1.0 μ f, 1 kV, oil-filled bath-tub (Cornell-Dubilier DYR-10100 or equiv.)
- C₁₅ — 50 μ f, 50 volt, electrolytic
- C₁₆ — 0.02 μ f, 50 volt, ceramic disc
- D₁ through D₈ — RCA-1N5218
- D₉ through D₁₂ — RCA-1N5215
- D₁₃ — 8.2 volt, 400mW, regulator diode (1N757 or equiv.)

- F — Fuse, 10 amperes
- J₁ — Cinch Jones P306AB, or equiv.
- L₁ — 50 turns, 12 AWG enamel, 2 layers, 0.375-inch I.D.
- Q₁, Q₂ — RCA-2N5034
- Q₃ — RCA-2N5295
- Q₄, Q₅, Q₆ — RCA-40311
- R₁ — 100 ohms, 10 watts, wire-wound
- R₂ — 10 ohms, 3 watts, wirewound
- R₃ through R₆ and R₈ through R₁₁ — 10 megohms, 1/2 watt, carbon
- R₇ — 18 ohms, 1 watt, carbon
- R₁₂, R₁₃ — 470 kilohms, 2 watts, carbon
- R₁₄ — 2,700 ohms, 1/4 watt, carbon
- R₁₅ — 1,800 ohms, 1/4 watt, carbon

- R₁₆ — 0.33 ohm, 5 watts, wire-wound
 - R₁₇ — 560 ohms, 1/2 watt, carbon
 - R₁₈ — 500 ohms, carbon potentiometer
 - R₁₉ — 1,000 ohms, 1/2 watt, carbon
 - T — Toroidal Transistor DC-to-DC Supply Transformer; 12.6 volts input and 500/250 volts output; 125 watts; (Triad TY83 or equiv.)
- Miscellaneous — Minibox (Bud CU-2108A or equiv.); heat sinks (Wakefield 254S1 and NC403K or equiv.)

Figure 2: Schematic diagram and parts list of WB2EGZ DC-to-DC converter.

A recurrent but seldom publicized problem confronting the radio amateur is the need for regulated low voltage in a transistorized mobile communications system. The stability of a receiver usually can be controlled by regulator (zener) diodes or even a separate battery, but a transmitter has more stringent requirements. An unregulated supply not only results in severe changes in power output, but may cause serious detuning as the supply voltage varies. The higher the transmitting frequency, the greater the need for regulation. Because class C transistors lose efficiency at low voltages, it is desirable to provide a voltage source at some value exceeding the lowest voltage of an automotive system.

As described in this article, the author has satisfied the power requirements for a small, transistorized transmitter with the aid of a regulated DC-to-DC converter using standard components and featuring RCA's new silicon power plastic transistors. The regulated low-voltage system of this converter provides 1 ampere of current at 15 volts. For the amateur who has a tube application in mind, unregulated 250-volt and 500-volt sources are also available. The rating of the unregulated system of the converter is 125 watts and will provide 250 mA at 500 volts or 500 mA at 250 volts.

Circuit Description

The basic multivibrator circuit (see Figure 2) consists of two RCA-2N5034 transistors and the toroidal transformer. The transformer is driven into saturation first in one polarity and then the other. The square-wave has a frequency of 1,800 Hz. High-voltage DC is generated by the secondary of the transformer and a full-wave bridge consisting of eight RCA-1N5218 diffused-junction silicon rectifiers. Note the simplicity of filtering this supply. The reduction in filter requirements is due primarily to the high frequency (1,800 Hz) of commutation.

The center tap of the secondary winding is used for a 250-volt supply. Use of this voltage is dependent on individual requirements; therefore, relays for switching supplies were not incorporated in the system.

Low voltage for use with transistor circuits is first derived from a voltage doubler, then controlled by a series-regulator circuit which compensates for the wide volt-

age variations in an automobile power system. This circuit is capable of providing 1.2 amperes at 15 volts, continuous service, and may be used for receivers or low-power solid-state transmitters such as the one described in the Fall, 1966, issue of RCA Ham Tips, i. e., "A Solid-State A-M Transmitter for Two-Meter Operation."

Featured in the series-regulator circuit is the newly announced RCA-2N5295 silicon power plastic transistor (Q_3). An RCA-40311 transistor (Q_4), used in conjunction with the 2N5295 in a Darlington circuit, increases the gain of the pass transistor, Q_3 , and thus improves its regulation. In order to compensate for variations in voltage at the output, a sample of that voltage must be fed to the base of the feedback amplifier, Q_5 , which is also an RCA-40311 transistor. This link is provided by R_{17} and R_{18} . Because R_{18} is made adjustable, the desired output voltage is easily attained. The error signal is coupled to the feedback amplifier through an 8.2-volt zener diode (D_{13}) which provides the reference voltage for regulation.

An inherent problem in series-regulated power supplies of this type is that the semiconductors cannot be protected by fusing. A relatively simple technique for

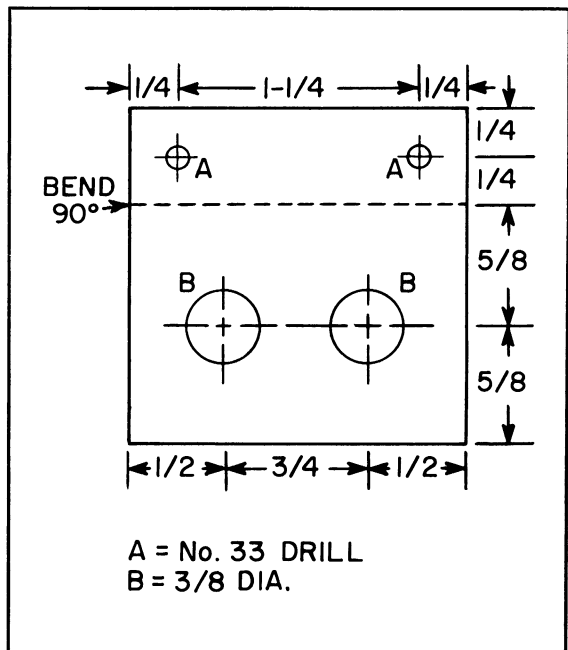


Figure 3: Layout of bracket used for mounting Q_4 and Q_5 in DC amplifier. (All dimensions are in inches.)

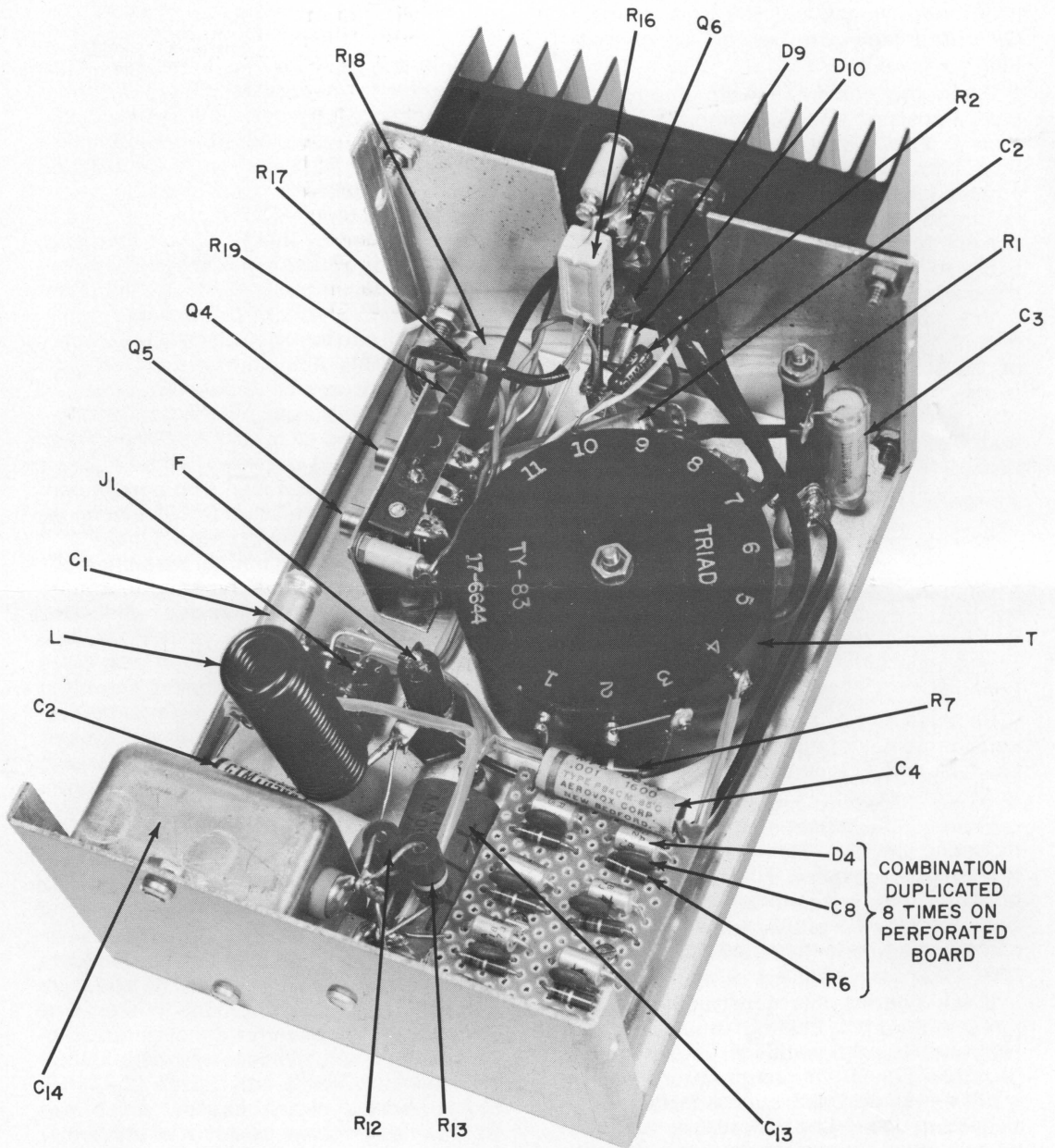


Figure 4: Interior view of DC-to-DC converter. The special heat sink for Q₆, which is bolted to the major heat sink, is not readily distinguishable in the photograph and lies directly in back of the 0.33-ohm wirewound resistor (R₁₆). End of minibox, lower right, obscures two diodes and associated resistors which are mounted on perforated board.

limiting the current through the regulating circuit is described on Page 194 of the "RCA Silicon Power Circuits Manual" (Technical Series SP-50). This method is used here. Diodes D_{11} , D_{12} , and transistor Q_6 form a protective network which operates as follows:

When the current flowing through the pass transistor and R_{16} becomes greater than a preset level, current is allowed to flow through the diodes and the base-emitter junction of Q_6 , and that transistor is turned on. With Q_6 in conduction, bias current is taken from Q_3 , the pass transistor, so that the resistance of Q_3 is increased.

Values shown here start limiting the current at 1.2 amperes with an absolute limit of 1.5 amperes. The action of this circuit is sufficiently fast to protect the regulating circuit against instantaneous surges of current. The overall system is protected by a fuse.

Construction

All components, except the three silicon power plastic transistors, are contained in a 3-by-5-by-7-inch minibox. A heat sink with the power devices is bolted to one end of the minibox. This same end is cut to accommodate wiring to the heat-sunk components.

Because mobile equipment is subject to considerable vibration, it is important to use lock-nuts or lock-washers on every bolt in this power supply.

Figure 3 illustrates a bracket used for mounting the two transistors used in the low-voltage regulator. This assembly must be wired before it is mounted in the minibox. Construction can be simplified by commencing assembly and wiring at the heat sink.

If the converter is constructed as pictured in Figure 4, cooling should not be a problem. Transistor ratings, of course, are dependent on the temperature of the transistor junctions. The power transistors can be mounted securely to the major heat sink by use of insulating-mica and nylon washers supplied with the transistors. Both sides of the mica washers should be coated with a thermal compound, such as silicone grease.

To emphasize the importance of using correct wire sizes, minimum wire sizes are shown in critical places in the Figure 2

schematic. Where sizes are not designated, any small-diameter wire should prove suitable.

Modifying Construction to Meet Individual Requirements

While the converter design described in this article is intended to power large amateur mobile systems, it was the objective of the author to provide the experimenter with sufficient flexibility as a basis for constructive modification. An amateur whose power requirements are different from those provided by this particular converter may find it practical to reduce costs by selecting a smaller transformer and semiconductor devices which are less expensive. The power capability of the 2N5034's is not tapped in this application; the transistor type is used only for its current rating. A power transistor such as the 2N5295 may be used instead of the 2N5034 if the input current does not exceed 8 amperes. The author believes, however, that a more conservative 6-ampere limit would insure reliability for the smaller power types.

Further cost reduction is possible if the high-voltage requirements are lower. In a square-wave application such as described in this article, the peak reverse voltage (PRV) of the diodes must be at least twice the output voltage. Since spikes and other variations may be present, it would be prudent to use a PRV of three times the output voltage. When redesigning this section, the experimenter should first consider eliminating series-connected diodes and their associated resistor-capacitor networks.

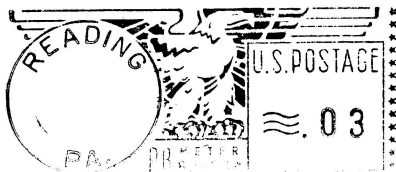
The oversize chassis box was selected for reasons of component visibility. Actually, all the circuitry can be contained in a smaller space. No doubt most builders will find it practical to integrate the converter with other equipment in use. One version of the converter constructed without the 500-volt section was easily compressed into a 3-by-4-by-5-inch box.

A desirable circuit change which can best be determined by experimentation is the selection of components for spike elimination. The parts involved in this change include C_1 , C_2 , C_3 , R_1 , and R_2 . While some circuits reviewed by the author have overlooked the need for spike, or overshoot, suppression, this consideration is vital to the operating efficiency and reliability of the converter. A perfect squarewave is op-

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timum, but in no case should the spike exceed 10 per cent of the squarewave amplitude. The values selected in this circuit were optimum for no-load and full-load conditions. The builder, however, may require slight changes to compensate for differences in components.

Additional Considerations

Nominally set at 125 watts, the "rating" of this converter merits some further explanation. In a high-voltage application, the converter will supply maximum rated power. In other words, 250 mA of current is available at 500 volts, or 500 mA of current is available at 250 volts.

The regulated low-voltage system, on the other hand, does not function quite that simply. The regulator draws as much current as the output; therefore, an output of 1 ampere at 15 volts would require about 30 watts from the system instead of 15 watts. This consideration is very important for the experimenter who decides on a smaller toroid. The regulator contained in the author's circuit will handle currents to 1.2 amperes only. Extensive redesign would be necessary to derive higher power from this section.

It is possible that the DC-to-DC converter presented by the author will not start under heavy loads. In this respect, it should be mentioned that no special circuitry was incorporated because the converter was intended solely for normal operation in an amateur radio application. Satisfactory results can be expected by placing the converter in operation before applying a heavy load.

The importance of correct wire sizes and solid connections cannot be overemphasized. Undersized wire or a bad connection on the input or multivibrator sections will cause the unit to fail at high power levels.

Conclusion

The results obtained with this mobile power supply during WB2EGZ transmissions have been very gratifying. Stability, a "must" in low-voltage power supplies, is excellent in this converter.

For the transistor experimenter, new doors are being opened by the many advantages of higher, more useful voltages. As for the "old-timer" — well, he may just want to replace that tottering vibrator supply before it gives its last sigh in the middle of an important transmission.