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RCA Plain Talk and Technical Tips

# RCA ColorVolt Voltage Regulator

Did you know that RCA Parts Distributors offer a voltage regulator transformer that delivers a constant AC voltage supply for television receivers, even though the input line voltage ranges from as low as 95 volts to as high as 135 volts? Although RCA television receivers will operate over a wide range of input line voltages, best performance is achieved when the AC power line voltage is close to the design value of 120 volts.

Most service technicians are aware of the problems encountered when a receiver operates from excessively low line voltage. Symptoms such as insufficient width, poor sync, and poor focus can often be traced directly to low line voltage. At the other extreme, excessively high line voltage can lead to premature tube and component failures. Sometimes both extremes of line voltage are encountered by the receiver. In older homes, which may not have adequate wiring, the start-up of an appliance such as the refrigerator or furnace will often cause a momentary pull-in of the picture, loss of sync, etc., which can greatly annoy the viewer. The use of a voltage regulator transformer will correct problems of this nature.

The RCA ColorVolt Voltage Regulator, available under Parts and Accessories Stock No. 10T200, provides the nominal input line voltage needed for best receiver operation under these extreme conditions. The ColorVolt is housed in a compact walnut grained and gold finished cabinet — 7 inches high by 5 inches deep by 9 inches wide. Installation is simple; the receiver is simply plugged in to the ColorVolt, which is then plugged into a wall outlet. An automatic AC input switch inside the regulator turns the unit "on" and "off" with the television receiver. Thus once the ColorVolt is put in service, no further attention is required.

In addition to providing constant AC input voltage (within the limits above) to television receivers, the ColorVolt is also useful in the service shop. One use is providing stabilized AC input voltage to test equipment so that the "on" and "off" operation of heavy electrical equipment in the vicinity will not disturb the operation of the test equipment. The ColorVolt is also handy to provide a constant 120 volts line voltage to a chassis being serviced. As all voltages in RCA Service Data are measured at 120 volts input, it is advantageous to have a constant 120 volts bench supply to assure good correlation between the schematic voltages and those actually measured.


*Figure 1—ColorVolt Regulator*

# Portable Power Sources

Portable instruments such as radios, phonographs, and tape recorders use a variety of battery types. Small portable radios, for example, operate with the battery voltages ranging from 4.5 to 9 volts. Because the power drain is low, the portable radio battery is often comprised of several small series-connected cells that are packaged with a terminal arrangement to easily contact the battery connector of the receiver. Larger portable radios and most tape recorders, having increased power requirements, use several individual series-connected "C" or "D" dry cells.

## Primary Batteries—Nonrechargeable

**Carbon-Zinc**: Several different types of batteries are used in portable instruments. The type of instrument and/or its application will determine the type battery that is used. Radios, which have low current drain, are ordinarily equipped with a battery of carbon-zinc cells; providing a reliable and inexpensive power source for equipment of this type. Unfortunately when carbon-zinc cells are used in long-duration, high-current applications (such as in tape recorders), hydrogen gas polarization of the positive electrode causes the terminal voltage of the battery to rapidly drop. However, if the battery is allowed to rest, the manganese-dioxide depolarizer within the battery removes the accumulation of hydrogen that interferes with battery operation.

**Alkaline**: For high-current applications the alkaline cell is available, which provides better high-current polarization characteristics than the carbon-zinc cell. The construction of the alkaline cell is similar to the carbon-zinc cell, although it uses an electrolyte of potassium hydroxide that furnishes a higher level of chemical action than ammonium chloride of the carbon-zinc cell. For this reason the alkaline cell is capable of delivering higher current loads for longer periods of time before polarization lowers the cell voltage. The alkaline-cell is also relatively inexpensive; however, it does cost more than the carbon-zinc cell. Thus it is not ordinarily used in low-current applications where the high-current capabilities are not required.

**Mercury:** The zinc-mercuric oxide cell is often used for replacement purposes in low current applications. The advantage of the mercury cell is that, although it has a somewhat lower open circuit voltage than carbon-zinc cells (1.4 volts), it has a better voltage/time discharge curve and a greater watt-hour capacity per unit of volume and weight than either of the forementioned cell types. Secondly, the mercury cell has a better shelf life than the carbon-zinc or alkaline cells; however, these advantages are realized at a greater cost.

The three types of cells just discussed are known as **primary** cells because they are used once, and when their energy capacity is exhausted they are discarded.

## Secondary Batteries—Rechargeable

Some portable equipment use rechargeable batteries which are comprised of the required number of **secondary** cells. The secondary cell is one in which the electricity producing chemical reaction is reversible. Thus, these cells may be used until all the available chemical energy is converted into electricity. They may then be recharged for another period of operation. Three types of rechargeable batteries are commonly used in portable equipment, one being the **lead-acid** type which is similar to the battery used in automobiles. The second type is the **nickel-cadmium** type. And finally, a battery comprised of special **rechargeable alkaline** cells is often used in inexpensive portable equipment that has low power requirements. The three types of batteries discussed here are sealed and require no addition of water or electrolyte as in the case of ordinary storage batteries.

**Lead-Acid**: The lead-acid battery offers the advantage of relatively high energy output, and high cell voltage (2.2 volts at full charge) at a reasonable cost. One of the disadvantages of the lead-acid battery is that it must be kept charged. Just as with a car battery, if the lead-acid battery used in portable equipment is allowed to remain in a discharged state over long period of time, an irreversible chemical reaction known as sulphation occurs. At best sulphation seriously reduces the capacity of the battery. More often, it renders the battery useless. The lead-acid battery also has limited tolerance to over charging, under charging, and deep cycling. However, despite these limitations, the lead-acid battery will give excellent service if it is properly cared for.

**Nickel-Cadmium**: The nickel-cadmium battery, on the other hand, is tolerant of both being stored for long periods of time in a discharged state and being subjected to periods of over charging. This battery also features a high power output for a given weight; however, the lower open-circuit voltage of approximately 1.25 volts per cell makes it necessary for additional cells to be used in the battery to provide the same voltage as that of a comparable lead-acid battery. The principle disadvantages of the nickel cadmium battery are two. First, expensive materials are used in the construction of these batteries, nickel and cadmium verses lead. Also, the larger number of the cells required to make up a battery of equivalent voltage makes the nickel-cadmium battery somewhat more expensive than a lead-acid battery of the same capacity. Another rather obscure limitation of the nickel-cadmium battery is that it has a memory. If it is not used frequently, or not often used through a full discharge cycle, the capacity of the battery diminishes. This means that a battery designed to deliver one ampere for four hours will continue to do this if it is allowed to perform within its design parameters, i.e. delivering one ampere for four hours. If the battery is often sub-

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# Crossover Diodes

Class-B complementary symmetry amplifier circuits are widely used in consumer electronics products. Although these circuits have been previously discussed in **"Plain Talk"**, the function of the crossover diode connected between the bases of the two complementary output transistors has never been fully explained.

Basic theory reveals that output transistors of Class-B amplifiers conduct on alternate half cycles. In the example illustrated, the active devices (tubes or transistors) are assumed to be perfectly matched and are linear in response to the input signal. Under these ideal conditions a smooth, distortion-free, transistion is made from the conduction of one output device to the other as the instantaneous signal voltage crosses the zero voltage line. In practice, however, transistors are non-linear at low currents because it is necessary that the base signal voltage exceed the .7 volts resulting from the diode voltage drop of the base-emitter junction. Thus it can be seen that the transistor that is being driven "on" remains non-conductive until base-emitter voltage exceeds the .7V barrier potential. Obviously, if a smooth transistion is not made from one output transistor to the other, the signal will be distorted.

### Crossover Distortion

To overcome this distortion (known as crossover distortion), Class-B amplifiers are designed so that the transistors are not driven completely into cut-off. Instead, they operate with a small value of base bias current under no signal conditions. This bias current assures that the base-emitter junction is always conducting so it can accept signal drive. The bias current is carefully chosen to provide minimum crossover distortion and minimum no-signal collector current. In practice the no-signal, or idle current of a Class-B output stage is quite low, being in the order of perhaps 2 to 10 mA. The required base bias is obtained by means of a resistor bias network.

### Complementary Class-B Circuit

In the complementary symmetry circuit shown, complementary output transistors Q1 and Q2 are biased, in a manner to be described, to provide equal conduction under no-signal conditions. With a supply voltage of +30V, the voltage at the mid-point of the circuit (emitters of both transistors) assumes a voltage equal to half the supply voltage, or in this case 15 volts.

In order to meet the requirements for base bias let's consider what is necessary to allow conduction of NPN transistor Q1, and PNP transistor Q2. Assuming that the mid-point voltage of the circuit must equal 15 volts (½ supply voltage) it is necessary for the base of transistor Q1 to be approximately .7 volts more positive than the emitter. (The exact voltage will depend upon the transconductance characteristics of the specific transistor used). Thus, with +15 volts at the emitter, the base voltage must be +15.7. For PNP transistor Q2 to conduct, the base must be more negative than the emitter by approximately .7 volts. This means the base voltage of transistor Q2 must be approximately +14.3 volts or .7 volts less than the supply voltage. When the voltage difference between the base of Q1 and the base of Q2 is determined, it is found to be 1.4 volts. It is then only necessary to caculate a resistance value which provides this voltage drop at the collector current of driver transistor Q3. Although in theory a resistor can be used for bias, in practice a diode package is nearly always used for this application because it provides a measure of bias stability under conditions

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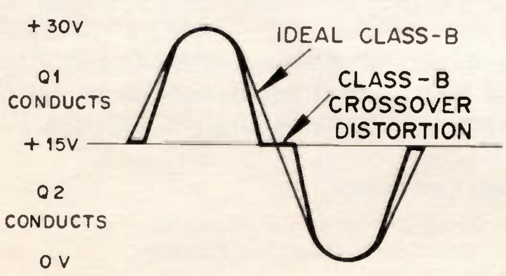


*Figure 2—Crossover Distortion*

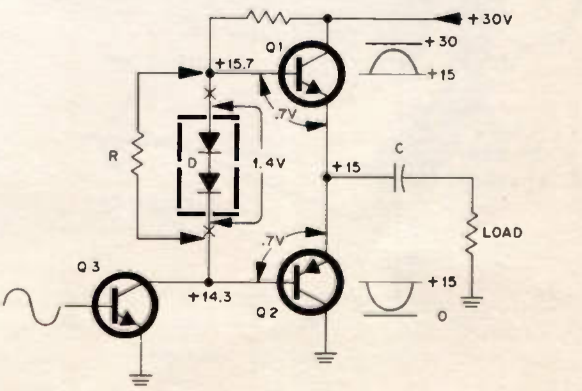


*Figure 3—Complementary Class-B Amplifier*

## Crossover Diodes

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of changing DC supply voltage and temperature. It's also interesting to note that in an actual amplifier, even though schematic symbol may show only one diode, in reality the circuit requires the junction drops of two series connected diodes, even though both are in a single package. Also, it is necessary to carefully choose the characteristics of the diodes used in order that the exact voltage drop required to set the no-signal operating point of the output transistors is obtained.

Why use diodes? If a resistor were used to establish the base bias of Q1 and Q2, the voltage drop across the resistor is a direct function of its current. In the event that the power supply voltage increases, increased bias is applied to the base of driver transistor Q3 causing increased collector current and a larger voltage drop across resistor R. This produces a higher base voltage and base current that results in increased collector idle current and more power dissipation in the output transistors. Consider now the use of diodes. The diodes, like the base-emitter junction of the output transistors, have an intrinsic voltage drop of approximately .7 volts that is for all practical purposes independent of current. Thus under conditions of changing collector current of driver transistor Q3, far less change in base-to-base voltage results when diodes are used. For this reason the output stage collector current and power dissipation remain more constant under conditions of varying input voltage.

Consider now the effects of elevated temperature on bias stability. As the temperature increases, the base-emitter voltages ($V_{BE}$) of the output transistors decrease. In the case of the circuit using bias resistor R, the decreased $V_{BE}$ permits increased base current and correspondingly more collector current. This in turn causes more heating and finally a condition which could regenerate until thermal runaway and transistor failure occurs. In a circuit using diode D, the decrease in $V_{BE}$ is accompanied by a similar decrease in diode junction voltage. Because of the diode compensation, the effect of elevated temperature on output stage idle current and power dissipation is minimized. The preceding discussion should make clear the important function played by the crossover diode as used in Class-B complementary symmetry amplifier circuits. It's equally obvious that characteristics of these diodes are specified to provide the required degree of circuit stability. Thus, when servicing, it is extremely important that crossover diodes be replaced with the correct type as specified by stock number in RCA Service Data.

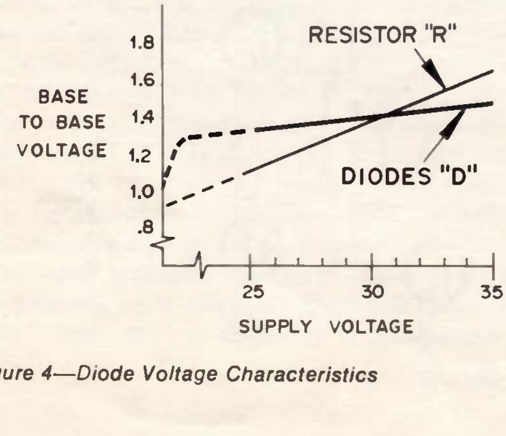


*Figure 4—Diode Voltage Characteristics*

## Portable Power Sources

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jected to periods of shorter use, such as only being used for an hour or two before recharging, the battery will lose capacity. However, the capacity of the battery can usually be restored by subjecting it to a number of full charge and discharge cycles until full capacity is restored.

**Rechargeable Alkaline**: The third type of rechargeable battery is one comprised of specially constructed alkaline cells. Batteries of this type are used in portable equipment where the current demands are relatively low, such as in tape recorders where the maximum current rarely exceeds one ampere on peaks. The advantages of rechargeable alkaline batteries are several. When properly used, alkaline rechargeable batteries provide a relatively high open-circuit voltage of 1.5 volts per cell, a relatively good energy storage capability, and most important, a rechargeable cell costing little more than the ordinary carbon-zinc dry cell.

One disadvantage of rechargeable alkaline cells is that they have a limited number of charge/discharge cycles, although this is offset by the low replacement cost of these cells. To assure maximum life it is necessary to carefully control the charge and discharge cycles. For example, the overall life of rechargeable alkaline batteries is shortened as the end point voltage is allowed to drop lower. (The end point voltage is defined as the voltage under load at which the battery is assumed to be discharged.) For example, batteries of this type that are allowed to discharge to an end point voltage of 1.2 volts per cell will last longer than those allowed to discharge to an end point voltage of 1.00 volts per cell.

There are two final comments about rechargeable alkaline cells. First, replacement cells are fully charged and should not be subjected to a charging period before use. Second, rechargeable cells of this type should not be discharged beyond 1.00 volts per cell or they will be ruined. Fortunately, these limitations are overcome by including special charge monitoring circuits in equipment that uses rechargeable alkaline batteries.

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