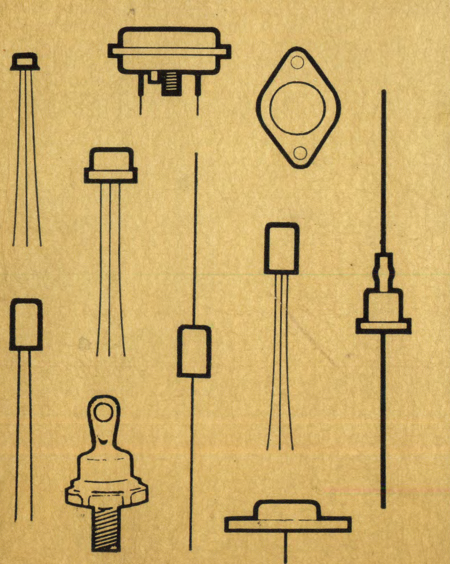
$1.50

OPTIONAL LIST PRICE

RCA Transistor Manual



including

Silicon Rectifiers and Diodes

RCA

TECHNICAL SERIES SC-10

CONTENTS

Copyright 1962 by Radio Corporation of America (All Rights Reserved)

Trade Mark(s) Registered
Marca(s) Registrada(s)

10-62
Printed in U. S. A.

RCA Transistor Manual

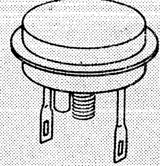
This book has been prepared to assist those who work or experiment with semiconductor devices and circuits. It will be useful to engineers, service technicians, educators, students, radio amateurs, hobbyists, and others technically interested in transistors, silicon rectifiers, and semiconductor diodes ■

The opening Section of the book includes easy-to-understand text material covering basic semiconductor theory, applications, and installation information. The TECHNICAL DATA Section contains detailed information on all semiconductor devices presently in the RCA line. Essential basic data on discontinued RCA types are also included for reference purposes. Many typical applications of semiconductor devices are illustrated in the CIRCUITS Section ■

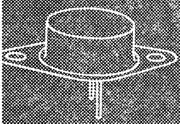
RCA SEMICONDUCTOR AND MATERIALS DIVISION

Somerville New Jersey

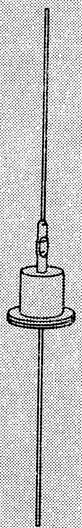
TYPICAL RCA SEMICONDUCTOR DEVICES



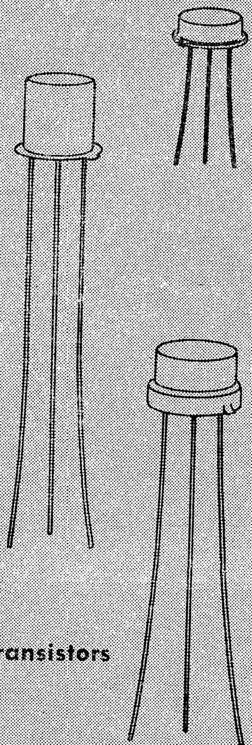
Transistor



Transistor

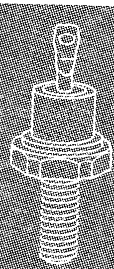


Rectifier

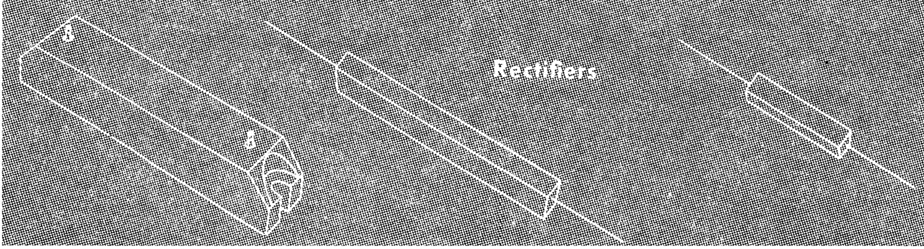


Transistors

Tunnel Diode



Rectifier



Rectifiers

RCA Transistor Manual

MATERIALS, JUNCTIONS, AND DEVICES

SEMICONDUCTOR devices are small but versatile units that can perform an amazing variety of control functions in electronic equipment. Like other electron devices, they have the ability to control almost instantly the movement of charges of electricity. They are used as rectifiers, detectors, amplifiers, oscillators, electronic switches, mixers, and modulators.

In addition, semiconductor devices have many important advantages over other types of electron devices. They are very small and light in weight (some are less than an inch long and weigh just a fraction of an ounce). They have no filaments or heaters, and therefore require no heating power or warm-up time. They consume very little power. They are solid in construction, extremely rugged, free from microphonics, and can be made impervious to many severe environmental conditions. The circuits required for their operation are usually simple.

SEMICONDUCTOR MATERIALS

Unlike other electron devices, which depend for their functioning on the flow of electric charges through a vacuum or a gas, semiconductor devices make use of the flow of current in a solid. In general, all materials may be classified in three major categories—conductors, semiconductors, and insulators—depending upon their ability to conduct an electric current. As the name indicates, a semiconductor material has poorer conductivity than a conductor, but better conductivity than an insulator.

The materials most often used in semiconductor devices are germanium and silicon. Germanium has higher electrical conductivity (less resistance to current flow) than silicon, and is used in most low- and medium-power diodes and transistors. Silicon is more suitable for high-power devices than germanium because it can be used at much higher temperatures. A relatively new material which combines the principal desirable features of both germanium and silicon is gallium arsenide. When further experience with this material has been obtained, it is expected to find much wider use in semiconductor devices.

Resistivity

The ability of a material to conduct current (conductivity) is directly proportional to the number of free (loosely held) electrons in the material. Good conductors, such as silver, copper, and aluminum, have large numbers of free electrons; their resistivities are of the order of a few millionths of an ohm-centimeter. Insulators such as glass, rubber, and mica, which have very few loosely held electrons, have resistivities as high as several million ohm-centimeters.

Semiconductor materials lie in the range between these two extremes, as shown in Fig. 1. Pure germanium has a resistivity of 60 ohm-centimeters. Pure silicon has a considerably higher resistivity, in the order of 60,000 ohm-centimeters. As used in semiconductor devices, however, these materials contain carefully controlled amounts of certain impurities

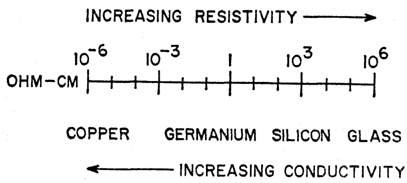


Figure 1. Resistivity of typical conductor, semiconductors, and insulator.

which reduce their resistivity to about 2 ohm-centimeters at room temperature (this resistivity decreases rapidly as the temperature rises).

Impurities

Carefully prepared semiconductor materials have a crystal structure. In this type of structure, which is called a lattice, the outer or valence electrons of individual atoms are tightly bound to the electrons of adjacent atoms in electron-pair bonds, as shown in Fig. 2. Because such a

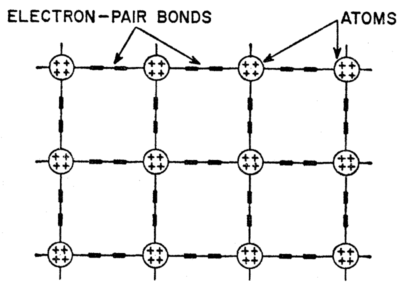


Figure 2. Crystal lattice structure.

structure has no loosely held electrons, semiconductor materials are poor conductors under normal conditions. In order to separate the electron-pair bonds and provide free electrons for electrical conduction, it would be necessary to apply high temperatures or strong electric fields.

Another way to alter the lattice structure and thereby obtain free electrons, however, is to add small amounts of other elements having a different atomic structure. By the addition of almost infinitesimal amounts of such other elements, called "impurities", the basic electrical properties of pure semiconductor materials can be modified and controlled. The ratio of impurity to the semiconductor material is usually extremely small, in the order of one part in ten million.

When the impurity elements are added to the semiconductor material, impurity atoms take the place of semiconductor atoms in the lattice structure. If the impurity atoms added have the same number of valence electrons as the atoms of the original semiconductor material, they fit neatly into the lattice, forming the required number of electron-pair bonds with semiconductor atoms. In this case, the electrical properties of the material are essentially unchanged.

When the impurity atom has one more valence electron than the semiconductor atom, however, this extra electron cannot form an electron-pair bond because no adjacent valence electron is available. The excess electron is then held very loosely by the atom, as shown in Fig. 3, and requires only slight excitation to break away. Consequently, the presence of such excess electrons makes the material a better conductor, i.e., its resistance to current flow is reduced.

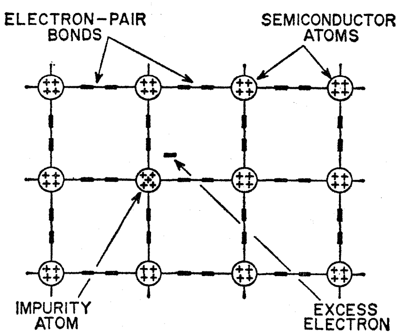


Figure 3. Lattice structure of n-type material.

Impurity elements which are added to germanium and silicon crystals to provide excess electrons include arsenic and antimony. When these elements are introduced, the resulting material is called **n-type** because the excess free electrons have a negative charge. (It should be noted, however, that the negative charge of the electrons is balanced by an equivalent positive charge in the center of the impurity atoms. Therefore, the net electrical charge of the semiconductor material is not changed.)

A different effect is produced when an impurity atom having one less valence electron than the semiconductor atom is substituted in the lattice structure. Although all the valence electrons of the impurity atom form electron-pair bonds with electrons of neighboring semiconductor atoms, one of the bonds in the lattice structure cannot be completed because the impurity atom lacks the final valence electron. As a result, a vacancy or "hole" exists in the lattice, as shown in Fig. 4. An electron from an adjacent electron-pair bond may then absorb enough energy to break its bond and move through the lattice to fill the hole. As in the case of excess electrons, the presence of "holes" encourages the flow of electrons in the semiconductor material; consequently, the conductivity is increased and the resistivity is reduced.

The vacancy or hole in the crystal structure is considered to have a positive electrical charge because it represents the absence of an electron. (Again, however, the net charge of the crystal is unchanged.) Semiconductor material which contains these "holes" or positive charges is called **p-type** material. P-type materials are formed by the addition of aluminum, gallium, or indium.

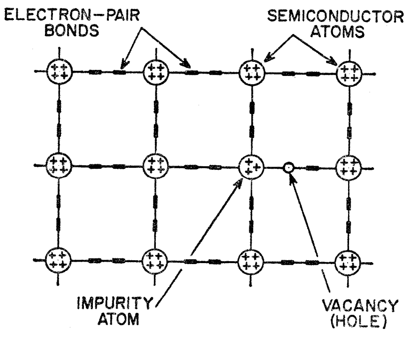


Figure 4. Lattice structure of p-type material.

Although the difference in the chemical composition of n-type and p-type materials is slight, the differences in the electrical characteristics of the two types are substantial, and are very important in the operation of semiconductor devices.

P-N JUNCTIONS

When n-type and p-type materials are joined together, as shown in Fig. 5, an unusual but very important phenomenon occurs at the surface where the two materials meet (called the **p-n junction**). An interaction takes place between the two types of material at the junction as a result of the holes in one material and the excess electrons in the other.

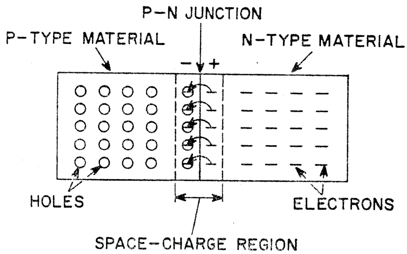


Figure 5. Interaction of holes and electrons at p-n junction.

When a p-n junction is formed, some of the free electrons from the n-type material diffuse across the junction and fill holes in the lattice structure of the p-type material. This interaction or diffusion occurs for a short time in the immediate vicinity of the junction, and produces a small space-charge region (sometimes called the **transition region** or **depletion layer**). The p-type material in this region acquires a slight negative charge as a result of the addition of electrons from the n-type material. Conversely, the n-type material in the junction region acquires a slight positive charge as a result of the loss of excess electrons.

The potential gradient established across the space-charge region by the diffusion process is represented in Fig. 6 by an imaginary battery connected across the junction. (The

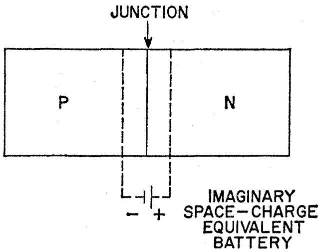


Figure 6. Potential gradient across space-charge region.

battery symbol is shown only to represent the internal effects; the potential is not measurable.) In the absence of external circuits or voltages, this potential gradient discourages further diffusion across the p-n junction because electrons from the n-type material are repelled by the slight negative charge induced in the p-type material. In effect, therefore, the potential gradient (or **energy barrier,** as it is sometimes called) prevents total interaction between the two types of material, and thus preserves the differences in their characteristics.

CURRENT FLOW

When an external battery is connected across a p-n junction, the amount of current flow is determined by the polarity of the applied voltage and its effect on the space-charge region. In Fig. 7a, the positive terminal of the battery is connected to the n-type material and the negative terminal to the p-type material. In this arrangement, the free electrons in the n-type material are attracted toward the positive terminal of the battery and away from the junction. At the same time, electrons from the negative terminal of the battery enter the p-type material and diffuse toward the junction, filling holes in the lattice structure as they approach the junction. As a result, the space-charge region at the junction becomes effectively wider, and the potential gradient increases until it approaches the potential of the external battery. Current flow is then extremely small because no voltage difference (electric field) exists across either the p-type or the n-type region. Under these conditions, the p-n junction is said to be **reverse-biased.**

In Fig. 7b, the positive terminal of the external battery is connected to the p-type material and the negative terminal to the n-type material. In this arrangement, electrons in the p-type material near the positive terminal of the battery break their electron-pair bonds and enter the battery, creating new holes. At the same time, electrons from the negative terminal of the battery enter the n-type material and diffuse toward the junction. As a result, the space-charge region becomes effectively narrower, and the energy barrier decreases to an insignificant value. Excess electrons from the n-type mate-

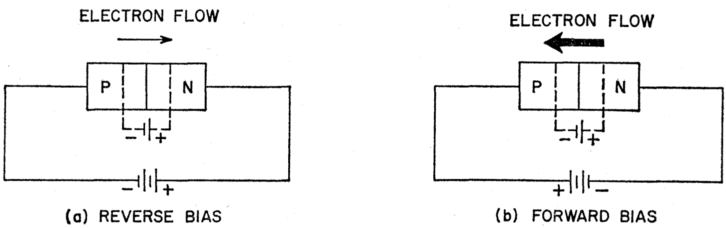


Figure 7. Electron current flow in biased p-n junctions.

rial can then penetrate the space-charge region, flow across the junction, and move by way of the holes in the p-type material toward the positive terminal of the battery. This electron flow continues as long as the external voltage is applied. Under these conditions, the junction is said to be **forward-biased.**

The generalized voltage-current characteristic for a p-n junction in Fig. 8 shows both the reverse-bias and forward-bias regions. In the forward-bias region, current rises

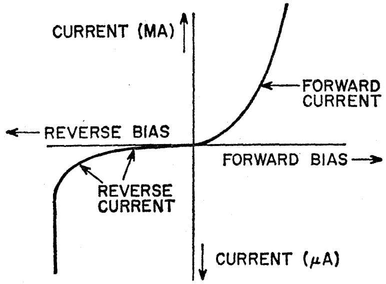


Figure 8. Voltage-current characteristic for a p-n junction.

rapidly as the voltage is increased and is quite high. Current in the reverse-bias region is usually much lower. Excessive voltage (bias) in either direction should be avoided in normal applications because excessive currents and the resulting high temperatures may permanently damage the semiconductor device.

N-P-N AND P-N-P STRUCTURES

Fig. 7 shows that a p-n junction biased in the reverse direction is equivalent to a high-resistance element (low current for a given applied voltage), while a junction biased in the forward direction is equivalent to a low-resistance element (high current for a given applied voltage). Because the power developed by a given current is greater in a high-resistance element than in a low-resistance element ($P=I^2R$), power gain can be obtained in a structure containing two such resistance elements if the current flow is not materially reduced. A device containing two p-n junctions biased in opposite directions can operate in this fashion.

Such a two-junction device is shown in Fig. 9. The thick end layers

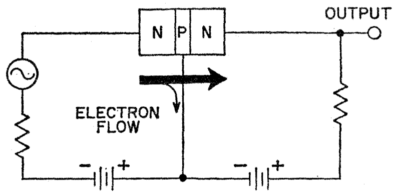


Figure 9. N-P-N structure biased for power gain.

are made of the same type of material (n-type in this case), and are separated by a very thin layer of the opposite type of material (p-type in the device shown). By means of the external batteries, the left-hand (n-p) junction is biased in the forward direction to provide a low-resistance input circuit, and the right-hand (p-n) junction is biased in the reverse direction to provide a high-resistance output circuit.

Electrons flow easily from the left-hand n-type region to the center p-type region as a result of the forward biasing. Most of these electrons diffuse through the thin p-type region, however, and are attracted by the positive potential of the external battery across the right-hand junction. In practical devices, approximately 95 to 99.5 per cent of the electron current reaches the right-hand n-type region. This high percentage of current penetration provides power gain in the high-resistance output circuit and is the basis for transistor amplification capability.

The operation of p-n-p devices is similar to that shown for the n-p-n device, except that the bias-voltage polarities are reversed, and electron-current flow is in the opposite direction. (Many discussions of semiconductor theory assume that the "holes" in semiconductor material constitute the charge carriers in p-n-p devices, and discuss "hole currents" for these devices and "electron currents" for n-p-n devices. Other texts discuss neither hole current nor electron current, but rather "conventional current flow", which is assumed to travel through a circuit in a direction from the positive terminal of the external battery back to its negative terminal. For the sake of simplicity, this discussion will be restricted to the concept of electron current flow, which travels from a negative to a positive terminal.)

TYPES OF DEVICES

The simplest type of semiconductor device is the **diode**, which is represented by the symbol shown in Fig. 10. Structurally, the diode is basically a p-n junction similar to those shown in Fig. 7. The n-type material which

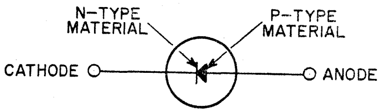


Figure 10. Schematic symbol for a semiconductor diode.

serves as the negative electrode is referred to as the **cathode**, and the p-type material which serves as the positive electrode is referred to as the **anode**. The arrow symbol used for the anode represents the direction of "conventional current flow" mentioned above; electron current flows in a direction opposite to the arrow.

Because the junction diode conducts current more easily in one direction than in the other, it is an effective rectifying device. If an ac signal is applied, as shown in Fig. 11, electron current flows freely during the positive half cycle, but little or no current flows during the negative half cycle.

One of the most widely used types of semiconductor diode is the **silicon rectifier.** These devices are available in a wide range of current capabilities, ranging from tenths of an ampere to 40 amperes or more, and are capable of operation at voltages as high as 800 volts or more. Parallel and series arrangements of silicon rectifiers permit even further extension of current and voltage

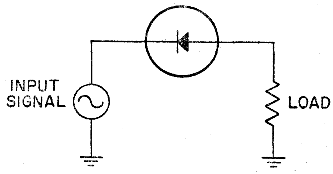


Figure 11. Simple diode rectifying circuit.

limits. Characteristics and applications of these devices are discussed in detail in the Silicon Rectifiers Section.

Several variations of the basic junction diode structure have been developed for use in special applications. The most important of these developments are the **tunnel diode,** which is used for amplification, oscillation, switching, and pulse generation, and the **varactor** or **parametric diode,** which amplifies at very high frequencies. These special diodes are described in the Tunnel, Varactor, and Other Diodes Section.

When a second junction is added to a semiconductor diode to provide power or voltage amplification (as shown in Fig. 9), the resulting device is called a **transistor.** The three regions of the device are called the **emitter,** the **base,** and the **collector,** as shown in Fig. 12. In normal operation, the emitter-to-base junction is

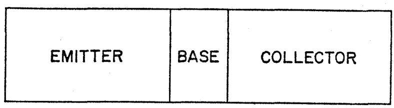
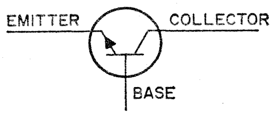


Figure 12. Functional diagram of transistor structure.

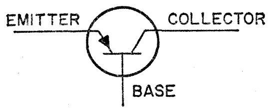
biased in the forward direction, and the collector-to-base junction in the reverse direction.

Different symbols are used for n-p-n and p-n-p transistors to show the difference in the direction of current flow in the two types of devices. In the n-p-n transistor shown in Fig.

13a, electrons flow from the emitter to the collector. In the p-n-p transistor shown in Fig. 13b, electrons flow from the collector to the emitter. In other words, the direction of dc electron current is always opposite to that of the arrow on the emitter lead. (As in the case of semiconductor diodes, the arrow indicates the direction of "conventional current flow" in the circuit.)



(a) N–P–N TRANSISTOR



(b) P–N–P TRANSISTOR

Figure 13. Schematic symbols for transistors.

The first two letters of the n-p-n and p-n-p designations indicate the respective polarities of the voltages applied to the emitter and the collector in normal operation. In an n-p-n transistor, the emitter is made negative with respect to both the collector and the base, and the collector is made positive with respect to both the emitter and the base. In a p-n-p transistor, the emitter is made positive with respect to both the collector and the base, and the collector is made negative with respect to both the emitter and the base.

The transistor, which is a three-element device, can be used for a wide variety of control functions, including amplification, oscillation, and frequency conversion. Transistor characteristics and applications are discussed in detail in the following sections.

TRANSISTOR DESIGNS AND CIRCUIT CONFIGURATIONS

THE performance of transistors in electronic equipment depends on many factors besides the basic characteristics of the semiconductor material. The two most important factors are the design and fabrication of the transistor structure and the general circuit configuration used.

DESIGN TECHNIQUES

The earliest transistors made were of the **point-contact** type shown in Fig. 14. In this type of structure, the emitter, base, and collector electrodes consisted of leads attached to a piece of n-type semiconductor material. The emitter and collector leads

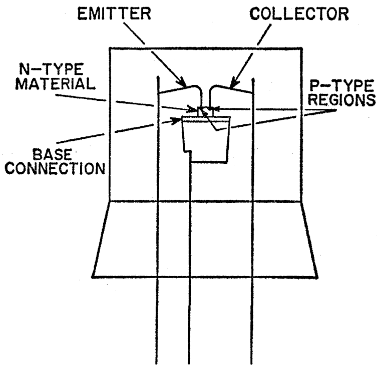


Figure 14. Structure of point-contact transistor.

had sharp, pointed ends to provide high-resistance contacts, while the base connection was a large-area, low-resistance contact. Small p-type regions under the "point contacts" of the emitter and the collector formed the p-n junctions which provided the basis for transistor action.

Point-contact transistors have now been almost completely superseded by various types of junction structures. In **grown-junction** transistors, the impurity content of the semiconductor material is changed during the preparation of a single crystal to provide the p-n-p or n-p-n regions. The grown crystal is then cut into a large number of small sections, and contacts are made to each region of a section, as shown in Fig. 15. The finished transistor is encased

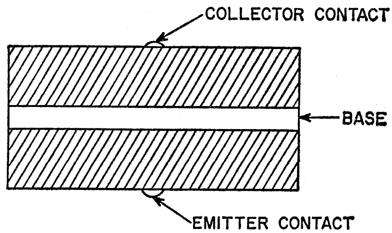


Figure 15. Structure of grown-junction transistor.

in plastic or a hermetically sealed enclosure.

In **alloy-junction** transistors, two small "dots" of a p-type or n-type impurity element are placed on opposite sides of a thin wafer of n-type or p-type semiconductor material, respectively, as shown in Fig. 16. After proper heating, the impurity "dots" alloy with the semiconductor material to form the regions for the emitter and collector junctions. The

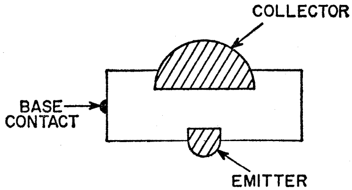


Figure 16. Structure of alloy-junction transistor.

base connection in this structure is made to the original semiconductor wafer.

The **drift-field** transistor is a modified alloy-junction device in which the impurity concentration in the base wafer is diffused or graded, as shown in Fig. 17. The resultant built-in voltage or "drift field" speeds up current flow and thus extends the

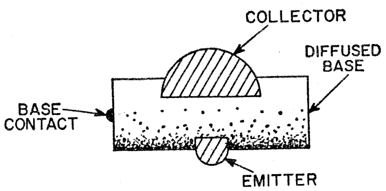


Figure 17. Structure of drift-field transistor.

frequency capabilities of the alloy-junction transistor.

The **micro-alloy diffused** transistor is a further variation of the drift-field type in which precision etching techniques are used to provide very narrow base widths, with consequent shortened current paths to the collector, as shown in Fig. 18.

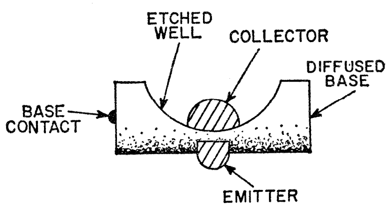


Figure 18. Structure of micro-alloy diffused transistor.

Mesa transistors use a newer construction technique which is better suited to many applications than the grown-junction or alloy methods. As shown in Fig. 19, the original semiconductor wafer serves as the collector. The base region is diffused

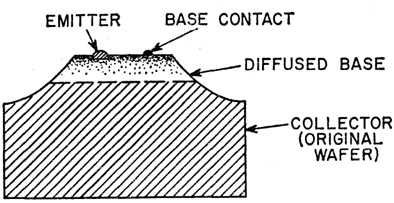


Figure 19. Structure of mesa transistor.

into the wafer, and the emitter dot is then alloyed into the base region. A "mesa" or flat-topped peak is then etched to reduce the collector area at the base-collector junction. The mesa structure is inherently rugged, has large power-dissipation capability, and can operate at very high frequencies.

In **epitaxial** mesa transistors, the principle of epitaxial crystal growth (the use of vapor deposition to build up a crystal layer on a crystal wafer) is used to permit precise control of the electrical and physical dimensions of the transistor independently of the nature of the original wafer. This technique is illustrated in Fig. 20.

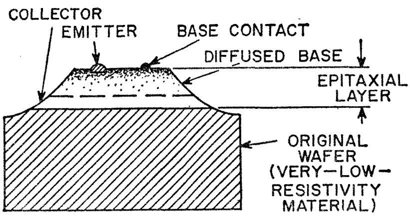


Figure 20. Structure of epitaxial mesa transistor.

In **double-diffused** transistors, both the base area and the emitter area are controlled by means of a masking technique which permits contact areas to be as small as the wires to be attached to them. In **planar** types, limited-area sources are used for both base diffusion and emitter diffusion to provide very small active areas with larger wire-contact areas. The planar approach is used with many of the various designs described above, including mesa types, epitaxial types, and single-, double-, and triple-diffused types.

BASIC CIRCUITS

There are three basic ways of connecting transistors in a circuit: common-base, common-emitter, and common-collector. In the **common-base** (or grounded-base) connection shown in Fig. 21, the signal is introduced into the emitter-base circuit and extracted from the collector-base circuit. (Thus the base element of the transistor is common to both the input and output circuits.) Because the input or emitter-base circuit has a low impedance (resistance plus reactance) in the order of 0.5 to 50 ohms, and the output or collector-base circuit has a high impedance in the order of 1000 ohms to one megohm, the voltage or power gain in this type of configuration may be in the order of 1500.

The direction of the arrows in Fig. 21 indicates electron current flow.

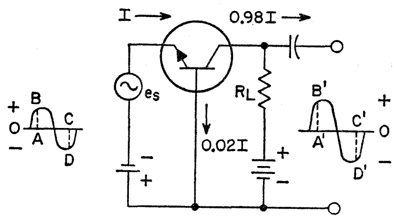


Figure 21. Common-base circuit configuration.

As stated previously, most of the current from the emitter flows to the collector; the remainder flows through the base. In practical transistors, from 95 to 99.5 per cent of the emitter current reaches the collector. The current gain of this configuration, therefore, is always less than unity, usually in the order of 0.95 to 0.995.

The waveforms in Fig. 21 represent the input voltage produced by the signal generator e_s and the output voltage developed across the load resistor R_L. When the input voltage is positive, as shown at AB, it opposes the forward bias produced by the base-emitter battery, and thus reduces current flow through the n-p-n transistor. The reduced electron current flow through R_L then causes the top point of the resistor to become less negative (or more positive) with respect to the lower point, as shown at A′B′ on the output waveform. Conversely, when the input signal is negative, as at CD, the output signal is also negative, as at C′D′. Thus, the phase of the signal remains unchanged in this circuit, i.e., there is no voltage phase reversal between the input and the output of a common-base amplifier.

In the **common-emitter** (or grounded-emitter) connection shown in Fig. 22, the signal is introduced into the base-emitter circuit and extracted from the collector-emitter circuit. This configuration has more moderate input and output impedances than the common-base circuit. The input (base-emitter) impedance is in the range of 20 to 5000 ohms, and the output (collector-emittter) impedance is about 50 to 50,000 ohms. Power gains in the order of 10,000 (or approximately 40 db) can be realized with this circuit because it provides both current gain and voltage gain.

Current gain in the common-emitter configuration is measured between the base and the collector, rather than between the emitter and the collector as in the common-base circuit. Because a very small change in base current produces a relatively large change in collector current, the current gain is always greater than unity in a common-emitter circuit; a typical value is about 50.

The input signal voltage undergoes a phase reversal of 180 degrees in a common-emitter amplifier, as shown by the waveforms in Fig. 22.

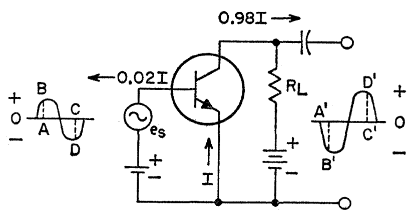


Figure 22. Common-emitter circuit configuration.

When the input voltage is positive, as shown at AB, it increases the forward bias across the base-emitter junction, and thus increases the total current flow through the transistor. The increased electron flow through R_L then causes the output voltage to become negative, as shown at A′B′. During the second half-cycle of the waveform, the process is reversed, i.e., when the input signal is negative, the output signal is positive (as shown at CD and C′D′.)

The third type of connection, shown in Fig. 23, is the **common-collector** (or grounded-collector) circuit. In

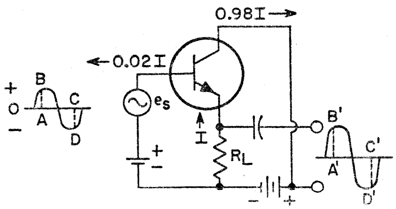


Figure 23. Common-collector circuit configuration.

this configuration, the signal is introduced into the base-collector circuit and extracted from the emitter-collector circuit. Because the input impedance of the transistor is high and the output impedance low in this connection, the voltage gain is less than unity and the power gain is usually lower than that obtained in either a common-base or a common-emitter circuit. The common-collector circuit is used primarily as an impedance-matching device. As in the case of the common-base circuit, there is no phase reversal of the signal between the input and the output.

The circuits shown in Figs. 21 through 23 are biased for n-p-n transistors. When p-n-p transistors are used, the polarities of the batteries must be reversed. The voltage phase relationships, however, remain the same.

TRANSISTOR CHARACTERISTICS

THE term "characteristic" is used to identify the distinguishing electrical features and values of a transistor. These values may be shown in curve form or they may be tabulated. When the characteristics values are given in curve form, the curves may be used for the determination of transistor performance and the calculation of additional transistor parameters.

Characteristics values are obtained from electrical measurements of transistors in various circuits under certain definite conditions of current and voltage. **Static** characteristics are obtained with dc potentials applied to the transistor electrodes. **Dynamic** characteristics are obtained with an ac voltage on one electrode under various conditions of dc potentials on all the electrodes. The dynamic characteristics, therefore, are indicative of the performance capabilities of the transistor under actual working conditions.

Published data for transistors include both electrode characteristic curves and transfer characteristic curves. These curves present the same information, but in two different forms to provide more useful data. Because transistors are used most often in the common-emitter configuration, characteristic curves are usually shown for the collector or output electrode. The **collector-characteristic curve** is obtained by varying collector-to-emitter voltage and measuring collector current for different values of base current. The **transfer-characteristic curve** is obtained by varying the base-to-emitter (bias) voltage at a specified or constant collector voltage, and measuring collector current for different base currents. A collector-characteristic family of curves is shown in Fig. 24. Fig. 25 shows the transfer-characteristic family of curves for the same transistor.

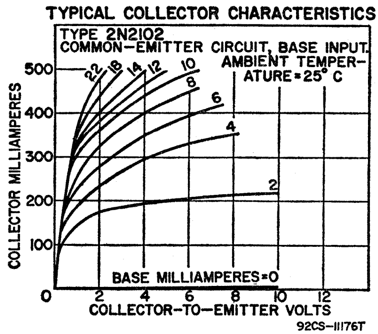


Figure 24. Collector-characteristic curves.

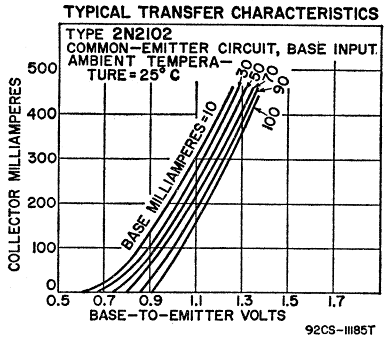


Figure 25. Transfer-characteristic curves.

One of the most important characteristics of a transistor is its **forward current-transfer ratio**, i.e., the ratio of the current in the output electrode to the current in the input electrode. Because of the different ways in which transistors may be connected in circuits, the forward current-transfer ratio is specified for a particular circuit configuration. The common-base forward current-transfer ratio is often called **alpha** (or α), and the common-emitter forward current-transfer ratio is often called **beta** (or β).

In the common-base circuit shown in Fig. 21, the emitter is the input electrode and the collector is the output electrode. The dc alpha, therefore, is the ratio of the dc collector current I_C to the dc emitter current I_E:

$$\alpha = \frac{I_C}{I_E} = \frac{0.98\ I}{I} = 0.98$$

In the common-emitter circuit shown in Fig. 22, the base is the input electrode and the collector is the ouput electrode. The dc beta, therefore, is the ratio of the dc collector current I_C to the dc base current I_B:

$$\beta = \frac{I_C}{I_B} = \frac{0.98\ I}{0.02\ I} = 49$$

Because the ratios given above are based on dc currents, they are properly called dc alpha and dc beta. It is more common, however, for the current-transfer ratio to be given in terms of the ratio of signal currents in the input and output electrodes, or the ratio of a change in the output current to the input signal current which causes the change. Fig. 26 shows typical electrode currents in a common-emitter circuit under no-signal conditions and with a one-microampere signal applied to the base. The signal current of one microampere in the base causes a change of 49 microamperes (147-98) in the collector current. Thus the ac beta for the transistor is 49.

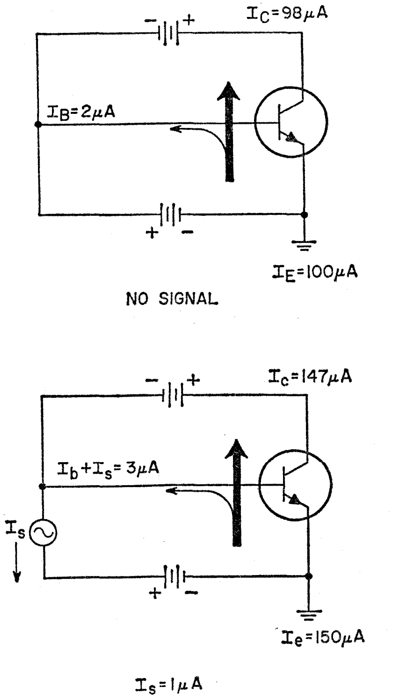


Figure 26. Electrode currents under no-signal and signal conditions.

The **frequency cutoff** of a transistor is defined as the frequency at which the value of alpha (for a common-base circuit) or beta (for a common-emitter circuit) drops to 0.707 times its one-kilocycle value. The **gain-bandwidth product** is the frequency at which the common-emitter forward current-transfer ratio (beta) is equal to unity. These characteristics provide an approximate indication of the useful frequency range of the device, and help to determine the most suitable circuit configuration for a particular application. Fig. 27 shows typical curves of alpha and beta as functions of frequency.

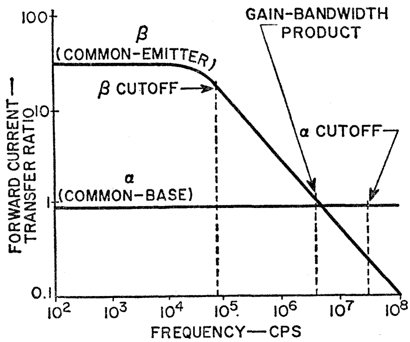


Figure 27. Forward current-transfer ratio as a function of frequency.

Extrinsic transconductance may be defined as the quotient of a small change in collector current divided by the small change in emitter-to-base voltage producing it, under the condition that other voltages remain unchanged. Thus, if an emitter-to-base voltage change of 0.1 volt causes a collector-current change of 3 milliamperes (0.003 ampere) with other voltages constant, the transconductance is 0.003 divided by 0.1, or 0.03 mho. (A "mho" is the unit of conductance, and was named by spelling "ohm" backward.) For convenience, a millionth of a mho, or a micromho (μmho), is used to express transconductance. Thus, in the example, 0.03 mho is 30,000 micromhos.

Cutoff currents are small dc reverse currents which flow when a transistor is biased into non-conduction. They consist of **leakage currents**, which are related to the surface characteristics of the semiconductor material, and **saturation currents**, which are related to the impurity concentration in the material and which increase with increasing temperatures. Collector-cutoff current is the dc current which flows in the reverse-biased collector-to-base circuit when the emitter-to-base circuit is open. Emitter-cutoff current is the current which flows in the reverse-biased emitter-to-base circuit when the collector-to-base circuit is open.

Transistor **breakdown voltages** define the voltage values between two specified electrodes at which the crystal structure changes and current begins to rise rapidly. The voltage then remains relatively constant over a wide range of electrode currents. Breakdown voltages may be measured with the third electrode open, shorted, or biased in either the forward or the reverse direction. For example, Fig. 28 shows a series of collector-characteristic curves for different base-bias conditions. It can be seen that the collector-to-emitter breakdown voltage increases as the base-to-emitter bias decreases from the normal forward values through zero to reverse values. The symbols shown on the abscissa are sometimes used to designate collector-to-emitter breakdown voltages with the base open (BV_{CEO}), with external base-to-emitter resistance (BV_{CER}), with the base shorted to the emitter (BV_{CES}),

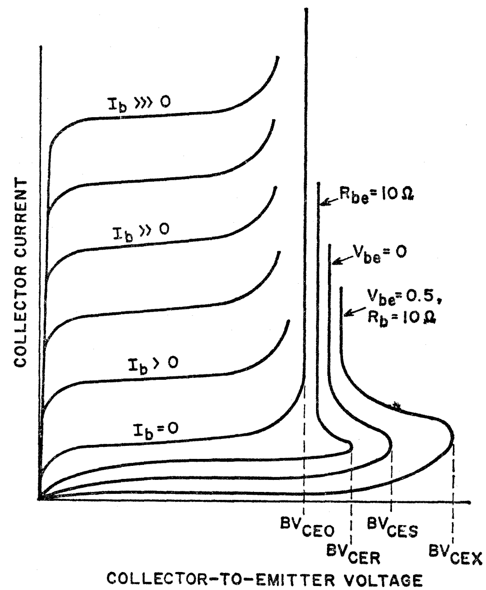


Figure 28. Typical collector-characteristic curves showing locations of various breakdown voltages.

and with a reverse base-to-emitter voltage (BV_{CEX}).

As the resistance in the base-to-emitter circuit decreases, the collector characteristic develops two breakdown points, as shown in Fig. 28. After the initial breakdown, the collector-to-emitter voltage decreases with increasing collector current until another breakdown occurs at a lower voltage. This minimum collector-to-emitter breakdown voltage is called the **sustaining voltage.**

(In large-area power transistors, there is a destructive mechanism referred to as **"second breakdown"**. This condition is not a voltage breakdown, but rather an electrically and thermally regenerative process in which current is focused in a very small area of the order of the diameter of a human hair. The very high current, together with the voltage across the transistor, causes a localized heating that may melt a minute hole from the collector to the emitter of the transistor and thus cause a short circuit. This regenerative process is not initiated unless certain high voltages and currents are coincident for certain finite lengths of time.)

The curves at the left of Fig. 28 show typical collector characteristics under normal forward-bias conditions. For a given base input current, the collector-to-emitter **saturation voltage** is the minimum voltage required to maintain the transistor in full conduction (i.e., in the saturation region). Under saturation conditions, a further increase in forward bias produces no corresponding increase in collector current. Saturation voltages are very important in switching applications, and are usually specified for several conditions of electrode currents and ambient temperatures.

Reach-through (or **punch-through)** voltage defines the voltage value at which the depletion region in the collector region passes completely through the base region and makes contact at some point with the emitter region. This "reach-through" phenomenon results in a relatively low-resistance path between the emitter and the collector, and causes a sharp increase in current. Punch-through voltage does not result in permanent damage to a transistor, provided there is sufficient impedance in the power-supply source to limit the transistor dissipation to safe values.

Stored base charge is a measure of the amount of charge which exists in the base region of the transistor at the time that forward bias is removed. This stored charge supports an undiminished collector current in the saturation region for some finite time before complete switching is effected. This delay interval, called the "storage time", depends on the degree of saturation into which the transistor is driven. (This effect is discussed in more detail under "Switching" in the Transistor Applications Section.)

TRANSISTOR APPLICATIONS

THE diversified applications of transistors are treated in this section under the three major classifications of Amplification, Oscillation, and Switching. Because various biasing and coupling methods are used in transistor circuits, bias and coupling arrangements are discussed separately before specific applications are considered.

BIASING

The operating point for a particular transistor is established by the quiescent (dc, no-signal) values of collector voltage and emitter current. In general, a transistor may be considered as a current-operated device, i.e., the current flowing in the emitter-base circuit controls the current flowing in the collector circuit. The voltage and current values selected, as well as the particular biasing arrangement used, depend upon both the transistor characteristics and the specific requirements of the application.

As mentioned previously, biasing of a transistor for most applications consists of forward bias across the emitter-base junction and reverse bias across the collector-base junction. In Figs. 21, 22, and 23, two batteries were used to establish bias of the correct polarity for an n-p-n transistor in the common-base, common-emitter, and common-collector circuits, respectively. Many variations of these basic circuits can also be used. (In these simplified circuits, inductors and transformers are represented only by their series resistances.)

A simplified biasing arrangement for the common-base circuit is shown in Fig. 29. Bias for both the collector-base junction and the emitter-base junction is obtained from the single battery through the voltage-divider network consisting of resistors R_2 and R_3. (For the n-p-n transistor shown in Fig. 29a, the emitter-base junction is forward-biased because the emitter is negative with respect to the base, and the collector-base junction is reverse-biased because the collector is positive with respect to the base, as shown. For the p-n-p transistor shown in Fig. 29b, the polarity of the battery and of the electrolytic bypass capacitor C_1 is reversed.) The electron current I from the battery and through the voltage divider causes a voltage drop across resistor R_2 which biases the emitter with respect to the base. This resistor is bypassed with capacitor C_1 so that the base is effectively grounded for ac signals.

The common-emitter circuit also can be biased by means of a single battery. The simplified arrangement shown in Fig. 30 is commonly called "fixed bias". In this case, both the base and the collector are made positive with respect to the emitter by means of the battery. The base resistance R_B is then selected to pro-

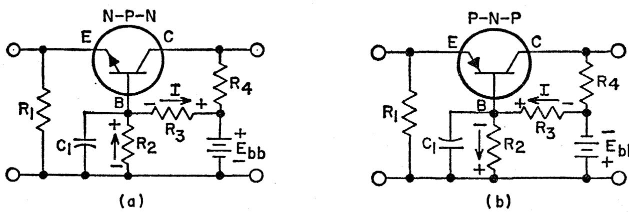


Figure 29. Biasing network for common-base circuit for (a) n-p-n and (b) p-n-p transistors.

vide the desired base current for the transistor (which, in turn, establishes the desired emitter current), by means of the following expression:

$$R_B = \frac{\text{Battery volts } E_{bb}}{\text{Desired base amperes } I_B}$$

In the circuit shown, for example, the battery voltage is six volts. The

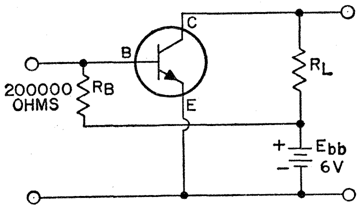


Figure 30. "Fixed-bias" arrangement for common-emitter circuit.

value of R_B was selected to provide a base current of 30 microamperes, as follows:

$$R_B = \frac{E_{bb}}{I_B} = \frac{6}{30 \times 10^{-6}} = 200{,}000 \text{ ohms}$$

The fixed-bias arrangement shown in Fig. 30, however, is not a satisfactory method of biasing the base in a common-emitter circuit. The critical base current in this type of circuit is very difficult to maintain under fixed-bias conditions because of variations between transistors and the sensitivity of these devices to temperature changes. This problem is partially overcome in the "self-bias" arrangement shown in Fig. 31.

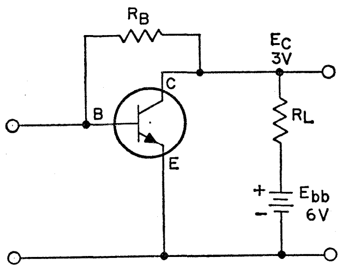


Figure 31. "Self-bias" arrangement for common-emitter circuit.

In this circuit, the base resistor is tied directly to the collector. This connection helps to stabilize the operating point because an increase or decrease in collector current produces a corresponding increase or decrease in base bias. The value of R_B is then determined as described above, except that the collector voltage E_C is used in place of the supply voltage E_{bb}:

$$R_B = \frac{E_C}{I_B} = \frac{3}{30 \times 10^{-6}} = 100{,}000 \text{ ohms}$$

The arrangement shown in Fig. 31 overcomes many of the disadvantages of fixed bias, although it reduces the effective gain of the circuit.

In the bias method shown in Fig. 32, the voltage-divider network composed of R_1 and R_2 provides the required forward bias across the base-emitter junction. The value of the base bias is determined by the current through the voltage divider. Any change in collector current

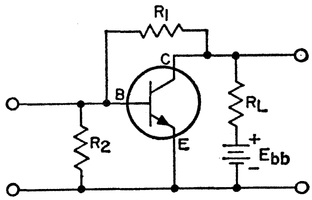


Figure 32. Bias network using voltage-divider arrangement for increased stability.

caused by a change in emitter current, therefore, automatically changes the base bias. This type of circuit provides less gain than the circuit of Fig. 31, but is commonly used because of its inherent stability.

The common-emitter circuits shown in Figs. 33 and 34 may be used to provide stability and yet minimize loss of gain. In Fig. 33, a resistor R_E is added to the emitter circuit, and the base resistor R_2 is returned

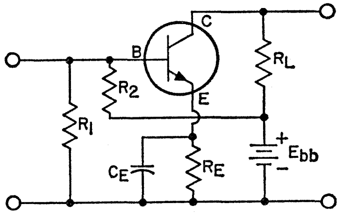


Figure 33. Bias network using emitter stabilizing resistor.

to the positive terminal of the battery instead of to the collector. The emitter resistor R_E provides additional stability; it is bypassed with capacitor C_E. The value of C_E is usually about 50 microfarads, but may be much higher depending, among other things, on the lowest frequency to be amplified.

In Fig. 34, the R_2R_3 voltage-divider network is split, and all ac feedback currents through R_3 are shunted to ground (bypassed) by capacitor C_1. The value of R_3 is usually larger than the value of R_2. The total resistance of R_2 and R_3 should equal the resistance of R_1 in Fig. 32.

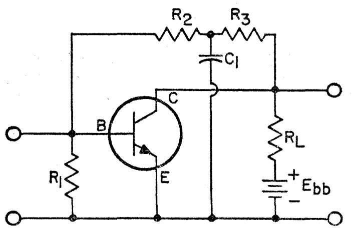


Figure 34. Bias network using split voltage-divider network.

In practical circuit applications, any combination of the arrangements shown in Figs. 31, 32, 33, and 34 may be used. However, the stability of Figs. 31, 32, and 34 may be poor unless the voltage drop across the load resistor R_L is at least one-third the value of the supply voltage. The determining factors in the selection of the biasing circuit are usually gain and circuit stability.

In many cases, the bias network may include special elements to compensate for the effects of variations in ambient temperature or in supply voltage. For example, the **thermistor** (temperature-sensitive resistor) shown in Fig. 35a is used to compensate for the rapid increase of collector current with increasing temperature. Because the thermistor resistance decreases as the temperature increases, the bias voltage is reduced and the collector current tends to remain constant. The addition of the shunt and series resistances provides most effective compensation over a desired temperature range.

The **diode biasing network** shown in Fig. 35b stabilizes collector current for variations in both temperature and supply voltage. The diode current determines a bias voltage which establishes the transistor **idling** current (collector current under no-signal conditions). As the temperature increases, this bias voltage decreases. Because the transistor characteristic also shifts in the same

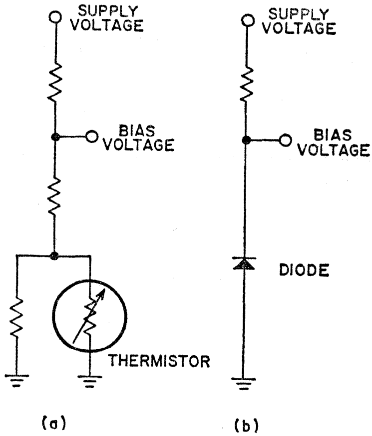


Figure 35. Bias networks including (a) a thermistor and (b) a temperature- and voltage-compensating diode.

direction and magnitude, however, the idling current remains essentially independent of temperature. Temperature stabilization with a diode network is substantially better than that provided by most thermistor bias networks.

In addition, the diode bias current varies in direct proportion with changes in supply voltage. The resultant change in bias voltage is small, however, so that the idling current also changes in direct proportion to the supply voltage. Supply-voltage stabilization with a diode biasing network reduces current variation to about one-fifth that obtained when resistor or thermistor bias is used.

COUPLING

Three basic methods are used to couple transistor stages: transformer, resistance-capacitance, and direct coupling.

The major advantage of **transformer coupling** is that it permits the input and output impedance of the transistor to be matched for maximum power gain. The transformer-coupled common-emitter n-p-n stage shown in Fig. 36 employs both fixed and self bias, and includes an emitter resistor R_E for stabilization. The voltage step-down transformer T_1 couples the signal from the collector of the preceding stage to the base of the common-emitter stage. The voltage loss inherent in this transformer is not significant in transistor circuits because, as mentioned previously, the transistor is a current-operated device. Although the voltage is stepped down, the available current is stepped up. The change in base current resulting from the presence of the signal causes an ac collector current to flow in the primary winding of transformer T_2, and a power gain can be measured between T_1 and T_2.

This use of a voltage step-down transformer is similar to that in the output stage of an audio amplifier, where a step-down transformer is normally used to drive the loudspeaker, which is also a current-operated device. The purpose of the transformer in both cases is to transfer power from one impedance level to another.

The voltage-divider network consisting of resistors R_1 and R_2 in Fig. 36 provides bias for the transistor. The voltage divider is bypassed by capacitor C_1 to avoid signal attenuation. The stabilizing emitter resistor R_E permits normal variations of the transistor and circuit elements to be compensated for automatically without adverse effects. This resistor R_E is bypassed by capacitor C_2. The voltage supply E_{bb} is also bypassed, by capacitor C_3, to prevent feedback in the event that ac signal voltages are developed across the power supply. Capacitor C_1 and C_2 may normally be replaced by a single capacitor connected between the emitter and the bottom of the secondary winding of transformer T_1 with little change in performance.

Because there is no resistor in the collector circuit to dissipate power, the efficiency of a transformer-coupled stage approaches the theoretical maximum of 50 per cent. In addition, the very low impedance in the base circuit may simplify the problem of temperature stabilization. When a large stabilizing resistor is used in series with the emitter, the circuit stability factor may be very high.

The use of **resistance-capacitance coupling** usually permits some economy of circuit costs and reduction of size, with some accompanying sacrifice of gain. This method of coupling is particularly desirable in low-level, low-noise audio amplifier stages to minimize hum pickup from stray magnetic fields. Use of resistance-capacitance (RC) coupling in

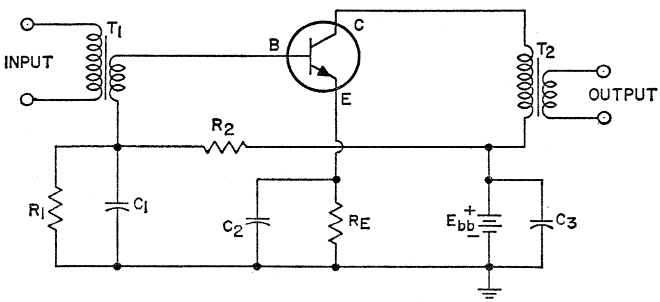


Figure 36. Transformer-coupled common-emitter stage.

battery-operated equipment is usually limited to low-power operation. The frequency response of an RC-coupled stage is normally better than that of a transformer-coupled stage.

Fig. 37 shows a two-stage RC-coupled circuit using n-p-n transistors in the common-emitter configuration. The method of bias is similar to that used in the transformer-coupled circuit of Fig. 36. The major additional components are the collector load resistances R_{L1} and R_{L2} and the coupling capacitor C_c. The value of C_c must be made fairly large, in the order of 2 to 10 microfarads, because of the small input and load resistances involved. (It should be noted that electrolytic capacitors are normally used for coupling in transistor audio circuits. Polarity must be observed, therefore, to obtain proper circuit operation. Occasionally, excessive leakage current through an electrolytic coupling capacitor may adversely affect transistor operating currents.)

Impedance coupling is a modified form of resistance-capacitance coupling in which inductances are used to replace the load resistors. This type of coupling is rarely used except in special applications where supply voltages are low and cost is not a factor.

Direct coupling is used primarily when cost is an important factor. (It should be noted that direct-coupled amplifiers are not inherently dc amplifiers, i.e., that they cannot always amplify dc signals. Low-frequency response is usually limited by other factors than the coupling network.) In the direct-coupled amplifier shown in Fig. 38, resistor R_3 serves as both the collector load resistor for the first stage and the bias resistor for the second stage. Resistors R_1 and R_2 provide circuit stability similar to that of Fig. 32 because the emitter voltage of transistor Q_2 and the collector voltage of transistor Q_1 are within a few tenths of a volt of each other.

Because so few circuit parts are required in the direct-coupled amplifier, maximum economy can be achieved. However, the number of

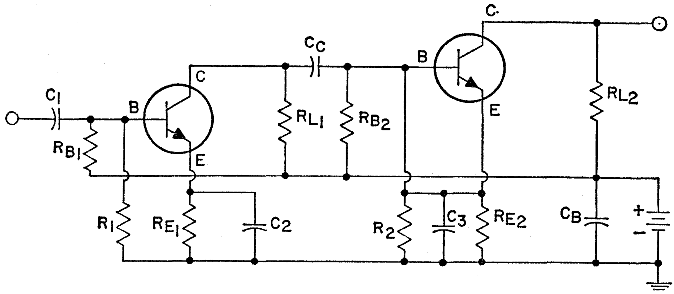


Figure 37. Two-stage resistance-capacitance-coupled circuit.

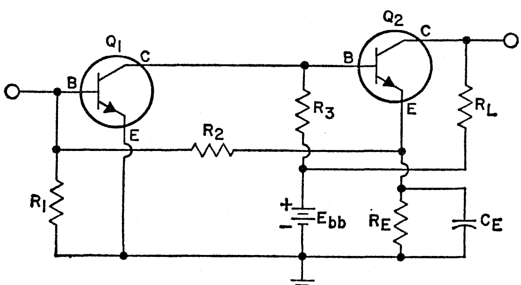


Figure 38. Two-stage direct-coupled circuit.

stages which can be directly coupled is limited. Temperature variation of the bias current in one stage is amplified by all the stages, and severe temperature instability may result.

AMPLIFICATION

The amplifying action of a transistor can be used in various ways in electronic circuits, depending on the results desired. The four recognized classes of amplifier service can be defined for transistor circuits as follows:

A **class A amplifier** is an amplifier in which the base bias and alternating signal are such that collector current in a specific transistor flows continuously during the complete electrical cycle of the signal, and even when no signal is present.

A **class AB amplifier** is an amplifier in which the base bias and alternating signal are such that collector current in a specific transistor flows for appreciably more than half but less than the entire electrical cycle.

A **class B amplifier** is an amplifier in which the base is biased to approximately collector-current cutoff, so that collector current is approximately zero when no signal is applied, and so that collector current in a specific transistor flows for approximately one-half of each cycle when an alternating signal is applied.

A **class C amplifier** is an amplifier in which the base is biased to such a degree that the collector current in each transistor is zero when no signal is applied, and so that collector current in a specific transistor flows for appreciably less than one-half of each cycle when an alternating signal is applied.

For radio-frequency (rf) amplifiers which operate into selective tuned circuits, or for other amplifiers in which distortion is not a prime factor, any of the above classes of amplification may be used with either a single transistor or a push-pull stage. For audio-frequency (af) amplifiers in which distortion is an important factor, single transistors can be used only in class A amplifiers. For class AB or class B audio-amplifier service, a balanced amplifier stage using two transistors is required. A push-pull stage can also be used in class A audio amplifiers to obtain reduced distortion and greater power output. Class C amplifiers cannot be used for audio applications.

Audio Amplifiers

Audio amplifier circuits are used in radio and television receivers, public address systems, sound recorders and reproducers, and similar applications to amplify signals in the frequency range from 10 to 20,000 cycles per second. Each transistor in an audio amplifier can be considered as either a current amplifier or a power amplifier.

Simple class A amplifier circuits are normally used in low-level audio stages such as **preamplifiers** and **drivers.** Preamplifiers usually follow low-level output transducers such as microphones, hearing-aid and phonograph pickup devices, and recorder-reproducer heads.

One of the most important characteristics of a low-level amplifier circuit is its **signal-to-noise ratio,** or **noise figure.** The input circuit of an amplifier inherently contains some thermal noise contributed by the resistive elements in the input device. All resistors generate a predictable quantity of noise power as a result of thermal activity. This power is about 160 db below one watt for a bandwidth of 10 kilocycles.

When an input signal is amplified, therefore, the thermal noise generated in the input circuit is also amplified. If the ratio of signal power to noise power (S/N) is the same in the output circuit as in the input circuit, the amplifier is considered to be "noiseless" and is said to have a noise figure of unity, or zero db.

In practical circuits, however, the ratio of signal power to noise power is inevitably impaired during amplification as a result of the generation of additional noise in the circuit elements. A measure of the degree of impairment is called the noise figure (NF) of the amplifier, and is expressed as the ratio of signal power to noise power at the input (S_i/N_i) divided by the ratio of signal power to noise power at the output (S_o/N_o), as follows:

$$NF = \frac{S_i/N_i}{S_o/N_o}$$

The noise figure in db is equal to ten times the logarithm of this power ratio. For example, an amplifier with a one-db noise figure decreases the signal-to-noise ratio by a factor of 1.26, a 3-db noise figure by a factor of 2, a 10-db noise figure by a factor of 10, and a 20-db noise figure by a factor of 100. A value of NF below 6 db is generally considered excellent.

In audio amplifiers, it is desirable that the noise figure be kept low. In general, the lowest value of NF is obtained by use of an emitter current of less than one milliampere, a collector voltage of less than two volts, and a signal-source resistance between 300 and 3000 ohms.

In the simple low-level amplifier stage shown in Fig. 39, the resistors R_1 and R_2 determine the base-emitter bias for the p-n-p transistor. Resistor R_3 is the emitter stabilizing resistor; capacitor C_1 bypasses the ac signal around R_3. The output signal is developed across the collector load resistor R_4. The collector voltage and the emitter current are kept relatively low to reduce the noise figure.

In many cases, low-level amplifier stages used as preamplifiers include some type of **frequency-compensation network** to improve either the low-frequency or the high-frequency components of the input signal. The simplest type of equalization network is shown in Fig. 40. Because

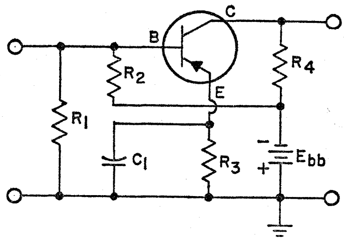


Figure 39. Simple low-level class A amplifier.

the capacitor C is effectively an open circuit at low frequencies, the low frequencies must be passed through the resistor R and are attenuated. The capacitor has a lower reactance at high frequencies, however, and bypasses high-frequency components around R so that they receive negligible attenuation. Thus the network effectively "boosts" the high frequencies.

Feedback networks may also be used for frequency compensation and for reduction of distortion. Basically, a feedback network returns a portion of the output signal to the input circuit of an amplifier. The feedback signal may be returned in phase with the input signal (**positive** or **regenerative** feedback) or 180 degrees out of phase with the input signal (**negative, inverse,** or **degenerative** feedback). In either case, the feedback can be made proportional to either the output voltage or the output current, and can be applied to either the input voltage or the input current. A negative feedback signal proportional to the output current raises the output impedance of the amplifier; negative feedback proportional to the output voltage reduces the output impedance. A negative feedback signal applied to the input current decreases the input impedance; negative feedback applied to the input voltage increases the input

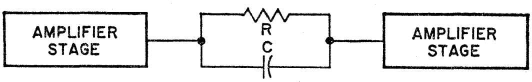


Figure 40. Simple RC frequency-compensation network.

impedance. Opposite effects are produced by positive feedback.

A simple negative or inverse feedback network which provides high-frequency boost is shown in Fig. 41. This network provides equalization comparable to that obtained with Fig. 40, but is more suitable for low-level amplifier stages because it does not require high-level low frequencies. In addition, the inverse feedback improves the distortion characteristics of the amplifier.

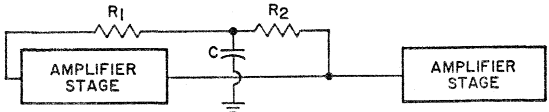


Figure 41. Negative-feedback frequency-compensation network.

As mentioned previously, it is undesirable to use a high-resistance signal source for an audio amplifier because of the high noise figure involved. High source resistance cannot be avoided, however, if an input device such as a crystal pickup is used. In such cases, the use of negative feedback to raise the input impedance of the amplifier circuit (to avoid mismatch loss) is no solution because feedback cannot improve the signal-to-noise ratio of the amplifier. A more practical method is to increase the input impedance somewhat by operating the transistor at the lowest practical current level and by using a transistor which has a high forward current-transfer ratio.

Some preamplifier or low-level audio amplifier circuits include variable resistors or potentiometers which function as **volume or tone controls.** Such circuits should be designed to minimize the flow of dc currents through these controls so that little or no noise will be developed by the movable contact during the life of the circuit. Volume controls and their associated circuits should permit variation of gain from zero to maximum, and should attenuate all frequencies equally for all positions of the variable arm of the control. Several examples of volume controls and tone controls are shown in the Circuits Section.

Driver stages in audio amplifiers are located immediately before the power-output stage. When a single-ended class A output stage is used, the driver stage is similar to a preamplifier stage. When a push-pull output stage is used, however, the audio driver must provide two output signals, each 180 degrees out of phase with the other. This phase requirement can be met by use of a tapped-secondary transformer between a single-ended driver stage and the output stage, as shown in Fig. 42. The transformer T_1 provides the required out-of-phase input signals for the two transistors Q_1 and Q_2 in the push-pull output stage.

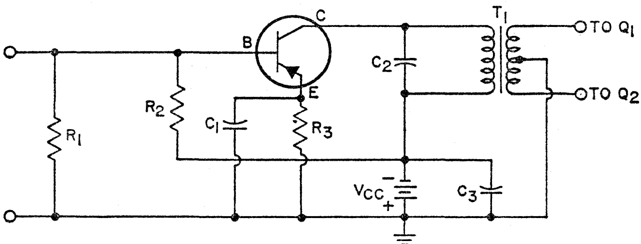


Figure 42. Driver stage for push-pull output circuit.

Transistor audio **power amplifiers** may be class A single-ended stages, or class A, class AB, or class B push-pull stages. A simple class A single-ended power amplifier is shown in Fig. 43. Component values which will provide the desired power output can be calculated from the transistor characteristics and the supply voltage. For example, an output of four watts may be desired from a circuit operating with a supply voltage of 14.5 volts (this voltage is normally available in automobiles which have a 12-volt ignition system). If losses are assumed to be negligible, the power output (PO) is equal to the peak collector voltage (e_c) times the peak collector current (i_c), both divided by the square root of two to obtain rms values. The peak collector current can then be determined as follows:

$$PO = \frac{e_c}{\sqrt{2}} \times \frac{i_c}{\sqrt{2}}$$

$$i_c = PO(\sqrt{2}) \times \frac{\sqrt{2}}{e_c}$$

$$= 4\sqrt{2} \times \frac{\sqrt{2}}{14.5}$$

$$= 0.55, \text{ or approximately } 0.6 \text{ ampere.}$$

In class A service, the dc collector current and the peak collector swing are about the same. Thus, the collector voltage and current are 14.5 volts and 0.6 ampere, respectively.

The voltage drop across the resistor R_E in Fig. 43 usually ranges from 0.3 to 1 volt; a typical value of 0.6 volt can be assumed. Because the emitter current is very nearly equal to the collector current (0.6 ampere), the value of R_E must equal the 0.6-volt drop divided by the 0.6-ampere current, or one ohm.

The current through resistor R_2 is about 10 to 20 per cent of the collector current; a typical value is 15 per cent of 0.6, or 90 milliamperes.

The voltage from base to ground is equal to the base-to-emitter voltage (determined from the transistor transfer-characteristics curves for the desired collector or emitter current; normally about 0.4 volt for an emitter current of 600 milliamperes) plus the emitter-to-ground voltage (0.6 volt as described above), or one volt. The voltage across R_2, therefore, is 14.5 minus 1, or 13.5 volts. The value of R_2 must equal 13.5 divided by 90, or about 150 ohms.

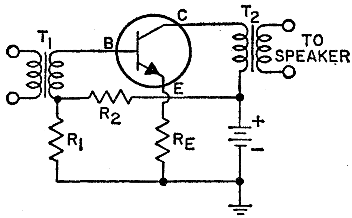


Figure 43. Class A power-amplifier circuit.

Because the voltage drop across the secondary winding of the driver transformer T_1 is negligible, the voltage drop across R_1 is one volt. The current through R_1 equals the current through R_2 (90 milliamperes) minus the base current. If the dc forward current-transfer ratio (beta) of the transistor selected has a typical value of 60, the base current equals the collector current of 600 milliamperes divided by 60, or 10 milliamperes. The current through R_1 is then 90 minus 10, or 80 milliamperes, and the value of R_1 is 1 divided by 80, or about 12 ohms.

The transformer requirements are determined from the ac voltages and currents in the circuit. The peak collector voltage swing that can be used before distortion occurs as a result of clipping of the output voltage is about 13 volts. The peak collector current swing available before current cutoff occurs is the dc current of 600 milliamperes. Therefore, the collector load impedance should be 13 volts divided by 600 milliamperes, or about 20 ohms, and the output transformer T_2 should be designed to match a 20-ohm primary impedance to the desired speaker impedance. If a 3.2-ohm speaker is used, for example, the impedance values for T_2 should be 20 ohms to 3.2 ohms.

The total input power to the circuit of Fig. 43 is equal to the voltage required across the secondary winding of the driver transformer T_1 times the current. The driver signal current is equal to the base current (10 milliamperes, or 7 milliamperes rms). The peak ac signal voltage is the sum of the base-to-emitter voltage across the transistor (0.4 volt as determined above), plus the voltage across R_E (0.6 volt), plus the peak ac signal voltage across R_1 (1.0 milliampere times 12 ohms, or 0.12 volt). The input voltage, therefore, is about one volt peak, or 0.7 volt rms. Thus, the total ac input power required to produce an output of 4 watts is 0.7 volt times 7 milliamperes, or 5 milliwatts, and the input impedance is 0.7 volt divided by 7 milliamperes, or 100 ohms.

Higher power output can be achieved with less distortion in class A service by the use of a **push-pull** circuit arrangement. One of the disadvantages of a transistor class A amplifier (single-ended or push-pull), however, is that collector current flows at all times. As a result, transistor dissipation is highest when no ac signal is present. This dissipation can be greatly reduced by use of class B push-pull operation. When two transistors are connected in class B push-pull, one transistor amplifies half of the signal, and the other transistor amplifies the other half. These half-signals are then combined in the output circuit to restore the original waveform in an amplified state.

Ideally, transistors used in class B service should be biased to collector cutoff so that no power is dissipated under zero-signal conditions. At low signal inputs, however, the resulting signal would be distorted, as shown in Fig. 44, because of the low forward current-transfer ratio of the transistor at very low currents. This type of distortion, called **cross-over distortion,** can be suppressed by the use of a bias which permits a small collector current flow at zero signal level. Any residual distortion can be further reduced by the use of negative feedback.

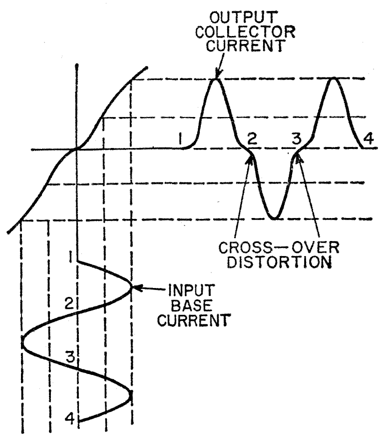


Figure 44. Waveforms showing cause of cross-over distortion.

A typical class B push-pull audio amplifier is shown in Fig. 45. Resistors R_{E1} and R_{E2} are the emitter stabilizing resistors. Resistors R_1 and R_2 form a voltage-divider network which provides the bias for the transistors. The base-emitter circuit is biased near collector cutoff so that very little collector power is dissipated under no-signal conditions. The characteristics of the bias network must be very carefully chosen so that the bias voltage will be just sufficient to minimize cross-over distortion at low signal levels. Because the collector current, collector dissipation, and dc operating point of a transistor vary with ambient temperature, a temperature-sensitive resistor (such as a thermistor) or a bias-compensating diode may be used in the biasing network to mini-

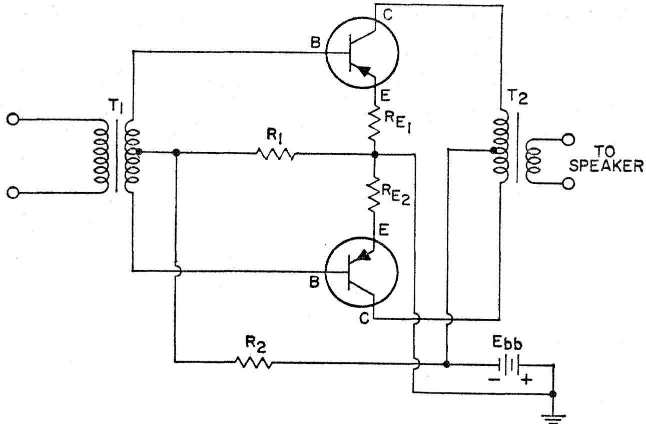


Figure 45. Class B push-pull audio-amplifier circuit.

mize the effect of temperature variations.

The advantages of class B operation can be obtained without the need for an output transformer by use of a single-ended class B circuit such as that shown in Fig. 46. In this circuit, the secondary windings of the driver transformer T_1 are phased so that a positive signal from base to emitter of one transistor is accompanied by a negative signal from base to emitter of the other transistor. When a positive signal is applied to the base of transistor Q_1, for example, Q_1 draws current. This current must flow through the speaker because the accompanying negative signal on the base of transistor Q_2 cuts Q_2 off. When the signal polarity reverses, transistor Q_1 is cut off, while Q_2 conducts current. The resistive dividers R_1R_2 and R_3R_4 provide a dc bias which keeps the transistors slightly above cutoff under no-signal conditions and thus minimizes cross-over distortion. The emitter resistors R_{E1} and R_{E2} help to compensate for differences between transistors and for the effects of ambient-temperature variations.

The secondary windings of any class B driver transformer should be bifilar-wound (i.e., wound together) to obtain tighter coupling and thereby minimize leakage inductance. Otherwise, "ringing" may occur in the cross-over region as a result of the energy stored in the leakage inductance.

Because junction transistors can be made in both p-n-p and n-p-n

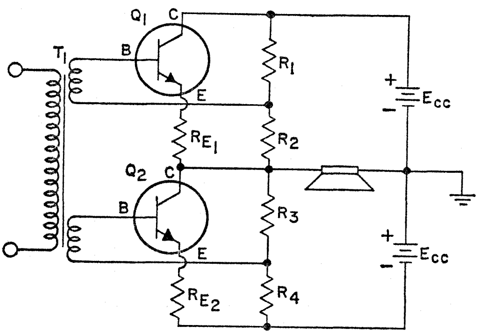


Figure 46. Single-ended class B circuit.

types, they can be used in **complementary-symmetry** circuits to obtain all the advantages of conventional push-pull amplifiers plus direct coupling. The arrows in Fig. 47 indicate the direction of electron current flow

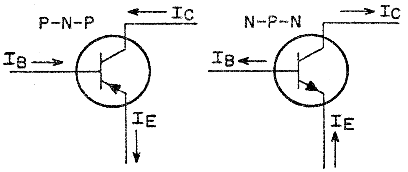


Figure 47. Electron-current flow in p-n-p and n-p-n transistors.

in the terminal leads of p-n-p and n-p-n transistors. When these two transistors are connected in a single stage, as shown in Fig. 48, the dc electron current path in the output circuit is completed through the collector-emitter circuits of the transistors. In the circuits of Figs. 45 and 48, essentially no dc current flows through the load resistor R_L. Therefore, the voice coil of a loudspeaker can be connected directly in place of R_L without excessive speaker cone distortion.

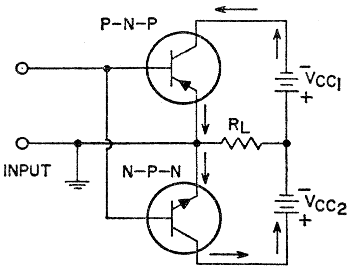


Figure 48. Basic complementary-symmetry circuit.

A **phase inverter** is a type of class A amplifier used when two out-of-phase outputs are required. In the split-load phase-inverter stage shown in Fig. 49, the output current of transistor Q_1 flows through both the collector load resistor R_4 and the emitter load resistor R_3. When the input signal is negative, the increased output current causes the collector side of resistor R_4 to become more positive and the emitter side of resistor R_3 to become more negative with respect to ground. When the input signal is positive, the output current decreases and opposite voltage polarities are established across resistors R_3 and R_4. Thus, two output signals are produced which are 180 degrees out of phase with each other. This circuit provides the 180-degree phase relationship only when each load is resistive throughout the entire signal swing. It is not suitable, therefore, as a driver stage for a class B output stage.

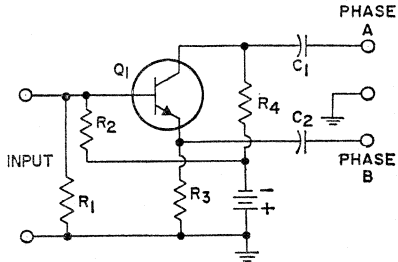


Figure 49. Split-load phase-inverter stage.

Tuned Amplifiers

In transistor radio-frequency **(rf)** and intermediate-frequency **(if) amplifiers,** the bandwidth of frequencies to be amplified is usually only a small percentage of the center frequency. Tuned amplifiers are used in these applications to select the desired bandwidth of frequencies and to suppress unwanted frequencies. The selectivity of the amplifier is obtained by means of tuned interstage coupling networks.

The properties of tuned amplifiers depend upon the characteristics of **resonant circuits.** A simple parallel resonant circuit (sometimes called a "tank" because it stores energy) is shown in Fig. 50. For practical purposes, the resonant frequency of such a circuit may be considered independent of the resistance R, provided R is small compared to the inductive reactance X_L. The resonant frequency f_r is then given by

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

For any given resonant frequency, the product of L and C is a constant; at low frequencies LC is large; at high frequencies it is small.

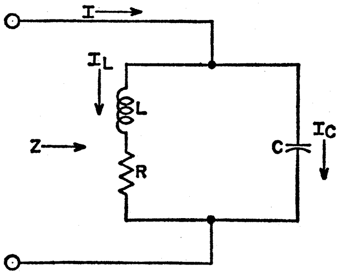


Figure 50. Simple parallel resonant circuit.

The Q (selectivity) of a parallel resonant circuit alone is the ratio of the current in the tank (I_L or I_C) to the current in the line (I). This unloaded Q, or Q_o, may be expressed in various ways, for example:

$$Q_o = \frac{I_C}{I} = \frac{X_L}{R} = \frac{Z}{X_C}$$

where X_L is the inductive reactance ($= 2\pi fL$), X_c is the capacitive reactance ($= 1/[2\pi fC]$), and Z is the total impedance of the parallel resonant circuit (tank). The Q varies inversely with the resistance of the inductor. The lower the resistance, the higher the Q and the greater the difference between the tank impedance at frequencies off resonance compared to the tank impedance at the resonant frequency.

The Q of a tuned interstage coupling network also depends upon the impedances of the preceding and following stages. The output impedance of a transistor can be considered as consisting of a resistance R_o in parallel with a capacitance C_o, as shown in Fig. 51. Similarly, the input impedance can be considered as consisting of a resistance R_i in parallel with a capacitance C_i. Because the tuned circuit is shunted by both the output impedance of the preceding transistor and the input impedance of the following transistor, the effective selectivity of the circuit is the loaded Q (or Q_L) based upon the total impedance of the coupled network, as follows:

$$Q_L = \frac{Z \text{ (total loading on coil)}}{X_L \text{ or } X_C}$$

The capacitances C_o and C_i in Fig. 51 are usually considered as part of the coupling network. For example, if the required capacitance between terminals 1 and 2 of the coupling network is calculated to be 500 picofarads and the value of C_o is 10 picofarads, a capacitor of 490 picofarads is used between terminals 1 and 2 so that the total capacitance is 500 picofarads. The same method is used to allow for the capacitance C_i at terminals 3 and 4.

When a tuned resonant circuit in the primary winding of a transformer is coupled to the nonresonant secondary winding of the transformer, as shown in Fig. 52, the effect of the input impedance of the following stage on the Q of the tuned circuit can be determined by considering the values reflected (or referred) to the primary circuit by transformer action. The reflected resistance r_i is equal to the resistance R_i in the secondary circuit times the square of the effective turns ratio between the primary and secondary windings of the transformer T:

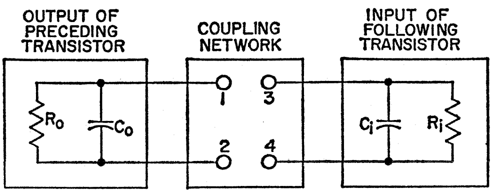


Figure 51. Equivalent output and input circuits of transistors connected by a coupling network.

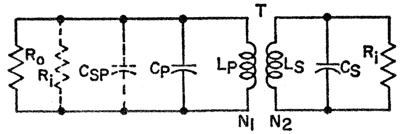


Figure 52. Equivalent circuit for transformer-coupling network having tuned primary winding.

$$r_i = R_i \, (N_1/N_2)^2$$

where N_1/N_2 represents the electrical turns ratio between the primary winding and the secondary winding of T. If there is capacitance in the secondary circuit (C_s), it is reflected to the primary circuit as a capacitance C_{sp}, and is given by

$$C_{sp} = C_p \div (N_1/N_2)^2$$

The loaded Q, or Q_L, is then calculated on the basis of the inductance L_p, the total shunt resistance (R_o plus r_i plus the tuned-circuit impedance $Z_t = Q_oX_c = Q_oX_L$), and the total capacitance ($C_p + C_{sp}$) in the tuned circuit.

Fig. 53 shows a coupling network which consists of a single-tuned circuit using magnetic or mutual inductive coupling. The capacitance C_t includes the effects of both the output capacitance of the preceding transistor and the input capacitance of the following transistor (referred to the primary of transformer T_1).

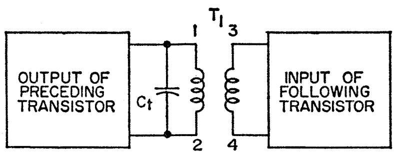


Figure 53. Single-tuned coupling network using inductive coupling.

The bandwidth, or effective frequency range, of a single-tuned transformer is determined by the half-power points on the resonance curve (−3 db or 0.707 down from the maximum). Under these conditions, the band pass Δf is equal to the ratio of the center or resonant frequency f_r divided by the loaded (effective) Q of the circuit, as follows:

$$\Delta f = f_r/Q_L$$

The inherent internal feedback in transistors can cause instability and oscillation as the gain of an amplifier stage is increased (i.e., as the load and source impedances are increased from zero to matched conditions). At low frequencies, therefore, where the potential gain of transistors is high, it is often desirable to keep the transistor load impedance low. Relatively high capacitance values in the tuned collector circuit can then be avoided by use of a tap on the primary winding of the coupling transformer, as shown in Fig. 54. At

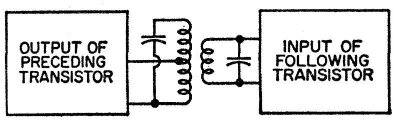


Figure 54. Transformer coupling network using tap on primary winding.

higher frequencies, the gain potential of the transistor decreases, and impedance matching is permissible.

External feedback circuits are often used in tuned coupling networks to counteract the effects of the internal transistor feedback and thus provide more gain or more stable performance. If the external feedback circuit cancels the effects of both the resistive and the reactive internal feedback, the amplifier is considered to be **unilateralized.** If the external circuit cancels the effect of only the reactive internal feedback, the amplifier is considered to be **neutralized.**

A typical tuned amplifier using neutralization is shown in Fig. 55. The input signal to the transistor is an if carrier (e.g., 455 kilocycles) amplitude-modulated by an audio signal. Capacitor C_1 and the primary winding of transformer T_1 form a parallel-tuned circuit resonant at 455 kilocycles. Transformer T_1 couples the signal power from the previous stage to the base of the transistor. Resistor R_3 provides forward bias to the transistor. Capacitor C_3 provides a low-impedance path

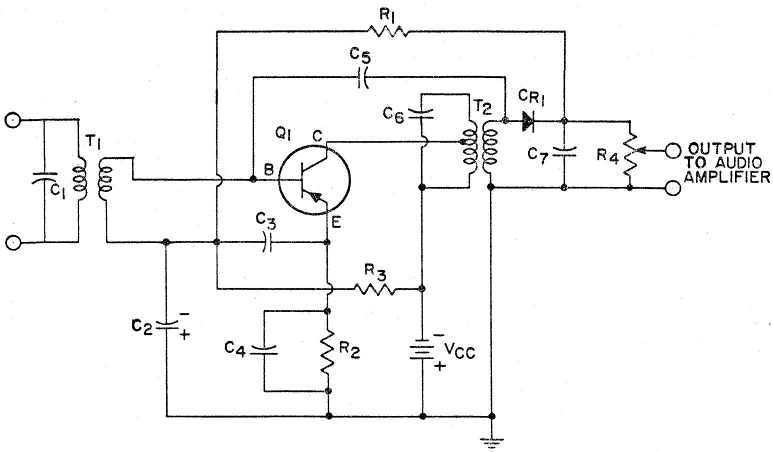


Figure 55. Neutralized if-amplifier and second-detector circuit.

for the 455-kilocycle signal from the input tuned circuit to the emitter. Resistor R_2, which is bypassed for 455 kilocycles by capacitor C_4, is the emitter dc stabilizing resistor. The amplified signal from the transistor is developed across the parallel resonant circuit (tuned to 455 kilocycles) formed by capacitor C_6 and the primary winding of transformer T_2, and is coupled by T_2 to the crystal-diode second detector CR.

Voltage at the intermediate frequency is taken from the secondary winding of the single-tuned output circuit and applied to the base of the transistor through the feedback (neutralizing) capacitor C_5. Because of the phase reversal in the common-emitter configuration, this external feedback is out of phase with the input from the if amplifier, and cancels the in-phase reactive feedback in the transistor due to the internal capacitance between the collector and the base.

The rectified output of the crystal diode CR is filtered by capacitor C_7 and resistor R_4 so that the voltage across capacitor C_7 consists of an audio signal and a dc voltage (positive with respect to ground for the arrangement shown in Fig. 55) that is directly proportional to the amplitude of the if carrier. This dc voltage is fed back to the emitter of the transistor through the resistor R_1 to provide automatic gain control. Resistor R_1 and capacitor C_2 form an audio decoupling network to prevent audio feedback to the base of the transistor.

Automatic gain control (agc) is often used in rf and if amplifiers in AM radio and television receivers to provide lower gain for strong signals and higher gain for weak signals. The dc component of the second-detector output, which is directly proportional to the strength of the signal carrier received, can be used to vary either the dc emitter current or the collector voltage of a transistor to provide agc. Fig. 56 shows typical curves of power gain

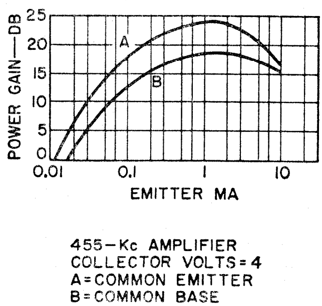


Figure 56. Power gain as a function of emitter current.

as a function of emitter current for a 455-kilocycle amplifier using either common-base or common-emitter configuration.

In high-frequency tuned amplifiers, where the input impedance is typically low, mutual inductive coupling may be impracticable because of the small number of turns in the secondary winding. It is extremely difficult in practice to construct a fractional part of a turn. In such cases, capacitance coupling may be used, as shown in Fig. 57. This arrangement, which is also called **capacitive division,** is similar to tapping down on a coil near resonance. Impedance transformation in this network is determined by the ratio between capacitors C_1 and C_2. Capacitor C_1 is normally much smaller than C_2; thus the capacitive reactance X_{C1} is normally much larger than X_{C2}. Provided the input resistance of the following transistor is much greater than X_{C2}, the effective turns ratio from the top of the coil to the input of the following transistor is $(C_1 + C_2)/C_1$. The total capacitance C_t across the inductance L is given by

$$C_t = \frac{C_1C_2}{C_1 + C_2}$$

The resonant frequency f_r is then given by

$$f_r = \frac{1}{2\pi\sqrt{L_1C_t}}$$

Double-tuned interstage coupling networks are often used in preference to single-tuned networks to provide flatter frequency response within the desired pass band and a sharper drop in response immediately adjacent to the ends of the pass band. In double-tuned networks, both the resonant circuit in the input of the coupling network and the resonant circuit in the output are tuned to the same resonant frequency. In "stagger-tuned" networks, the two resonant circuits are tuned to slightly different resonant frequencies to provide a more rectangular band pass. Double-tuned or stagger-tuned networks may use capacitive, inductive, or mutual inductance coupling, or any combination of the three.

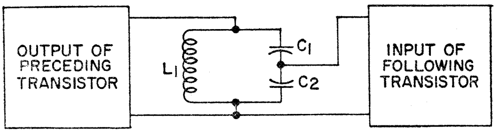


Figure 57. Single-tuned coupling network using capacitive division.

Direct-Coupled Amplifiers

Direct-coupled amplifiers are normally used in transistor circuits to amplify small dc or very-low-frequency ac signals. Typical applications of such amplifiers include the output stages of series-type and shunt-type regulating circuits, chopper-type circuits, differential amplifiers, and pulse amplifiers.

In **series regulator circuits** such as that shown in Fig. 58, direct-coupled amplifiers are used to amplify an

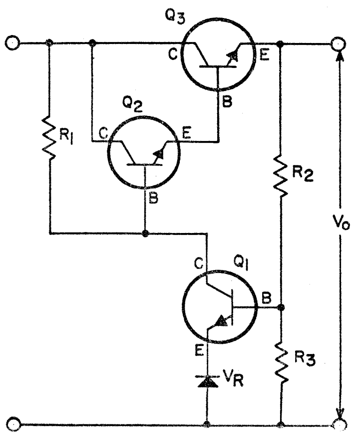


Figure 58. Typical series regulator circuit.

error or difference signal obtained from a comparison between a portion of the output voltage and a reference source. The reference-voltage source V_R is placed in the emitter circuit of the amplifier transistor Q_1 so that the error or difference signal between V_R and some portion of the output voltage V_O is developed and amplified. The amplified error signal forms the input to the regulating element consisting of transistors Q_2 and Q_3, and the output from the regulating element develops a controlling voltage across the resistor R_1.

Shunt regulator circuits are not as efficient as series regulator circuits for most applications, but they have the advantage of greater simplicity. In the shunt voltage regulator circuit shown in Fig. 59, the current

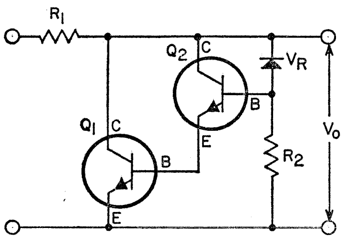


Figure 59. Typical shunt regulator circuit.

through the shunt element consisting of transistors Q_1 and Q_2 varies with changes in the load current or the input voltage. This current variation is reflected across the resistance R_1 in series with the load so that the output voltage V_O is maintained nearly constant.

Direct-coupled amplifiers are also used in **chopper-type** circuits to amplify low-level dc signals, as illustrated by the block diagram in Fig. 60. The dc signal modulates an ac carrier wave, usually a square wave, and the modulated wave is then amplified to a convenient level. The series of amplified pulses can then be detected and integrated into the desired dc output signal.

Differential amplifiers can be used to provide voltage regulation, as described above, or to compensate for fluctuations in current due to signal, component, or temperature variations. Typical differential amplifier elements such as those shown in Fig. 61 include an output stage which supplies current to the load resistor R, and the necessary number of direct-coupled cascaded stages to provide the required amount of gain for a given condition of line-voltage or load-current regulation. The reference-voltage source V_R is placed in one of the cascaded stages in such a manner that an error or difference signal between V_R and some portion of the output voltage V_O is developed and amplified. Some form of temperature compensation is usually included to insure stability of the direct-coupled amplifier.

OSCILLATION

Transistor oscillator circuits are similar in many respects to the tuned amplifiers discussed previously, except that a portion of the output power is returned to the input network in phase with the starting power (regenerative or positive feedback) to sustain oscillation.

DC bias-voltage requirements for oscillators are similar to those dis-

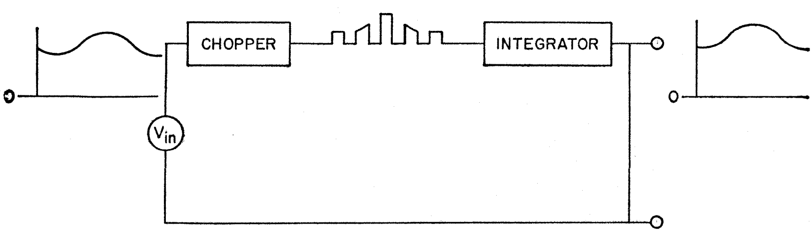


Figure 60. Block diagram showing action of "chopper" circuit.

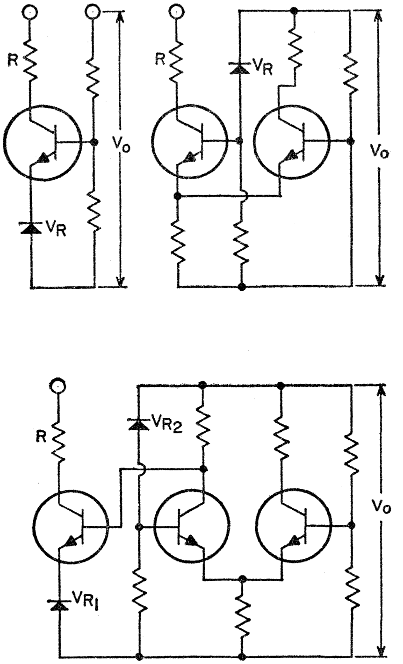


Figure 61. Typical differential amplifier circuits.

cussed for amplifiers. Stabilization of the operating point is important because this point affects both the output amplitude and waveform and the frequency stability. Operation is normally maintained within the linear portion of the transistor characteristic by use of a constant supply voltage. Because the collector-to-emitter capacitance of the transistor affects frequency stability more than other parameters, a relatively large stabilizing capacitor is often used between the collector and emitter terminals to reduce the sensitivity of the circuit to voltage variations and to capacitance variations between transistors.

The maximum operating frequency of an oscillator circuit is limited by the frequency capability of the transistor used. The maximum frequency of a transistor is defined as the frequency at which the power gain is unity (i.e., an input signal appears in the output circuit at the same level, with no loss or gain). Because some power gain is required in an oscillator circuit to overcome losses in the feedback network, the operating frequency must be some value below the transistor maximum frequency.

The transistor configuration selected for an oscillator circuit depends on the oscillator requirements. With the common-base and common-collector configurations, the feedback network must include compensation for the difference between the input and output impedances. Phase inversion is not required, however, because no phase reversal occurs between input and output in these circuits. Voltage and power gains are greater than unity with the common-base circuit, but current gain is less than unity. Current and power gains are greater than unity with the common-collector circuit, but voltage gain is less than unity.

With the common-emitter configuration, current, voltage, and power gains are all greater than unity. This configuration is generally desirable for use in transistor oscillators because it provides highest power gains. The input and output impedances are more closely matched than in the other configurations, but phase inversion is necessary to compensate for the 180-degree phase reversal between input and output circuits. (The phase inversion required in a common-emitter oscillator may be less than 180 degrees, depending on the operating frequency of the circuit. The transistor develops a certain amount of phase shift as the frequency increases, usually in the order of 45 degrees at the beta-cutoff frequency and about 90 degrees at the gain-bandwidth product. The feedback network is required to supply only enough phase inversion to produce a net phase shift of 360 degrees around the entire loop.)

For sustained oscillation in a transistor oscillator, the power gain of the amplifier network must be equal to or greater than unity. When the amplifier power gain becomes less than unity, oscillations become smaller with time (are "damped") until they cease to exist. In practical oscillator circuits, power gains greater than unity are required because the power output is divided between the load and the feedback network, as shown in Fig. 62. The feedback power must be equal to the input power plus the losses in the feedback network to sustain oscillation. For example, if the power gain of the transistor amplifier is 50 and the input power is 2 milliwatts, the total output power is 100 milliwatts. If the losses in the feedback network equal 20 milliwatts, the feedback power must be 2 plus 20, or 22 milliwatts. The power delivered to the load is then 100 minus 22, or 78 milliwatts.

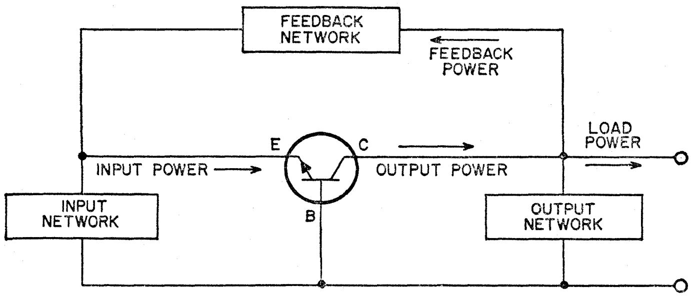


Figure 62. Block diagram of transistor oscillator showing division of output power.

LC Resonant Feedback Oscillators

The frequency-determining elements of an oscillator circuit may consist of an inductance-capacitance (LC) network, a crystal, or a resistance-capacitance (RC) network. Fig. 63a shows a simplified diagram for a transistor oscillator which uses a "tickler" coil L_1 for inductive feedback. (DC bias circuits are omitted for simplicity; as in the case of amplifiers, the emitter-base junction is forward-biased and the collector-base junction is reverse-biased.) The waveforms of ac (instantaneous) emitter current i_e and collector current i_c are shown in Fig. 63b.

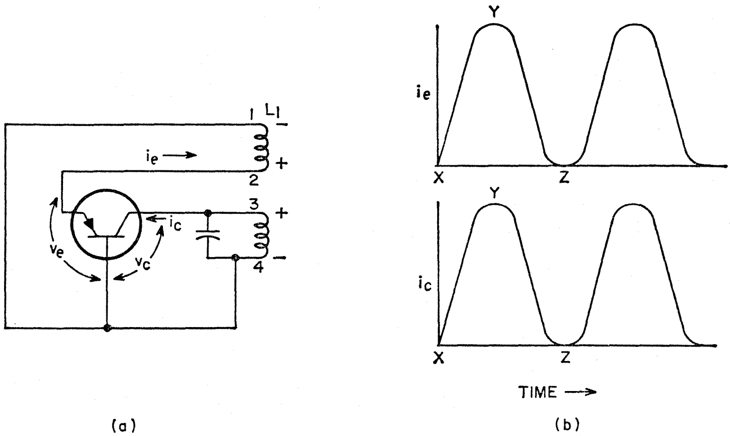


Figure 63. (a) Simplified transistor LC oscillator and (b) corresponding current waveforms.

When the bias conditions of the transistor are normal and input power is applied, current flow in the circuit increases (between points X and Y in Fig. 63b) as a result of the regenerative feedback coupled from the collector circuit to the emitter circuit by the transformer windings (3-4 to 1-2). A point (Y) is reached, however, at which the collector-base junction of the transistor becomes forward-biased (the transistor is saturated), and collector current can no longer increase. The feedback current then reverses, and emitter and collector current decrease (between points Y and Z) until the emitter-base junction becomes reverse-biased (the transistor is cut off). The bias conditions then revert to their original state, and the process is repeated. The time for change from saturation to cutoff is determined primarily by the tuned circuit (tank), which, in turn, determines the frequency of oscillation.

When the common-emitter configuration is used, the tuned circuit may be placed in either the base circuit or the collector circuit. In the tuned-base oscillator shown in Fig. 64, one battery is used to provide all the dc operating voltages for the transistor. Resistors R_1, R_3, and R_4 provide the necessary bias conditions. Resistor R_3 is the emitter stabilizing resistor. The components within the dotted lines comprise the transistor amplifier. The collector shunt-feed arrangement prevents dc current flow through the tickler (primary) winding of transformer T. Feedback is accomplished by the mutual inductance between the transformer windings.

The tank circuit consisting of the secondary winding of transformer T and variable capacitor C_1 is the frequency-determining element of the oscillator. Variable capacitor C_1 permits tuning through a range of frequencies. Capacitor C_2 couples the oscillation signal to the base of the transistor, and also blocks dc. Capacitor C_4 bypasses the ac signal around the emitter resistor R_3 and prevents degeneration. The output signal is coupled from the collector through coupling capacitor C_5 to the load.

A tuned-collector transistor oscillator is shown in Fig. 65. In this circuit, resistors R_1 and R_3 establish the base bias. Resistor R_2 is the emitter stabilizing resistor. Capacitors C_1 and C_2 bypass ac around resistors R_1 and R_2, respectively. Although a series-feed arrangement is shown, a shunt-feed arrangement is also possible with slight circuit modifications. The shunt-feed circuit would be almost identical with the one shown in the tuned-base oscillator in Fig. 64, except for the loca-

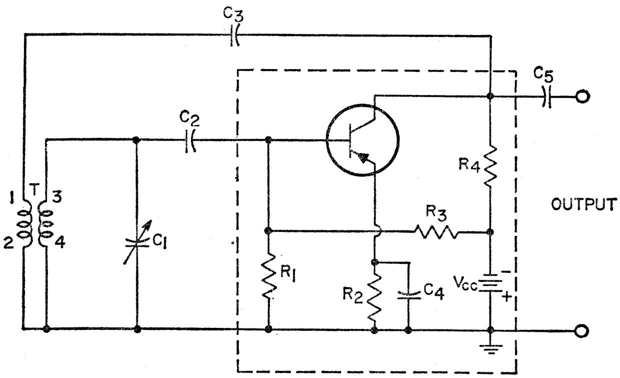


Figure 64. Tuned-base oscillator.

tion of the tank circuit. The tuned circuit consists of the primary winding of transformer T and the variable capacitor C_3. Regeneration is accomplished by coupling the feedback signal from transformer winding 3-4 to the tickler coil winding

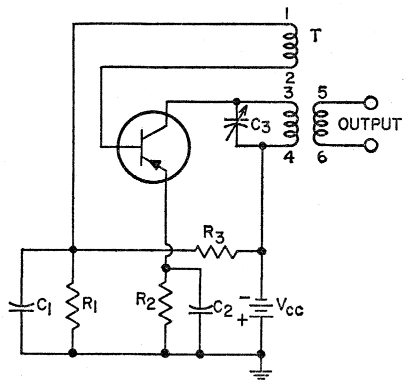


Figure 65. Tuned-collector oscillator.

1-2. The secondary winding of the transformer couples the signal output to the load.

Another form of LC resonant feedback oscillator is the transistor version of the familiar Colpitts oscillator, shown in Fig. 66. Regenera-

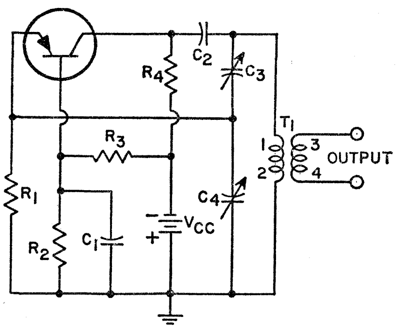


Figure 66. Transistor Colpitts oscillator.

tive feedback is obtained from the tuned circuit consisting of capacitors C_3 and C_4 in parallel with the primary winding of the transformer, and is applied to the emitter of the transistor. Base bias is provided by resistors R_2 and R_3. Resistor R_4 is the collector load resistor. Resistor R_1 develops the emitter input signal and also acts as the emitter stabilizing resistor. Capacitors C_3 and C_4 form a voltage divider; the voltage developed across C_4 is the feedback voltage. The frequency and the amount of feedback voltage can be controlled by adjustment of either or both capacitors. For minimum feedback loss, the ratio of the capacitive reactance between C_3 and C_4 should be approximately equal to the ratio between the output impedance and the input impedance of the transistor.

A Clapp oscillator is a modification of the Colpitts circuit shown in Fig. 66 in which a capacitor is added in series with the primary winding of the transformer to improve frequency stability. When the added capacitance is small compared to the series capacitance of C_3 and C_4, the oscillator frequency is determined by the series LC combination of the transformer primary and the added capacitor.

The Hartley oscillator shown in Fig. 67 is similar to the Colpitts

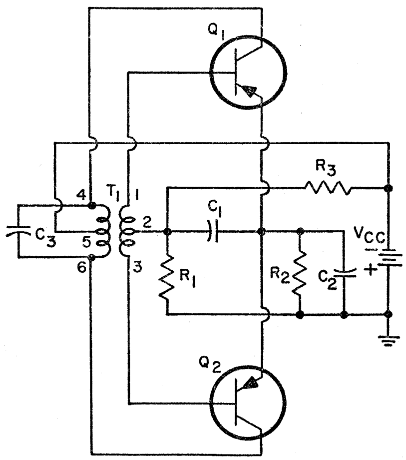


Figure 67. Hartley-type transistor push-pull oscillator.

oscillator, except that a split inductance is used instead of a split capacitance to obtain feedback. The circuit in Fig. 67 is modified for push-pull operation to provide greater output. The regenerative signal is applied between base and emitter of each transistor by means of the induced voltages in the transformer windings 1-3 and 4-6. After the feedback signal is applied to transformer winding 1-3, circuit operation is similar to that of a push-pull amplifier. Capacitor C_1 places terminal 2 of the transformer at ac ground potential through capacitor C_2.

Crystal Oscillators

A quartz crystal is often used as the frequency-determining element in a transistor oscillator circuit because of its extremely high Q (narrow bandwidth) and good frequency stability over a given temperature range. A quartz crystal may be operated as either a series or parallel resonant circuit. As shown in Fig. 68, the electrical equivalent of the mechanical vibrating characteristic of the crystal can be represented by a resistance R, an inductance L, and a capacitance C_s in series. The lowest impedance of the crystal occurs at the series resonant frequency of C_s and L; the resonant frequency of the circuit is then determined only by the mechanical vibrating characteristics of the crystal.

The parallel capacitance C_p shown in Fig. 68 represents the electrostatic capacitance between the crystal electrodes. At frequencies above the

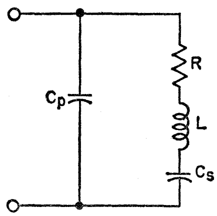


Figure 68. Equivalent circuit of quartz crystal.

series resonant frequency, the combination of L and C_s has the effect of a net inductance because the inductive reactance of L is greater than the capacitive reactance of C_s. This net inductance forms a parallel resonant circuit with C_p and any circuit capacitance across the crystal. The impedance of the crystal is highest at the parallel resonant frequency; the resonant frequency of the circuit is then determined by both the crystal and externally connected circuit elements.

Increased frequency stability can be obtained in the tuned-collector and tuned-base oscillators discussed previously if a crystal is used in the feedback path. The oscillation frequency is then fixed by the crystal. At frequencies above and below the series resonant frequency of the crystal, the impedance of the crystal increases and the feedback is reduced. Thus, oscillation is prevented at frequencies other than the series resonant frequency.

The parallel mode of crystal resonance is used in the Pierce oscillator shown in Fig. 69. (If the crystal

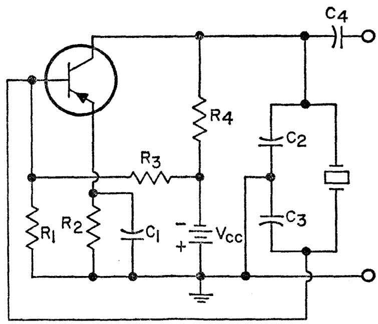


Figure 69. Pierce-type transistor crystal oscillator.

were replaced by its equivalent circuit, the functioning of the oscillator would be analogous to that of the Colpitts oscillator shown in Fig. 67.) The resistances shown in Fig. 69 provide the proper bias and stabilizing conditions for the common-emitter circuit. Capacitor C_1 is the emitter bypass capacitor. The required 180-degree phase inversion of the feedback signal is accomplished through the arrangement of the voltage-divider network C_2 and C_3. The connection between the capacitors is grounded so that the voltage developed across C_3 is applied between base and ground and 180-degree phase reversal is obtained. The oscillating frequency of the circuit is determined by the crystal and the capacitors connected in parallel with it.

RC Resonant Feedback Oscillators

A resistance-capacitance (RC) network is sometimes used in place of an inductance-capacitance network when phase shift is required in a transistor oscillator. In the phase-shift oscillator shown in Fig. 70, the

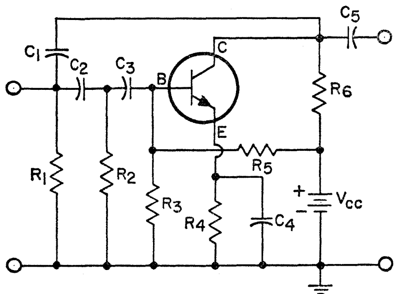


Figure 70. Transistor RS phase-shift oscillator.

RC network consists of three sections (C_1R_1, C_2R_2, and C_3R_3), each of which contributes a phase shift of 60 degrees at the frequency of oscillation. Because the capacitive reactance of the network increases or decreases at other frequencies, the 180-degree phase shift required for the common-emitter oscillator occurs only at one frequency; thus, the output frequency of the oscillator is fixed. Phase-shift oscillators may be made variable over particular frequency ranges by the use of ganged variable capacitors or resistors in the RC networks. More than three sections may be used in the phase-shifting networks to reduce feedback losses.

An RC network is also used in the Wien-bridge oscillator shown in Fig. 71 to provide a sinusoidal output. In this circuit, transistor Q_2 functions as an amplifier and phase inverter. The feedback voltage developed between the collector of Q_2 and ground is impressed across the entire bridge network. The voltage developed across capacitor C_2 is regenerative (positive), and is applied to the input circuit of transistor Q_1. Because this voltage is in phase with the input signal only at the resonant frequency, the magnitude of the positive feedback is reduced at other frequencies.

Negative feedback (degeneration) is applied to the emitter of Q_1 through resistor R_2 to improve frequency stability and to minimize distortion. R_2 normally provides greater negative feedback at frequencies other than the resonant frequency.

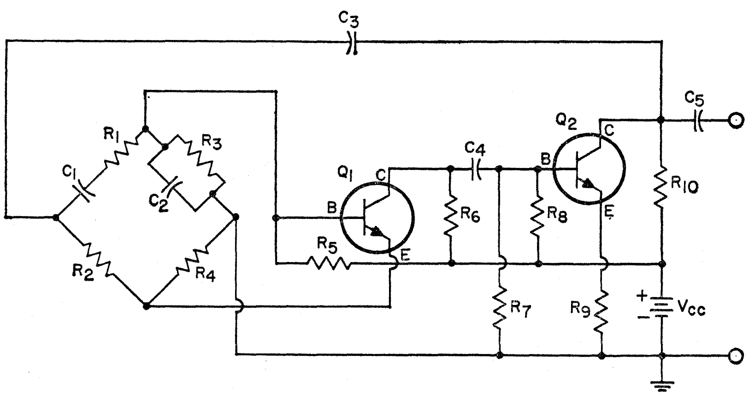


Figure 71. Wein-bridge-type transistor oscillator.

Therefore, at other frequencies the negative feedback exceeds the positive feedback and a highly stable oscillator results.

The resonant frequency f_r of the oscillator is determined by capacitors C_1 and C_2 and resistors R_1 and R_3, as follows:

$$f_r = \frac{1}{2\pi\sqrt{R_1C_1R_3C_2}}$$

If resistor R_1 is made equal to R_3, and capacitor C_1 to capacitor C_2, this expression reduces to

$$f_r = \frac{1}{2\pi R_1C_1}$$

Either capacitors C_1 and C_2 or resistors R_1 and R_3 may be made variable to provide a variable-frequency oscillator.

Nonsinusoidal Oscillators

Oscillator circuits which produce nonsinusoidal output waveforms are generally classified as **relaxation oscillators.** This type of oscillator uses a regenerative circuit in conjunction with resistance-capacitance (RC) or resistance-inductance (RL) components to produce a switching action. The charge and discharge times of the reactive elements (R x C or L/R) are used to produce sawtooth, square, or pulse output waveforms.

A **multivibrator** is essentially a nonsinusoidal two-stage oscillator in which one stage conducts while the other is cut off until a point is reached at which the conditions of the stages are reversed. This type of oscillator is normally used to produce a square-wave output. In the RC-coupled common-emitter multivibrator shown in Fig. 72, the output of transistor Q_1 is coupled to the input of transistor Q_2 through the feedback network R_3C_2, and the output of Q_2 is coupled to the input of Q_1 through the feedback network R_6C_3. Because the feedback in each case is in phase with the signal on the base electrode, oscillations can be sustained.

In the multivibrator circuit, an increase in the collector current of transistor Q_1 causes a decrease in the collector voltage, and a corresponding reduction in the regenerative feedback through capacitor C_2 to the base of transistor Q_2. As a result, the current through Q_2 decreases steadily as the current through Q_1 increases, until a point is reached where Q_2 is cut off. Capacitor C_2 then discharges through resistor R_3 until forward bias is reestablished across the base-emitter junction of Q_2. Current through Q_2 then increases, while current through Q_1 decreases until Q_1 is cut off. The oscillating frequency of the multivibrator is determined by the values of resistance and capacitance in the circuit.

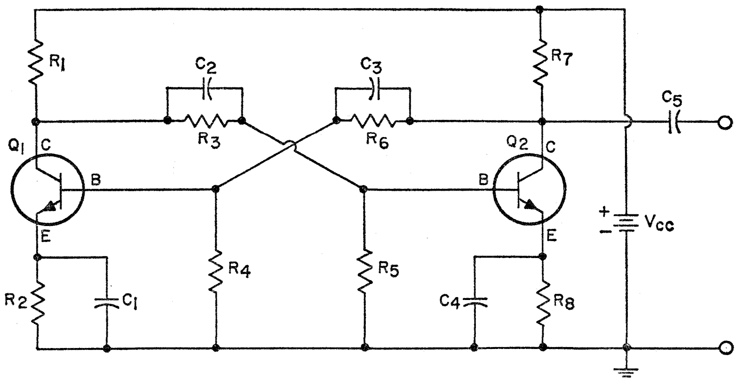


Figure 72. RC-coupled common-emitter multivibrator.

The output signal is coupled through capacitor C_5 to the load. The output waveform, which is essentially square, may be obtained from either collector. A sawtooth output can be obtained by connection of a capacitor from collector to ground. A sinusoidal output wave can be obtained by connection of a parallel tuned circuit between the base electrodes of the two transistors.

A **blocking oscillator** is a form of nonsinusoidal oscillator which conducts for a short period of time and is cut off (blocked) for a much longer period. A basic circuit for this type of oscillator is shown in Fig. 73.

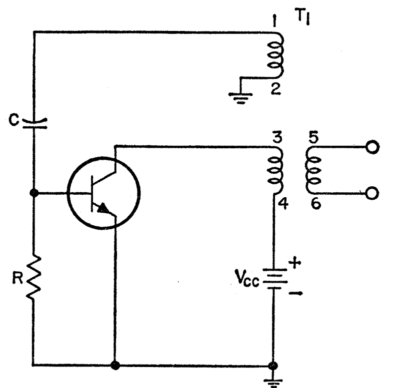


Figure 73. Basic circuit of blocking oscillator.

Regenerative feedback through the tickler-coil winding 1-2 of transformer T_1 and capacitor C causes current through the transistor to rise rapidly until saturation is reached. The transistor is then cut off until C discharges through resistor R. The output waveform is a pulse, the width of which is primarily determined by winding 1-2. The time between pulses (resting or blocking time) is determined by the time constant of capacitor C and resistor R.

SWITCHING

Transistors are often used in pulse and switching circuits in radar, television, telemetering, pulse-code communication, and computing equipment. These circuits act as generators, amplifiers, inverters, frequency dividers, and wave-shapers to provide limiting, triggering, gating, and signal-routing functions. These applications are normally characterized by large-signal or nonlinear operation of the transistor.

In large-signal operation, the transistor acts as an overdriven amplifier which is driven from the cutoff region to the saturation region. In the simple transistor-switching circuit shown in Fig. 74, the collector-base junction is reverse-biased by battery V_{CC}

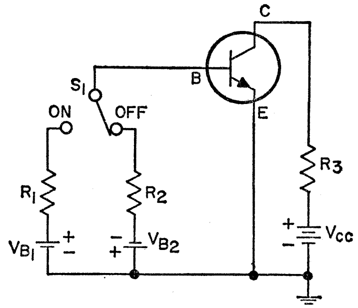


Figure 74. Simple switching circuit.

through resistor R_3. Switch S_1 controls the polarity and amount of base current from battery V_{B1} or V_{B2}. When S_1 is in the OFF position, the emitter-base junction of the transistor is reverse-biased by battery V_{B2} through the current-limiting resistor R_2. The transistor is then in the OFF (cutoff) state. (Normal quiescent conditions for a transistor switch in the cutoff region require that both junctions be reverse-biased.)

When the switch is in the ON position, forward bias is applied to the emitter-base junction by battery V_{B1} through the current-limiting resistor R_1. The base current and collector current then increase rapidly until the transistor reaches saturation. The active linear region is called the transition region in switching operation because the signal passes through this region rapidly.

In the saturation region, the collector current is usually at a maximum and collector voltage at a minimum. This value of collector voltage is referred to as the saturation voltage, and is an important characteristic of the transistor. A transistor operating in the saturation region is in the ON (conducting) state. (Both junctions are forward-biased.)

Regions of operation are similar for all transistor configurations used as switches. When both junctions of the transistor are reverse-biased (cutoff condition), the output current is very small and the output voltage is high. When both junctions are forward-biased (saturation condition), the output current is high and the output voltage is small. For most practical purposes, the small output current in the cutoff condition and the small output voltage in the saturated condition may be neglected.

Switching Times

When switch S_1 in Fig. 74 is operated in sequence from OFF to ON and then back to OFF, the current pulses shown in Fig. 75 are obtained. The rectangular input current

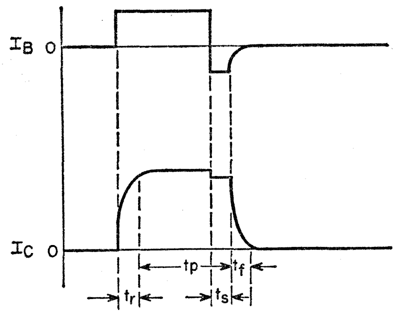


Figure 75. Current waveforms obtained in switching circuit.

pulse I_B drives the transistor from cutoff to saturation and back to cutoff. The output current pulse I_C is distorted because the transistor cannot respond instantaneously to a change in signal level. The response of the transistor during the rise time t_r and the fall time t_f is called the transient response, and is essentially determined by the transistor characteristics in the active linear region.

The **delay time** t_d is the length of time that the transistor remains cut off after the input pulse is applied. This finite time is required before the applied forward bias overcomes the emitter depletion capacitance of the transistor and collector current begins to flow.

The **rise time** t_r (which is also referred to as build up time) is the time required for the leading edge of the pulse to increase in amplitude from 10 to 90 per cent of its maximum value. Rise time can be reduced by overdriving the transistor, but only small amounts of overdrive are normally used because turn-off time (storage time plus fall time) is also affected.

The **pulse time** t_p (or pulse duration) is the length of time that the pulse remains at, or very near, its maximum value. Pulse time duration is measured between the points on the leading edge and on the trailing edge where the amplitude is 90 per cent of the maximum value.

The **storage time** t_s is the length of time that the output current I_C remains at its maximum value after the input current I_B is reversed. The length of storage time is essentially governed by the degree of saturation into which the transistor is driven and by the amount of reverse (or turn-off) base current supplied.

The **fall time** t_f (or decay time) of the pulse is the time required for the trailing edge to decrease in amplitude from 90 to 10 per cent of its maximum value. Fall time may be reduced by the application of a reverse current at the end of the input pulse.

The total **turn-on** time of a transistor switch is the sum of the delay time and the rise time. The total **turn-off** time is the sum of the storage time and the fall time. A reduction in either storage time or fall time decreases turn-off time and increases the usable pulse repetition rate of the circuit.

Triggered Circuits

When an externally applied signal is used to cause an instantaneous change in the operating state of a transistor circuit, the circuit is said to be triggered. Such circuits may be astable, monostable, or bistable. **Astable** triggered circuits have no stable state; they operate in the active linear region, and produce relaxation-type oscillations. A **monostable** circuit has one stable state in either of the stable regions (cutoff or saturation); an external pulse "triggers" the transistor to the other stable region, but the circuit then switches back to its original stable state after a period of time determined by the time constants of the circuit elements. A **bistable (flip-flop)** circuit has two stable states in the two stable regions. The transistor is triggered from one stable state to the other by an external pulse, and a second trigger pulse is required to switch the circuit back to its original stable state.

The multivibrator circuit shown in Fig. 76 is an example of a monostable circuit. The bias network holds

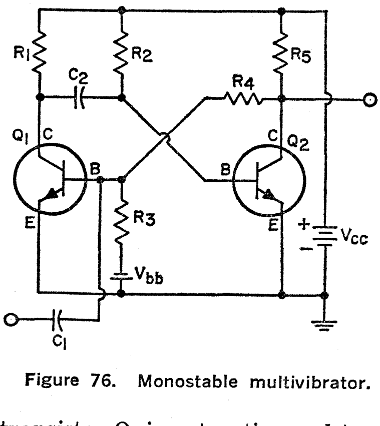


Figure 76. Monostable multivibrator.

transistor Q_2 in saturation and transistor Q_1 at cutoff during the quiescent or steady-state period. When an input signal is applied through the coupling capacitor C_1, however, transistor Q_1 begins to conduct. The decreasing collector voltage of Q_1 (coupled to the base of Q_2 through capacitor C_2) causes the base current and collector current of Q_2 to decrease. The increasing collector voltage of Q_2 (coupled to the base of Q_1 through resistor R_4) then increases the forward base current of Q_1. This regeneration rapidly drives transistor Q_1 into saturation and transistor Q_2 into cutoff. The base of transistor Q_2 at this point is at a negative potential almost equal to the magnitude of the battery voltage V_{cc}.

Capacitor C_2 then discharges through resistor R_2 and the low saturation resistance of transistor Q_1. As the base potential of Q_2 becomes slightly positive, transistor Q_2 again conducts. The decreasing collector potential of Q_2 is coupled to the base of Q_1 and transistor Q_1 is driven into cutoff, while transistor Q_2 becomes saturated. This stable condition is maintained until another pulse triggers the circuit. The duration of the output pulse is primarily determined by the time constant of capacitor C_2 and resistor R_2 during discharge.

The Eccles-Jordan-type multivibrator circuit shown in Fig. 77 is an example of a bistable circuit. The resistive and bias values of this circuit are chosen so that the initial application of dc power causes one transistor to be cut off and the other to be driven into saturation. Because of the feedback arrangement, each transistor is held in its original state by the condition of the other. The application of a positive trigger pulse to the base of the OFF transistor or a negative pulse to the base of the ON transistor switches the conducting state of the circuit. The new condition is then maintained until a second pulse triggers the circuit back to the original condition.

In Fig. 77, two separate inputs are shown. A trigger pulse at input A will change the state of the circuit. An input of the same polarity at input B or an input of opposite polarity at input A will then return the circuit to its original state. (Collector triggering can be accomplished in a similar manner.) The time constants of C_3R_2 and of C_4R_5 essentially deter-

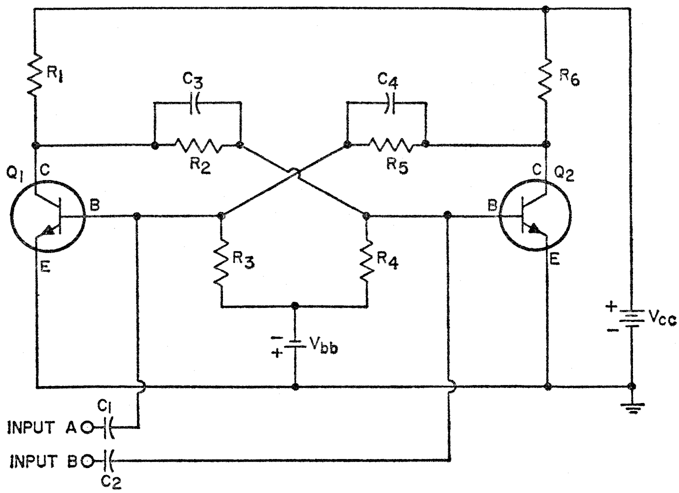


Figure 77. Eccles-Jordan-type bistable multivibrator.

mine the fall time (from conduction to cutoff) of transistors Q_1 and Q_2, respectively. The output of the circuit is a unit step voltage when one trigger is applied, or a square wave when continuous pulsing of the input is used.

A type of high-speed switching transistor which is particularly suitable for use in triggered circuits is called the **thyristor.** Thyristors can function in a manner similar to that of conventional high-speed transistors at collector currents below a critical "breakover" value. At this critical value of collector current (breakover point), the thyristor switches to a high-conductance stable state. It then remains ON even though the triggering voltage to the base is removed. However, it can be turned off readily by the application of a reverse triggering current to the base without removal of the collector voltage. This feature permits the use of a single thyristor in the design of multivibrators in place of two conventional transistors. Fig. 78 shows a typical "set-reset" flip-flop circuit using a thyristor.

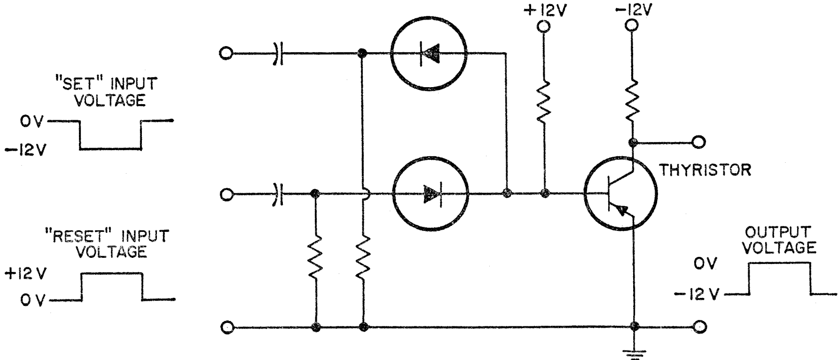


Figure 78. Thyristor "flip-flop" circuit.

Gating Circuits

A transistor switching circuit in which the transistor operates as an effective open or short circuit is called a "gate". These circuits are used extensively in computer applications to provide a variety of functions such as circuit triggering at prescribed intervals and level and waveshape control. Because these circuits are designed to evaluate input conditions to provide a predetermined output, they are primarily used as **logic circuits.** Logic circuits include OR, AND, NOR (NOT-OR), NAND (NOT-AND), series (clamping), and shunt or inhibitor circuits.

An OR gate has more than one input, but only one output. It provides a prescribed output condition when one or another prescribed input condition exists. In the simple OR gate shown in Fig. 79, the high resistance of R_1 and R_2 isolates one input source from the other. When a negative input pulse is applied at either input resistor, a negative output pulse is obtained. Application of negative pulses to both inputs results only in widening of the output pulse. If a common-emitter configuration is used instead of the common-base configuration, phase inversion of the signal results, and the OR gate becomes a NOT-OR (NOR) gate.

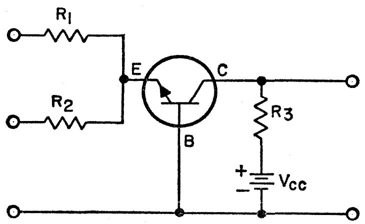


Figure 79. Simple OR-type logic circuit.

An AND gate also has more than one input, but only one output. However, it provides an output only when all the inputs are applied simultaneously. As in the case of the OR gate, the use of a common-emitter configuration provides phase inversion and provides a NOT-AND (NAND) gate. In the simple NAND gate shown in Fig. 80, forward (saturation) bias is provided by battery V_{bb}. The bias value is chosen so that saturating current continues to flow when only one input pulse is applied, and both input pulses are required to turn the transistor off.

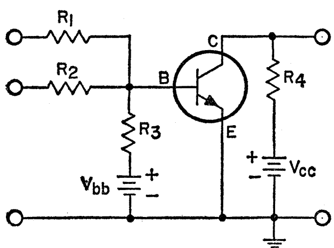


Figure 80. Simple NAND circuit.

The AND-OR gate shown in Fig. 81 illustrates the use of a direct-coupled transistor logic circuit to trigger a bistable multivibrator. The over-all gating function, which consists of a NAND function and a NOR function, is performed by transistors Q_1, Q_2, and Q_3. Transistor Q_4 is part of the bistable multivibrator.

Transistors Q_1 and Q_2 are series-connected and form a NAND gate.

Similarly, transistors Q_1 and Q_3 are series-connected and form a NAND gate. Transistors Q_2 and Q_3 are parallel-connected and form a NOR gate. conditions for either of the NAND gates are met, i.e., when either transistors Q_1 and Q_2 or transistors Q_1 and Q_3 are triggered into conduction.

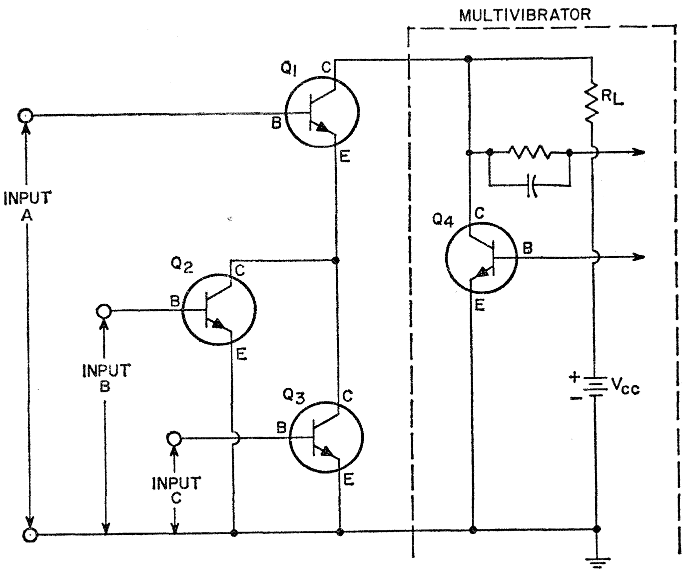


Figure 81. AND-OR gate or trigger circuit.

Reverse collector bias for all transistors is provided by battery V_{cc}. Provided all transistors are cut off (quiescent condition), triggering of the bistable multivibrator is accomplished when the prescribed input

Gating circuits are also used as amplitude discriminators (limiters), clippers, and clamping circuits, and as signal-shunting or transmission gates.

SILICON RECTIFIERS

SILICON rectifiers, like other semiconductor diodes, are essentially cells containing a simple p-n junction. As a result, they have low resistance to current flow in one (forward) direction, but high resistance to current flow in the opposite (reverse) direction. They can be operated at ambient temperatures up to 200 degrees centigrade and at current levels as high as 40 amperes, with voltage levels as high as 1000 volts. In addition, they can be used in parallel or series arrangements to provide higher current or voltage capabilities.

Because of their high forward-to-reverse current ratios, silicon rectifiers can achieve rectification efficiencies in the order of 99 per cent. When properly used, they have excellent life characteristics which are not affected by aging, moisture, or temperature. They are very small and light-weight, and can be made impervious to shock and other severe environmental conditions.

THERMAL CONSIDERATIONS

Although rectifiers can operate at high temperatures, they are sensitive to sudden temperature changes because of the extremely small crystals used in their structure. The thermal capacity of a silicon rectifier is quite low, and the junction temperature rises rapidly during high-current operation. Sudden rises in junction temperature caused by either high currents or excessive ambient-temperature conditions can cause failure. (A silicon rectifier is considered to have failed when either the forward voltage drop or the reverse current has increased to a point where the crystal structure or surrounding material breaks down.) Consequently, temperature effects are very important in the consideration of silicon rectifier characteristics.

REVERSE CHARACTERISTICS

When a reverse-bias voltage is applied to a silicon rectifier, a limited amount of reverse current (usually measured in microamperes, as compared to milliamperes or amperes of forward current) begins to flow. As shown in Fig. 82, this reverse current flow increases slightly as the bias voltage increases, but then tends

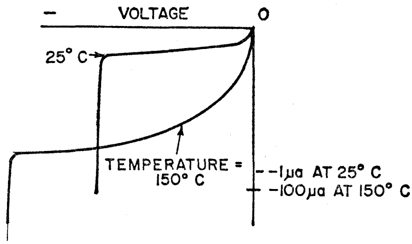


Figure 82. Typical reverse characteristics.

to remain constant even though the voltage continues to increase significantly. However, an increase in operating temperature multiplies the reverse current considerably for a given reverse bias.

At a specific reverse voltage (which varies for different types of diodes), a very sharp increase in reverse current occurs. This voltage is called the breakdown or avalanche (or zener) voltage. In many applications, rectifiers can operate safely at the avalanche point. If the reverse voltage is increased beyond this point, however, or if the ambient temperature is raised sufficiently (for example, a rise from 25 to 150 degrees centigrade increases the current by a factor of several hundred), "thermal runaway" results and the diode may be destroyed.

FORWARD CHARACTERISTICS

A silicon rectifier usually requires a forward voltage of 0.4 to 0.7 volt (depending upon the temperature and the impurity concentration in the p-type and n-type materials) to overcome the potential barrier at the p-n junction. As shown in Fig. 83, a slight rise in voltage beyond this point increases the forward current

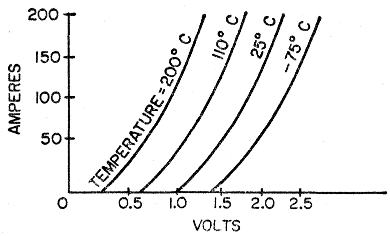


Figure 83. Typical forward characteristics.

sharply. Because of the small mass of the silicon rectifier, the forward voltage drop must be carefully controlled so that the specified maximum value for the device is not exceeded. Otherwise, the diode may be seriously damaged or destroyed.

Fig. 83 shows the effects of an increase in temperature on the forward-current characteristic of a silicon rectifier. In certain applications, close control of ambient temperature is required for satisfactory operation. Close control is not usually required, however, in power circuits.

RATINGS

Ratings for silicon rectifiers are determined by the manufacturer on the basis of extensive reliability testing. One of the most important ratings is the maximum **peak reverse voltage** (PRV), i.e., the highest amount of reverse voltage which can be applied to a specific rectifier before the avalanche breakdown point is reached. PRV ratings range from about 50 volts to as high as 1000 volts for some single-junction diodes. As will be discussed later, several junction diodes can be connected in series to obtain the PRV values required for very-high-voltage power-supply applications.

Three current ratings are usually given for silicon rectifiers: the **maximum average forward current,** the **peak recurrent forward current,** and the **maximum surge current.** As shown in Fig. 84, the first of these currents refers to the maximum average value of current which is allowed to flow in the forward direction for a specified ambient or case temperature. Typical average current outputs range from 0.5 ampere to as high as 40 amperes for single silicon diodes.

The peak recurrent forward current is the maximum repetitive instantaneous forward current permitted under stated conditions. The maximum surge current is the maximum non-repetitive peak current of a single forward cycle. The surge, or **fault,** current is permitted for only a very short time interval (about eight

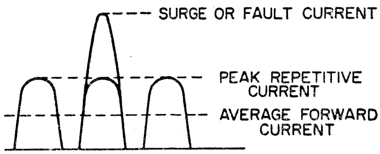


Figure 84. Representation of rectifier currents.

milliseconds). Surge currents generally occur when the equipment is first turned on, or when unusual voltage transients are introduced in the ac supply line. Protection against excessive currents of this type can be provided in various ways, as will be discussed later.

Because these maximum current ratings are all affected by thermal variations, ambient-temperature conditions must be considered in the application of silicon rectifiers. Temperature-rating charts are usually provided to show the percentage by which maximum currents must be decreased for operation at temperatures higher than normal room temperature (25 degrees centigrade).

HEAT SINKS

Silicon rectifiers are often mounted on devices called "heat sinks". A heat sink generally consists of a relatively large metal plate attached to the heat-conducting side of the rectifier. Because of its large surface, a heat sink can readily dissipate heat and thereby safeguard the rectifier against damage.

The size of a heat sink for a given rectifier application depends upon the ambient temperature and the maximum average forward current of the rectifier. As a result, the actual size must be calculated for each application which involves an ambient temperature or forward current other than that recommended by the manufacturer. For this calculation, two charts are used: the current-multiplying-factor chart shown in Fig. 85,

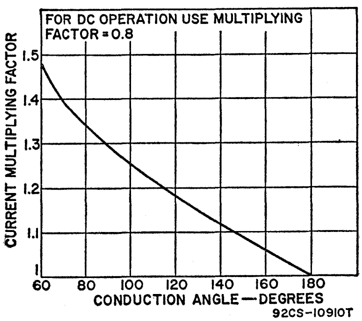


Figure 85. Current-multiplying-factor chart.

and the heat-sink cooling chart shown in Fig. 86. Fig. 85 applies to all rectifier types for both polyphase and dc operation; Fig. 86 differs for different rectifier types.

The calculation requires four steps:

1. From Fig. 85, the current-multiplying factor is determined for the applicable conduction angle (i.e., the fraction of the ac input cycle during which forward current is expected to flow in the particular application). For dc operation of a silicon rectifier, a multiplying factor of 0.8 is generally specified.

2. The desired output current (expressed in amperes) is divided by the number of current paths. The actual number of paths depends on the type of operation intended, and can be determined from the table below.

Type of Operation	Number of Current Paths
Single-Phase, Full-Wave:	
Center-Tapped	2
Bridge	2
Three-Phase:	
Y	3
Double Y	6
Bridge	3
Six-Phase Star	6

The resulting figure is the average forward current of the rectifier.

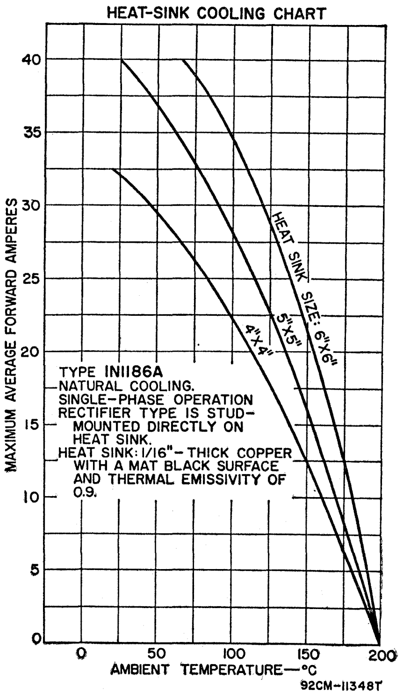


Figure 86. Typical heat-sink cooling chart.

3. The average current is then multiplied by the current-multiplying factor obtained in Step 1. The resulting figure represents the adjusted average forward current of the rectifier.

4. This adjusted current is applied to Fig. 86 to determine either the maximum allowable ambient temperature for a given heat-sink size or the minimum heat-sink size for a given ambient temperature. (Published data may also include a chart similar to Fig. 86 for forced-air-cooling applications.)

The following example illustrates the calculation of minimum heat-sink size for a three-phase, half-wave (Y) circuit. The conduction angle is 120 degrees, the desired output current is 90 amperes, and the ambient temperature is 90 degrees centigrade.

1. From Fig. 85, the current-multiplying factor for a conduction angle of 120 degrees is 1.18.

2. For three-phase half-wave operation, the number of current paths is 3. The average forward current through the rectifier, therefore, is 90 divided by 3, or 30 amperes.

3. This average forward current is then multiplied by the current-multiplying factor (1.18) obtained in Step 1 to provide an adjusted forward current of 35.4 amperes.

4. From Fig. 86, the minimum heat-sink size for the above conditions is found to be 6 by 6 inches.

SERIES AND PARALLEL ARRANGEMENTS

Series arrangements of silicon rectifiers are used when the applied reverse voltage is expected to be greater than the maximum peak reverse voltage rating of a single silicon rectifier (or cell). For example, four rectifiers having a maximum reverse voltage rating of 200 volts each could be connected in series to handle an applied reverse voltage of 800 volts.

In a series arrangement, the most important consideration is that the applied voltage be divided equally across the individual rectifiers. If the instantaneous voltage is not uniformly divided, one of the rectifiers may be subjected to a voltage greater than its specified maximum reverse voltage, and, as a result, may be destroyed. Uniform voltage division can usually be assured by connection of either resistors or capacitors in parallel with individual cells. Shunt resistors are used in steady-state applications, and shunt capacitors in applications in which transient voltages are expected. Both resistors and capacitors should be used if the circuit is to be exposed to both dc and ac components.

A parallel arrangement of rectifiers can be used when the maximum average forward current required is larger than the maximum current rating of an individual rectifier cell. To avoid differences in voltage across the parallel rectifiers, it is desirable to add either a resistor or an inductor in series with each cell. Balanced transformers or separate transformer windings can be used for this purpose. Although resistors are considered the simplest method of current division, individual inductors in series with each cell are more efficient because they do not consume as much power as the resistor arrangement.

Parallel rectifier arrangements are not in general use. Designers normally use a polyphase arrangement to provide higher currents, or simply substitute the readily available higher-current rectifier types.

OVERLOAD PROTECTION

In the application of silicon rectifiers, it is necessary to guard against both over-voltage and over-current (surge) conditions. A voltage surge in a rectifier arrangement can be caused by dc switching, reverse recovery transients, transformer switching, inductive-load switching, and various other causes. The effects of such surges can be reduced by the use of a capacitor connected across the input or the output of the rectifier. In addition, the magnitude of the voltage surge can be reduced by changes in the switching elements or the sequence of switching, or by a reduction in the speed of current interruption by the switching elements.

In all applications, a rectifier having a more-than-adequate peak reverse voltage rating should be used. The safety margin for reverse voltage usually depends on the application. For a single-phase half-wave application using switching of the transformer primary and having no transient suppression, a rectifier having a peak reverse voltage three or four times the expected working voltage should be used. For a full-wave bridge using load switching and having adequate suppression of transients, a margin of 1.5 to 1 is generally acceptable.

Because of the small size of the silicon rectifier, excessive surge currents are particularly harmful to rectifier operation. Current surges may be caused by short circuits, capacitor inrush, dc overload, or failure of a single cell in a multiple arrangement. In the case of low-power cells, fuses or circuit breakers are often placed in the ac input circuit to the rectifier to interrupt the fault current before it damages the rectifier. When circuit requirements are such that service must be continued in case of failure of an individual diode, a number of cells can be used in parallel, each with its own fuse. Additional fuses should be used in the ac line and in series with the load for protection against dc load faults. In high-power cells, an arrangement of circuit breakers, fuses, and series resistances is often used to reduce the amplitude of the surge current.

APPLICATIONS

Silicon rectifiers are used in a continually broadening range of applications. Originally developed for use in such equipment as dc-to-dc converters, battery chargers, mobile power supplies, transmitters, and electroplating devices, silicon rectifiers are also used in power supplies for radio and television receivers and phonograph amplifiers, as well as in such applications as in-line-type modulators, hold-off and charging diodes, pulse-forming networks, and brushless alternators. They are also being used in many aircraft applications because of their small size, light weight, and high efficiency.

The most suitable type of rectifier circuit for a particular application depends on the dc voltage and current requirements, the amount of rectifier **"ripple"** (undesired fluctuation in the dc output caused by an ac component) that can be tolerated in the circuit, and the type of ac power available. Figs. 87 through 93 show seven basic rectifier configurations. (Filters used to smooth the rectifier output are not shown for each circuit, but are discussed later.) Figs. 87 through 93 also include the output-voltage waveforms for the various circuits and the current waveforms for each individual rectifier cell in the circuits. Ideally, the voltage waveform should be as flat as possible (i.e., approaching almost pure dc). A flat curve indicates a peak-to-average voltage ratio of one. In the case of the current waveform, the smaller the current flowing through the individual rectifier, the

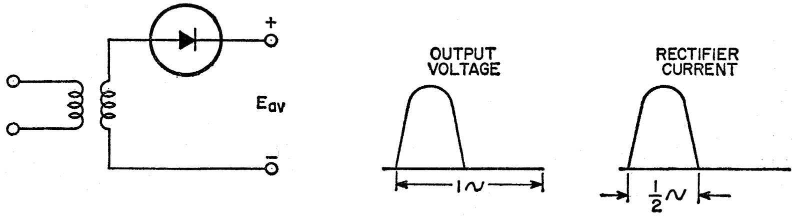


Figure 87. Single-phase half-wave circuit.

less chance there is for malfunction or burnout of the cell.

The **half-wave single-phase** circuit shown in Fig. 87 delivers only one pulse of current for each cycle of ac input voltage. As shown by the current waveform, the single rectifier cell is exposed to the entire current flow. This type of circuit, which contains a very high percentage of output ripple, is used principally in low-voltage high-current applications and in low-current high-voltage applications.

Fig. 88 shows a **single-phase full-wave** circuit with a center-tapped high-voltage winding. This circuit has a higher peak-to-average voltage ratio than the circuit of Fig. 87, and about 50 per cent less ripple. This type of circuit is widely used in television receivers and large audio amplifiers.

The **single-phase full-wave bridge** circuit shown in Fig. 89 uses four rectifiers, and does not require the use of a transformer center-tap. It supplies twice as much output voltage as the circuit of Fig. 88 for the same transformer voltage. In addition, it exposes the individual rectifier cell to only half as much peak reverse voltage, and allows only 50 per cent of the total current to flow through each cell. This type of circuit is popular in amateur transmitter use.

The three-phase circuits shown in Figs. 90 through 93 are usually found in heavy industrial equipment such as high-power transmitters. The **three-phase (Y) half-wave** circuit shown in Fig. 90 uses three rectifier cells. This circuit has considerably less ripple than the circuits discussed above. In addition, it allows only one-third of the total current to flow through each rectifier cell. This type of circuit is used in alternator rectifiers in automobiles.

Fig. 91 shows a **three-phase (Y) full-wave bridge** circuit which uses a total of six rectifier cells. In this arrangement, two half-wave rectifiers are connected in series across each leg of a high-voltage transformer. This circuit delivers twice as much voltage output as the circuit of Fig. 90 for the same voltage condi-

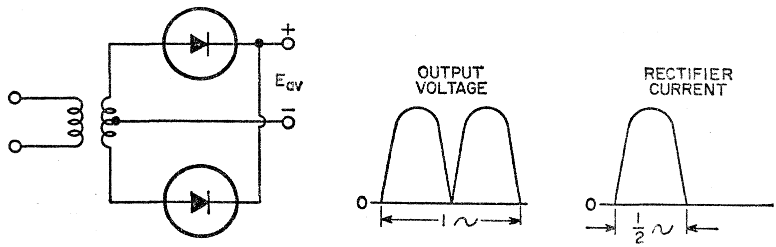


Figure 88. Single-phase full-wave circuit with center-tap.

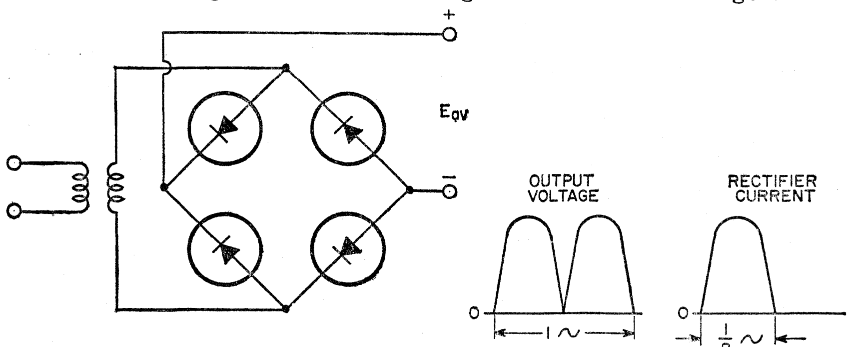


Figure 89. Single-phase full-wave circuit without center-tap.

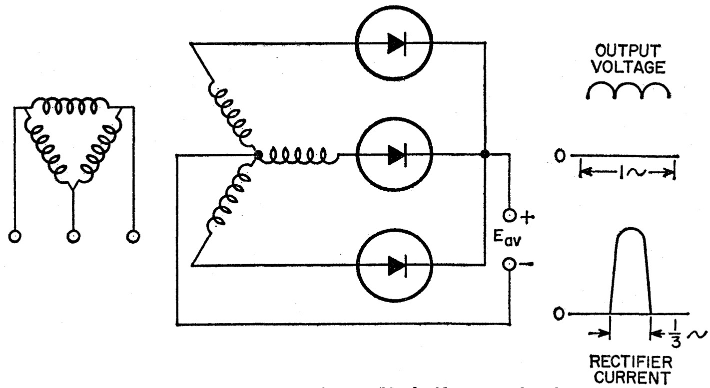


Figure 90. Three-phase (Y) half-wave circuit.

tions. In addition, this circuit, as well as the two shown on page 55, has an extremely small percentage of ripple and a very low ratio of peak-to-average voltage.

The **six-phase "star"** circuit shown in Fig. 92, which also uses six rectifier cells, allows the least amount of the total current (one-sixth) to flow through each cell. The **three-phase double-Y and interphase transformer** circuit shown in Fig. 93 uses six half-wave rectifiers in parallel. This arrangement delivers six current pulses per cycle and twice as much output current as the circuit shown in Fig. 90.

Table I lists voltage and current ratios for the circuits shown in Figs. 87 through 93 for an inductive load. These ratios apply for sinusoidal ac input voltages. It is generally recommended that inductive loads rather than resistive loads be used for filtering of rectifier current, except for the circuit of Fig. 87. Current ratios given for inductive loads apply only when a filter choke is used between the output of the rectifier and any capacitor in the filter circuit. Values shown do not take into consideration voltage drops which occur in the power transformer, the silicon rectifiers, or the filter components under load conditions. When a particular rectifier type has been selected for use in a specific circuit, Table I can be used to determine the parameters and characteristics of the circuit.

In Table I, all ratios are shown as functions of either the average output voltage E_{av} or the average dc output current I_{av}, both of which are expressed as unity for each circuit. In practical applications, the magni-

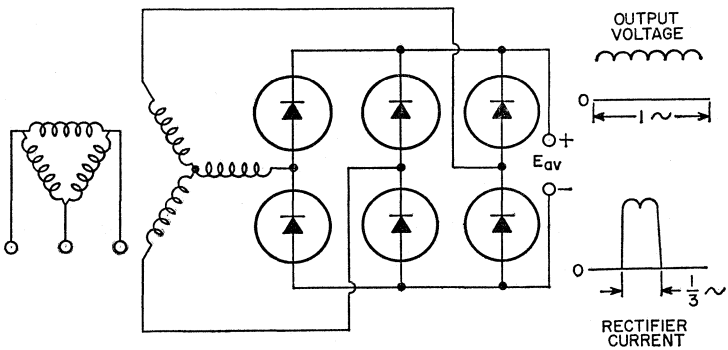


Figure 91. Three-phase (Y) full-wave bridge circuit.

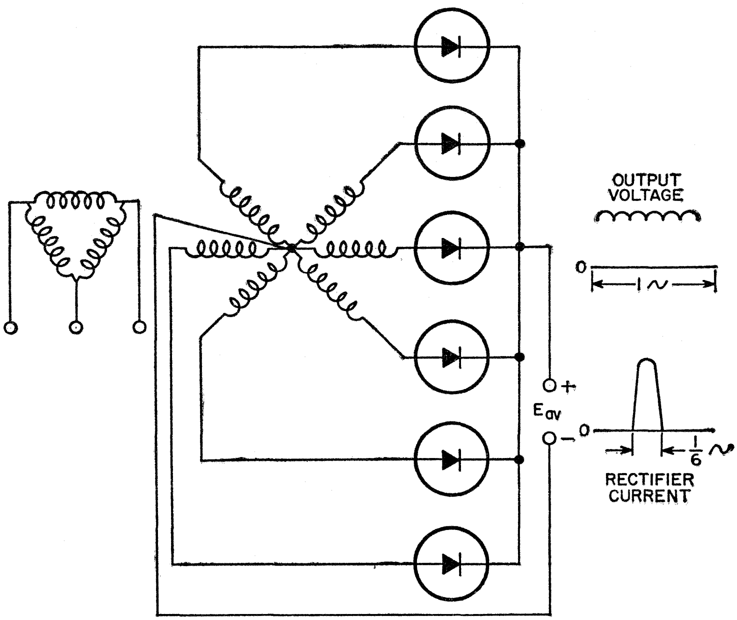


Figure 92. Six-phase "star" circuit.

tudes of these average values will, of course, vary for the different circuit configurations.

Filter circuits are generally used to smooth out the ac ripple in the output of a rectifier circuit. A smooth-

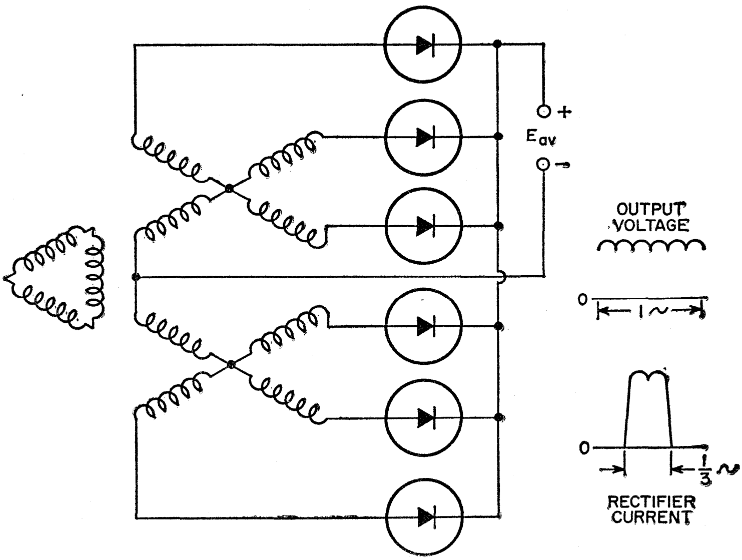


Figure 93. Three-phase double-Y and interphase transformer circuit.

CIRCUIT RATIOS:							
Output Voltage	*Fig. 6*	*Fig. 7*	*Fig. 8*	*Fig. 9*	*Fig. 10*	*Fig. 11*	*Fig. 12*
Average	Eav	Eav	Eav	Eav	Eav	Eav	Eav
Peak (x Eav)	3.14	1.57	1.57	1.21	1.05	1.05	1.05
Ripple (%)	121	48	48	18.3	4.3	4.3	4.3
Input Voltage (RMS)							
Phase (x Eav)	2.22	1.11*	1.11	0.855●	0.428●	0.74●	0.855●
Line-to-Line (x Eav)	2.22	2.22	1.11	1.48	0.74	1.48†	1.71‡
Average Output (Load) Current	Iav	Iav	Iav	Iav	Iav	Iav	Iav
RECTIFIER CELL RATIOS							
Forward Current							
Average (x Iav)	1.00	0.5	0.5	0.333	0.333	0.167	0.167
RMS (x Iav)	1.57	0.785	0.785	0.587	0.579	0.409	0.293
Peak (x Iav)	3.14	1.57	1.57	1.21	1.05	1.05	0.525
Peak Reverse Voltage							
x Eav	3.14	3.14	1.57	2.09	1.05	2.09	2.42
x Erms	1.41	2.82	1.41	2.45	2.45	2.83	2.83

* to center tap
● to neutral
† maximum value
‡ maximum value, no load

Table I — Voltage and current ratios for rectifier circuits shown in Figs. 6 through 12. Fig. 6 uses a resistive load, and Figs. 7 through 12 an inductive load.

ing filter usually consists of capacitors and iron-core chokes. In any filter-design problem, the load impedance must be considered as an integral part of the filter because the load is an important factor in filter performance. Smoothing effect is obtained from the chokes because they are in series with the load and offer a high impedance to the ripple voltage. Smoothing effect is obtained from the capacitors because they are in parallel with the load and store energy on the voltage peaks; this energy is released on the voltage dips and serves to maintain the voltage at the load substantially constant. Smoothing filters are classified as **choke-input** or **capacitor-input** according to whether a choke or capacitor is placed next to the rectifier. Typical filter circuits are shown in Fig. 94.

If an input capacitor is used, consideration must be given to the instantaneous peak value of the ac input voltage. This peak value is about 1.4 times the rms value as measured by an ac voltmeter. Filter capacitors, therefore, especially the input capacitor, should have a rating high enough to withstand the instantaneous peak value if breakdown is to be avoided. When the input-choke method is used, the available dc output voltage will be somewhat lower than with the input-capacitor method for a given ac voltage. However, improved regulation together with lower peak current will be obtained.

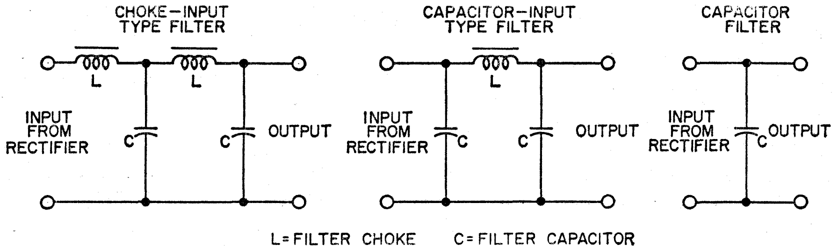


Figure 94. Typical filter circuits.

TUNNEL, VARACTOR, AND OTHER DIODES

TUNNEL DIODES

A TUNNEL diode is a small p-n junction device having a very high concentration of impurities in the p-type and n-type semiconductor materials. This high impurity density makes the junction depletion region (or space-charge region) so narrow that electrical charges can transfer across the junction by a quantum-mechanical action called "tunneling". This tunneling effect provides a negative-resistance region on the characteristic curve of the device that makes it possible to achieve amplification, pulse generation, and rf-energy generation.

Construction

The structure of a tunnel diode is extremely simple, as shown in Fig. 95. A small "dot" of highly conductive n-type (or p-type) material is alloyed to a pellet of highly conductive p-type (or n-type) material to form the semiconductor junction. The pellet (approximately 0.025 inch square) is then soldered into a low-inductance, low-capacitance case. A very fine mesh screen is added to make the connection to the "dot". The device is then encapsulated, and a lid is welded over the cavity.

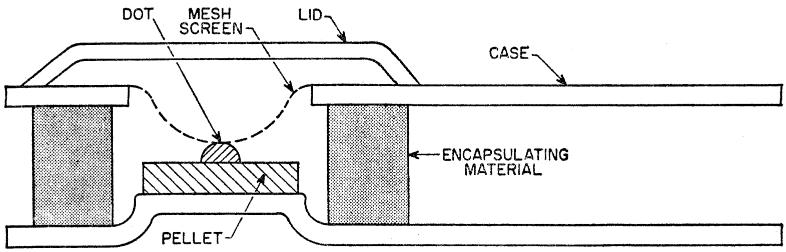


Figure 95. Structure of a tunnel diode.

Characteristics

Typical current-voltage characteristics for a tunnel diode are shown in Fig. 96. Conventional diodes do not conduct current under conditions of reverse bias until the breakdown voltage is reached; under forward bias they begin to conduct at approximately 300 millivolts. In tunnel diodes, however, a small reverse bias causes the valence electrons of semiconductor atoms near the junction to "tunnel" across the junction from the p-type region into the n-type region; as a result, the tunnel diode is highly conductive for all reverse biases. Similarly, under conditions of small forward bias, the electrons in the n-type region "tunnel" across the junction to the p-type region and the tunnel-diode current rises rapidly to a sharp maximum peak I_p. At intermediate values of forward bias, the tunnel diode exhibits a negative-resistance characteristic and the current drops to a deep minimum valley point I_v. At higher values of forward bias, the tunnel diode exhibits the diode characteristic associated with conventional semiconductor current flow. The decreasing current with increasing forward bias in the negative-resistance region of the characteristic provides the tunnel diode with its ability to amplify, oscillate, and switch.

Equivalent Circuit

In the equivalent circuit for a tunnel diode shown in Fig. 97, the n-type and p-type regions are shown as pure resistances r_1 and r_2. The tran-

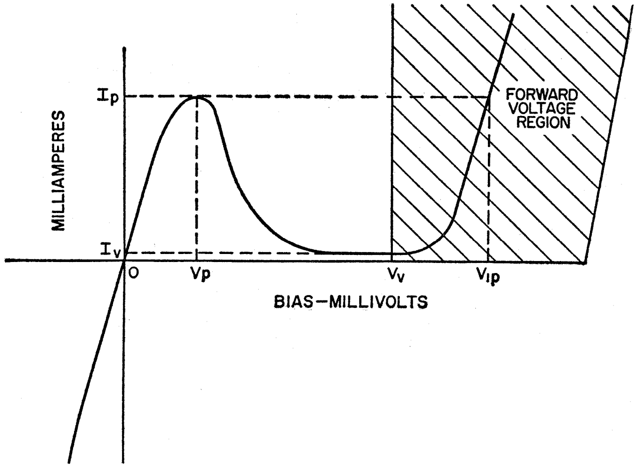


Figure 96. Typical current-voltage characteristic of a tunnel diode.

sition region is represented as a voltage-sensitive resistance R(v) in parallel with a voltage-sensitive capacitance C(v) because tunneling is a function of both voltage and junction capacitance. This capacitance is similar to that of a parallel-plate capacitor having plates separated by the transition region.

The dashed portion L in Fig. 97 represents an inductance which re-

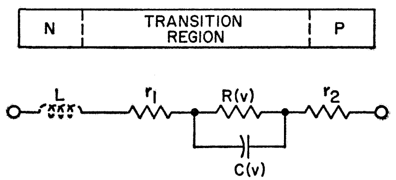


Figure 97. Equivalent circuit for a tunnel diode.

sults from the case and mounting of the tunnel diode. This inductance is unimportant for low-frequency diodes, but becomes increasingly important at high frequencies (above 100 megacycles).

Fig. 98 shows the form of the equivalent circuit when the diode is biased so that its operating point is in the negative-resistance region; dynamic characteristics of tunnel diodes are defined with respect to this circuit. L_S represents the total series inductance, and R_S the total series resistance. C_D is the capacitance and $-R_D$ is the negative resistance of the diode. For small signal variations, both the resistance R_D and the capacitance C_D are constant.

The figure of merit F of a tunnel diode is equal to the reciprocal of $2\pi RC$, where R and C are the equivalent values $-R_D$ and C_D, respectively, shown in Fig. 98. This expression

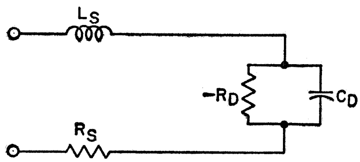


Figure 98. Equivalent circuit for a tunnel diode biased in the negative-resistance region.

has two very useful interpretations: (1) it is the diode gain-bandwidth product for circuits operating in the linear negative-resistance region of the characteristic, and (2) its reciprocal is the diode switching time when the device is used as a logic element.

Applications

When the tunnel diode is used in circuits such as amplifiers and oscillators, the operating point must be established in the negative-resistance region. The dc load line, shown as a solid line in Fig. 99, must be very steep so that it intersects the static characteristic curve at only one point A. The ac load line can be either steep with only one intersection B, as in the case of an amplifier, or relatively flat with three intersections C, D, and E, as in the case of an oscillator. The location of the operating point is determined by the

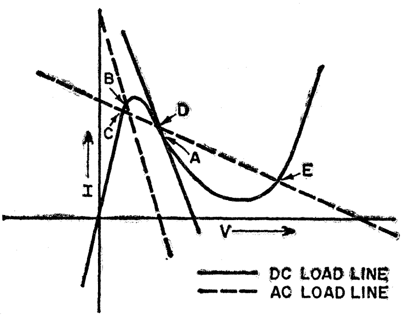


Figure 99. Typical load lines for tunnel-diode circuits.

anticipated signal swing, the required signal-to-noise ratio, and the operating temperature of the device. Biasing at the center of the linear portion of the negative-resistance slope permits the greatest signal swing. For high-temperature operation, a higher operating current is chosen; for low noise, the device is operated at the lowest possible bias current.

As a two-terminal switch, the tunnel diode is particularly suited to computer applications because of its high speed, small size, and low power consumption. Switching operation is obtained by the use of a load line which intersects the diode characteristic in three points, as shown in Fig. 99; however, only points C and E are stable operating points. If the circuit is operated at point C and a positive current step of sufficient amplitude is applied, the operating point switches to point E. Correspondingly, a negative input signal switches the operating point back to point C.

An advantage of the switching mode is its nonsensitivity to the exact linearity of the negative-resistance region of the tunnel-diode characteristics. Slight irregularities in the negative characteristic have negligible effect on the switching action.

In the basic monostable circuit or "gate" shown in Fig. 100a, the static load line is determined by the resistance R_o and the voltage V_o. If R_o is less than the minimum dynamic negative resistance of the diode, only a single operating point exists. The gate is stable in its low state if V_o is adjusted so that the operating point is at E. The dynamic load line is determined by the inductive time constant L/R_o. When the inductive time constant is long compared to the switching time t_s, the current in the circuit is effectively constant.

If a small step of current I_{in} is applied to the diode, the operating point switches to the high-voltage point F along the constant-current path shown by the dashed line in Fig. 100b. Removal of the input causes the operating point to move to F′. At this point, the energy stored in the inductor L must be dissipated before the circuit can return to its original operating point. As the energy in the inductor decreases, the

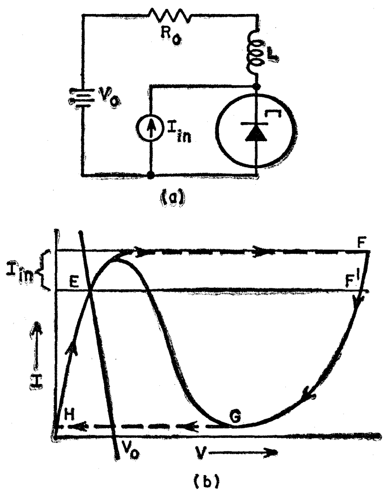


Figure 100. Basic tunnel-diode logic circuit.

operating point moves along the diode characteristic to the point of minimum current at G. When this point is reached, switching again occurs along a constant-current path to point H. The cycle of operation is completed by a recovery region in which the energy in the inductor builds up to its original level; during this period the operating point moves up the diode characteristic to the starting point.

Fig. 101a shows a simple tunnel-diode logic circuit. If the static operating bias is adjusted so that only one input is required to trigger the diode, an OR function is performed.

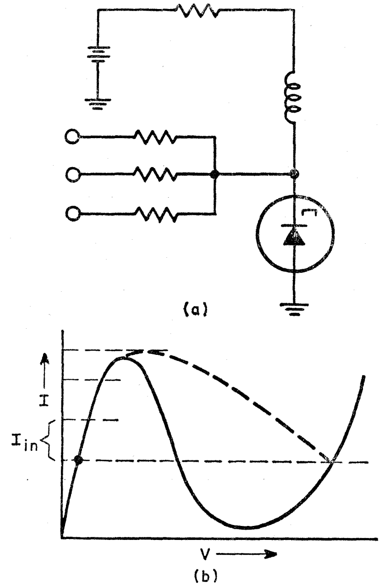


Figure 101. Tunnel-diode "AND" gate.

If all inputs are required to trigger the diode, an AND function is performed. Because the coupling impedance is high compared to the diode impedance, the inputs can be considered as current sources during the triggering period. Fig. 101b shows the biasing for a three-input AND gate. If the operating-point bias is increased slightly, the circuit can be made to trigger on two of its inputs; the logical function performed would then be that of a "majority gate".

Radiation and Thermal Considerations

One of the most important features of the tunnel diode is its resistance to nuclear radiation. Experimental results have shown tunnel diodes to be at least ten times more resistant to radiation than transistors. Because the resistivity of tunnel diodes is so low initially, it is not critically affected by radiation until large doses have been applied. In addition, tunnel diodes are less affected by ionizing radiation because they are relatively insensitive to surface changes produced by such radiation.

In general, the tunnel-diode voltage-current characteristic is relatively independent of temperature. Specific tunnel-diode applications may be affected, however, by the relative temperature dependence of the various circuit components. In such applications, negative feedback or direct (circuit) compensation may be required.

TUNNEL RECTIFIERS

A tunnel rectifier is basically a tunnel diode in which drastic etching of the junction area substantially reduces the peak currents, as shown in Fig. 102. Ratios of peak current to valley current of two to one or more are necessary to maintain good rectification efficiency. Tunnel rectifiers are essentially "backward-used" tunnel diodes, i.e., they conduct more heavily with negative than with positive applied voltages. They are used as nonlinear coupling devices which provide directional isolation because of the difference in their forward and reverse impedances. Fig. 103 shows the use of tunnel rectifiers to provide directional coupling in a tunnel-diode circuit.

VARACTOR DIODES

A varactor or variable-reactance diode is a microwave-frequency p-n junction semiconductor device in which the depletion-layer capacitance bears a nonlinear relation to the junction voltage, as shown in Fig. 104a. When biased in the reverse direction, a varactor diode can be represented

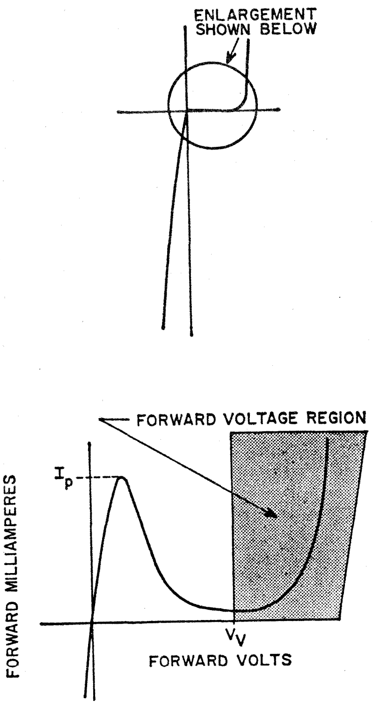


Figure 102. Typical current-voltage characteristic of a tunnel rectifier.

by a voltage-sensitive capacitance C(v) in series with a resistance R_s, as shown in Fig. 104b. This nonlinear capacitance and low series resistance, which permit the device to perform frequency-multiplication, oscillation, and switching functions, result from a very high impurity concentration

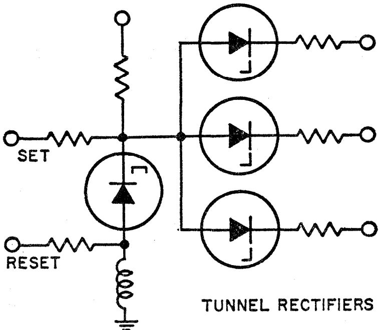


Figure 103. Logic circuit using a tunnel diode and three tunnel rectifiers.

outside the depletion-layer region and a relatively low concentration at the junction. Very low noise levels are possible in circuits using varactor diodes because the dominant current across the junction is reactive and shot-noise components are absent.

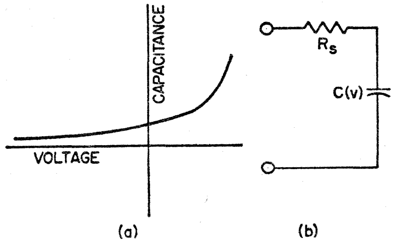


Figure 104. (a) Capacitance-voltage relationship and (b) equivalent circuit for a varactor diode.

Reactive nonlinearity, without an appreciable series resistance component, enables varactor diodes to generate harmonics with very high efficiency in circuits such as the shunt-type frequency multiplier shown in Fig. 105. The circuit is driven by a sinusoidal voltage source V_s having

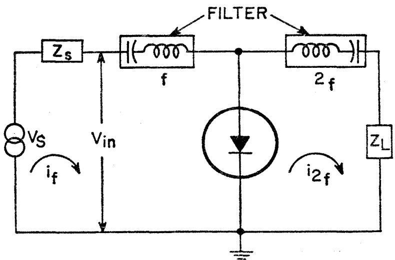


Figure 105. Varactor-diode frequency multiplier.

a fundamental frequency f and an internal impedance Z_s. Because the ideal input filter is an open circuit for all frequencies except the fundamental frequency, only the fundamental component of current i_f can flow in the input loop. A second-harmonic current i_{2f} is generated by the varactor diode and flows toward the load Z_L; another ideal filter is used in the output loop to block the fundamental-frequency component of the input current.

Varactor diodes can amplify signals when their voltage-dependent capacitance is modulated by an alternating voltage at a different frequency. This alternating voltage supply, which is often referred to as the "pump", adds energy to the signal by changing the diode capacitance in a specific phase relation with the stored signal charge so that potential energy is added to this charge. An "idler" circuit is generally used to provide the proper phase relationship between the signal and the "pump".

VOLTAGE-REFERENCE DIODES

Voltage-reference or zener diodes are silicon rectifiers in which the reverse current remains small until the breakdown voltage is reached and then increases rapidly with little further increase in voltage. The breakdown voltage is a function of the diode material and construction, and can be varied from one volt to several hundred volts for various current and power ratings, depending on the junction area and the method of cooling. A stabilized supply can deliver a constant output (voltage or current) unaffected by temperature, output load, or input voltage, within given limits. The stability provided by voltage-reference diodes makes them useful as stabilizing devices and as reference sources capable of supplying extremely constant current loads.

COMPENSATING DIODES

Excellent stabilization of collector current for variations in both supply voltage and temperature can be obtained by the use of a compensating diode operating in the forward direction in the bias network of amplifier or oscillator circuits. Fig. 106 shows the transfer characteristics of a transistor plotted above the forward characteristics of a compensating diode. In a typical circuit, the diode is biased in the forward direction; the operating point is represented on the diode characteristics by the dashed horizontal line. The diode current at this point determines a bias voltage which establishes the transistor idling current. This bias voltage shifts with varying temperature in the same direction and magnitude as the transistor characteristic, and thus provides an idling current that is essentially independent of temperature.

The use of a compensating diode also reduces the variation in transistor idling current as a result of

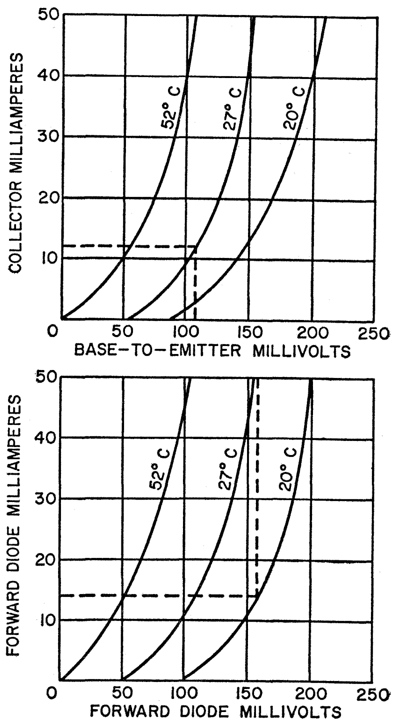


Figure 106. Characteristic curves of a transistor and a compensating diode.

supply-voltage variations. Because the diode current changes in proportion with the supply voltage, the bias voltage to the transistor changes in the same proportion and idling-current changes are minimized. (The use of diode compensation is discussed in more detail under "Biasing" in the Transistor Applications Section.)

TRANSISTOR INSTALLATION

THIS section covers installation suggestions and precautions which are generally applicable to all types of transistors. Careful observance of these suggestions will help experimenters and technicians to obtain the best results from semiconductor devices and circuits.

ELECTRICAL CONNECTIONS

The collector, base, and emitter terminals of transistors can be connected to associated circuit elements by means of sockets, clips, or solder connections to the leads or pins. If connections are soldered close to the lead or pin seals, care must be taken to conduct excessive heat away from the seals, otherwise the heat of the soldering operation may crack the glass seals and damage the transistor. When dip soldering is employed in the assembly of printed circuits using transistors, the temperature of the solder should be limited to about 225 to 250 degrees centigrade for a maximum immersion period of 10 seconds. Furthermore, the leads should not be dip-soldered too close to the transistor case. Under no circumstances should the mounting flange of a transistor be soldered to a heat sink because the heat of the soldering operation may permanently damage the transistor.

When the metal case of a transistor is connected internally to the collector, the case operates at the collector voltage. If the case is to operate at a voltage appreciably above or below ground potential, consideration must be given to the possibility of shock hazard and suitable precautionary measures taken.

TESTING

A quick check can be made of transistors prior to their installation in a circuit by resistance measurements with an electronic voltmeter (such as a VoltOhmyst*). Resistance between any two electrodes should be very high (more than 10,000 ohms) in one direction, and considerably lower in the other direction (100 ohms or less between emitter and base or collector and base; about 1000 ohms between emitter and collector). It is very important to limit the amount of voltage used in such tests (particularly between emitter and base) so that the breakdown voltages of the transistor will not be exceeded; otherwise the transistor may be damaged by excessive currents.

TEMPERATURE EFFECTS

Many transistor characteristics are sensitive to variations in temperature, and may change enough at high operating temperatures to affect circuit performance. Fig. 107 illustrates the effect of increasing temperature on the common-emitter forward current-transfer ratio (beta), the dc collector-cutoff current, and the input and output impedances. To avoid undesired changes in circuit operation, it is recommended that transistors be located away from heat sources in equipment, and also that provisions be made for adequate heat dissipation and, if necessary, for temperature compensation.

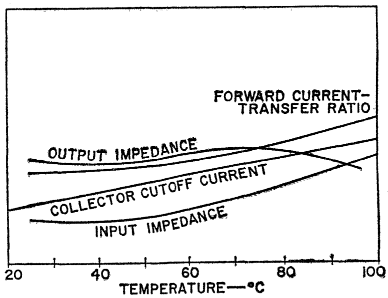


Figure 107. Variation of transistor characteristics with temperature.

*Trade Mark Reg. U.S. Pat. Off.

HEAT SINKS

In some transistors, the collector electrode is connected internally to the metal case to improve heat-dissipation capabilities. More efficient cooling of the collector junction in these transistors can be accomplished by connection of the case to a heat sink. It is recommended that a 0.002-inch mica insulator or an anodized aluminum insulator having high thermal conductivity be used between the transistor base and the heat sink, usually the chassis. The insulator should extend beyond the mounting clamp, as shown in Fig. 108. It should be drilled or punched to provide both the two mounting holes and the clearance holes for the collector, emitter, and base pins. Burrs should be removed from both the insulator and the holes in the chassis so that the insulating layer will not be destroyed during mounting. It is also recommended that a fiber washer be used between the mounting bolt and the chassis, as shown in Fig. 108, to prevent a short circuit between them.

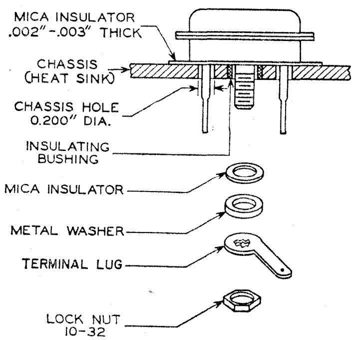


Figure 108. Suggested mounting arrangement for transistor on heat sink.

The use of an external resistance in the emitter or collector circuit of a transistor is an effective deterrent to damage which might be caused by thermal runaway. The minimum value of this resistance for low-level stages may be obtained from the following equation:

$$R_{min} = \frac{E^2}{4\left(P_0 + \frac{25}{K}\right)}$$

where E is the dc collector supply voltage in volts, P_O is the product of the collector-to-emitter voltage and the collector current at the desired operating point in watts, and K is the thermal resistance of the transistor and heat sink in degrees centigrade per watt.

CIRCUIT STABILITY

Because transistor currents tend to increase with temperature, it is necessary in the design of transistor circuits to include a "stability factor" to limit dissipation to safe values under the expected high-temperature operating conditions. The circuit stability factor SF is expressed as the ratio between a change in dc collector current I_C and the corresponding change in dc collector-cutoff current with the emitter open I_{CBO}.

For a given set of operating voltages, the stability factor can be calculated for a maximum permissible rise in dc collector current from the room-temperature value, as follows:

$$SF = \frac{I_{Cmax} - I_{C1}}{I_{CBO2} - I_{CBO1}}$$

where I_{C1} and I_{CBO1} are measured at 25 degrees centigrade, I_{CBO2} is measured at the maximum expected ambient (or junction) temperature, and I_{Cmax} is the maximum permissible collector current for the specified collector-to-emitter voltage at the maximum expected ambient (or junction) temperature (to keep transistor dissipation within ratings).

The calculated values of SF can then be used, together with the appropriate values of beta and r_b (base-connection resistance), to determine suitable resistance values for the transistor circuit. Fig. 109 shows equations for SF in terms of resistance values for three typical circuit configurations. The maximum value which SF can assume is the value of beta.

SHIELDING

In high-frequency stages having high gain, undesired feedback may occur and produce harmful effects on circuit performance unless shielding is used. The output circuit of each stage is usually shielded from the input of the stage, and each high-frequency stage is usually shielded from other high-frequency stages. It is also desirable to shield separately each unit of the high-frequency stages. For example, each if and rf coil in a superheterodyne receiver may be mounted in a separate shield can. Baffle plates may be mounted on the ganged tuning capacitor to shield each section of the capacitor from the other section.

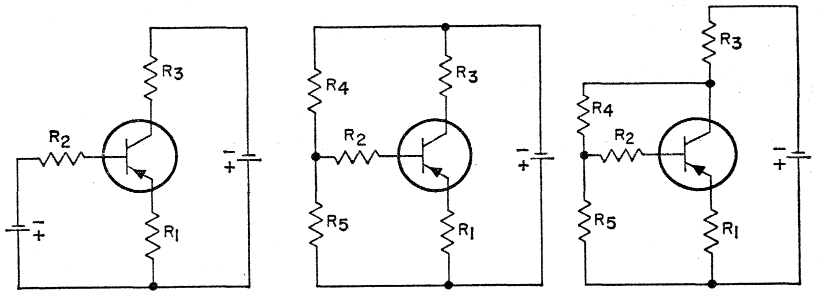
The shielding precautions required in a circuit depend on the design of the circuit and the layout of the parts. When the metal case of a transistor is grounded at the socket terminal, the grounding connection should be as short as possible to minimize lead inductance. Many transistors have a separate lead connected to the case and used as a ground lead; where present, these leads are indicated in the terminal diagrams.

DRESS OF CIRCUIT LEADS

At high frequencies such as are encountered in FM and television receivers, lead dress (i.e., the location and arrangement of the leads used for connections in the receiver) is very important. Because even a short lead provides a large impedance at high frequencies, it is necessary to keep all high-frequency leads as short as possible. This precaution is especially important for ground connections and for all connections to bypass capacitors and high-frequency filter capacitors. It is recommended that a common ground return be used for each stage, and that short, direct connections be made to the common ground point. The emitter lead especially should be kept as short as possible.

Particular care should be taken with the lead dress of the input and output circuits of high-frequency stages so that the possibility of stray coupling is minimized. Unshielded leads connected to shielded components should be dressed close to the chassis.

In high-gain audio amplifiers, these same precautions should be taken to minimize the possibility of self-oscillation.



$$SF = \frac{\beta(R_1 + R_2')}{R_2' + \beta R_1}$$

$$R_2' = R_2 + r_b$$

$$SF = \frac{\beta(R_1 + Req)}{Req + \beta R_1}$$

$$Req = R_2' + \frac{R_4 R_5}{R_4 + R_5}$$

$$R_2' = R_2 + r_b$$

$$SF = \frac{\beta(P + Q)}{Q + \beta P}$$

$$Q = R_2'(R_3 + R_4 + R_5) + R_4 R_5$$

$$P = R_1(R_3 + R_4 + R_5) + R_3 R_5$$

$$R_2' = R_2 + r_b$$

Figure 109. Circuit-stability-factor equations for three typical circuit configurations.

FILTERS

Feedback effects may occur in radio or television receivers as a result of coupling between stages through common voltage-supply circuits. Filters find an important use in minimizing such effects. They should be placed in voltage-supply leads to each transistor to provide isolation between stages.

Capacitors used in transistor rf circuits, particularly at high frequencies, should be mica or ceramic. For audio bypassing, electrolytic capacitors are required.

INTERPRETATION OF DATA

THE technical data for RCA transistors given in the following section include ratings, characteristics, typical operation values, and characteristic curves. Unless otherwise specified, all voltages and currents are dc values, and all values are obtained at an ambient temperature of 25 degrees centigrade.

Ratings are established for semiconductor devices to help equipment designers utilize the performance and service capabilities of each type to the best advantage. These ratings are based on careful study and extensive testing, and indicate limits within which the specified characteristics must be maintained to ensure satisfactory performance. The maximum ratings given for the semiconductor devices included in this Manual are based on the Absolute Maximum system. This system has been defined by the Joint Electron Device Engineering Council (JEDEC) and standardized by the National Electrical Manufacturers Association (NEMA) and the Electronic Industries Association (EIA).

Absolute-maximum ratings are limiting values of operating and environmental conditions which should not be exceeded by any device of a specified type under any condition of operation. Effective use of these ratings requires close control of supply-voltage variations, component variations, equipment-control adjustment, load variations, signal variations, and environmental conditions.

Electrode voltage and current ratings for transistors are in general self-explanatory, but a brief explanation of some ratings will aid in the understanding and interpretation of transistor data.

Voltage ratings are established with reference to a specified electrode (e.g., collector-to-emitter voltage), and indicate the maximum potential which can be placed across the two given electrodes before crystal breakdown occurs. These ratings may be specified with the third electrode open, or with specific bias voltages or external resistances.

Transistor dissipation is the power dissipated in the form of heat by the collector. It is the difference between the power supplied to the collector and the power delivered by the transistor to the load. Because of the sensitivity of semiconductor materials to variations in thermal conditions, maximum dissipation ratings are usually given for specific temperature conditions.

For many types, the maximum value of transistor dissipation is specified for ambient, case, or mounting-flange temperatures up to 25 degrees centigrade, and must be reduced linearly for higher temperatures. For such types, Fig. 110 can be used to determine maximum permissible dissipation values at particular temperature conditions above 25 degrees centigrade. (This figure cannot be assumed to apply to types other than those for which it is specified in the data section.) The curves show the permissible percentage of the maximum dissipation ratings as a function of ambient or case temperature. Individual curves are plotted for maximum operating temperatures of 50, 71, 85, 100, 175, and 200 degrees centigrade. If the maximum operating temperature of a desired transistor type is some other value, a new curve can be drawn from point A in the figure to the desired maximum temperature value on the abscissa.

To use the chart, it is necessary to know the maximum dissipation rating and the maximum operating temperature for a given transistor. The

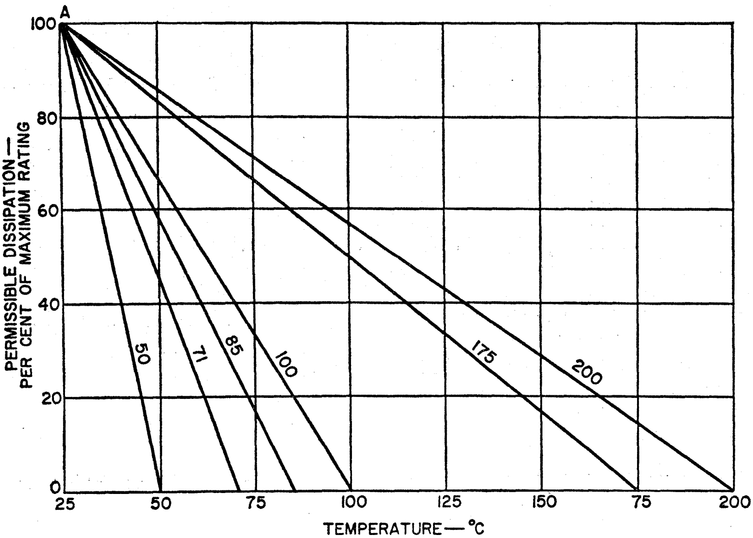


Figure 110. Chart showing maximum permissible percentage of maximum rated dissipation as a function of temperature.

calculation then involves only two steps:

1. A vertical line is drawn at the desired operating temperature value on the abscissa to intersect the curve representing the maximum operating temperature specified for the transistor.

2. A horizontal line drawn from this intersection point to the ordinate establishes the permissible percentage of the maximum dissipation for the transistor at the given temperature.

The following example illustrates the calculation of the maximum permissible dissipation for transistor type 2N1490 at a case temperature of 100 degrees centigrade. This type has a maximum dissipation rating of 75 watts at a case temperature of 25 degrees centigrade, and a maximum permissible case-temperature rating of 200 degrees centigrade.

1. A perpendicular line is drawn from the 100-degree point on the abscissa to the 200-degree curve.

2. The projection of this point to the ordinate indicates a percentage of 57.5.

Therefore, the maximum permissible dissipation for the 2N1490 at a case temperature of 100 degrees centigrade is 0.575 times 75, or approximately 43 watts.

Semiconductor devices require close control of thermal variations not only during operation, but also during storage. For this reason, the maximum ratings for transistors usually include a maximum permissible storage temperature, as well as a maximum operating temperature.

Characteristics are covered in the Transistor Characteristics Section, and such data should be interpreted in accordance with the definitions given in that section. Characteristic curves represent the characteristics of an average transistor. Individual transistors, like any manufactured product, may have characteristics that range above or below the values given in the characteristic curves. Although some curves are extended beyond the maximum ratings of the transistor, this extension has been made only for convenience in calculations; no transistor should be operated outside of its maximum ratings.

Although **transistor symbols** have not yet been standardized for the industry, many symbols have become fairly well established by common usage. Some of the more familiar transistor symbols are listed and defined below. Unless otherwise specified, the symbols represent parameters measured under dc or static conditions.

BV_{CBO} collector-to-base breakdown voltage with emitter open

BV_{CEO} collector-to-emitter breakdown voltage with base open

BV_{CER} collector-to-emitter breakdown voltage with specified resistance between base and emitter

BV_{CERL} collector-to-emitter breakdown voltage with specified resistance between base and emitter and with a specified load resistance in the collector circuit.

BV_{CES} collector-to-emitter breakdown voltage with base short-circuited to emitter

BV_{CEV} collector-to-emitter breakdown voltage with base biased in the reverse direction with respect to emitter

BV_{CEX} collector-to-emitter breakdown voltage with base biased in the reverse direction with respect to emitter through a specified circuit or under specified conditions

BV_{EBO} emitter-to-base breakdown voltage with collector open

C_{ib} common-base input capacitance (emitter to base)

C_{ie} common-emitter input capacitance (base to emitter)

C_{ob} common-base output capacitance (collector to base)

C_{oe} common-emitter output capacitance (collector to emitter)

f_{hfb} small-signal common-base forward-current-transfer-ratio cutoff frequency

f_{hfe} small-signal common-emitter forward-current-transfer-ratio cutoff frequency

f_T gain-bandwidth product (measured in the common-emitter circuit)

h_{FB} common-base forward current-transfer ratio

h_{fb} small-signal common-base forward current-transfer ratio

h_{FE} common-emitter forward current-transfer ratio

h_{fe} small-signal common-emitter forward current-transfer ratio

h_{RB} common-base open-circuit reverse voltage-transfer ratio

h_{RE} common-emitter open-circuit reverse voltage-transfer ratio

I_B base current

I_C collector current

I_{CBO} collector-cutoff current with emitter open

I_{CEO} collector-cutoff current with base open

I_E emitter current

I_{EBO} emitter-cutoff current with collector open

P_C collector dissipation

P_T total transistor dissipation

Q_{SB} stored base charge

V_{BC} base-to-collector voltage

V_{BE} base-to-emitter voltage

V_{CB} collector-to-base voltage

V_{CE} collector-to-emitter voltage

V_{EB} emitter-to-base voltage

V_{EC} emitter-to-collector voltage

V_{RT} reach-through (or punch-through) voltage

SELECTION CHARTS

THE accompanying charts classify RCA semiconductor devices by function and by performance level. These charts are particularly useful for an initial selection of suitable transistors or rectifiers for a specific application. More complete data on these devices, given in the Technical Data Section, should then be consulted to determine the most suitable type. For information on photoconductive devices, refer to the charts at the end of the Technical Data Section.

TRANSISTORS

AUDIO-FREQUENCY APPLICATIONS

Small-Signal Class A

2N104	2N215	2N1010
2N175	2N220	

Driver

2N405	2N406	2N591

Large-Signal Class A and Class B

2N109	2N407	2N647
2N217	2N408	2N649
2N270		

Power Amplifier

Dissipation up to 4.9 W

• 2N497	• 2N699	• 2N1613
• 2N656	• 2N1092	• 2N1711

Dissipation from 5 W to 49.9 W

2N176	2N1183B	• 2N1485
2N301	2N1184	• 2N1486
2N301A	2N1184A	• 2N1700
2N307	2N1184B	• 2N1701
2N351	• 2N1479	• 2N1768
2N376	• 2N1480	• 2N1769
• 2N1067	• 2N1481	• 2N2102
• 2N1068	• 2N1482	• 2N2270
2N1183	• 2N1483	• 2N2339
2N1183A	• 2N1484	

Dissipation of 50 W or More

2N173	2N441	• 2N1070
2N174	2N442	2N1099
2N277	2N443	2N1100
2N278	• 2N1069	2N1358
2N1412	• 2N1512	2N1905
2N1487	• 2N1513	2N1906
• 2N1488	• 2N1514	• 2N2015
• 2N1489	• 2N1702	• 2N2016
• 2N1490	• 2N1703	• 2N2338
• 2N1511		

RADIO-FREQUENCY APPLICATIONS

IF Amplifier

2N139	2N1066	2N1425
2N218	2N1180	2N1524
2N274	2N1224	2N1525
2N373	2N1225	2N1633
2N384	2N1226	2N1634
2N409	2N1395	2N1638
2N410	2N1396	2N2273
2N1023	2N1397	

Converter

2N140	2N1023	2N1397
2N219	2N1066	2N1426
2N274	2N1224	2N1526
2N374	2N1225	2N1527
2N384	2N1226	2N1635
2N411	2N1395	2N1636
2N412	2N1396	2N1639

Oscillator

2N274	2N1066	2N1226
2N371	2N1178	2N1395
2N384	2N1224	2N1396
2N1023	2N1225	2N1397

• Silicon type.

TRANSISTORS (cont'd)

RADIO-FREQUENCY APPLICATIONS (cont'd)

Mixer

2N274	2N1066	2N1226
2N372	2N1178	2N1395
2N384	2N1224	2N1396
2N1023	2N1225	2N1397

HF Amplifier

2N274	2N1224	• 2N1491
2N370	2N1225	• 2N1492
2N384	2N1226	• 2N1493
• 2N708	2N1395	2N1631
2N1023	2N1396	2N1632
2N1066	2N1397	2N1637

VHF Amplifier

2N384	2N1225	• 2N1492
2N1023	2N1396	• 2N1493
2N1066	2N1397	• 2N2482
2N1177	• 2N1491	

COMPUTER SWITCHING APPLICATIONS

Low-Speed Switching

2N398	2N398A	2N398B

Medium-Speed Switching

2N269	2N580	2N1303
2N388	2N581	2N1304
2N388A	2N582	2N1305
2N395	2N583	2N1306
2N396	2N584	2N1307
2N396A	2N585	2N1308
2N397	2N1090	2N1309
2N404	2N1091	* 2N1319
2N404A	* 2N1169	2N1605
2N414	* 2N1170	2N1605A
2N578	2N1302	3907/2N404
2N579		

High-Speed Switching

2N643	2N794	† 2N1216
2N644	2N795	2N1300
2N645	2N796	2N1301
• 2N696	2N828	2N1384
• 2N697	• 2N914	2N1450
2N705	2N955	2N1683
• 2N706	2N955A	2N1853
• 2N706A	† 2N1213	2N1854
2N710	† 2N1214	2N2476
2N711	† 2N1215	2N2477

Very-High-Speed Switching

• 2N708	• 2N1708	• 2N2206
• 2N834	• 2N2205	

Ultra-High-Speed Switching

• 2N709	• 2N2475

POWER SWITCHING APPLICATIONS

Dissipation up to 4.9 W

• 2N497	• 2N699	• 2N1613
• 2N656	• 2N1092	• 2N1711

Dissipation from 5 W to 49.9 W

• 2N1067	• 2N1479	• 2N1700
• 2N1068	• 2N1480	• 2N1701
2N1183	• 2N1481	• 2N1768
2N1183A	• 2N1482	• 2N1769
2N1183B	• 2N1483	• 2N2102
2N1184	• 2N1484	• 2N2270
2N1184A	• 2N1485	• 2N2339
2N1184B	• 2N1486	

Dissipation of 50 W or More

2N173	2N1100	• 2N1513
2N174	2N1358	• 2N1514
2N277	2N1412	• 2N1702
2N278	• 2N1487	• 2N1703
2N441	• 2N1488	2N1905
2N442	• 2N1489	2N1906
2N443	• 2N1490	• 2N2015
• 2N1069	• 2N1511	• 2N2016
• 2N1070	• 2N1512	• 2N2338
2N1099		

• Silicon type.
* Bidirectional type.
† Thyristor type.

RECTIFIERS

TYPE	MAX. PEAK REVERSE VOLTS	MAX. AMBIENT TEMPERATURE (Operating — °C)
Average Forward Current = 0.125 A (Note 1)		
1N3754	100	100
1N3755	200	100
1N3756	400	100
Average Forward Current = 0.4 A		
1N3563	1000	100
Average Forward Current = 0.5 A		
1N1763	400	100
1N1764	500	100
1N3196	800	100
1N3256	800	100
Average Forward Current = 0.75 A		
1N440B	100	165
1N441B	200	165
1N442B	300	165
1N443B	400	165
1N444B	500	150
1N445B	600	150
1N536	50	165
1N537	100	165
1N538	200	165
1N539	300	165
1N540	400	165
1N547	600	165
1N1095	500	165
1N2859	100	125
1N2860	200	125
1N2861	300	125
1N2862	400	125
1N2863	500	125
1N2864	600	125
1N3193	200	100
1N3194	400	100
1N3195	600	100
1N3253	200	100
1N3254	400	100
1N3255	600	100
Average Forward Current = 5 A (Note 2)		
1N1612	50	175
1N1613	100	175
1N1614	200	175
1N1615	400	175
1N1616	600	175

TYPE	MAX. PEAK REVERSE VOLTS	MAX. AMBIENT TEMPERATURE (Operating — °C)
Average Forward Current = 12 A (Note 2)		
1N1199A	50	200
1N1200A	100	200
1N1202A	200	200
1N1203A	300	200
1N1204A	400	200
1N1205A	500	200
1N1206A	600	200
Average Forward Current = 18 A (Note 2)		
1N1195	300	175
1N1196	400	175
1N1197	500	175
1N1198	600	175
Average Forward Current = 20 A (Note 2)		
1N248A	50	175
1N248B	55	175
1N248C	55	175
1N249A	100	175
1N249B	110	175
1N249C	110	175
1N250A	200	175
1N250B	220	175
1N250C	220	175
1N1195A	300	175
1N1196A	400	175
1N1197A	500	175
1N1198A	600	175
Average Forward Current = 35 A (Note 2)		
1N1187	300	175
1N1188	400	175
1N1189	500	175
1N1190	600	175
Average Forward Current = 40 A (Note 2)		
1N1183A	50	200
1N1184A	100	200
1N1186A	200	200
High-Voltage, Low-Current Types		
CR101	1200	125
CR102	2000	125
CR103	3000	125
CR104	4000	125
CR105	5000	125

RECTIFIERS (cont'd)

TYPE	MAX. PEAK REVERSE VOLTS	MAX. AMBIENT TEMPERATURE (Operating — °C)
High-Voltage, Low-Current Types (cont'd)		
CR106	6000	125
CR107	7000	125
CR108	8000	125
CR109	9000	125
CR110	10000	125
CR201	1500	125
High-Voltage, Low-Current Types (cont'd)		
CR203	3000	125
CR204	4500	125
CR206	6000	125
CR208	8000	125
CR210	10000	125
CR212	12000	125

Note 1: With capacitive load. All other current values are for resistive or inductive load.

Note 2: Types in these groups are available in reverse-polarity versions. Maximum operating temperatures are case temperatures.

DIODES

TEMPERATURE AND VOLTAGE-COMPENSATION APPLICATIONS

1N2326

COMPUTER APPLICATIONS

Germanium Tunnel Diodes

1N3128 1N3129 1N3130

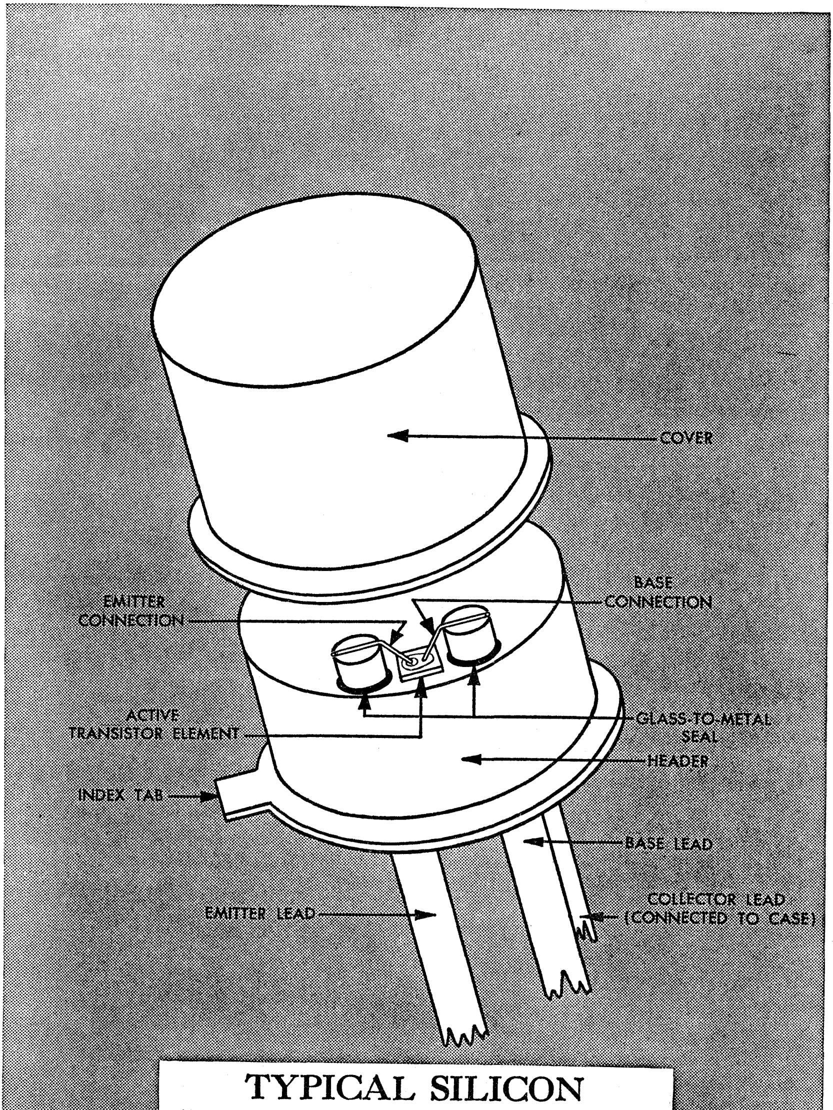
COMPUTER APPLICATIONS (Cont'd)

Gallium Arsenide Tunnel Diode

1N3138

Germanium Multiple Diodes

2DG001 (Twin) 3DG001 (Triple)



TYPICAL SILICON
SWITCHING TRANSISTOR

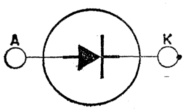
TECHNICAL DATA

This section contains technical descriptions of RCA transistors, silicon rectifiers, tunnel diodes, and other semiconductor devices. It includes data on current types, as well as information on those RCA discontinued types in which there may still be some interest. Unless otherwise specified, the ratings given are based on the Absolute Maximum system. Information on solid-state photosensitive devices is shown at the end of this section.

Types are listed in this section according to the numerical-alphabetical-numerical sequence of their type designations. For Key to Terminal Diagrams, see inside back cover.

1N34A

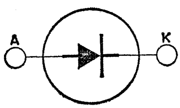
GERMANIUM RECTIFIER



Point-contact type used in low-power applications such as isolating, clipping, and switching circuits. Maximum ratings: peak reverse volts, 60; average forward ma, 50; ambient-temperature range, −50 to 75°C. Maximum over-all length (including leads), 4⅛ inches; maximum diameter, ¼ inch. This is a DISCONTINUED type listed for reference only.

1N38A

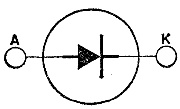
GERMANIUM RECTIFIER



Point-contact type used in large-signal power applications such as computer and clamping circuits. Maximum ratings: peak reverse volts, 100; average forward ma, 50; ambient-temperature range, −50 to 75°C. Maximum over-all length (including leads), 4⅛ inches; maximum diameter, ¼ inch. This is a DISCONTINUED type listed for reference only.

1N54A

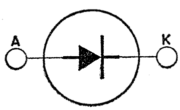
GERMANIUM RECTIFIER



Point-contact type used in large-signal power applications such as clipping, high-impedance high-voltage probe, dc restorer, and high-impedance detector circuits. Maximum ratings: peak reverse volts, 50; average forward ma, 50; ambient-temperature range, −50 to 75°C. Maximum over-all length (including leads), 4⅛ inches; maximum diameter, ¼ inch. This is a DISCONTINUED type listed for reference only.

1N55A

GERMANIUM RECTIFIER

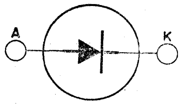


Point-contact type used in low-power applications. Maximum ratings: peak reverse volts, 150; average forward ma, 50; ambient-temperature range, −50 to 75°C. Maximum over-all length (including leads), 4⅛ inches; maximum diameter, ¼ inch. This is a DISCONTINUED type listed for reference only.

GERMANIUM RECTIFIER

1N56A

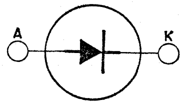
Point-contact type used in low-power applications. Maximum ratings: peak reverse volts, 40; average forward ma, 60; ambient-temperature range, −50 to 75°C. Maximum over-all length (including leads), 4⅛ inches; maximum diameter, ¼ inch. This is a DISCONTINUED type listed for reference only.



GERMANIUM RECTIFIER

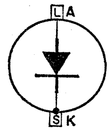
1N58A

Point-contact type used in large-signal power applications such as computer and clamping circuits. Maximum ratings: peak reverse volts, 100; average forward ma, 50; ambient-temperature range −50 to 75°C. Maximum over-all length (including leads), 4⅛ inches; maximum diameter, ¼ inch. This is a DISCONTINUED type listed for reference only.



SILICON RECTIFIERS

1N248A
1N248B
1N248C



Hermetically sealed 20-ampere types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Types 1N248A and 1N248B are used principally for renewal purposes; they are similar to type 1N248C except for some slightly lower ratings, and can be directly replaced by type 1N248C. Type 1N248C is identical with type 1N1198A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	55 *max*	volts
RMS SUPPLY VOLTAGE	39 *max*	volts
DC BLOCKING VOLTAGE	50 *max*	volts

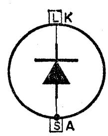
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	3.8	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

SILICON RECTIFIERS

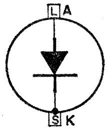
1N248RA
1N248RB
1N248RC



Hermetically sealed 20-ampere types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N248A, 1N248B, and 1N248C, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIERS

1N249A
1N249B
1N249C



Hermetically sealed 20-ampere types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Types 1N249A and 1N249B are used principally for renewal purposes; they are similar to type 1N249C except for some slightly lower ratings, and can be directly replaced by type 1N249C. Type 1N249C is identical with type 1N1198A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	110 *max*	volts
RMS SUPPLY VOLTAGE	77 *max*	volts
DC BLOCKING VOLTAGE	100 *max*	volts

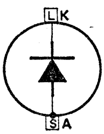
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	3.6	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

SILICON RECTIFIERS

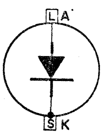
1N249RA
1N249RB
1N249RC



Hermetically sealed 20-ampere types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N249A, 1N249B, and 1N249C, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIERS

1N250A
1N250B
1N250C



Hermetically sealed 20-ampere types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Types 1N250A and 1N250B are used principally for renewal purposes; they are similar to type 1N250C except for some slightly lower ratings, and can be directly replaced by type 1N250C. Type 1N250C is identical with type 1N1198A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	220 *max*	volts
RMS SUPPLY VOLTAGE	154 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	volts

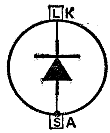
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	3.4	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

1N250RA 1N250RB 1N250RC

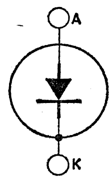
SILICON RECTIFIERS



Hermetically sealed 20-ampere types used in generator-type supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N250A, 1N250B, and 1N250C, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

1N440B

SILICON RECTIFIER



Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 100 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N443B except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

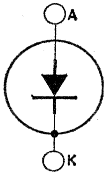
PEAK REVERSE VOLTAGE	100 *max*	volts
RMS SUPPLY VOLTAGE	70 *max*	volts
DC BLOCKING VOLTAGE	100 *max*	volts

CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	100	μa
Static†	0.3	μa

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature = 25°C.



SILICON RECTIFIER

1N441B

Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 200 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N443B except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	200 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	volts

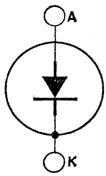
CHARACTERISTICS

Maximum Reverse Current:

Dynamic*	100	μa
Static†	0.75	μa

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature =25°C.



SILICON RECTIFIER

1N442B

Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 300 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N443B except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	300 *max*	volts
RMS SUPPLY VOLTAGE	210 *max*	volts
DC BLOCKING VOLTAGE	300 *max*	volts

CHARACTERISTICS

Maximum Reverse Current:

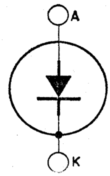
Dynamic*	200	μa
Static†	1	μa

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature = 25°C.

1N443B

SILICON RECTIFIER



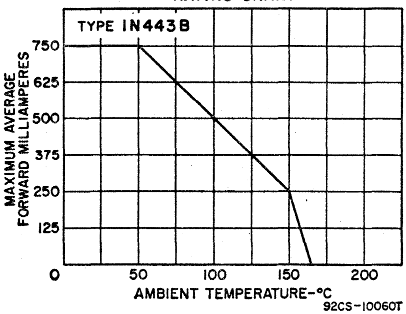
Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 400 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	280 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperature of 50°C	750 *max*	ma
At other ambient temperatures	See Rating Chart	
PEAK RECURRENT CURRENT	3.5 *max*	amperes
SURGE CURRENT (One Cycle)	15 *max*	amperes
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 165	°C
Storage	−65 to 175	°C

RATING CHART



CHARACTERISTICS

Maximum Forward Voltage Drop*	1.5	volts
Maximum Reverse Current:		
Dynamic‡	200	μa
Static†	1.5	μa

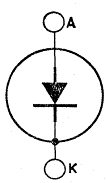
* DC value at full-load average current and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, ambient temperature = 25°C.

1N444B

SILICON RECTIFIER

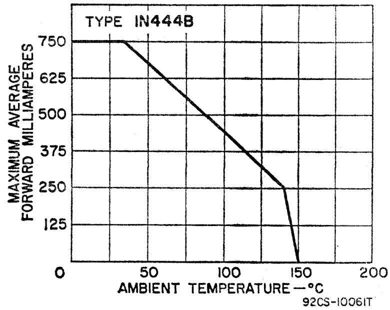


Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 500 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	500 *max*	volts
RMS SUPPLY VOLTAGE	350 *max*	volts
DC BLOCKING VOLTAGE	500 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperature of 35°C	750 *max*	ma
At other ambient temperatures	See Rating Chart	
PEAK RECURRENT CURRENT	3.5 *max*	amperes
SURGE CURRENT (One Cycle)	15 *max*	amperes
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 150	°C
Storage	−65 to 175	°C



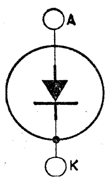
CHARACTERISTICS

Maximum Forward Voltage Drop*	1.5	volts
Maximum Reverse Current:		
Dynamic‡	200	μa
Static†	1.75	μa

* DC value at full-load average current and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature = 25°C.



SILICON RECTIFIER

1N445B

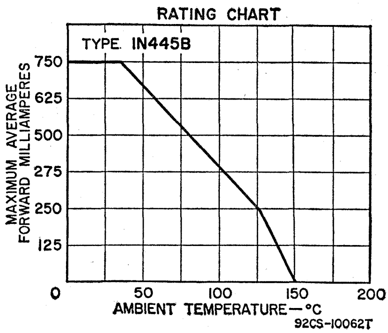
Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 600 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	600 *max*	volts
RMS SUPPLY VOLTAGE	420 *max*	volts
DC BLOCKING VOLTAGE	600 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperature of 35°C	750 *max*	ma
At other ambient temperatures	See Rating Chart	

PEAK RECURRENT CURRENT	3.5 *max*	amperes
SURGE CURRENT (One Cycle)	15 *max*	amperes
AMBIENT-TEMPERATURE RANGE:		
Operating	–65 to 150	°C
Storage	–65 to 175	°C



CHARACTERISTICS

Maximum Forward Voltage Drop*	1.5	volts
Maximum Reverse Current:		
Dynamic‡	200	μa
Static†	2	μa

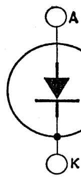
* DC value at full-load average current and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature = 25°C.

1N536

SILICON RECTIFIER



Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 50 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N547 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

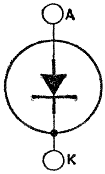
PEAK REVERSE VOLTAGE	50 *max*	volts
RMS SUPPLY VOLTAGE	35 *max*	volts
DC BLOCKING VOLTAGE	50 *max*	volts

CHARACTERISTICS

Maximum Forward Voltage Drop*	1.1	volts
Maximum Reverse Current:		
Dynamic‡	0.4	ma

* DC value at average forward ma = 500 and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.



SILICON RECTIFIER

1N537

Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 100 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N547 except for the following items:

MAXIMUM RATINGS

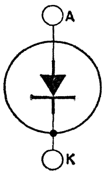
For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	100 *max*	volts
RMS SUPPLY VOLTAGE	70 *max*	volts
DC BLOCKING VOLTAGE	100 *max*	volts

CHARACTERISTICS

Maximum Forward Voltage Drop*	1.1	volts
Maximum Reverse Current:		
Dynamic‡	0.4	ma

* DC value at average forward ma = 500 and ambient temperature = 25°C.
‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.



SILICON RECTIFIER

1N538

Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 200 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N547 except for the following items:

MAXIMUM RATINGS

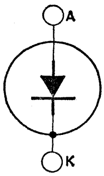
For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	200 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	volts

CHARACTERISTICS

Maximum Forward Voltage Drop*	1.1	volts
Maximum Reverse Current:		
Dynamic‡	0.3	ma

* DC value at average forward ma = 500 and ambient temperature = 25°C.
‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.



SILICON RECTIFIER

1N539

Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 300 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package;

outline 1, Outlines Section. This type is identical with type 1N547 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	300 *max*	volts
RMS SUPPLY VOLTAGE	210 *max*	volts
DC BLOCKING VOLTAGE	300 *max*	volts

CHARACTERISTICS

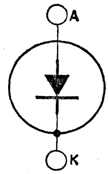
Maximum Forward Voltage Drop*	1.1	volts
Maximum Reverse Current:		
Dynamic‡	0.3	ma

* DC value at average forward ma = 500 and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

SILICON RECTIFIER

1N540



Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 400 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N547 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	280 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	volts

CHARACTERISTICS

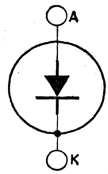
Maximum Forward Voltage Drop*	1.1	volts
Maximum Reverse Current:		
Dynamic‡	0.3	ma

* DC value at average forward ma = 500 and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

SILICON RECTIFIER

1N547



Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 600 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section.

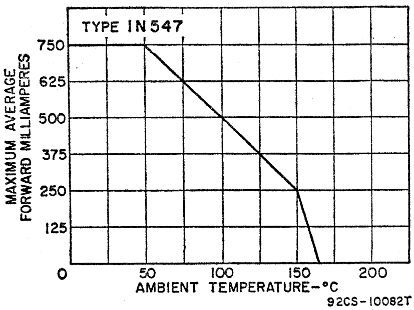
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	600 *max*	volts

RMS SUPPLY VOLTAGE	420 *max*	volts
DC BLOCKING VOLTAGE	600 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperature of 50°C	750 *max*	ma
At other ambient temperatures	See Rating Chart	
SURGE CURRENT (One Cycle)	15 *max*	amperes
OPERATING FREQUENCY	100 *max*	kc
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 165	°C
Storage	−65 to 175	°C

RATING CHART



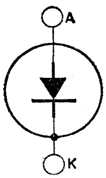
CHARACTERISTICS

Maximum Forward Voltage Drop*	1.2	volts
Maximum Reverse Current:		
Dynamic‡	0.35	ma
Static†	5	μa

* DC value at average forward ma = 500 and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature = 25°C.



SILICON RECTIFIER

1N1095

Hermetically sealed 750-milliampere type for use at peak reverse voltages up to 500 volts. It is used in magnetic amplifiers, dc-blocking circuits, power supplies, and other rectifying applications. This type is designed to meet stringent environmental and mechanical tests. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N547 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	500 *max*	volts
RMS SUPPLY VOLTAGE	350 *max*	volts
DC BLOCKING VOLTAGE	500 *max*	volts

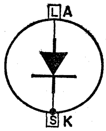
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	0.3	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 150°C.

SILICON RECTIFIER

1N1183A



Hermetically sealed 40-ampere type for use at peak reverse voltages up to 50 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty equipment. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. This type is identical with type 1N1186A except for the following items:

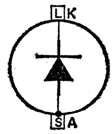
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	50 *max*	volts
RMS SUPPLY VOLTAGE	35 *max*	volts
DC BLOCKING VOLTAGE	50 *max*	volts

SILICON RECTIFIER

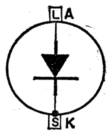
1N1183RA



Hermetically sealed 40-ampere type for use at peak reverse voltages up to 50 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty equipment. This type is a reverse-polarity version of type 1N1183A. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER

1N1184A



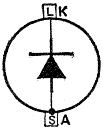
Hermetically sealed 40-ampere type for use at peak reverse voltages up to 100 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty equipment. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. This type is identical with type 1N1186A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	100 *max*	volts
RMS SUPPLY VOLTAGE	70 *max*	volts
DC BLOCKING VOLTAGE	100 *max*	volts

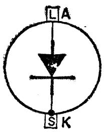
SILICON RECTIFIER



1N1184RA

Hermetically sealed 40-ampere type for use at peak reverse voltages up to 100 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty equipment. This type is a reverse-polarity version of type 1N1184A. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER



1N1186A

Hermetically sealed 40-ampere type for use at peak reverse voltages up to 200 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	200 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	volts
AVERAGE FORWARD CURRENT:		
At case temperature of 150°C	40 *max*	amperes
At other case temperatures	See Rating Chart I	
PEAK RECURRENT CURRENT	195 *max*	amperes
SURGE CURRENT:*		
For one-half cycle, sine wave	800 *max*	amperes
For one or more cycles	See Rating Chart II	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 200	°C

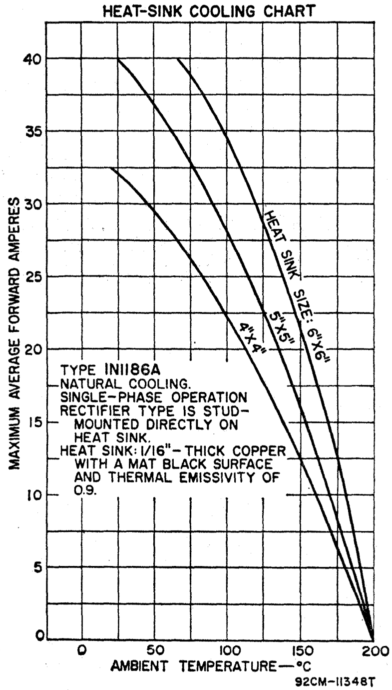
* Superimposed on device operating within maximum voltage, current, and temperature ratings; may be repeated after sufficient time has elapsed for the device to return to the presurge thermal-equilibrium conditions.

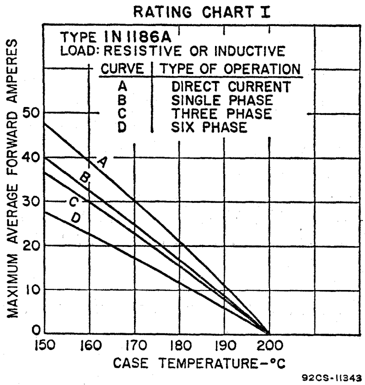
CHARACTERISTICS

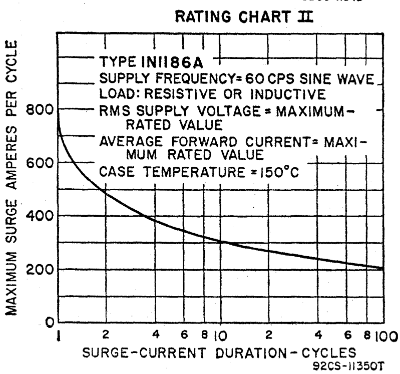
Maximum Forward Voltage Drop‡	0.65	volt
Maximum Reverse Current:		
Dynamic‡	2.5	ma
Static†	0.025	ma
Maximum Thermal Resistance:		
Junction-to-case	1	°C/watt

‡ Average value over one complete cycle at maximum peak reverse voltage, maximum average forward amperes, and case temperature = 150°C.

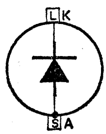
† DC value at maximum peak reverse voltage, average forward current = 0, and case temperature = 25°C.







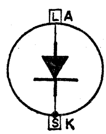
SILICON RECTIFIER



1N1186RA

Hermetically sealed 40-ampere type for use at peak reverse voltages up to 200 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1186A. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER



1N1187

Hermetically sealed 35-ampere type for use at peak reverse voltages up to 300 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. This type is identical with type 1N1190 except for the following items:

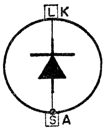
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	300 *max*	volts
RMS SUPPLY VOLTAGE	212 *max*	volts
DC BLOCKING VOLTAGE	240 *max*	volts

SILICON RECTIFIER

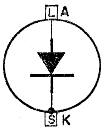
1N1187R



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 300 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1187. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER

1N1188



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 400 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. This type is identical with type 1N1190 except for the following items:

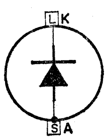
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	284 *max*	volts
DC BLOCKING VOLTAGE	320 *max*	volts

SILICON RECTIFIER

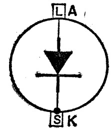
1N1188R



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 400 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1188. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER

1N1189



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 500 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. This type is identical with type 1N1190 except for the following items:

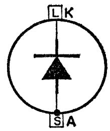
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	500 *max*	volts
RMS SUPPLY VOLTAGE	355 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	volts

SILICON RECTIFIER

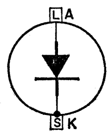
1N1189R



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 500 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1189. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER

1N1190



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 600 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section.

MAXIMUM RATINGS

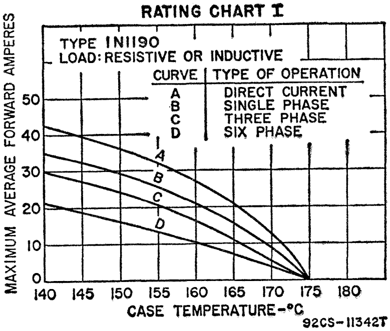
For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	600 *max*	volts

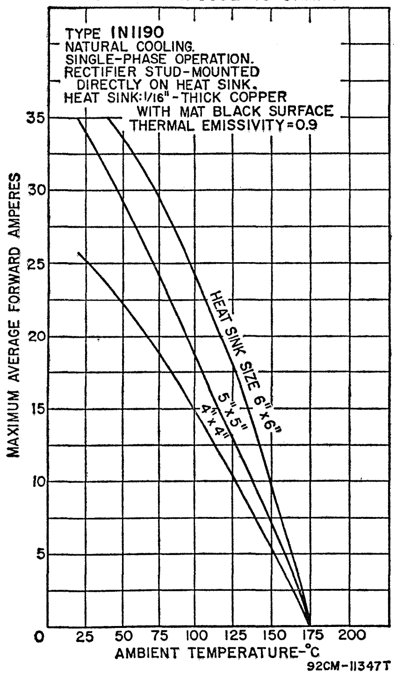
RMS SUPPLY VOLTAGE	424 *max*	volts
DC BLOCKING VOLTAGE	480 *max*	volts
AVERAGE FORWARD CURRENT:		
At case temperature of 140°C	35 *max*	amperes
At other case temperatures	See Rating Chart I	
PEAK RECURRENT CURRENT	130 *max*	amperes
SURGE CURRENT:▲		
For one-half cycle, sine wave	500 *max*	amperes
For one or more cycles	See Rating Chart II	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 175	°C

▲ Superimposed on device operating within maximum voltage, current, and temperature ratings; may be repeated after sufficient time has elapsed for the device to return to the presurge thermal-equilibrium conditions.

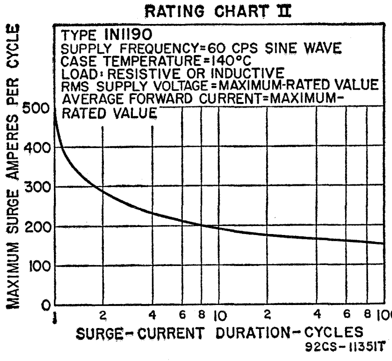
RATING CHART I



HEAT-SINK COOLING CHART



RATING CHART II



CHARACTERISTICS

Maximum Forward Voltage Drop*	1.7	volts
Maximum Reverse Current:		
Dynamic‡	10	ma
Static†	0.025	ma
Maximum Thermal Resistance:		
Junction-to-case	1	°C/watt

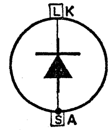
* Peak value at maximum average forward current, case temperature = 140°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 140°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and case temperature = 25°C.

SILICON RECTIFIER

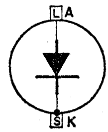
1N1190R



Hermetically sealed 35-ampere type for use at peak reverse voltages up to 600 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1190. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIERS

1N1195
1N1195A



Hermetically sealed types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Type 1N1195 is used principally for renewal purposes; it is similar to type 1N1195A except for some slightly lower ratings, and can be directly replaced by type 1N1195A. Type 1N1195A is identical with type 1N1198A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	300 *max*	volts
RMS SUPPLY VOLTAGE	212 *max*	volts
DC BLOCKING VOLTAGE	300 *max*	volts

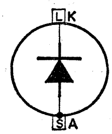
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	3.2	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward amperes, and case temperature = 150°C.

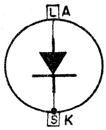
SILICON RECTIFIERS

1N1195R
1N1195RA



Hermetically sealed types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers; and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N1195 and 1N1195A, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIERS



1N1196
1N1196A

Hermetically sealed types used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Type 1N1196 is used principally for renewal purposes; it is similar to type 1N1196A except for some slightly lower ratings, and can be directly replaced by type 1N1196A. Type 1N1196A is identical with type 1N1198A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

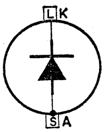
PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	284 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	volts

CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	2.5	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward amperes, and case temperature = 150°C.

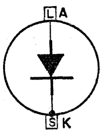
SILICON RECTIFIERS



1N1196R
1N1196RA

Hermetically sealed types for use at peak reverse voltages up to 400 volts. They are used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N1196 and 1N1196A, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIERS



1N1197
1N1197A

Hermetically sealed types for use at peak reverse voltages up to 500 volts. They are used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Type 1N1197 is used principally for renewal purposes; it is similar to type 1N1197A except for some slightly lower ratings, and can be directly replaced by type 1N1197A. Type 1N1197A is identical with type 1N1198A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	500 *max*	volts
RMS SUPPLY VOLTAGE	355 *max*	volts
DC BLOCKING VOLTAGE	500 *max*	volts

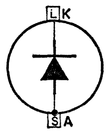
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	2.2	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward amperes, and case temperature = 150°C.

SILICON RECTIFIERS

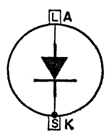
1N1197R
1N1197RA



Hermetically sealed types for use at peak reverse voltages up to 500 volts. They are used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N1197 and 1N1197A, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIERS

1N1198
1N1198A



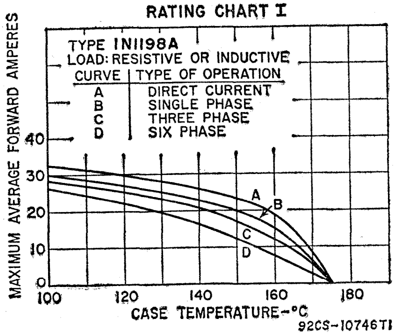
Hermetically sealed 20-ampere types for use at peak reverse voltages up to 600 volts. They are used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. These types are designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 50 inch-pounds. JEDEC No. DO-5 package; outline 3, Outlines Section. Type 1N1198 is used principally for renewal purposes; it is similar to type 1N1198A except for some slightly lower ratings, and can be directly replaced by type 1N1198A.

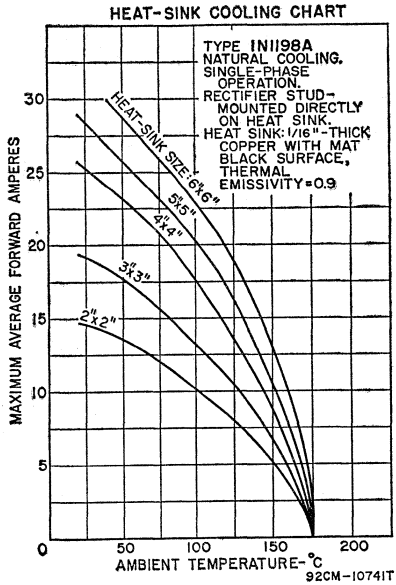
MAXIMUM RATINGS

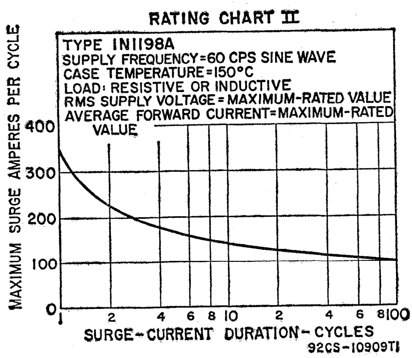
For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	600 *max*	volts
RMS SUPPLY VOLTAGE	424 *max*	volts
DC BLOCKING VOLTAGE	600 *max*	volts
AVERAGE FORWARD CURRENT:		
At case temperature of 150°C	20 *max*	amperes
At other case temperatures	See Rating Chart I	
PEAK RECURRENT CURRENT	90 *max*	amperes
SURGE CURRENT:*		
For one-half cycle, sine wave	350 *max*	amperes
For one or more cycles	See Rating Chart II	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 175	°C

* Superimposed on device operating within maximum voltage, current, and temperature ratings; may be repeated after sufficient time has elapsed for the device to return to the presurge thermal-equilibrium conditions.







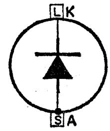
CHARACTERISTICS

Maximum Forward Voltage Drop‡	0.6	volt
Maximum Reverse Current:		
Dynamic‡	1.5	ma

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

SILICON RECTIFIERS

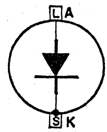
1N1198R
1N1198RA



Hermetically sealed 20-ampere types for use at peak reverse voltages up to 600 volts. They are used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. These types are reverse-polarity versions of types 1N1198 and 1N1198A, respectively. JEDEC No. DO-5 package; outline 3, Outlines Section.

SILICON RECTIFIER

1N1199A



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 50 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1206A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	50 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	100 *max*	volts
RMS SUPPLY VOLTAGE	35 *max*	volts
DC BLOCKING VOLTAGE	50 *max*	volts

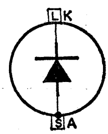
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	3	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

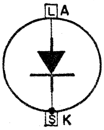
SILICON RECTIFIER

1N1199RA



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 50 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1199A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER



1N1200A

Hermetically sealed 12-ampere type for use at peak reverse voltages up to 100 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1206A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

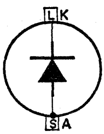
PEAK REVERSE VOLTAGE	100 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	200 *max*	volts
RMS SUPPLY VOLTAGE	70 *max*	volts
DC BLOCKING VOLTAGE	100 *max*	volts

CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	2.5	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

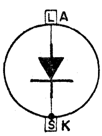
SILICON RECTIFIER



1N1200RA

Hermetically sealed 12-ampere type for use at peak reverse voltages up to 100 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1200A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER



1N1202A

Hermetically sealed 12-ampere type for use at peak reverse voltages up to 200 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1206A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	200 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	350 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	volts

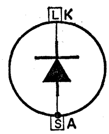
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	2	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

SILICON RECTIFIER

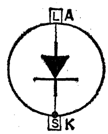
1N1202RA



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 200 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1202A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1203A



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 300 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1206A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

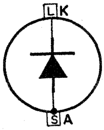
PEAK REVERSE VOLTAGE	300 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	450 *max*	volts
RMS SUPPLY VOLTAGE	212 *max*	volts
DC BLOCKING VOLTAGE	300 *max*	volts

CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	1.75	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

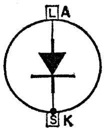
SILICON RECTIFIER



1N1203RA

Hermetically sealed 12-ampere type for use at peak reverse voltages up to 300 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1203A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER



1N1204A

Hermetically sealed 12-ampere type for use at peak reverse voltages up to 400 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1206A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

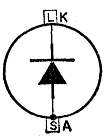
PEAK REVERSE VOLTAGE	400 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	600 *max*	volts
RMS SUPPLY VOLTAGE	284 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	volts

CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	1.5	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

SILICON RECTIFIER

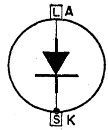


1N1204RA

Hermetically sealed 12-ampere type for use at peak reverse voltages up to 400 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1204A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1205A



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 500 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1206A except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	500 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	700 *max*	volts
RMS SUPPLY VOLTAGE	355 *max*	volts
DC BLOCKING VOLTAGE	500 *max*	volts

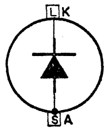
CHARACTERISTICS

Maximum Reverse Current:		
Dynamic*	1.25	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

SILICON RECTIFIER

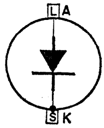
1N1205RA



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 500 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1205A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1206A



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 600 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section.

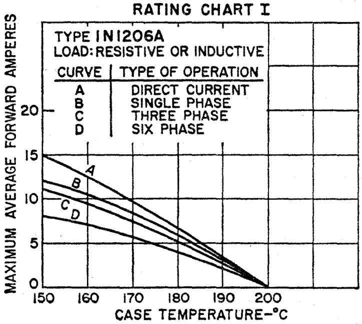
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

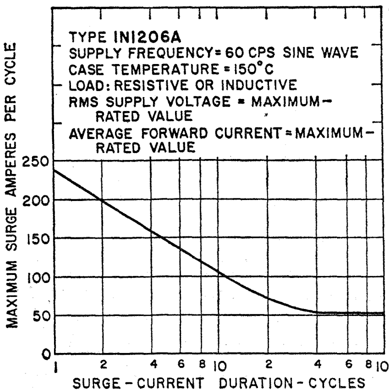
PEAK REVERSE VOLTAGE	600 *max*	volts
TRANSIENT REVERSE VOLTAGE:		
Non-repetitive, for duration of 5 milliseconds maximum	800 *max*	volts
RMS SUPPLY VOLTAGE	424 *max*	volts
DC BLOCKING VOLTAGE	600 *max*	volts
AVERAGE FORWARD CURRENT:		
At case temperature of 150°C	12 *max*	amperes
At other case temperatures	See Rating Chart I	
PEAK RECURRENT CURRENT	50 *max*	amperes
SURGE CURRENT:▲		
For one-half cycle, sine wave	240 *max*	amperes
For one or more cycles	See Rating Chart II	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 200	°C

▲Superimposed on device operating within maximum voltage, current, and temperature ratings; may be repeated after sufficient time has elapsed for the device to return to the presurge thermal-equilibrium conditions.

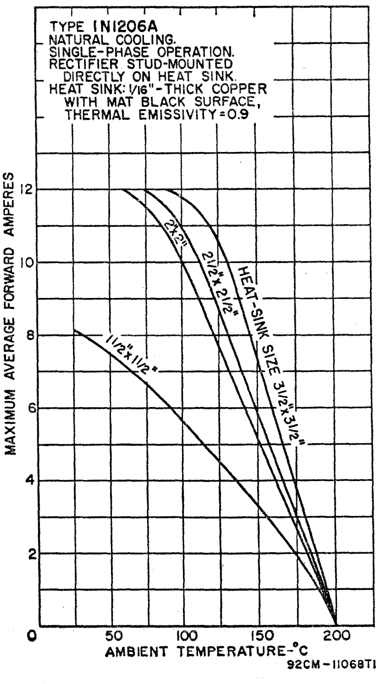
RATING CHART I



RATING CHART II



HEAT-SINK COOLING CHART



CHARACTERISTICS

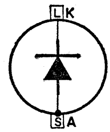
Maximum Forward Voltage Drop*	0.55	volt
Maximum Reverse Current:		
Dynamic*	1	ma
Static†	0.004	ma
Maximum Thermal Resistance:		
Junction-to-case	2	°C/watt

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 150°C.

† DC value at maximum peak reverse voltage and case temperature = 25°C.

SILICON RECTIFIER

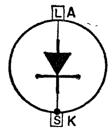
1N1206RA



Hermetically sealed 12-ampere type for use at peak reverse voltages up to 600 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1206A. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1612



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 50 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1616 except for the following items:

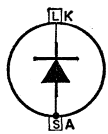
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	50 *max*	volts
RMS SUPPLY VOLTAGE	35 *max*	volts
DC BLOCKING VOLTAGE	50 *max*	volts

SILICON RECTIFIER

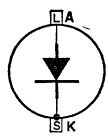
1N1612R



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 50 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1612. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1613



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 100 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power

supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1616 except for the following items:

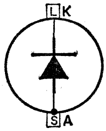
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	100 *max*	volts
RMS SUPPLY VOLTAGE	70 *max*	volts
DC BLOCKING VOLTAGE	100 *max*	volts

SILICON RECTIFIER

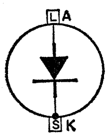
1N1613R



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 100 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1613. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1614



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 200 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1616 except for the following items:

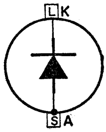
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	200 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	volts

SILICON RECTIFIER

1N1614R

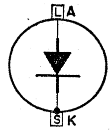


Hermetically sealed 5-ampere type for use at peak reverse voltages up to 200 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power

supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1614. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1615



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 400 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section. This type is identical with type 1N1616 except for the following items:

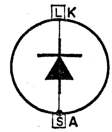
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	280 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	volts

SILICON RECTIFIER

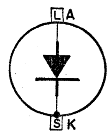
1N1615R



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 400 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1615. JEDEC No. DO-4 package; outline 2, Outlines Section.

SILICON RECTIFIER

1N1616



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 600 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power

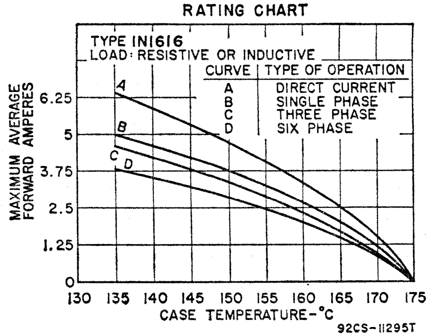
supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is designed to meet stringent environmental and mechanical specifications. The special copper-alloy mounting stud can withstand an installing torque up to 25 inch-pounds. JEDEC No. DO-4 package; outline 2, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	600 *max*	volts
RMS SUPPLY VOLTAGE	420 *max*	volts
DC BLOCKING VOLTAGE	600 *max*	volts
AVERAGE FORWARD CURRENT:		
At case temperature of 135°C	5 *max*	amperes
At other case temperatures	See Rating Chart	
PEAK RECURRENT CURRENT	15 *max*	amperes
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 175	°C

RATING CHART



CHARACTERISTICS

Maximum Forward Voltage Drop*	1.5	volts
Maximum Reverse Current:		
Dynamic‡	1	ma
Static†	0.01	ma

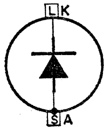
* At maximum average forward current and case temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and case temperature = 135°C.

† DC value at maximum peak reverse voltage and case temperature = 25°C.

SILICON RECTIFIER

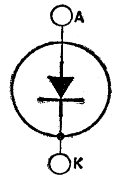
1N1616R



Hermetically sealed 5-ampere type for use at peak reverse voltages up to 600 volts. It is used in generator-type power supplies in mobile equipment; dc-to-dc converters and battery chargers; power supplies for aircraft, marine, and missile equipment; transmitters, rf generators, and dc-motor power supplies; machine-tool controls; welding and electroplating equipment; dc-blocking service; magnetic amplifiers, and a wide variety of other heavy-duty applications. This type is a reverse-polarity version of type 1N1616. JEDEC No. DO-4 package; outline 2, Outlines Section.

1N1763

SILICON RECTIFIER



Hermetically sealed 500-milliampere type for use at peak reverse voltages up to 400 volts. It is used in power supplies of color and black-and-white television receivers, radio receivers, and phonographs, and in other rectifying applications. This type is intended for rectifier applications in which the device operates direct from a power line at ac voltages up to 140 volts. JEDEC No. DO-1 package; outline 1, Outlines Section. For forward-characteristic curve, refer to type 1N3196.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with capacitor input to filter

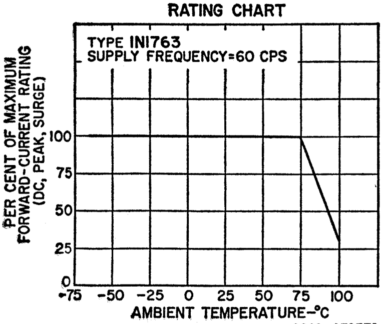
PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 75°C	500 *max*	ma
At ambient temperatures above 75°C	See Rating Chart	
PEAK RECURRENT CURRENT:		
At ambient temperatures up to 75°C	5 *max*	amperes
At ambient temperatures above 75°C	See Rating Chart	
SURGE CURRENT (for turn-on time of 2 milliseconds duration):		
At ambient temperatures up to 75°C	35 *max*	amperes
At ambient temperatures above 75°C	See Rating Chart	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 100	°C
Storage	−65 to 150	°C

CHARACTERISTICS

Maximum Forward Voltage Drop*	3	volts
Maximum Reverse Current (at maximum peak reverse voltage):		
At ambient temperature of 25°C	100	μa
At ambient temperature of 100°C	1	ma

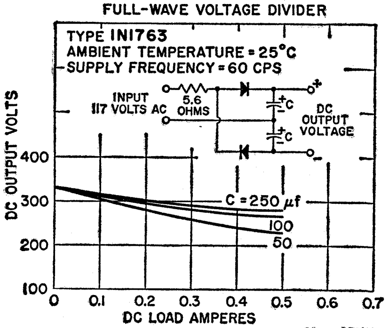
*Instantaneous value at average forward amperes = 15 and ambient temperature=25°C.

RATING CHART



92CS-9727T2

TYPICAL CHARACTERISTICS
FULL-WAVE VOLTAGE DIVIDER



92CS-9716T

TYPICAL OPERATION

As Half-Wave Rectifier

RMS Supply Voltage	117	117	117	volts
Filter-Input Capacitor	50	100	250	μf
Surge-Limiting Resistance▲	5.6	5.6	5.6	ohms
DC Output Voltage (Approx.) at input to filter:				
At half-load current of 250 milliamperes	126	146	150	volts
At full-load current of 500 milliamperes	100	132	139	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	26	14	11	volts

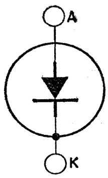
As Half-Wave Voltage Doubler

RMS Supply Voltage	117	117	volts
Filter-Input Capacitor	100	250	µf
Surge-Limiting Resistance▲	5.6	5.6	ohms
DC Output Voltage (Approx.) at input to filter:			
At half-load current of 250 milliamperes	273	288	volts
At full-load current of 500 milliamperes	235	262	volts
Voltage Regulation (Approx.):			
Half-load to full-load current	38	26	volts

As Full-Wave Voltage Doubler

RMS Supply Voltage	117	117	117	volts
Filter-Input Capacitor	50	100	250	µf
Surge-Limiting Resistance▲	5.6	5.6	5.6	ohms
DC Output Voltage (Approx.) at input to filter:				
At half-load current of 250 milliamperes	260	280	290	volts
At full-load current of 500 milliamperes	220	260	275	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	40	20	15	volts

▲The transformer series resistance or other resistance in the line may be deducted from the value shown.



SILICON RECTIFIER

1N1764

Hermetically sealed 500-milliampere type for use at peak reverse voltages up to 500 volts. It is used in power supplies of color and black-and-white television receivers, radio receivers, and phonographs, and in other rectifying applications. This type is intended for rectifier applications in which the device operates from the power line through a step-up transformer at ac output voltages up to 175 volts. JEDEC No. DO-1 package; outline 1, Outlines Section. For forward-characteristic curve, refer to type 1N3196.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with capacitor input to filter

PEAK REVERSE VOLTAGE	500 *max*	volts
RMS SUPPLY VOLTAGE	175 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 75°C	500 *max*	ma
At ambient temperatures above 75°C	See Rating Chart	
PEAK RECURRENT CURRENT:		
At ambient temperatures up to 75°C	5 *max*	amperes
At ambient temperatures above 75°C	See Rating Chart	
SURGE CURRENT (for turn-on time of 2 milliseconds duration):		
At ambient temperatures up to 75°C	35 *max*	amperes
At ambient temperatures above 75°C	See Rating Chart	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 100	°C
Storage	−65 to 150	°C

CHARACTERISTICS

Maximum Forward Voltage Drop*	3	volts
Maximum Reverse Current (at maximum peak reverse voltage):		
At ambient temperature of 25°C	100	µa
At ambient temperature of 100°C	1	ma

* Instantaneous value at average forward amperes = 15 and ambient temperature = 25°C.

TYPICAL OPERATION

As Half-Wave Rectifier

RMS Supply Voltage	150	150	150	volts
Filter-Input Capacitor	50	100	250	µf
Surge-Limiting Resistance▲	6.8	6.8	6.8	ohms
DC Output Voltage (Approx.) at input to filter:				
At half-load current of 250 milliamperes	158	184	190	volts
At full-load current of 500 milliamperes	128	170	178	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	30	14	12	volts

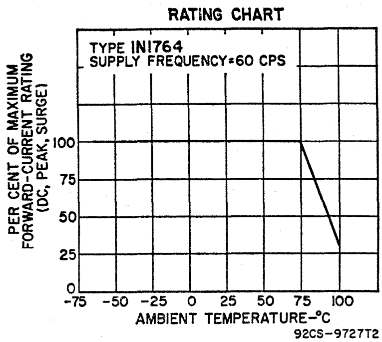
As Half-Wave Voltage Doubler

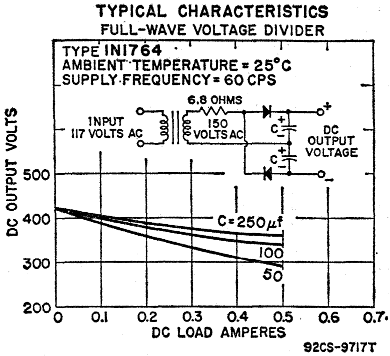
RMS Supply Voltage	150	150	volts
Filter-Input Capacitor	100	250	μf
Surge-Limiting Resistance▲	6.8	6.8	ohms
DC Output Voltage (Approx.) at input to filter:			
At half-load current of 250 milliamperes	345	367	volts
At full-load current of 500 milliamperes	301	336	volts
Voltage Regulation (Approx.):			
Half-load to full-load current	44	31	volts

As Full-Wave Voltage Doubler

RMS Supply Voltage	150	150	150	volts
Filter-Input Capacitor	50	100	250	μf
Surge-Limiting Resistance▲	6.8	6.8	6.8	ohms
DC Output Voltage (Approx.) at input to filter:				
At half-load current of 250 milliamperes	340	370	380	volts
At full-load current of 500 milliamperes	290	340	360	volts
Voltage Regulation (Approx.):				
Half-load to full-load current	50	30	20	volts

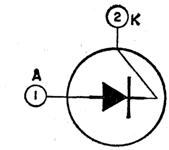
▲ The transformer series resistance or other resistance in the line may be deducted from the value shown.





DIODE

1N2326



Hermetically sealed germanium type used to compensate for the effects of temperature and supply-voltage changes in class B push-pull audio-frequency power-amplifier stages. In a typical af power-amplifier circuit, it maintains the bias voltage applied to the output stage within ±0.015 volt for supply-voltage variations up to −40 per cent, and simultaneously compensates for ambient-temperature variations over the range from −20 to 71°C. Package is similar to JEDEC No. TO-1; outline 20, Outlines Section.

MAXIMUM RATINGS

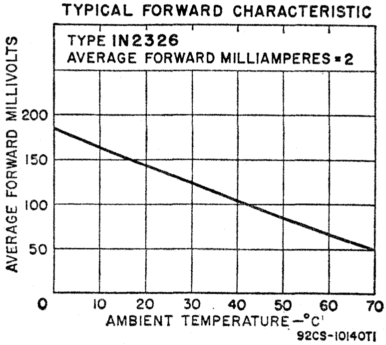
Temperature and voltage-compensation service

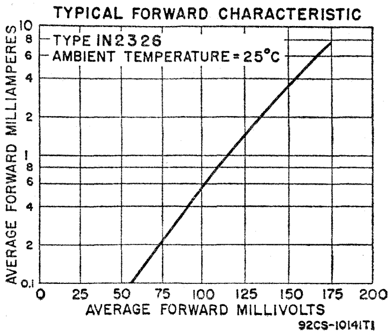
REVERSE VOLTAGE*	−1 *max*	volt
AVERAGE FORWARD CURRENT	10 *max*	ma
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

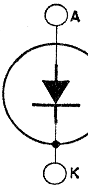
CHARACTERISTICS

Forward Voltage Drop at average forward ma = 2	135	mv

* Operation with reverse voltages is not recommended.







SILICON RECTIFIER

1N2858

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 50 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N2864 except for the following items:

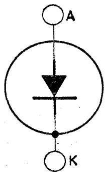
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	Capacitive Load	
PEAK REVERSE VOLTAGE..............	50 *max*	50 *max*	volts
RMS SUPPLY VOLTAGE................	35 *max*	17 *max*	volts
DC BLOCKING VOLTAGE...............	50 *max*	50 *max*	volts

CHARACTERISTICS

Maximum Reverse Current (at maximum peak reverse voltage).........	0.4	ma



SILICON RECTIFIER

1N2859

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 100 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N2864 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

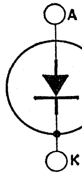
	Resistive or Inductive Load	Capacitive Load	
PEAK REVERSE VOLTAGE..............	100 *max*	100 *max*	volts
RMS SUPPLY VOLTAGE................	70 *max*	35 *max*	volts
DC BLOCKING VOLTAGE...............	100 *max*	100 *max*	volts

CHARACTERISTICS

Maximum Reverse Current (at maximum peak reverse voltage).........	0.4	ma

SILICON RECTIFIER

1N2860



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 200 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N2864 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

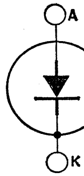
	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	200 *max*	200 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	70 *max*	volts
DC BLOCKING VOLTAGE	200 *max*	200 *max*	volts

CHARACTERISTICS

Maximum Reverse Current (at maximum peak reverse voltage)	0.4	ma

SILICON RECTIFIER

1N2861



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 300 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N2864 except for the following items:

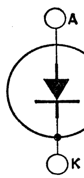
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	300 *max*	300 *max*	volts
RMS SUPPLY VOLTAGE	210 *max*	105 *max*	volts
DC BLOCKING VOLTAGE	300 *max*	300 *max*	volts

SILICON RECTIFIER

1N2862

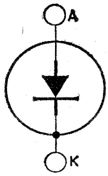


Hermetically sealed type used in power-supply applications at peak reverse voltages up to 400 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N2864 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	400 *max*	400 *max*	volts
RMS SUPPLY VOLTAGE	280 *max*	140 *max*	volts
DC BLOCKING VOLTAGE	400 *max*	400 *max*	volts



SILICON RECTIFIER

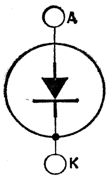
1N2863

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 500 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section. This type is identical with type 1N2864 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	500 *max*	500 *max*	volts
RMS SUPPLY VOLTAGE	350 *max*	175 *max*	volts
DC BLOCKING VOLTAGE	500 *max*	500 *max*	volts



SILICON RECTIFIER

1N2864

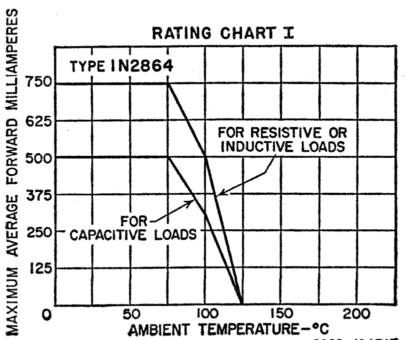
Hermetically sealed type used in power-supply applications at peak reverse voltages up to 600 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. JEDEC No. DO-1 package; outline 1, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

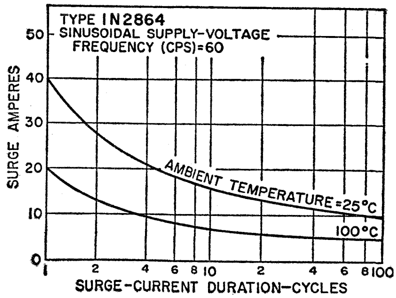
	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	600 *max*	600 *max*	volts
RMS SUPPLY VOLTAGE	420 *max*	210 *max*	volts
DC BLOCKING VOLTAGE	600 *max*	600 *max*	volts
AVERAGE FORWARD CURRENT:			
At ambient temperatures up to 75°C	750 *max*	500 *max*	ma
At ambient temperatures above 75°C	See Rating Chart I		
SURGE CURRENT:			
For one cycle at ambient temperature of 25°C	40 *max*	40 *max*	amperes
For more than one cycle and at other ambient temperatures	See Rating Chart II		
AMBIENT-TEMPERATURE RANGE:			
Operating and storage	−65 to 125	−65 to 125	°C

RATING CHART I



92CS-10474T

RATING CHART II



92CS-10476T

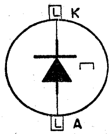
CHARACTERISTICS

Maximum Forward Voltage Drop*.....	1.2	volts
Maximum Reverse Current (at maximum peak reverse voltage)	0.3	ma

* DC value at average forward ma = 500 and ambient temperature = 25°C.

TUNNEL DIODE

1N3128



Low-current germanium type used in computer switching applications employing clock (pulse-repetition) rates up to 100 megacycles with typical switching times of 2 nanoseconds or less. Because of the very low power dissipation and match-head size, this type can be used in equipment packages operating at high ambient temperatures. The low-inductance ceramic-to-metal package makes possible extremely short rise time and minimizes the possibility of parasitic oscillation. Outline 28, Outlines Section. Identifying dots on bottom of device are red and gray. For discussion of static and dynamic characteristics, refer to *Tunnel, Varactor, and other Diodes* in text section.

MAXIMUM RATINGS

Switching Service

INSTANTANEOUS FORWARD CURRENT	40 *max*	ma
INSTANTANEOUS REVERSE CURRENT	70 *max*	ma
DISSIPATION:		
At ambient temperature of 25°C	20 *max*	mw
At other ambient temperatures	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−35 to 100	°C
CASE TEMPERATURE:		
For 10 seconds maximum	230 *max*	°C

CHARACTERISTICS

Static Values

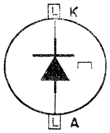
Peak-Point Current	5 ± 5%	ma
Valley-Point Current:		
Typical	0.45	ma
Maximum	0.6	ma
Peak-Point-to-Valley-Point Current Ratio:		
Minimum	8:1	
Typical	11:1	
Peak-Point Voltage	40 to 80	mv
Valley-Point Voltage	280 *min*	mv
Positive Voltage at peak-point ma = 5.25	445 to 530	mv

Dynamic Values

Terminal Valley-Point Capacitance:*		
Typical	7	pf
Maximum	15	pf
Total Series Inductance	0.6 *max*	nh
Total Series Resistance	3 *max*	ohms
Negative Resistance of Intrinsic Diode	22	ohms
Dissipation at positive mv = 530, peak-point ma = 5.25	2.8	mw
Rise Time for 20 per cent overdrive (dc forward voltage and driving pulse provided by constant-current sources)	5 *max*	nsec
Figure of Merit	0.33	ma/pf

* At measured valley-point current of individual diode; includes case capacitance of 0.3 pf.

TUNNEL DIODE



1N3129

Germanium type used in intermediate-speed computer switching applications employing clock (pulse-repetition) rates up to 500 megacycles with typical switching times of ½ nanosecond or less. As a memory device this type can operate at a clock rate of 1000 megacycles at high temperatures. Because of the match-head size, this type can be used in high-density equipment packages. The low-inductance ceramic-to-metal package makes possible extremely short rise time and minimizes the possibility of parasitic oscillation. Outline 28, Outlines Section. Identifying dots on bottom of device are red and white. For discussion of static and dynamic characteristics, refer to *Tunnel, Varactor, and Other Diodes* in text section.

MAXIMUM RATINGS

Switching Service

INSTANTANEOUS FORWARD CURRENT	55 *max*	ma
INSTANTANEOUS REVERSE CURRENT	85 *max*	ma
DISSIPATION:		
At ambient temperature of 25°C	30 *max*	mw
At other ambient temperatures	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−35 to 100	°C
CASE TEMPERATURE:		
For 10 seconds maximum	230 *max*	°C

CHARACTERISTICS

Static Values

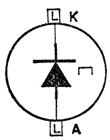
Peak-Point Current	20 ± 5%	ma
Valley-Point Current:		
Typical	1.8	ma
Maximum	2.4	ma
Peak-Point-to-Valley-Point Current Ratio:		
Minimum	8:1	
Typical	11:1	
Peak-Point Voltage	50 to 100	mv
Valley-Point Voltage	300 *min*	mv
Positive Voltage at peak-point ma = 21	475 to 575	mv

Dynamic Values

Terminal Valley-Point Capacitance:*		
Typical	10	pf
Maximum	20	pf
Total Series Inductance	0.6 *max*	nh
Total Series Resistance	2.5 *max*	ohms
Negative Resistance of Intrinsic Diode	6	ohms
Dissipation at positive mv = 575, peak-point ma = 21	12	mw
Rise Time for 20 per cent overdrive (dc forward voltage and driving pulse provided by constant-current sources)	2 *max*	nsec
Figure of Merit	1	ma/pf

*At measured valley-point current of individual diode; includes case capacitance of 0.3 pf.

TUNNEL DIODE



1N3130

Germanium type used in ultra-high-speed computer switching applications employing clock (pulse-repetition) rates up to 1000 megacycles with typical switching times of 1/5 nanosecond or less. Because of the match-head size, this type can be used in high-density equipment packages. The low-inductance ceramic-to-metal package makes possible extremely short rise time and minimizes the possibility of parasitic oscillation. Outline 28, Outlines Section. Identifying dots on bottom of device are orange and green. For discussion of static and dynamic characteristics, refer to *Tunnel, Varactor, and Other Diodes* in text section.

MAXIMUM RATINGS

Switching Service

INSTANTANEOUS FORWARD CURRENT	70 *max*	ma
INSTANTANEOUS REVERSE CURRENT	100 *max*	ma
DISSIPATION:		
At ambient temperature of 25°C	40 *max*	mw
At other ambient temperatures	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−35 to 100	°C
CASE TEMPERATURE:		
For 10 seconds maximum	230 *max*	°C

CHARACTERISTICS

Static Values

Peak-Point Current	50 ± 5%	ma
Valley-Point Current:		
Typical	4.5	ma
Maximum	6	ma
Peak-Point-to-Valley-Point Current Ratio:		
Minimum	8:1	
Typical	11:1	
Peak-Point Voltage	70 to 120	mv
Valley-Point Voltage	350 *min*	mv
Positive Voltage at peak-point ma = 52.5	520 to 620	mv

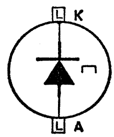
Dynamic Values

Terminal Valley-Point Capacitance:*		
Typical	12	pf
Maximum	25	pf
Total Series Inductance	0.6 *max*	nh
Total Series Resistance	1.5 *max*	ohms
Negative Resistance of Intrinsic Diode	2.4	ohms
Dissipation at positive mv = 620, peak-point ma = 52.5	32.5	mw
Rise Time for 20 per cent overdrive (dc forward voltage and driving pulse provided by constant-current sources)	0.5 *max*	nsec
Figure of Merit	2	ma/pf

* At measured valley-point current of individual diode; includes case capacitance of 0.3 pf.

TUNNEL DIODE

1N3138



Gallium-arsenide type used in high-speed computer switching applications employing clock (pulse-repetition) rates up to 1000 megacycles with typical switching times of ½ nanosecond or less. It is used as a switching device in digital-pulse circuits and memory matrices. Because of the match-head size, this type can be used in high-density equipment packages. The low-inductance ceramic-to-metal package makes possible extremely short rise time and minimizes the possibility of parasitic oscillation. Outline 28, Outlines Section. Identifying dots on bottom of device are yellow and black. For discussion of static and dynamic characteristics, refer to *Tunnel, Varactor, and Other Diodes* in text section.

MAXIMUM RATINGS

Switching Service

INSTANTANEOUS FORWARD CURRENT	100 *max*	ma
INSTANTANEOUS REVERSE CURRENT	200 *max*	ma

DISSIPATION:		
At ambient temperature of 25°C	75 *max*	mw
At other ambient temperatures	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 150	°C
Storage	−65 to 175	°C
CASE TEMPERATURE:		
For 10 seconds maximum	275 *max*	°C

CHARACTERISTICS

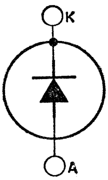
Static Values

Peak-Point Current	50 ± 5%	ma
Valley-Point Current:		
Typical	2.5	ma
Maximum	3.5	ma
Peak-Point-to-Valley-Point Current Ratio:		
Minimum	13:1	
Typical	20:1	
Peak-Point Voltage	120 to 260	mv
Valley-Point Voltage	510 to 620	mv
Positive Voltage at peak-point ma = 52.5	1100 to 1400	mv

Dynamic Values

Terminal Valley-Point Capacitance:*		
Typical	10	pf
Maximum	30	pf
Total Series Inductance	0.6 *max*	nh
Total Series Resistance	2.6 *max*	ohms
Negative Resistance of Intrinsic Diode	2.6	ohms
Dissipation at positive mv = 1400, peak-point ma = 52.5	73	mw
Rise Time for 20 per cent overdrive (dc forward voltage and driving pulse provided by constant-current sources)	2 *max*	nsec
Figure of Merit	0.9	ma/pf

* At measured valley-point current of individual diode; includes case capacitance of 0.3 pf.



SILICON RECTIFIER

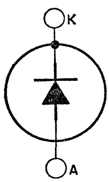
1N3193

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 200 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. It is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 21, Outlines Section. This type is identical with type 1N3196 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	200 *max*	200 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	70 *max*	volts
AVERAGE FORWARD CURRENT:			
At ambient temperatures up to 75°C.	750 *max*	500 *max*	ma
PEAK RECURRENT CURRENT	—	6 *max*	amperes



SILICON RECTIFIER

1N3194

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 400 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. It is designed to meet stringent temperature-

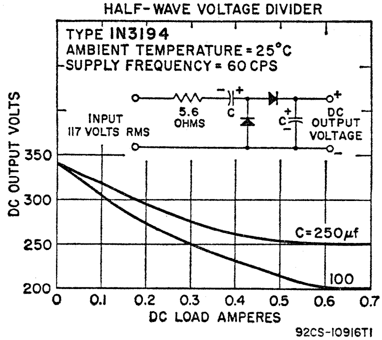
cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 21, Outlines Section. This type is identical with type 1N3196 except for the following items:

MAXIMUM RATINGS

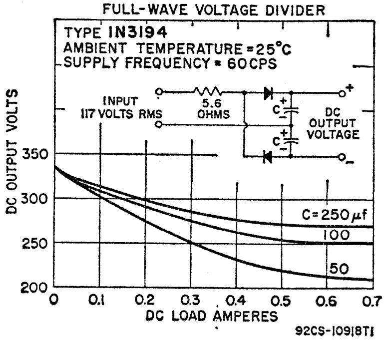
For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	400 *max*	400 *max*	volts
RMS SUPPLY VOLTAGE	280 *max*	140 *max*	volts
AVERAGE FORWARD CURRENT:			
At ambient temperatures up to 75°C	750 *max*	500 *max*	ma
PEAK RECURRENT CURRENT	—	6 *max*	amperes

TYPICAL CHARACTERISTICS
HALF-WAVE VOLTAGE DIVIDER

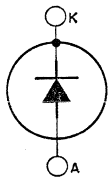


TYPICAL CHARACTERISTICS
FULL-WAVE VOLTAGE DIVIDER



SILICON RECTIFIER

1N3195



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 600 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. It is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 21, Outlines Section. This type is identical with type 1N3196 except for the following items:

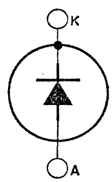
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	600 *max*	600 *max*	volts
RMS SUPPLY VOLTAGE	420 *max*	210 *max*	volts
AVERAGE FORWARD CURRENT:			
At ambient temperatures up to 75°C	750 *max*	500 *max*	ma
PEAK RECURRENT CURRENT	—	6 *max*	amperes

SILICON RECTIFIER

1N3196



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 800 volts. This type has a maximum average-forward-current rating of 500 milliamperes for resistive or inductive loads and 400 milliamperes for capacitive loads. It is designed to meet stringent temperature-

cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 21, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	800 *max*	800 *max*	volts
RMS SUPPLY VOLTAGE	560 *max*	280 *max*	volts
AVERAGE FORWARD CURRENT:			
At ambient temperatures up to 75°C.	500 *max*	400 *max*	ma
At other ambient temperatures	See Rating Chart		
PEAK RECURRENT CURRENT	—	5 *max*	amperes
SURGE CURRENT:			
For turn-on time of 2 milliseconds duration	—	35 *max*	amperes
AMBIENT-TEMPERATURE RANGE:			
Operating	−65 to 100	−65 to 100	°C
Storage	−65 to 175	−65 to 175	°C
LEAD TEMPERATURE:			
For 10 seconds maximum	255 *max*	255 *max*	°C

CHARACTERISTICS

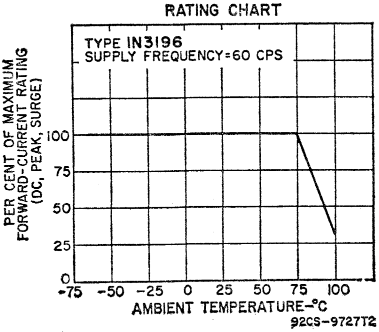
Maximum Forward Voltage Drop*	1.2	volts
Maximum Reverse Current:		
Dynamic‡	0.2	ma
Static†	0.005	ma

* Instantaneous value at average forward amperes = 0.5 and ambient temperature = 25°C.

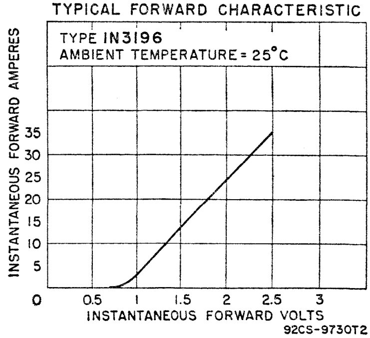
‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 75°C.

† DC value at maximum peak reverse volts, average forward current = 0, and ambient temperature = 25°C.

RATING CHART

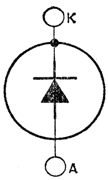


TYPICAL FORWARD CHARACTERISTIC



SILICON RECTIFIER

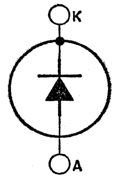
1N3253



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 200 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. It is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 22, Outlines Section. This type is identical with type 1N3193 except that it has a transparent, high-dielectric-strength plastic sleeve over the metal case.

SILICON RECTIFIER

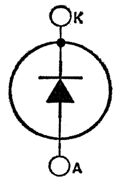
1N3254



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 400 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. It is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 22, Outlines Section. This type is identical with type 1N3194 except that it has a transparent, high-dielectric-strength plastic sleeve over the metal case.

SILICON RECTIFIER

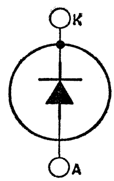
1N3255



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 600 volts. This type has a maximum average-forward-current rating of 750 milliamperes for resistive or inductive loads and 500 milliamperes for capacitive loads. It is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 22, Outlines Section. This type is identical with type 1N3195 except that it has a transparent, high-dielectric-strength plastic sleeve over the metal case.

SILICON RECTIFIER

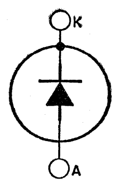
1N3256



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 800 volts. This type has a maximum average-forward-current rating of 500 milliamperes for resistive or inductive loads and 400 milliamperes for capacitive loads. It is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 22, Outlines Section. This type is identical with type 1N3196 except that it has a transparent, high-dielectric-strength plastic sleeve over the metal case.

SILICON RECTIFIER

1N3563



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 1000 volts. This type has a maximum average-forward-current rating of 400 milliamperes for resistive or inductive loads and 300 milliamperes for capacitive loads. It is designed to meet stringent temperature-

cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 22, Outlines Section. In addition, this type has a transparent, high-dielectric-strength plastic sleeve over the metal case and a protective coating to guard against the effects of severe environmental conditions. This type is electrically identical with type 1N3196 except for the following items:

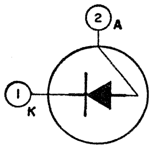
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation

	Resistive or Inductive Load	*Capacitive Load*	
PEAK REVERSE VOLTAGE	1000 *max*	1000 *max*	volts
RMS SUPPLY VOLTAGE	700 *max*	350 *max*	volts
AVERAGE FORWARD CURRENT: At ambient temperatures up to 75°C.	400 *max*	300 *max*	ma
PEAK RECURRENT CURRENT	—	4 *max*	amperes

SILICON RECTIFIER

1N3754



Hermetically sealed 125-milliampere type used in power-supply applications at peak reverse voltages up to 100 volts. This type is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 20, Outlines Section. This type is identical with type 1N3756 except for the following items:

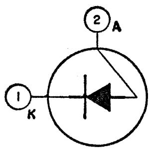
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with capacitive load

PEAK REVERSE VOLTAGE	100 *max*	volts
RMS SUPPLY VOLTAGE	35 *max*	volts

SILICON RECTIFIER

1N3755



Hermetically sealed 125-milliampere type used in power-supply applications at peak reverse voltages up to 200 volts. This type is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 20, Outlines Section. This type is identical with type 1N3756 except for the following items:

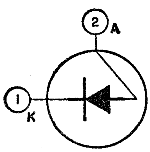
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with capacitive load

PEAK REVERSE VOLTAGE	200 *max*	volts
RMS SUPPLY VOLTAGE	70 *max*	volts

SILICON RECTIFIER

1N3756



Hermetically sealed 125-milliampere type used in power-supply applications at peak reverse voltages up to 400 volts. This type is designed to meet stringent temperature-cycling and humidity requirements of critical applications. Package is similar to JEDEC No. TO-1; outline 20, Outlines Section.

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with capacitive load

PEAK REVERSE VOLTAGE	400 *max*	volts
RMS SUPPLY VOLTAGE	140 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 65°C	125 *max*	ma
At ambient temperatures above 65°C	See Rating Chart	
PEAK RECURRENT CURRENT	1.3 *max*	amperes
SURGE CURRENT:		
For turn-on time of 2 milliseconds duration	30 *max*	amperes
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 100	°C
Storage	−65 to 175	°C
LEAD TEMPERATURE:		
For 10 seconds maximum	255 *max*	°C

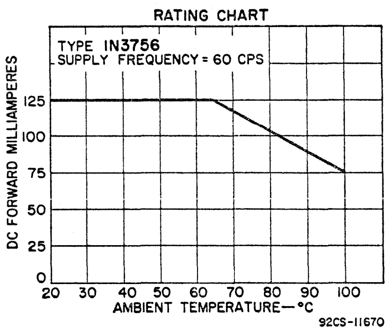
CHARACTERISTICS

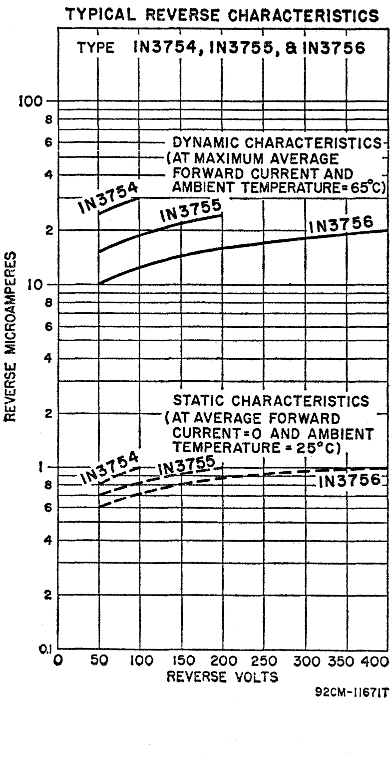
Maximum Forward Voltage Drop*	1	volt
Maximum Reverse Current:		
Dynamic‡	0.3	ma
Static†	0.005	ma

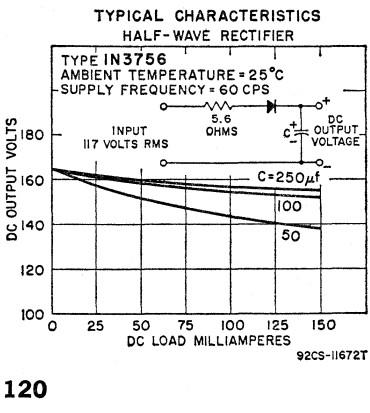
* Instantaneous value at maximum average forward current and ambient temperature = 25°C.

‡ Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 65°C.

† DC value at maximum peak reverse voltage, average forward current = 0, and ambient temperature = 25°C.

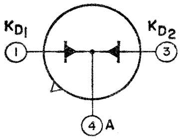






TWIN DIODE

2DG001



Hermetically sealed germanium type used in high-speed switching service in electronic data-processing systems. It is used primarily in high-speed "AND" gates and "OR" gates in computer logic circuits. Advanced transistor-type diffusion techniques assure high switching speeds and a high degree of uniformity of characteristics between diode units. Package is similar to JEDEC No. TO-33; outline 13, Outlines Section, except that lead No. 2 is omitted.

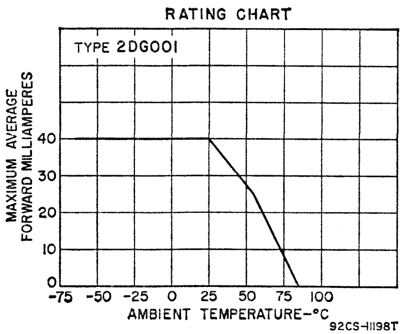
MAXIMUM RATINGS (Each diode unit)

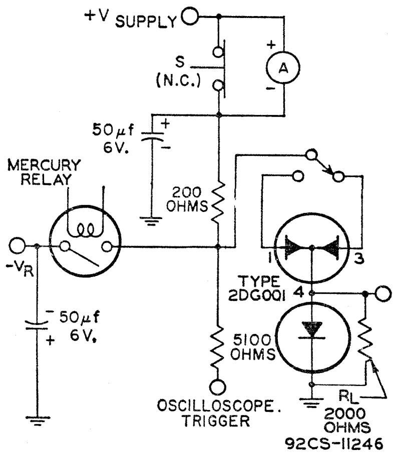
Switching Service

DC REVERSE VOLTAGE	−20 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 25°C	40 *max*	ma
At ambient temperatures above 25°C	See Rating Chart	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C

CHARACTERISTICS

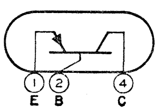
DC Forward Voltage:		
With average forward ma = 5	0.4 *max*	volt
With average forward ma = 9	0.55 *max*	volt
DC Reverse Breakdown Voltage (with dc reverse μa = −200)	−20 *min*	volts
Average Forward Current (with dc forward volts = 1)	40 *min*	ma
DC Reverse Current at ambient temperature = 55°C:		
With dc reverse volts = −2	−15 *max*	μa
With dc reverse volts = −10	−75 *max*	μa
Reverse Recovery Time with dc reverse volts = −6 and average forward ma = 20 (see circuit below):		
To a reverse impedance of 35000 ohms	0.25 *max*	μsec
To a reverse impedance of 82000 ohms	0.3 *max*	μsec





TRANSISTOR

2N32

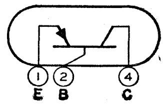


Germanium p-n-p point-contact type used in pulse or switching applications. Maximum ratings: collector-to-base volts, −40; collector dissipation, 40 milliwatts; ambient temperature, 40°C. Mechanical data: case, plastic; maximum case length, 0.340 inch; maximum width, 0.185 inch; maximum height (including leads), 0.660 inch. This is a DISCONTINUED type listed for reference only.

TRANSISTOR

2N33

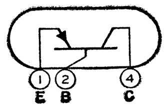
Germanium p-n-p point-contact type used in vhf oscillator applications in the 50-megacycle region. Maximum ratings: collector-to-base volts, −8.5; collector dissipation, 30 milliwatts; ambient temperature, 40°C. Mechanical data: case, plastic; maximum case length, 0.340 inch; maximum width, 0.185 inch; maximum height (including leads), 0.660 inch. This is a DISCONTINUED type listed for reference only.



TRANSISTOR

2N34

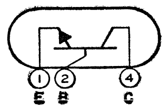
Germanium p-n-p point-contact type used in low-power audio-frequency amplifier applications. Maximum ratings: collector-to-base volts, −25; collector dissipation, 50 milliwatts; ambient temperature, 50°C. Mechanical data: case, plastic; maximum case length, 0.340 inch; maximum width, 0.185 inch; maximum height (including leads), 0.885 inch. This is a DISCONTINUED type listed for reference only.



TRANSISTOR

2N35

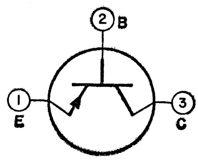
Germanium n-p-n point-contact type used in low-power audio-frequency amplifier applications. Maximum ratings: collector-to-base volts, 25; collector dissipation, 50 milliwatts; ambient temperature, 50°C. Mechanical data: case, plastic; maximum case length, 0.340 inch; maximum width, 0.185 inch; maximum height (including leads), 0.885 inch. This is a DISCONTINUED type listed for reference only.



TRANSISTOR

2N41

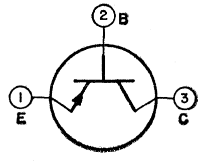
Germanium p-n-p type used in low-drain audio-frequency amplifier applications such as the output stages of hearing-aid devices. Maximum ratings: collector-to-base volts, −25; collector dissipation, 50 milliwatts; ambient temperature, 50°C. Mechanical data: case, plastic; maximum case length, 0.420 inch; maximum diameter, 0.224 inch; maximum height (including leads), 2.170 inch. This is a DISCONTINUED type listed for reference only.



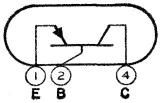
TRANSISTOR

2N77

Germanium p-n-p type used in low-power audio-frequency amplifier applications such as hearing-aid devices. Maixmum ratings: collector-to-base volts, −25; collector ma, −15; transistor dissipation, 35 milliwatts; ambient-temperature range (operating), −65 to 50°C. Maximum case length, 0.405 inch; maximum diameter, 0.240 inch; maximum height (including leads), 1.905 inches. This is a DISCONTINUED type listed for reference only.



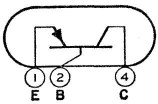
TRANSISTOR



Germanium p-n-p type used in low-power audio-frequency applications. Maximum ratings: collector-to-base volts, −30; collector ma, −50; collector dissipation, 35 milliwatts; ambient-temperature range, −55 to 70°C. JEDEC No. TO-40 package; outline 15, Outlines Section. This is a DISCONTINUED type listed for reference only.

2N79

TRANSISTOR



Germanium p-n-p type used in low-power audio-frequency amplifier applications. In a common-emitter circuit, this type has a forward-current transfer ratio of 44, a low-frequency power gain of 41 db, and an integrated noise factor of 12 db maximum. JEDEC No. TO-40 package; outline 15, Outlines Section.

2N104

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
COLLECTOR CURRENT	−50 *max*	ma
EMITTER CURRENT	50 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperature of 50°C	80 *max*	mw
At ambient temperature of 70°C	30 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 70	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −20 and emitter current = 0)	−30 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−10 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −12 and collector current = 0)	−10 *max*	μa
Thermal Resistance:		
Junction-to-ambient	0.4	°C/mw

In Common-Base Circuit

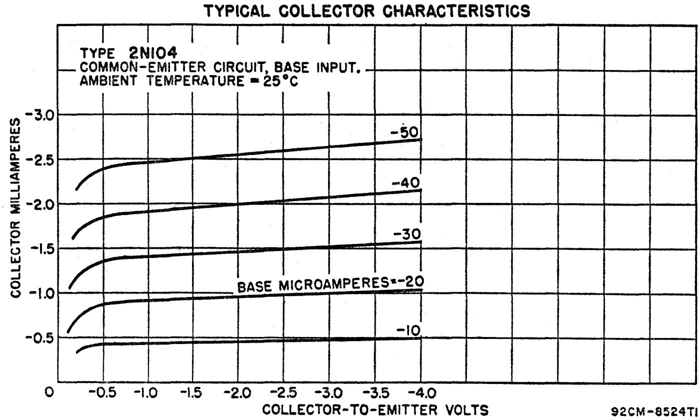
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency:		
With collector-to-base volts = −6 and collector ma = −1	700	kc
With collector-to-base volts = −3 and collector ma = −0.2	530	kc
Power Gain (with collector-to-base volts = −6, collector ma = −1, input resistance = 170 ohms, and load resistance = 0.5 megohm)	32.4	db

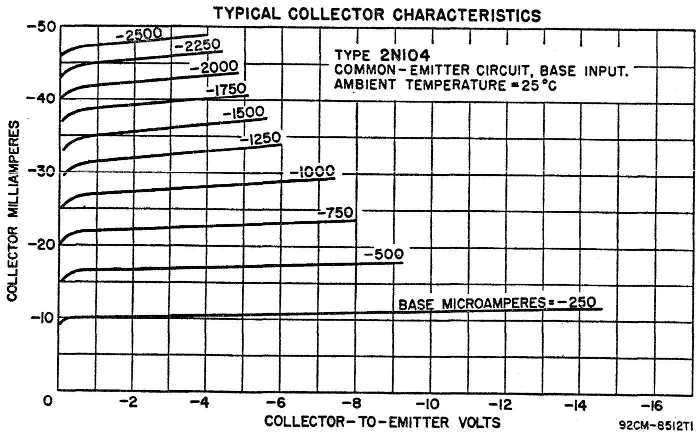
In Common-Emitter Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency:		
With collector-to-emitter volts = −6 and collector ma = −1	13.9	kc
With collector-to-emitter volts = −3 and collector ma = −0.2	16.5	kc
Power Gain (with collector-to-emitter volts = −6, collector ma = −1, input resistance = 1400 ohms, and load resistance = 20000 ohms)	41	db
Noise Figure (with collector-to-emitter volts = −4, collector ma = −0.7, and generator resistance = 518 ohms)	12 *max*	db

In Common-Collector Circuit

Power Gain (with emitter-to-collector volts = −3, collector ma = −0.2, input resistance = 0.5 megohm, and load resistance = 18000 ohms)	14.3	db

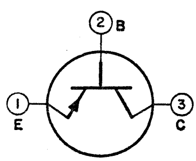




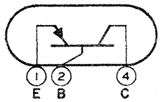
TRANSISTOR

2N105

Germanium p-n-p type used in low-power audio-frequency amplifier applications such as hearing-aid devices. Maximum ratings: collector-to-base volts, −25; collector ma, −15; transistor dissipation, 35 milliwatts; ambient-temperature range (operating), −65 to 55°C. Maximum over-all length, 0.255 inch; maximum diameter, 0.135 inch; minimum lead length, 1.5 inches. This is a DISCONTINUED type listed for reference only.



TRANSISTOR



2N109

Germanium p-n-p type used in large-signal audio-frequency amplifier applications. It is used in class B push-pull power-output stages of battery-operated portable radio receivers and audio amplifiers and in class A high-gain driver stages. JEDEC No. TO-40 package; outline 15, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE	−25 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT	−70 *max*	ma
EMITTER CURRENT	70 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	20 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = −25 and emitter current = 0)	−14	µa
Emitter-Cutoff Current (with emitter-to-base volts = −12 and collector current = 0)	−14	µa

In Common-Emitter Circuit

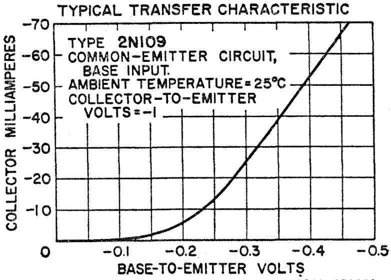
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −1 and collector ma = −50)	75

TYPICAL OPERATION IN CLASS B PUSH-PULL AF AMPLIFIER CIRCUIT

Values are for two transistors except as noted

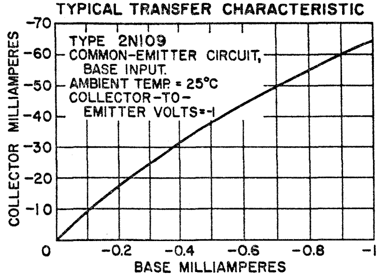
DC Collector-to-Emitter Supply Voltage	−4.5	−9	volts
DC Base-to-Emitter Voltage	−0.15	−0.15	volt
Peak Collector Current (approx.) per transistor	−35	−40	ma
Maximum-Signal DC Collector Current (approx.) per transistor	−11.5	−13	ma
Zero-Signal DC Collector Current (approx.) per transistor	−2	−2	ma
Signal-Source Impedance per base	375	375	ohms
Load Impedance per collector	100	200	ohms
Signal Frequency	1	1	kc
Circuit Efficiency at maximum rated output	60	69	per cent
Power Gain	30	33	db
Total Harmonic Distortion	10 *max*	10 *max*	per cent
Maximum-Signal Power Output	75	160	mw

TYPICAL TRANSFER CHARACTERISTIC

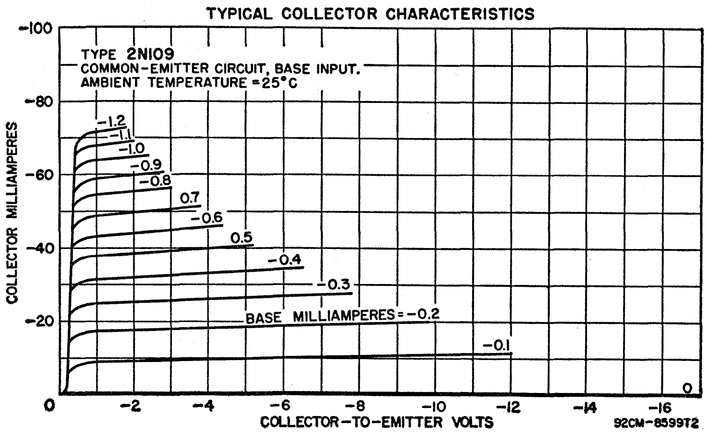


92CS-8598T2

TYPICAL TRANSFER CHARACTERISTIC

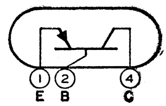


92CS-8600T2



TRANSISTOR

2N139



Germanium p-n-p type used primarily in 455-kilocycle intermediate-frequency amplifier applications in battery-operated portable radio receivers and automobile radio receivers operating from either a 6-volt or a 12-volt supply. JEDEC No. TO-40 package; outline 15, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−16 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT	−15 *max*	ma
EMITTER CURRENT	15 *max*	ma
TRANSISTOR DISSIPATION	35 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 70	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −10 and emitter current = 0)	−16 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−6 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −12 and collector current = 0)	−40 *max*	μa

In Common-Base Circuit

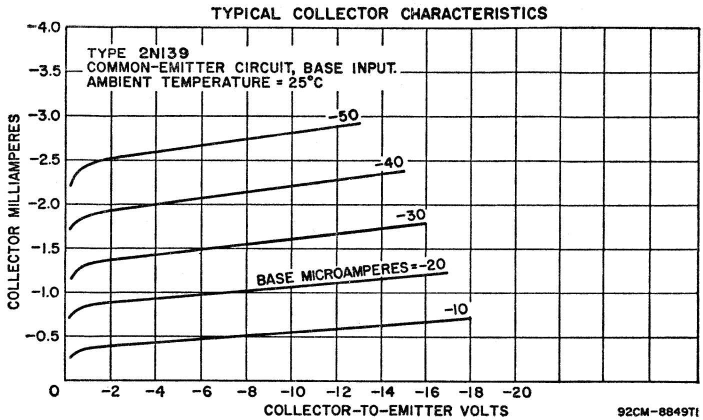
Small-Signal Forward Current-Transfer Ratio:		
With collector-to-base volts = −9 and collector ma = −0.5	0.978	
With collector-to-base volts = −9 and collector ma = −1	0.98	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency:		
With collector-to-base volts = −9 and collector ma = −0.5	4.5	Mc
With collector-to-base volts = −9 and collector ma = −1	4.7	Mc

In Common-Emitter Circuit

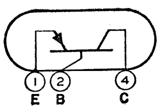
Small-Signal Forward Current-Transfer Ratio:	
With collector-to-emitter volts = −9 and collector ma = −0.5	45
With collector-to-emitter volts = −9 and collector ma = −1	48

TYPICAL OPERATION IN 455-KC IF AMPLIFIER CIRCUIT

DC Collector-to-Emitter Voltage	−9	−9	volts
DC Collector Current	−0.5	−1	ma
Input Resistance (approx.)	1000	500	ohms
Output Resistance (approx.)	70000	30000	ohms
Maximum Power Gain (approx.)	38	37	db
Useful Power Gain (approx.)	27.6	30.4	db
Spot Noise Figure (approx.)	4.5	4.5	db



TRANSISTOR



2N140

Germanium p-n-p type used primarily in converter and mixer-oscillator applications in AM battery-operated portable radio receivers and automobile radio receivers operating from either a 6-volt or a 12-volt supply. JEDEC No. TO-40 package; outline 15, Outlines Section. For curves of typical collector characteristics, refer to type 2N139.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−16 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−15 *max*	ma
EMITTER CURRENT	15 *max*	ma
TRANSISTOR DISSIPATION	80 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −10 and emitter current = 0)	−16 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−6 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−12 *max*	μa

In Common-Emitter Circuit

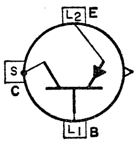
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −9 and collector ma = −0.6)	75

TYPICAL OPERATION AT 1 MC IN SELF-EXCITED CONVERTER CIRCUIT

DC Collector-to-Emitter Voltage	−9	volts
DC Collector Current	−0.6	ma
RMS Base-to-Emitter Oscillator Injection Voltage (approx.)	100	mv
Input Resistance (approx.)	700	ohms
Output Resistance (approx.)	75000	ohms
Useful Conversion Power Gain (approx.)	32	db

POWER TRANSISTOR

2N173



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−60 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−40 *max*	volts
COLLECTOR CURRENT	−15 *max*	amperes
EMITTER CURRENT	15 *max*	amperes
BASE CURRENT	−4 *max*	amperes
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	150 *max*	watts
At case temperatures above 25°C	See curve page 68	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 100	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to emitter and collector amperes = 0.3	−50 *min*	volts
With base open and collector amperes = 0.3	−50	volts
With base open and collector amperes = −1	−45 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = −2 and collector amperes = −5)	−0.65	volt
Emitter-to-Base Voltage (with collector-to-base volts = −80 and emitter current = 0)	−0.15	volt
Collector-to-Emitter Saturation Voltage (with collector amperes = −12 and base amperes = −2)	−0.3	volt
Collector-to-Emitter Reach-Through Voltage	−60 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −40 and collector current = 0)	−1	ma
Collector-Cutoff Current:		
With collector-to-base volts = −2 and emitter current = 0	−100	μa
With collector-to-base volts = −60 and emitter current = 0	−2	ma
Thermal Resistance (junction-to-case)	0.35	°C/watt
Thermal Capacity (for pulses in the 1-to-10-millisecond range)	0.075	watt-sec/°C
Themal Time Constant	26.25	msec

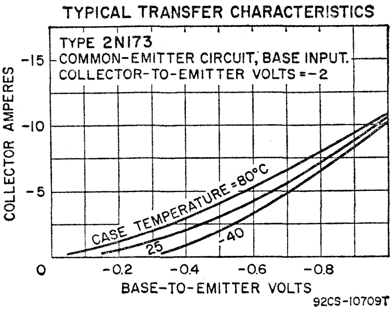
In Common-Emitter Circuit

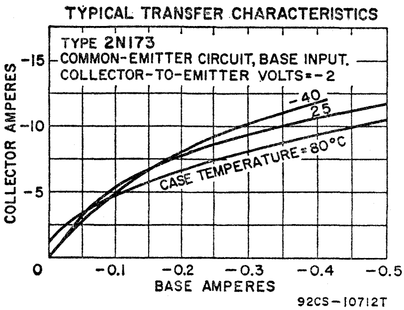
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2):	
With collector amperes = −5	35 to 70
With collector amperes = −12	25

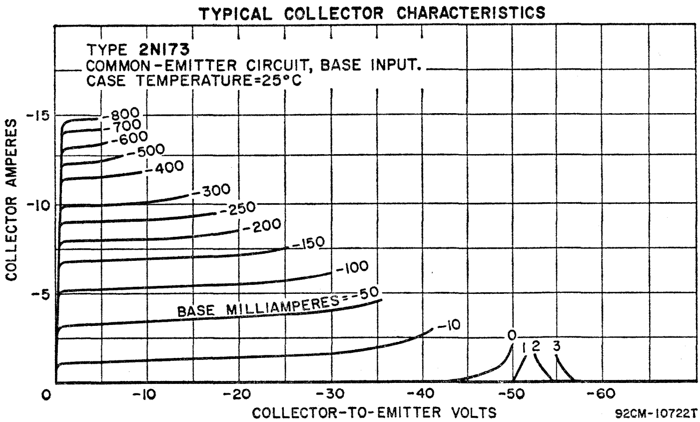
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = −6 and collector amperes = −5)	10	kc

TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT

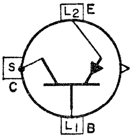
DC Collector Supply Voltage	−12	volts
DC Base Supply Voltage	6	volts
On DC Collector Current	−12	amperes
Turn-On DC Base Current	−2	amperes
Turn-Off DC Base Current	0	amperes
Switching Time:		
Rise time	15	μsec
Fall time	15	μsec







POWER TRANSISTOR



2N174

Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-

supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−80 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−60 *max*	volts
COLLECTOR CURRENT	−15 *max*	amperes
EMITTER CURRENT	15 *max*	amperes
BASE CURRENT	−4 *max*	amperes
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	150 *max*	watts
At case temperatures above 25°C	See curve page 68	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 100	°C

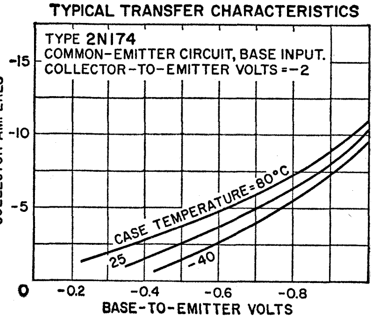
CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to the emitter and collector amperes = −0.3	−70 *min*	volts
With base open and collector amperes = −1	−55 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = −2 and collector amperes = −5)	−0.65	volt
Emitter-to-Base Voltage (with collector-to-base volts = −80 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector amperes = −12 and base amperes = −2)	−0.3	volt
Collector-to-Emitter Reach-Through Voltage	−80	volts
Emitter-Cutoff Current (with emitter-to-base volts = −60 and collector current = 0)	−1	ma
Collector-Cutoff Current:		
With collector-to-base volts = −2 and emitter current = 0	−100	μa
With collector-to-base volts = −80 and emitter current = 0	−2	ma
Thermal Resistance (junction-to-case)	0.35	°C/watt
Thermal Capacity (for pulses in the 1-to-10-millisecond range)	0.075	watt-sec/°C
Thermal Time Constant	26.25	msec

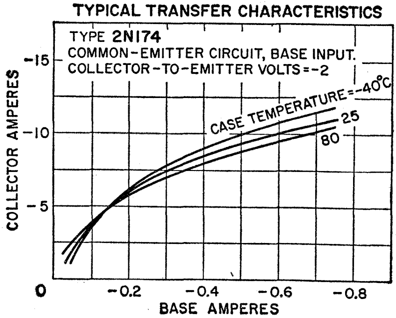
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2):		
With collector amperes = −5	25 to 50	
With collector amperes = −12	20	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = −6 and collector amperes = −5)	10	kc

TYPICAL TRANSFER CHARACTERISTICS

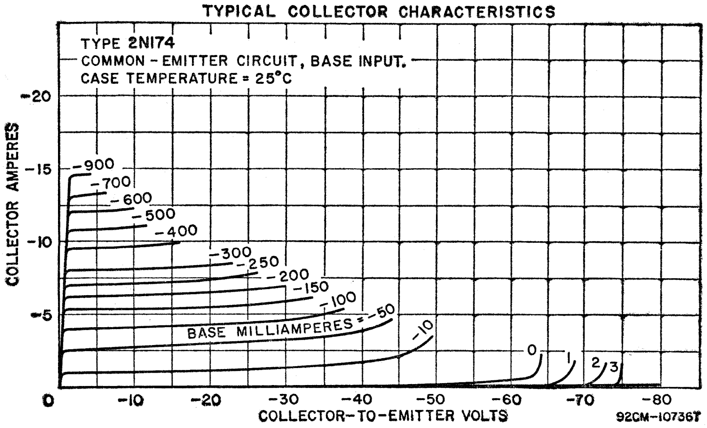


TYPICAL TRANSFER CHARACTERISTICS



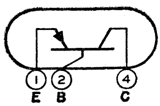
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT

DC Collector Supply Voltage	−12	volts
DC Base Supply Voltage	6	volts
On DC Collector Current	−12	amperes
Turn-On DC Base Current	−2	amperes
Turn-Off DC Base Current	0	amperes
Switching Time:		
Rise time	15	μsec
Fall time	15	μsec



TRANSISTOR

2N175



Germanium p-n-p type used in low-level preamplifier or input stages of audio-frequency amplifiers. This type is free from microphonism and hum and has a low noise figure. These features make it possible to obtain high small-signal sensitivity in transistorized audio equipment such as hearing aids, microphone preamplifiers, and recorders. In addition, the low noise figure and the low input impedance permit the design of audio amplifiers in which the transistor is operated directly from low-level, low-impedance devices such as magnetic microphones and magnetic pickups without an input coupling transformer. JEDEC No. TO-40 package; outline 15, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−10 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−10 *max*	volts
COLLECTOR CURRENT	−2 *max*	ma
EMITTER CURRENT	2 *max*	ma
TRANSISTOR DISSIPATION	20 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 50	°C
Storage	−65 to 85	°C

CHARACTERISTICS

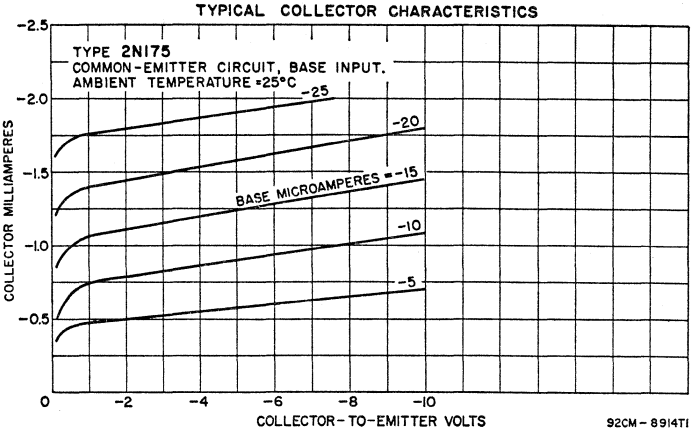
Collector-Cutoff Current (with collector-to-base volts = −25 and emitter current = 0)	−12 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −12 and collector current = 0)	−12 *max*	μa

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −4 and collector ma = −0.5)	0.85	Mc

In Common-Emitter Circuit

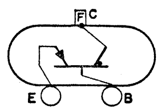
Noise Figure (with collector-to-emitter volts = −4, collector ma = −0.5, and generator resistance = 1000 ohms)	6 *max*	db
Matched-Impedance Power Gain (with collector-to-emitter volts = −4, collector ma = −0.5, input resistance = 2000 ohms, and output resistance = 70000 ohms)	43	db



POWER TRANSISTOR

2N176

Germanium p-n-p type used in large-signal audio-frequency amplifier applications. It is used in class A power-output stages and class B push-pull amplifier stages in automobile radio receivers. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−40 *max*	volts
COLLECTOR CURRENT	−3 *max*	amperes
EMITTER CURRENT	3 *max*	amperes
TRANSISTOR DISSIPATION:		
At mounting-flange temperatures up to 80°C*	10 *max*	watts
MOUNTING-FLANGE-TEMPERATURE RANGE:		
Operating and storage	−65 to 90	°C

* This rating is reduced 1 watt/C° for mounting-flange temperatures above 80°C.

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with collector ma = −330 and base short-circuited to emitter)	−30 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −30 and emitter current = 0)	−3 *max*	ma
Emitter-Cutoff Current (with emitter-to-base volts = −10 and collector current = 0)	−2 *max*	ma
Thermal Resistance:		
Junction-to-ambient	1	°C/watt

In Common-Emitter Circuit

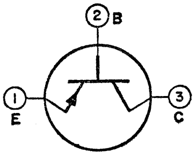
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2 and collector amperes = −0.5)	63	
Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −2 and collector amperes = −0.5)	45	
Small-Signal Input Resistance at 1 kilocycle	13.5	ohms

TYPICAL OPERATION IN CLASS A POWER-AMPLIFIER CIRCUIT

DC Collector-Supply Voltage	−14.4	volts
DC Collector-to-Emitter Voltage	−13.7	volts
DC Base-to-Emitter Voltage	−0.24	volt
Peak Collector Current	−1	ampere
Zero-Signal Collector Current	−0.5	ampere
Emitter Resistance	1	ohm
Load Impedance	25	ohms
Signal Frequency	1	kc
Signal-Source Impedance	10	ohms
Power Gain	35.5	db
Total Harmonic Distortion	4	per cent
Zero-Signal Collector Dissipation	6.83	watts
Maximum-Signal Power Output	2	watts

TRANSISTOR

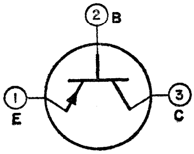
2N206



Germanium p-n-p type used in audio-frequency amplifier applications. Maximum ratings: collector-to-base volts, −30; collector ma, −50; transistor dissipation, 75 milliwatts; ambient temperature range, −65 to 85°C. JEDEC No. TO-1 package; outline 4, Outlines Section. This is a DISCONTINUED type listed for reference only.

TRANSISTOR

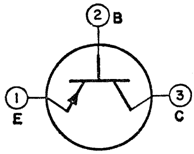
2N215



Germanium p-n-p type used in low-power audio-frequency amplifier applications. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N104.

TRANSISTOR

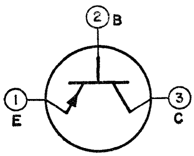
2N217



Germanium p-n-p type used in large-signal audio-frequency amplifier applications. It is used in class B push-pull power-output stages of battery-operated portable radio receivers and audio amplifiers and in class A high-gain driver stages. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N109.

TRANSISTOR

2N218

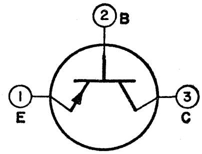


Germanium p-n-p type used primarily in 455-kilocycle intermediate-frequency amplifier applications in battery-operated portable radio receivers and automobile radio receivers operating from either a 6-volt or a 12-volt supply. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N139.

TRANSISTOR

2N219

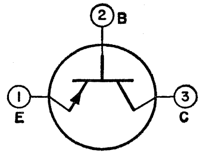
Germanium p-n-p type used primarily in converter and mixer-oscillator applications in AM battery-operated portable radio receivers and automobile radio receivers operating from either a 6-volt or a 12-volt supply. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N140.



TRANSISTOR

2N220

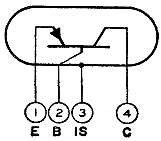
Germanium p-n-p low-noise type used in low-level preamplifier or input stages of audio-frequency amplifiers. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N175.



TRANSISTOR

2N247

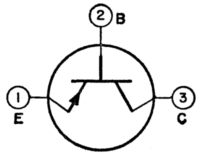
Germanium p-n-p type used in radio-frequency and intermediate-frequency amplifier, converter, and mixer-oscillator applications. Maximum ratings: collector-to-base volts, −35; collector ma, −10; transistor dissipation, 80 milliwatts; ambient temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This is a DISCONTINUED type listed for reference only; it can be replaced by type 2N274.



TRANSISTOR

2N269

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N404 except for the following items:



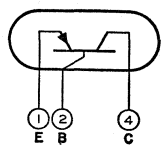
MAXIMUM RATINGS

TRANSITOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C

TRANSISTOR

2N270

Germanium p-n-p type used in large-signal audio-frequency amplifier applications. It is used in single-ended or double-ended output stages, in high-gain class A driver stages of radio receivers and audio amplifiers, and in class B push-pull audio-amplifier service. This type is also used in battery-operated



equipment such as radio receivers, communication receivers, and phonographs. Package is similar to JEDEC No. TO-7; outline 25, Outlines Section.

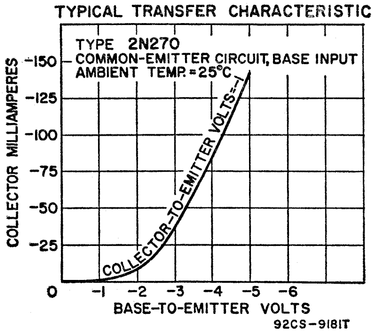
MAXIMUM RATINGS

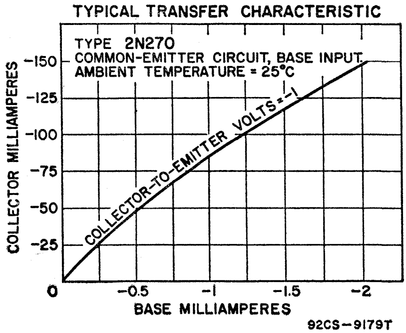
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT:		
Peak	−150 *max*	ma
DC	−75 *max*	ma
EMITTER CURRENT:		
Peak	150 *max*	ma
DC	75 *max*	ma
TRANSITOR DISSIPATION:		
At ambient temperatures up to 25°C	250 *max*	mw
At ambient temperature of 55°C	150 *max*	mw
At ambient temperature of 71°C	60 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −1 and collector ma = −150)	70





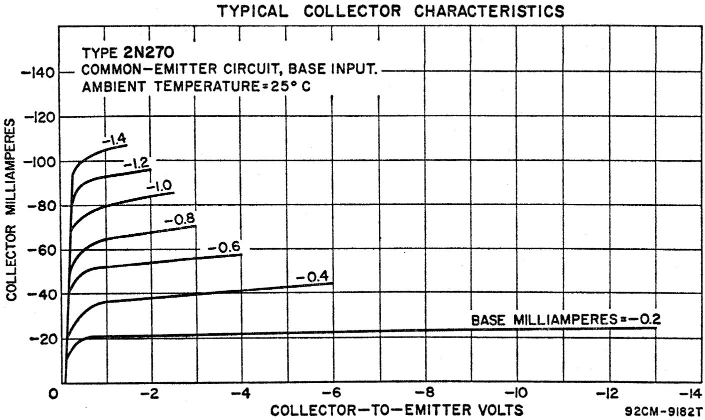
TYPICAL OPERATION IN CLASS A AF AMPLIFIER CIRCUIT

DC Collector Supply Voltage	−9	volts
DC Collector-to-Emitter Voltage	−6.7	volts
DC Base-to-Emitter Voltage	−0.19	volt
DC Collector Current	−19	ma
Emitter Resistance	400	ohms
Load Impedance	400	ohms
Signal Frequency	1	kc
Power Gain	35	db
Total Harmonic Distortion:		
At power output = 60 mw	10 *max*	per cent
At power output = 10 mw	4 *max*	per cent
Zero-Signal Transistor Dissipation	128	mw
Maximum-Signal Power Output	60	mw

TYPICAL OPERATION IN CLASS B PUSH-PULL AF AMPLIFIER CIRCUIT

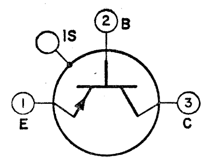
Values are for two transistors except as noted

DC Collector Supply Voltage	−12	volts
Zero-Signal DC Base-to-Emitter Voltage	−0.11	volt
Peak Collector Current per transistor	−110	ma
Maximum-Signal DC Collector Current per transistor	−35	ma
Zero-Signal DC Collector Current per transistor	−2	ma
Signal-Source Impedance per base	1000	ohms
Load Impedance per collector	150	ohms
Signal Frequency	1	kc
Circuit Efficiency	75	per cent
Power Gain	32	db
Total Harmonic Distortion:		
At power output = 500 mw	10 *max*	per cent
At power output = 10 mw	5 *max*	per cent
Maximum-Signal Power Output	500	mw



TRANSISTOR

2N274



Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at higher frequencies. The center lead connected internally to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. For curves of typical collector characteristics and for video-amplifier circuit, refer to type 2N384. JEDEC No. TO-44 package; outline 16, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 0.5)	−40	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
At case temperatures up to 25°C (with heat sink)	240 *max*	mw
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating and storage	−65 to 100	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −50 and emitter current = 0)	−80	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = −0.5)	−80	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−4	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−1	μa
Thermal Resistance:		
Junction-to-case	0.31 *max*	°C/mw
Junction-to-ambient	0.62 *max*	°C/mw

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and emitter ma = 1.5)	30	Mc
Collector-to-Base Capacitance (with collector-to-base volts = −12 and emitter current = 0)	2	pf

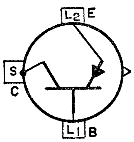
In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −12 and emitter ma = 1.5)	60	
Input Resistance with ac output circuit shorted:		
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 12.5 Mc	150	ohms
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 1.5 Mc	1350	ohms
Output Resistance with ac input circuit shorted:		
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 12.5 Mc	4000	ohms
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 1.5 Mc	70000	ohms
Power Gain:		
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 12.5 Mc	22	db
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 1.5 Mc	45	db

TYPICAL OPERATION IN VIDEO-AMPLIFIER CIRCUIT

DC Collector-to-Emitter Voltage	−12	volts
DC Emitter Current	5.8	ma
Source Impedance	150	ohms
Capacitive Load	16	pf
Frequency Response	20 cps to 9 Mc	
Pulse-Rise Time	0.039	μsec
Voltage Gain	26	db
Maximum Peak-to-Peak Output Voltage	20	volts

POWER TRANSISTOR



2N277

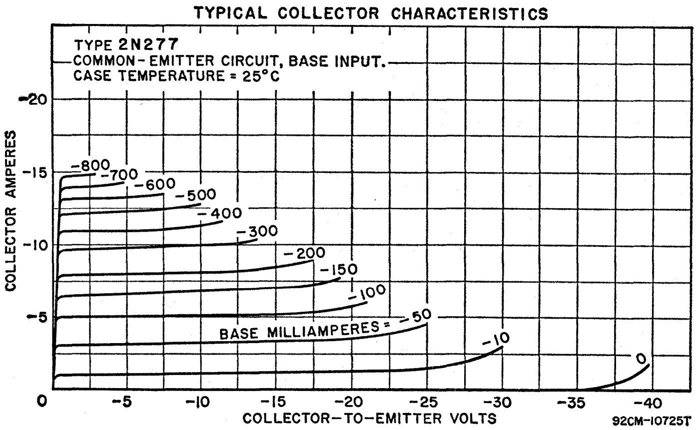
Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N173 except for the following items:

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−20 *max*	volts

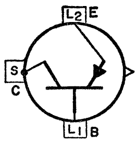
CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to emitter and collector amperes = −0.3	−40 *min*	volts
With base open and collector amperes = −0.3	−40	volts
With base open and collector amperes = −1	−25 *min*	volts
Emitter-to-Base Voltage (with collector-to-base volts = −40 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Reach-Through Voltage	−40 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −20 and collector current = 0)	−1	ma
Collector-Cutoff Current (with collector-to-base volts = −40 and emitter current = 0)	−2	ma



POWER TRANSISTOR

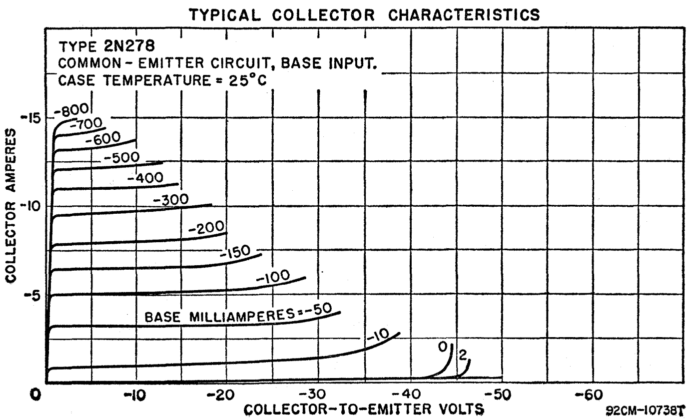
2N278



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N173 except for the following items:

MAXIMUM RATINGS

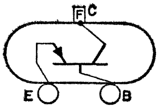
COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−50 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−30 *max*	volts



CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to the emitter and collector amperes = −0.3	−45 *min*	volts
With base open and collector amperes = −0.3	−45	volts
With base open and collector amperes = − 1	−30 *min*	volts
Emitter-to-Base Voltage (with collector-to-base volts = −50 and emitter current =0)	−1 *max*	volt
Collector-to-Emitter Reach-Through Voltage	−50 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −30 and collector current = 0)	−1	ma
Collector-Cutoff Current (with collector-to-base volts = −50 and emitter current = 0)	−2	ma

POWER TRANSISTORS



2N301
2N301A

Germanium p-n-p types used in large-signal audio-frequency amplifier applications. They are used primarily in class A power-output stages and class B push-pull amplifier stages in automobile radio receivers and communications equipment. These types have a high dc forward current-transfer ratio which helps to minimize distortion in applications requiring high power outputs at low supply voltages. JEDEC No. TO-3 package; outline 5, Outlines Section.

MAXIMUM RATINGS

	2N301	*2N301A*	
COLLECTOR-TO-BASE VOLTAGE (with emitter open):			
Peak	−40 *max*	−60 *max*	volts
DC (inductive load)	−20 *max*	−30 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance of 30 ohms	−32 *min*	−32 *min*	volts
With base short-circuited to emitter			
Peak	−32 *max*	−32 *max*	volts
DC (inductive load)	−16 *max*	−16 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−10 *max*	−10 *max*	volts
COLLECTOR CURRENT:			
Peak	−3 *max*	−3 *max*	amperes
DC	−1.5 *max*	−1.5 *max*	amperes
EMITTER CURRENT:			
Peak	3 *max*	3 *max*	amperes
DC	1.5 *max*	1.5 *max*	amperes
COLLECTOR DISSIPATION:*			
At mounting-flange temperatures up to 80°C	11 *max*	11 *max*	watts
MOUNTING-FLANGE TEMPERATURE RANGE:			
Operating and storage	−65 to 91		°C

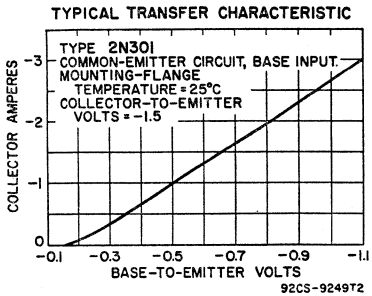
*This rating is reduced 1 watt per °C for mounting-flange temperatures above 80°C.

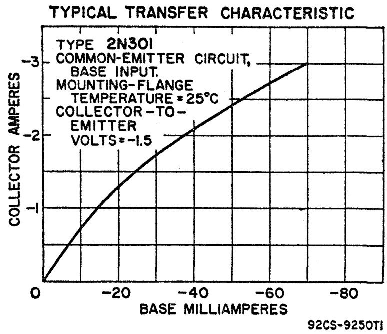
CHARACTERISTICS

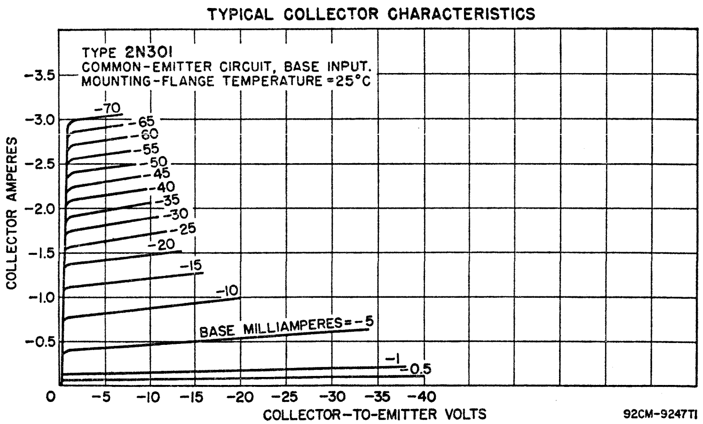
	2N301	*2N301A*	
Collector-to-Base Breakdown Voltage (with collector ma = −5 and emitter current = 0)	−40 *min*	−60 *min*	volts
Collector-to-Emitter Breakdown Voltage:			
With base open	−40 *min*	−60 *min*	volts
With collector ma = −300 and base short-circuited to emitter	−32 *min*	−32 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = −2 and collector current = 0)	−10 *min*	−10 *min*	volts
Collector-Cutoff Current:			
With collector-to-base volts = −0.5 and emitter current = 0	−100 *max*	−100 *max*	μa
With collector-to-base volts = − 30 and emitter current = 0	−3 *max*	−3 *max*	ma
Thermal Resistance:			
Junction-to-ambient	1	1	°C/watt

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = − 1.5 and collector ma = − 0.7)	62.5	
Small-Signal Input Resistance	18	ohms
DC Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = − 1.5 and collector ma = −1)	70	
Large-Signal Input Resistance	23	ohms







TYPICAL OPERATION IN CLASS A AF POWER-AMPLIFIER CIRCUIT

Mounting-flange temperature of 80°C

DC Collector Supply Voltage	−14.4	volts
DC Collector-to-Emitter Voltage	−12.2	volts
DC Base-to-Emitter Voltage	−0.38	volt
Zero-Signal Collector Current	−0.9	ampere
Peak Collector Current	−1.8	amperes
Signal Frequency	400	cps
Signal-Source Impedance	10	ohms
Load Impedance	15	ohms
Power Gain	33	db
Circuit Efficiency	43	per cent
Total Harmonic Distortion	7	per cent
Zero-Signal Collector Dissipation	11	watts
Maximum-Signal Power Output	5	watts

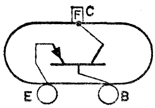
TYPICAL OPERATION IN CLASS B PUSH-PULL POWER-AMPLIFIER CIRCUIT

Mounting-flange temperature of 80°C; values are for two transistors except as noted

DC Supply Voltage	−14.4	volts
Zero-Signal DC Base-to-Emitter Voltage	−0.13	volt
Peak Collector Current	−2	amperes
Maximum-Signal DC Collector Current	−0.64	ampere
Zero-Signal DC Collector Current (per transistor)	−0.05	ampere
Signal Frequency	400	cps
Signal-Source Impedance per base	10	ohms
Load Impedance per collector	6	ohms
Power Gain	30	db
Total Harmonic Distortion	7	per cent
Circuit Efficiency	67	per cent
Collector Dissipation (per transistor)	3	watts
Maximum-Signal Power Output	12	watts

POWER TRANSISTOR

2N307



Germanium p-n-p type used in large-signal audio-frequency amplifier applications such as class A and class B audio-frequency amplifiers, class A driver amplifiers, low-frequency oscillators, converters, inverters, power supplies, light flashers, and communications systems. Package is similar to JEDEC No. TO-3; outline 26, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−35 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE	−35 *max*	volts
COLLECTOR CURRENT	−1 *max*	ma
EMITTER CURRENT	1 *max*	ma
TRANSISTOR DISSIPATION:		
At mounting-flange temperatures up to 25°C	10 *max*	watts
At mounting-flange temperatures above 25°C	See curve page 68	
MOUNTING-FLANGE TEMPERATURE RANGE:		
Operating and storage	−65 to 75	

CHARACTERISTICS

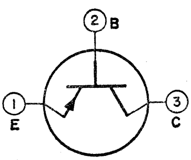
Collector-to-Emitter Saturation Voltage (with collector ma = −200 and base ma = −20)	−1 *max*	volt
Collector-Cutoff Current (with collector-to-emitter volts = −35 and external base-emitter resistance = 30 ohms)	−15 *max*	ma
Thermal Resistance:		
Junction-to-mounting flange	5	°C/watt

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −1.5 and collector ma = −200)	20	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = −1.5 and collector ma = 200)	3	kc

TRANSISTOR

2N331

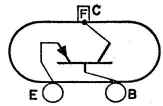


Germanium p-n-p type used in low-power class A audio-frequency amplifier applications. Maximum ratings: collector-to-base volts, −30; collector ma, −200; collector dissipation, 200 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-9 package; outline 9, Outlines Section. This is a DISCONTINUED type listed for reference only.

POWER TRANSISTOR

2N351

Germanium p-n-p type used in large-signal audio-frequency amplifier applications. It is used primarily in class A power-output stages and class B push-pull amplifier stages in automobile radio receivers. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section. This type is identical with type 2N176 except for the following items:



CHARACTERISTICS

In Common-Emitter Circuit

DC Forward-Current Transfer Ratio (with collector-to-emitter volts = −2 and collector amperes = −0.7)	65	
Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −2 and collector amperes = −0.7)	45	
Small-Signal Input Resistance	13	ohms

TYPICAL OPERATION IN CLASS A POWER-AMPLIFIER CIRCUIT

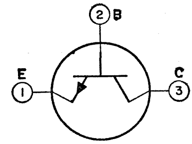
Mounting-flange temperature of 80°C

DC Collector Supply Voltage	−14.4	volts
DC Collector-to-Emitter Voltage	−13.2	volts
DC Base-to-Emitter Voltage	−0.3	volt
Peak Collector Current	−1.4	amperes
Zero-Signal DC Collector Current	−0.7	ampere
Emitter Resistance	1	ohm
Load Impedance	15	ohms
Signal Frequency	1	kc
Signal-Source Impedance	10	ohms
Power Gain	33.5	db
Total Harmonic Distortion at power output of 4 watts	5	per cent
Zero-Signal Transistor Dissipation	9.25	watts
Maximum-Signal Power Output	4	watts

TRANSISTOR

2N356

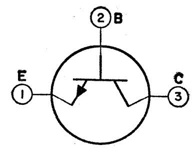
Germanium n-p-n type used in medium-speed high-current applications in data-processing equipment. Maximum ratings: collector-to-base volts, 20; peak collector ma, 500; collector dissipation, 100 milliwatts; ambient-temperature range, −55 to 85 degrees centigrade. This type has a common-emitter large-signal dc forward current-transfer ratio of 30, and a common-base forward-current-transfer-ratio cutoff frequency of 3 megacycles. Maximum case height, 0.260 inch; maximum diameter, 0.370 inch; maximum over-all-length (including leads), 1.760 inches. This is a DISCONTINUED type listed for reference only.



TRANSISTOR

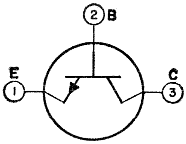
2N357

Germanium n-p-n type used in medium-speed high-current applications in data-processing equipment. Maximum ratings: collector-to-base volts, 20; peak collector ma, 500; collector dissipation, 100 milliwatts; ambient-temperature range, −55 to 85 degrees centigrade. This type has a common-emitter large-signal dc forward current-transfer ratio of 30, and a common-base forward-current-transfer-ratio cutoff frequency of 6 megacycles. Maximum case height, 0.260 inch;



maximum diameter, 0.370 inch; maximum over-all length (including leads), 1.760 inches. This is a DISCONTINUED type listed for reference only.

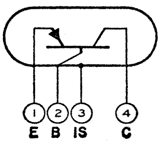
TRANSISTOR



2N358

Germanium n-p-n type used in medium-speed high-current applications in data-processing equipment. Maximum ratings: collector-to-base volts, 20; peak collector ma, 500; collector dissipation, 100 milliwatts; ambient-temperature range, −55 to 85 degrees centigrade. This type has a common-emitter large-signal dc forward current-transfer ratio of 30, and a common-base forward-current-transfer-ratio cutoff frequency of 9 megacycles. Maximum case height, 0.260 inch; maximum diameter, 0.370 inch; maximum over-all length (including leads), 1.760 inches. This is a DISCONTINUED type listed for reference only.

TRANSISTOR



2N370

Germanium p-n-p type used as an amplifier in AM broadcast-band battery-operated portable radio receivers and short-wave receivers. JEDEC No. TO-7 package; outline 7, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1.5 *max*	volts
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	40 *max*	mw
At ambient temperature of 71°C	20 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−20 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −1.5 and collector current = 0)	−50 *max*	μa

In Common-Base Circuit

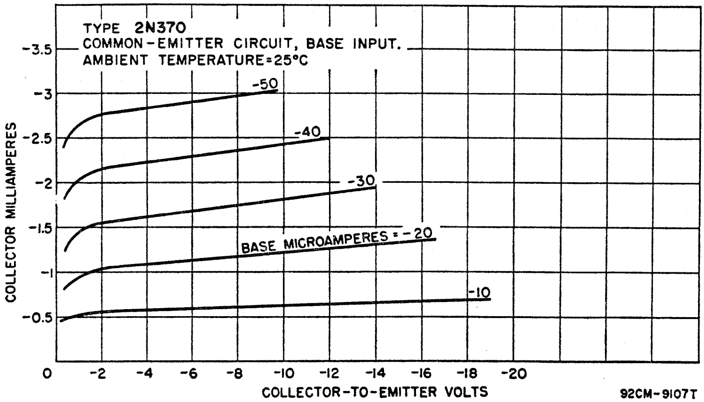
Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-base volts = −12 and collector ma = 1)	0.984	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = 1)	30	Mc
Interlead Capacitance between collector and base leads (with interlead shield grounded and all leads cut to 5/16 inch)	0.3	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −12 and collector ma = −1)	60	
Gain-Bandwidth Product (with collector-to-emitter volts = −12 and collector ma = −1)	132	Mc

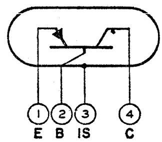
TYPICAL OPERATION

Frequency	1.5	10	20	Mc
DC Collector-to-Emitter Voltage	−12	−12	−12	volts
DC Collector Current	1	1	1	ma
Input Resistance	1750	200	100	ohms
Output Resistance	180000	18000	11000	ohms
Maximum Power Gain	50.5	26.2	17	db
Maximum Useful Power Gain in an unneutralized circuit	31	17.6	12.5	db
Intrinsic Transconductance	37800	21400	13700	μmhos
Collector Transition Capacitance	1.7	1.7	1.7	pf



TRANSISTOR

2N371



Germanium p-n-p type used as a radio-frequency oscillator in AM broadcast-band battery-operated portable radio receivers and short-wave receivers. JEDEC No. TO-7 package; outline 7, Outlines Section. Ratings and characteristics for this type are the same as for type 2N370 except for the following items:

MAXIMUM RATINGS

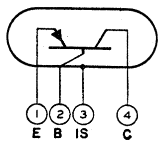
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt

CHARACTERISTICS

Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current =0)	−50 *max*	μa

TRANSISTOR

2N372



Germanium p-n-p type used as a radio-frequency mixer in AM broadcast-band battery-operated portable radio receivers and short-wave receivers. JEDEC No. TO-7 package; outline 7, Outlines Section. This type is electrically identical with type 2N370 except for the following items:

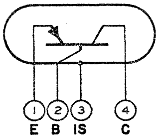
MAXIMUM RATINGS

EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt

CHARACTERISTICS

Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−50	μa

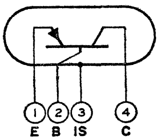
TRANSISTOR



2N373

Germanium p-n-p type used in 455-kilocycle intermediate-frequency amplifier applications in AM broadcast-band battery-operated radio receivers. Maximum ratings: collector-to-base volts, −25; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This type is used principally for renewal purposes; it can be replaced by types 2N1633 or 2N1634.

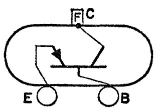
TRANSISTOR



2N374

Germanium p-n-p type used in converter (mixer-oscillator) applications in battery-operated radio receivers. Maximum ratings: collector-to-base volts, −25; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This type is used principally for renewal purposes; it can be replaced by types 2N1631 or 2N1635.

POWER TRANSISTOR



2N376

Germanium p-n-p type used in large-signal audio-frequency amplifier applications. It is used primarily in class A power-output stages and class B push-pull amplifier stages of automobile radio receivers. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section. This type is identical with type 2N176 except for the following items:

CHARACTERISTICS

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −2 and collector amperes = −0.7)	60	
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2 and collector amperes = −0.7)	78	
Small-Signal Input Resistance	16	ohms

TYPICAL OPERATION IN CLASS A POWER-AMPLIFIER CIRCUIT

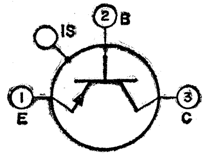
Mounting-flange temperature of 80°C

DC Collector Supply Voltage	−14.4	volts
DC Collector-to-Emitter Voltage	−13.2	volts

DC Base-to-Emitter Voltage	−0.3	volt
Peak Collector Current	−1.4	amperes
Zero-Signal DC Collector Current	−0.7	ampere
Emitter Resistance	1	ohm
Load Impedance	15	ohms
Signal Frequency	1	kc
Signal-Source Impedance	10	ohms
Power Gain	35	db
Total Harmonic Distortion	5	per cent
Zero-Signal Transistor Dissipation	9.25	watts
Maximum-Signal Power Output	4	watts

TRANSISTOR

2N384



Germanium p-n-p type used in rf- and if-amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at higher frequencies. The center lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-44 package; outline 16, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 0.5)	−40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	240 *max*	mw
At case temperatures above 25°C	See Rating Chart	
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperatures above 25°C	See Rating Chart	
AMBIENT-TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 100	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −50 and emitter current = 0)	−80	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = −0.5)	−80	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−4	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−1	μa
Thermal Resistance:		
Junction-to-case	0.31 *max*	°C/mw
Junction-to-ambient	0.62 *max*	°C/mw

In Common-Base Circuit

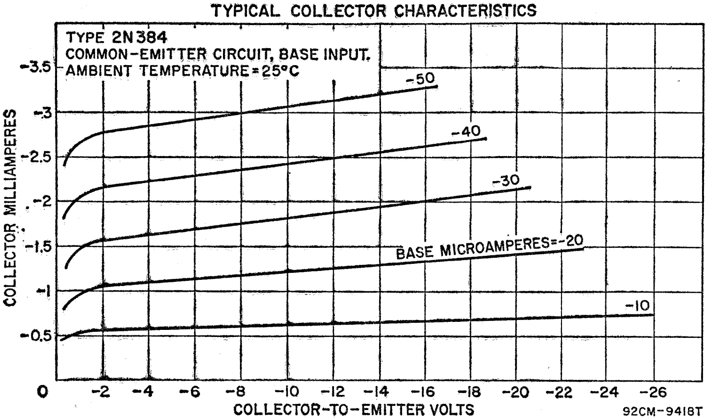
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and emitter ma = 1.5)	100	Mc
Input Resistance with ac output circuit shorted (with collector-to-base volts = −12, emitter ma = 1.5, and signal frequency = 50 Mc)	30	ohms
Output-Resistance with ac input circuit shorted (with collector-to-base volts = −12, emitter ma = 1.5, and signal frequency = 50 Mc)	5000	ohms
Collector-to-Base Capacitance (with collector-to-base volts = −12, and emitter current = 0)	2	pf
Power Gain (with collector-to-base volts = −12, emitter ma = 1.5, signal frequency = 50 Mc)	18	db

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −12 and emitter ma = 1.5)	60

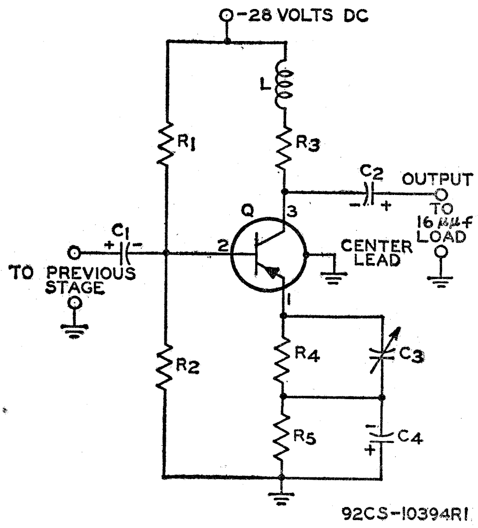
Input Resistance with ac output circuit shorted:		
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 30 Mc	50	ohms
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 12.5 Mc	250	ohms
Output Resistance with ac input circuit shorted:		
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 30 Mc	5000	ohms
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 12.5 Mc	16000	ohms
Power Gain:		
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 30 Mc	20	db
With collector-to-emitter volts = −12, emitter ma = 1.5, and signal frequency = 12.5 Mc	28	db

TYPICAL COLLECTOR CHARACTERISTICS



TYPICAL OPERATION IN VIDEO-AMPLIFIER CIRCUIT SHOWN BELOW

DC Collector-to-Emitter Voltage	−12	volts
DC Emitter Current	5.8	ma
Source Impedance	150	ohms
Capacitive Load	16	pf
Frequency Response	20 cps to 10 Mc	
Pulse-Rise Time	0.035	μsec
Voltage Gain	26	db
Maximum Peak-to-Peak Output Voltage	20	volts

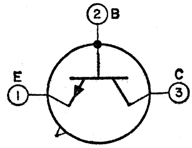


C_1 = 25 μf, 12 volts
C_2 = 25 μf, 25 volts
C_3 = 100 to 300 μμf (variable)
C_4 = 100 μf, 12 volts
L = 30 μh
R_1 = 20000 ohms, 0.25 watt
R_2 = 3600 ohms, 0.25 watt
R_3 = 2000 ohms, 0.25 watt
R_4 = 62 ohms, 0.25 watt
R_5 = 620 ohms, 0.25 watt

TRANSISTORS

2N388
2N388A

Germanium n-p-n types used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

	2N388	2N388A	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance = 10000 ohms	20 *max*	20 *max*	volts
With base-to-emitter volts = −0.5	—	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	15 *max*	15 *max*	volts
COLLECTOR CURRENT	200 *max*	200 *max*	ma
TRANSISTOR DISSIPATION:			
At ambient temperatures up to 25°C	150 *max*	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68		
AMBIENT-TEMPERATURE RANGE:			
(Operating and storage)	−65 to 100		°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	235 *max*	°C

CHARACTERISTICS

	2N388	2N388A	
Base-to-Emitter Voltage:			
With collector ma = 200 and base ma = 10	1.5 *max*	1.5 *max*	volts
With collector ma = 100 and base ma = 4	0.8 *max*	0.8 *max*	volt
Collector-Cutoff Current:			
With collector-to-base volts = 40 and emitter current = 0	—	40 *max*	μa
With collector-to-base volts = 25 and emitter current = 0	10 *max*	10 *max*	μa
With collector-to-base volts = 1 and emitter current = 0	5 *max*	5 *max*	μa

In Common-Emitter Circuit

	2N388	2N388A	
Forward Current-Transfer Ratio:			
With collector-to-emitter volts = 0.75 and collector ma = 200	30 *min*	30 *min*	
With collector-to-emitter volts = 0.5 and collector ma = 30	60 to 180	60 to 180	

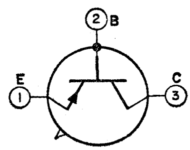
In Common-Base Circuit

	2N388	2N388A	
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 6 and collector ma = 1)	5 *min*	5 *min*	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 6 and collector ma = 1)	20 *max*	20 *max*	pf

TRANSISTOR

2N395

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10000 ohms)	−15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−20 *max*	volts
COLLECTOR CURRENT	−200 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 85	°C
Storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	230 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = 50 and base ma = −5)	−0.2 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −15 and emitter current = 0)	−6 *max*	μa

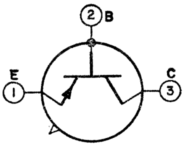
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = −5 and emitter ma = 1)	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	3 *min*	Mc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:	
With collector-to-emitter volts = −1 and collector ma = −10	20 to 150
With collector-to-emitter volts = −0.35 and collector ma = −200	10 *min*

TRANSISTORS



Germanium p-n-p types used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. Ratings for these types are the same as for type 2N395 except for the following items:

2N396
2N396A

MAXIMUM RATINGS

	2N396	*2N396A*	
COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	—	−20 *max*	volts
With external base-to-emitter resistance = 10000 ohms	−20 *max*	—	volts
TRANSISTOR DISSIPATION:			
At ambient temperatures up to 25°C	150 *max*	200 *max*	mw

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −50 and base ma = −3.3)	−0.2 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −20 and emitter current = 0)	−6 *max*	μa

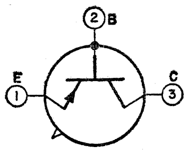
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = −5 and emitter ma = 1)	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	5 *min*	Mc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:	
With collector-to-emitter volts = −1 and collector ma = −10	30 to 150
With collector-to-emitter volts = −0.35 and collector ma = −200	15 *min*

TRANSISTOR



Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N395 except for the following items:

2N397

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −50 and base ma = −2.5)	−0.2 *max*	volt

In Common-Base Circuit

Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	10 *min*	Mc

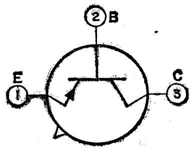
In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −1 and collector ma = −10	40 to 150	
With collector-to-emitter volts = −0.35 and collector ma = −200	20 *min*	

TRANSISTORS

2N398
2N398A
2N398B

Germanium p-n-p types used for direct high-voltage control of "on-off" devices such as neon indicators, relays, incandescent-lamp indicators, and indicating counters of electronic computers. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

	2N398	2N398A	2N398B	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−105 *max*	−105 *max*	−105 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−105 *max*	−105 *max*	−105 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−50 *max*	−50 *max*	−75 *max*	volts
COLLECTOR CURRENT	−100 *max*	−200 *max*	−200 *max*	ma
EMITTER CURRENT	100 *max*	200 *max*	200 *max*	ma
TRANSISTOR DISSIPATION:				
At ambient temperatures up to 25°C.	50 *max*	150 *max*	250 *max*	mw
At ambient temperatures above 25°C.		See curve page 68		
AMBIENT-TEMPERATURE RANGE:				
Operating	−65 to 55	−65 to 100	−65 to 100	°C
Storage	−65 to 85	−65 to 100	−65 to 100	°C
LEAD TEMPERATURE				

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = −5 and base ma = −0.25)	−0.4 *max*	−0.4 *max*	−0.3 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −5 and base ma = −0.25)	−0.35 *max*	−0.35 *max*	−0.25 *max*	volt
Collector-Cutoff Current:				
With collector-to-base volts = −2.5 and emitter current = 0	−14 *max*	−14 *max*	−6 *max*	μa
With collector-to-base volts = −105 and emitter current = 0	−50 *max*	−50 *max*	−25 *max*	μa

In Common-Base Circuit

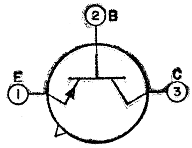
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	—	—	1 *min*	Mc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:			
With collector-to-emitter volts = −0.35 and collector ma = −5	20 *min*	20 *min*	—
With collector-to-emitter volts = −0.25 and collector ma = −5	—	—	20 *min*

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −6, collector ma = −1, and frequency = 1 kilocycle)	20 *min*	40 *min*

TRANSISTORS



Germanium p-n-p types used in medium-speed switching applications in data-processing equipment. These types also have wide application in other low-level, medium-speed "on-off" control circuits. JEDEC No. TO-5 package; outline 6, Outlines Section.

2N404
2N404A

MAXIMUM RATINGS

	2N404A	*2N404A*	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	−40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−24 *max*	−35 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	−25 *max*	volts
COLLECTOR CURRENT	−100 *max*	−150 *max*	ma
EMITTER CURRENT	100 *max*	150 *max*	ma
TRANSISTOR DISSIPATION:			
At ambient temperatures up to 25°C	150 *max*	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68		
AMBIENT-TEMPERATURE RANGE:			
Operating	−65 to 85	−65 to 100	°C
Storage	−65 to 100	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	255 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage:		
With collector ma = −12 and base ma = −0.4	−0.15 *max*	volt
With collector ma = −24 and base ma = −1	−0.2 *max*	volt
Base-to-Emitter Saturation Voltage:		
With collector ma = −12 and base ma = −0.4	−0.35 *max*	volt
With collector ma = −24 and base ma = −1	−0.40 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−5 *max*	μa
Stored Base Charge (with collector ma = −10 and base ma = −1)	−1400 *max*	pcoul

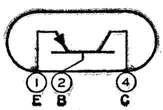
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = −6 and collector current = 0)	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and collector ma = −1)	4 *min*	Mc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:	
With collector-to-emitter volts = −0.2 and collector ma = −24	24 *min*
With collector-to-emitter volts = −0.15 and collector ma = −12	30 *min*

TRANSISTOR



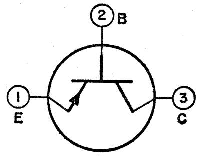
Germanium p-n-p type used in low-power class A audio-frequency driver-amplifier applications in battery-operated portable radio-receivers. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is electrically identical with type 2N406.

2N405

TRANSISTOR

2N406

Germanium p-n-p type used in class A audio-frequency driver-amplifier applications in battery-operated portable radio receivers. JEDEC No. TO-1 package; outline 4, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−20 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE	−18 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−2.5 *max*	volts
COLLECTOR CURRENT	−35 *max*	ma
EMITTER CURRENT	35 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	20 *max*	mw
AMBIENT TEMPERATURE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−14 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −2.5 and collector current = 0)	−14 *max*	μa

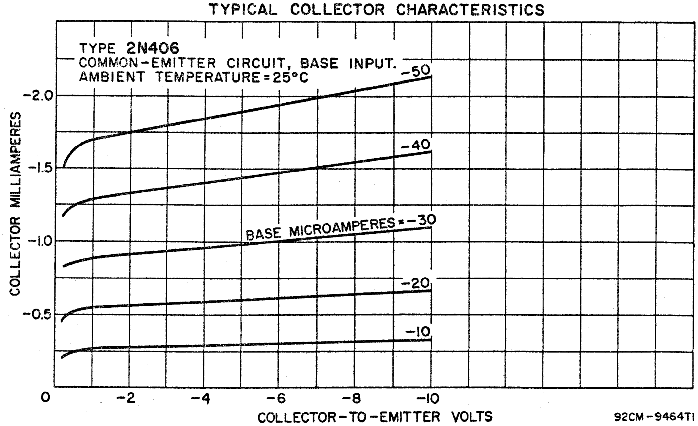
In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and collector ma = −1)	650	kc

In Common-Emitter Circuit

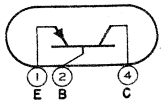
DC Collector-to-Emitter Voltage	−6	volts
DC Collector Current	−1	ma
Power Gain (with load resistance of 8500 ohms and input resistance of 750 ohms)	43	db

TYPICAL COLLECTOR CHARACTERISTICS



TRANSISTOR

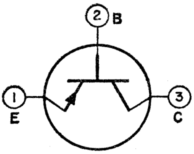
2N407



Germanium p-n-p type used in class A output stages and class B push-pull output stages of battery-operated portable radio receivers and audio amplifiers. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is electrically identical with type 2N408.

TRANSISTOR

2N408



Germanium p-n-p type used in class A output stages and class B push-pull output stages of battery-operated portable radio receivers and audio amplifiers. JEDEC No. TO-1 package; outline 4, Outlines Section. For curves of collector characteristics and transfer characteristics, refer to type 2N109.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−20 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE	−18 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−2.5 *max*	volts
COLLECTOR CURRENT	−70 *max*	ma
EMITTER CURRENT	70 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	20 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−14 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −1.5 and collector current = 0)	−14 *max*	μa

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −1 and collector ma = −50)	75	

TYPICAL OPERATION IN CLASS B AF AMPLIFIER CIRCUIT

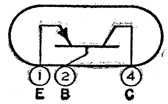
Values are for two transistors except as noted

DC Collector Supply Voltage	−4.5	−9	volts
Base-to-Emitter Voltage	−0.15	−0.15	volt
Peak Collector Current (Approx.) per transistor	−35	−40	ma
Maximum-Signal DC Collector Current (Approx.) per transistor	−11.5	−13	ma
Zero-Signal DC Collector Current (Approx.) per transistor	−2	−2	ma
Signal Frequency	1	1	kc
Signal-Source Impedance per base	375	375	ohms
Load Impedance per collector	100	200	ohms
Power Gain	30	33	db
Circuit Efficiency	60	69	per cent
Total Harmonic Distortion	10 *max*	10 *max*	per cent
Maximum-Signal Power Output	75	160	mw

TRANSISTOR

2N409

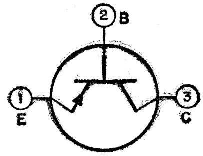
Germanium p-n-p type used in 455-kilocycle intermediate-frequency amplifier applications in battery-operated portable radio receivers. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is electrically identical with type 2N410.



TRANSISTOR

2N410

Germanium p-n-p type used in 455-kilocycle intermediate-frequency amplifier applications in battery-operated portable radio receivers. JEDEC No. TO-1 package; outline 4, Outlines Section. For curves of collector characteristics, refer to type 2N139.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−13 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−15 *max*	ma
EMITTER CURRENT	15 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-To-Base Breakdown Voltage (with collector μa = −10 and emitter current = 0)	−13 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −13 and emitter current = 0)	−10 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−12 *max*	μa

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio at 1 kilocycle:		
With collector-to-base volts = −9 and collector ma = −0.5	0.978	
With collector-to-base volts = −9 and collector ma = −1	0.98	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency at 1 kilocycle:		
With collector-to-base volts = −9 and collector ma = −0.5	6.8	Mc
With collector-to-base volts = −9 and collector ma = −1	6.7	Mc

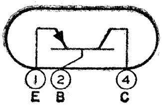
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio at 1 kilocycle:	
With collector-to-emitter volts = −9 and collector ma = −0.5	45
With collector-to-emitter volts = −9 and collector ma = −1	48

TYPICAL OPERATION IN 455-KC IF AMPLIFIER CIRCUIT

DC Collector-to-Emitter Voltage	−9	−9	volts
DC Emitter Current	0.5	1	ma
Input Resistance	1000	500	ohms
Output Resistance	70000	30000	ohms
Spot Noise Factor	4.5	4.5	db
Maximum Power Gain	38.8	37.8	db
Useful Power Gain	28.4	31.2	db

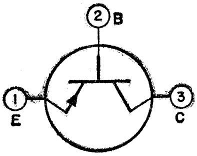
TRANSISTOR



2N411

Germanium p-n-p type used in converter and mixer-oscillator applications in battery-operated portable radio receivers. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is electrically identical with type 2N412.

TRANSISTOR



2N412

Germanium p-n-p type used in converter and mixer-oscillator applications in battery-operated portable radio receivers. JEDEC No. TO-1 package; outline 4, Outlines Section. For curves of collector characteristics, refer to type 2N139.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−13 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−15 *max*	ma
EMITTER CURRENT	15 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

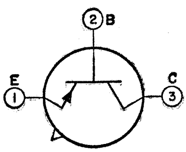
Collector-to-Base Breakdown Voltage (with collector μa = −10 and emitter current = 0)	−13 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −13 and emitter current = 0)	−10 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−12 *max*	μa

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −9 and collector ma = −0.6)	75	

TYPICAL OPERATION IN CONVERTER CIRCUIT

DC Collector-to-Emitter Voltage	−9	volts
DC Collector Current	−0.6	ma
Input Resistance	700	ohms
Output Resistance	75000	ohms
RMS Base-to-Emitter Oscillator-Injection Voltage (Approx.)	100	mv
Signal Frequency	1	Mc
Useful Conversion Power Gain (Approx.)	32	db



TRANSISTOR

2N414

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5; outline 6, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base open	−15 *max*	volts
With base-to-emitter volts = 1	−20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−20 *max*	volts
PEAK COLLECTOR CURRENT	−400 *max*	ma
DC COLLECTOR CURRENT	−200 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	240 *max*	°C

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−5 *max*	μa

In Common-Base Circuit

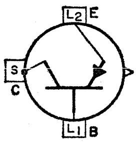
Collector-to-Base Capacitance (with collector-to-base volts = −6 and emitter ma = 1)	11	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	8	Mc
Small-Signal Open-Circuit Reverse Voltage-Transfer Ratio (with collector-base volts = −6, emitter ma = 1, and frequency = 1 kilocycle)	0.0005	

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −6, emitter ma = 1, and frequency = 1 kilocycle)	80	

POWER TRANSISTOR

2N441



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−20 *max*	volts
COLLECTOR CURRENT	−15 *max*	amperes
EMITTER CURRENT	15 *max*	amperes
BASE CURRENT	−4 *max*	amperes
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	150 *max*	watts
At case temperatures above 25°C	See curve page 68	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 100	

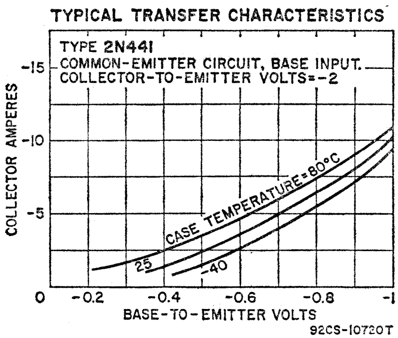
CHARACTERISTICS

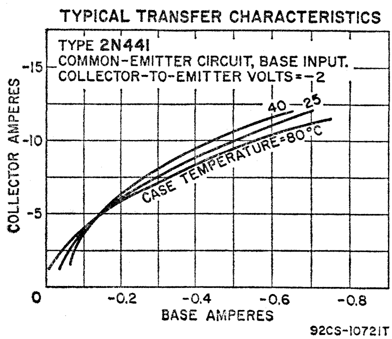
Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to emitter and collector amperes = −0.3	−40 *min*	volts
With base open and collector amperes = −0.3	−40	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = −2 and collector amperes = −5)	−0.65	volt

Emitter-to-Base Voltage (with collector-to-base volts = −40 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector amperes = −12 and base amperes = −2)	−0.3	volt
Collector-to-Emitter Reach-Through Voltage	−40 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −20 and collector current = 0)	−1	ma
Collector-Cutoff Current:		
With collector-to-base volts = −2 and emitter current = 0	−100	μa
With collector-to-base volts = −40 and emitter current = 0	−2	ma
Thermal Resistance (junction-to-case)	0.35	°C/watt
Thermal Capacity (for pulse durations of 1 to 10 milliseconds)	0.075	watt-sec/°C
Thermal Time Constant	26.25	msec

In Common-Emitter Circuit

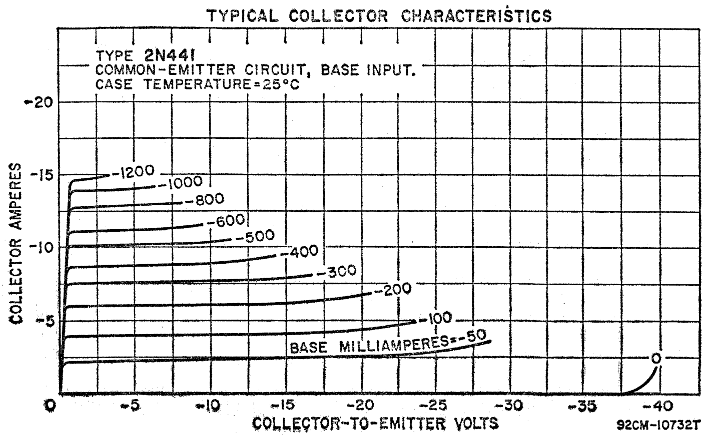
DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −2 and collector amperes = −5	20 to 40	
With collector-to-emitter volts = −2 and collector amperes = −12	20	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = −6 and collector amperes = −5)	10	kc





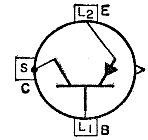
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT

DC Collector Supply Voltage	−12	volts
DC Base Supply Voltage	6	volts
On DC Collector Current	−12	amperes
Turn-On DC Base Current	−2	amperes
Turn-Off DC Base Current	0	amperes
Switching Time:		
Rise time	15	μsec
Fall time	15	μsec



POWER TRANSISTOR

2N442



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N441 except for the following items:

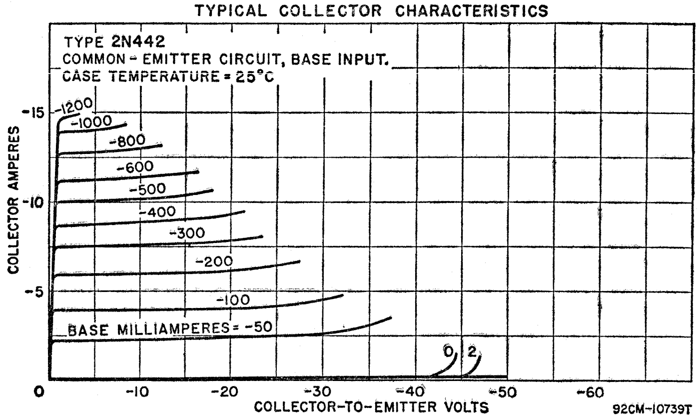
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−50 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−30 *max*	volts

CHARACTERISTICS

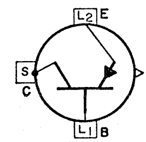
Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to the emitter and collector amperes = −0.3	−45 *min*	volts
With base open and collector amperes = −0.3	−45	volts
Emitter-to-Base Voltage (with collector-to-base volts = −50 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Reach-Through Voltage	−50 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −30 and collector current = 0)	−1	ma
Collector-Cutoff Current (with collector-to-base volts = −40 and emitter current = 0)	−2	ma

TYPICAL COLLECTOR CHARACTERISTICS



POWER TRANSISTOR

2N443



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-

supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N441 except for the following items:

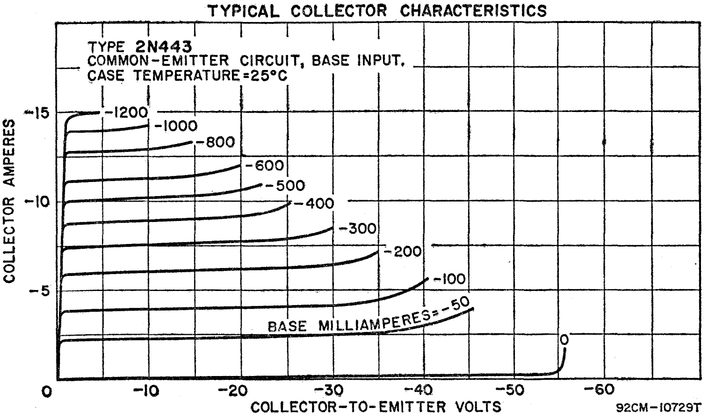
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−60 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−40 *max*	volts

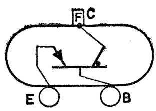
CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to the emitter and collector amperes = −0.3	−50 *min*	volts
With base open and collector amperes = −0.3	−55	volts
Emitter-to-Base Voltage (with collector-to-base volts = −60 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Reach-Through Voltage	−60 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −40 and collector current = 0)	−1	ma
Collector-Cutoff Current (with collector-to-base volts = −60 and emitter current = 0)	−2	ma

TYPICAL COLLECTOR CHARACTERISTICS



POWER TRANSISTOR



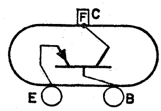
2N456

Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment. Maximum ratings: collector-to-base volts, −40; collector amperes, −5; dissipation (at mounting-flange temperature = 25°C), 50 watts; mounting-flange-temperature range (operating), −65 to 95°C. Package is similar to JEDEC No. TO-3; outline 26, Outlines Section. This type is used principally for renewal purposes.

POWER TRANSISTOR

2N457

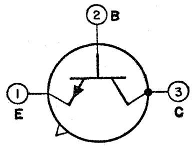
Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment. Maximum ratings: collector-to-base volts, −60; collector amperes, −5; transistor dissipation (at mounting-flange temperature = 25°C), 50 watts; mounting-flange-temperature range (operating), −65 to 95°C. Package is similar to JEDEC No. TO-3; outline 26, Outlines Section. This type is used principally for renewal purposes.



POWER TRANSISTOR

2N497

Silicon n-p-n type used in a wide variety of medium-power switching and amplifier applications in industrial and military equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	60 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	8 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	4 *max*	watts
At case temperatures above 25°C	See curve page 68	
CASE-TEMPERATURE RANGE:		
Operating and storage	−65 to 200	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	60 *min*	volts
Collector-to-Emitter Breakdown Voltage (with collector ma = 0.25 and base current = 0)	60 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.25 and collector current = 0)	8 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = 10 and emitter current = 0)	10 *max*	µa
Thermal Resistance:		
Junction-to-case	43.75 *max*	°C/watt
Junction-to-ambient	200 *max*	°C/watt
Thermal Time Constant	10	msec

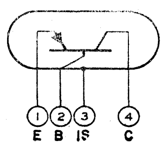
In Common-Emitter Circuit

Input Resistance (with collector-to-emitter volts = 10 and collector ma = 200)	500 *max*	ohms
Collector-to-Emitter Saturation Resistance (with collector ma = 200 and base ma = 20)	25 *max*	ohms
Forward Current-Transfer Ratio (with collector-to-emitter volts = 10 and collector ma = 200)	12 to 36	

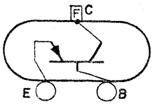
TRANSISTOR

2N544

Germanium p-n-p type used in class A radio-frequency amplifier circuits in battery-operated portable radio receivers and communications receivers. Maximum ratings: collector-to-base volts, −18; collector ma, −10; collector dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This is a DISCONTINUED type listed for reference only.



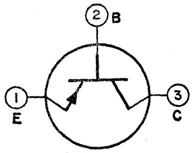
POWER TRANSISTOR



2N561

Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment. Maximum ratings: collector-to-base volts, −80; peak collector amperes, −10; transistor dissipation (at mounting-flange temperature = 25°C), 50 watts; mounting-flange-temperature range (operating), −65 to 100°C. Package is similar to JEDEC No. TO-3; outline 26, Outlines Section, except that maximum case height is 0.72 inch. This type is used principally for renewal purposes.

TRANSISTOR



2N578

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-9 package; outline 9, Outlines Section.

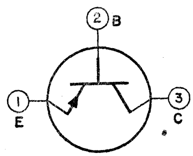
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−20 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = 1)	−14 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT	−400 *max*	ma
EMITTER CURRENT	400 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −400 and base ma = −40)	−0.3 *max*	volt
Base-to-Emitter Voltage (with collector ma = −400 and base ma = −40)	−1.2 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−5 *max*	μa
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	3 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio (collector-to-emitter volts = −0.3 and collector ma = −400)	10 *min*	

TRANSISTOR



2N579

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-9 package; outline 9, Outlines Section. This type is identical with type 2N578 except for the following items:

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −400 and base ma = −20)	−0.3 *max*	volt
Base-to-Emitter Voltage (with collector ma = −400 and base ma = −20)	−1.1 *max*	volts

In Common-Base Circuit

Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	5 *min*	Mc

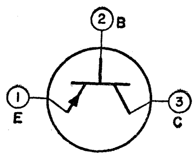
In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −400)	20 *min*	

TRANSISTOR

2N580

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-9 package; outline 9, Outlines Section. This type is identical with type 2N578 except for the following items:



CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −400 and base ma = −13.3)	−0.3 *max*	volt
Base-to-Emitter Voltage (with collector ma = −400 and base ma = −13.3)	−1 *max*	volt

In Common-Base Circuit

Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	10 *min*	Mc

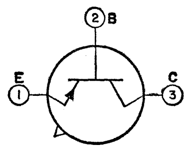
In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −400)	30 *min*	

TRANSISTOR

2N581

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N404 except for the following items:



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−18 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−10 *max*	volts

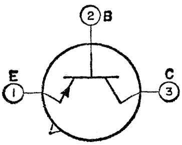
CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −20 and base ma = −1)	−0.3	volt
Base-to-Emitter Saturation Voltage (with collector ma = −20 and base ma = −1)	−0.5 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−10 *max*	μa
Stored Base Charge (with collector ma = −20 and base ma = −2)	2400 *max*	pcoul

In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −20)	20 *min*	

TRANSISTOR



Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N404 except for the following items:

2N582

MAXIMUM RATINGS

COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−14 *max*	volts

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage:		
With collector ma = −24 and base ma = −0.6	−0.2 *max*	volt
With collector ma = −100 and base ma = −5	−0.3 *max*	volt
Base-to-Emitter Saturation Voltage:		
With collector ma = −24 and base ma = −0.6	−0.4 *max*	volt
With collector ma = −100 and base ma = −5	−0.8 *max*	volt
Stored Base Charge (with collector ma = −24 and base ma = −1.2)	1200 *max*	pcoul

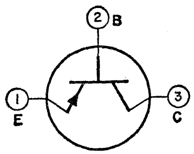
In Common-Base Circuit

Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and collector ma = −1)	14 *min*	Mc

In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −0.2 and collector ma = −24	40 *min*	
With collector-to-emitter volts = −0.3 and collector ma = −100	20 *min*	

TRANSISTOR



Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-1 package; outline 4, Outlines Section.

2N583

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−18 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−10 *max*	volts
COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = −20 and base ma = −1)	−0.3 *max*	volt
Base-to-Emitter Saturation Voltage (with collector ma = −20 and base ma = −1)	−0.5 *max*	volt

Collector-Cutoff Current (with collector-to-base voltage = −12 and emitter current = 0)	−10 *max*	μa
Stored Base Charge (with collector ma = −20 and base ma = −2)	2400 *max*	pcoul

In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = −6 and collector current = 0)	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and collector ma = −1)	4 *min*	Mc

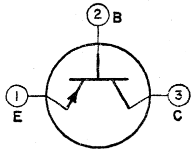
In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −20)	20 *min*	

TRANSISTOR

2N584

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-1 package; outline 4, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−14 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage:		
With collector ma = − 24 and base ma = −0.6	−0.2 *max*	volt
With collector ma = −100 and base ma = −5	−0.3 *max*	volt
Base-to-Emitter Saturation Voltage:		
With collector ma = − 24 and base ma = −0.6	−0.4 *max*	volt
With collector ma = −100 and base ma = −5	−0.8 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−5 *max*	μa
Stored Base Charge (with collector ma = −24 and base ma = −1.2)	1200 *max*	pcoul

In Common-Base Circuit

Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and collector ma = −1)	14 *min*	Mc
Collector-to-Base Capacitance (with collector-to-base volts = −6 and collector current = 0)	−20 *max*	pf

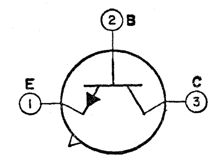
In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −0.2 and collector ma = − 24	40 *min*	
With collector-to-emitter volts = −0.3 and collector ma = −100	20 *min*	

TRANSISTOR

2N585

Germanium n-p-n type used in switching circuits of compact, medium-speed electronic computers. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base open	15 *max*	volts
With base-to-emitter volts = −1	24 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	20 *max*	volts
COLLECTOR CURRENT	200 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage (with collector ma = 20 and base ma = 1)	0.2 *max*	volt
Base-to-Emitter Saturation Voltage (with collector ma = 20 and base ma = 1)	0.45 *max*	volt
Collector-Cutoff Current:		
With collector-to-base volts = 0.25 and emitter current = 0	6 *max*	μa
With collector-to-base volts =12 and emitter current = 0	8 *max*	μa
Stored Base Charge (with collector ma = 20 and base ma = 2)	3000 *max*	pcoul

In Common-Base Circuit

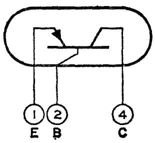
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 6 and collector ma = 1)	3 *min*	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 6 and emitter open)	25 *max*	pf

In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = 0.2 and collector ma = 20)	20 *min*	

TRANSISTOR

2N586



Germanium p-n-p type used in low-speed switching applications in industrial and military equipment. It is used as a relay-actuating device and in voltage-regulator, multivibrator, dc-to-dc converter, and power-supply circuits. It can also be used in audio-frequency service as an oscillator and in large-signal class A and class B circuits as a push-pull audio amplifier. Outline is similar to JEDEC No. TO-7 package; outline 25, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−45 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT	−250 *max*	ma
EMITTER CURRENT	250 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	250 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C

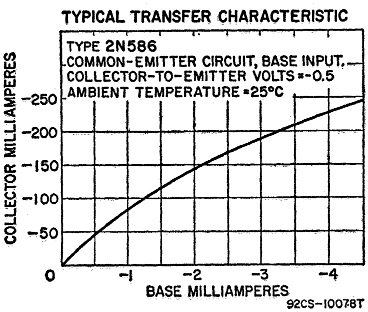
CHARACTERISTICS

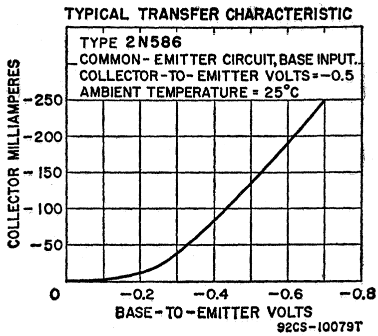
Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to emitter and collector μa = −50	−70	volts
With base open and collector ma = −1	−35	volts

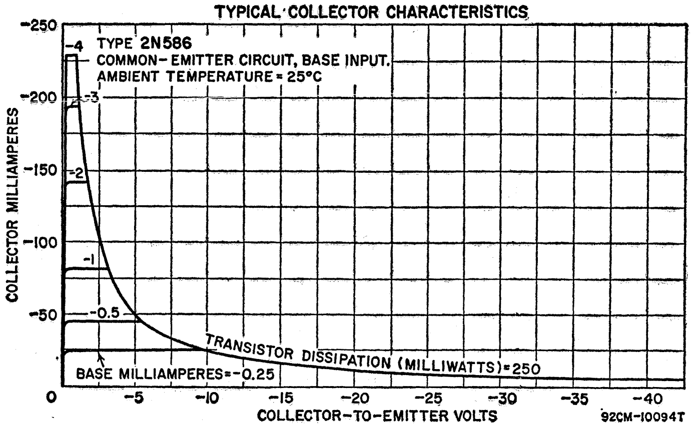
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = −1 and emitter current = 0)	−75	volts
Base-to-Emitter Voltage (with collector ma = −250 and base ma = −7)	−0.7	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −250 and base ma = −25)	−0.25	volt
Collector-Cutoff Current (with collector-to-base volts = −45 and emitter current = 0)	−8	μa
Emitter-Cutoff Current (with emitter-to-base volts = −12 and collector current = 0)	−4	μa

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.5 and collector ma = −250)	55	



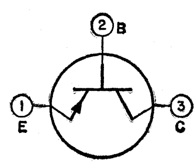




TRANSISTOR

2N591

Germanium p-n-p type used in large-signal audio-frequency driver-amplifier applications. It is used primarily in high-gain class A audio-driver stages in automobile radio receivers. JEDEC No. TO-1 package; outline 4, Outlines Section.



MAXIMUM RATINGS

	With heat sink	Without heat sink	
COLLECTOR-TO-EMITTER VOLTAGE		−32 *max*	volts
COLLECTOR CURRENT:			
Peak		−40 *max*	ma
DC		−20 *max*	ma
EMITTER CURRENT:			
Peak		40 *max*	ma
DC		20 *max*	ma
COLLECTOR DISSIPATION:			
At ambient temperatures up to 55°C	100	50	mw
At ambient temperature of 71°C	40	20	mw
AMBIENT-TEMPERATURE RANGE:			
Operating		71 *max*	°C
Storage		−65 to 85	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with collector ma = −0.3, base resistance = 4700 ohms, and emitter resistance = 500 ohms)	−32 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −10 and emitter current = 0)	−7 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −1 and collector current = 0)	−20 *max*	μa
Thermal Resistance:		
Junction-to-ambient	0.34	°C/mw
Junction-to-heat sink	0.15	°C/mw

In Common-Emitter Circuit

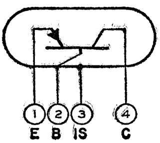
DC Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = −12 and collector ma = −2)	70	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = −12 and collector ma = −2)	0.7	Mc

TYPICAL OPERATION IN CLASS A AF DRIVER-AMPLIFIER CIRCUIT

DC Collector Supply Voltage	−14.4	volts
DC Collector-to-Emitter Voltage	−12	volts
DC Base-to-Emitter Voltage	−0.13	volt
DC Collector Current	−2	ma
Signal Frequency	1	kc
Input Resistance	1000	ohms
Output Resistance	10000	ohms
Power Gain	41	db
Total Harmonic Distortion	3	per cent
Transistor Dissipation	25	mw
Power Output	5	mw

TRANSISTOR

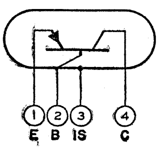
2N640



Germanium p-n-p type used in rf-amplifier applications in automobile radio receivers. Maximum ratings: collector-to-base volts, −34; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This is a DISCONTINUED type listed for reference only; it can be replaced by type 2N1637.

TRANSISTOR

2N641

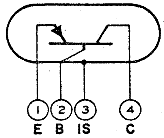


Germanium p-n-p type used in 262.5-kilocycle or 455-kilocycle intermediate-frequency amplifier applications in automobile radio receivers. Maximum ratings: collector-to-base volts, −34; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This is a DISCONTINUED type listed for reference only; it can be replaced by type 2N1638.

TRANSISTOR

2N642

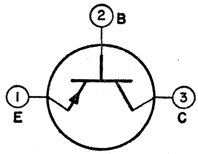
Germanium p-n-p type used in converter applications in automobile radio receivers. Maximum ratings: collector-to-base volts, −34; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This is a DISCONTINUED type listed for reference only; it can be replaced by type 2N1639.



TRANSISTOR

2N643

Germanium p-n-p type used in high-speed current-switching computer circuits in which high gain-bandwidth product is a primary design requirement. JEDEC No. TO-9 package; outline 9, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 1)	−29 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−2 *max*	volts
COLLECTOR CURRENT	−100 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

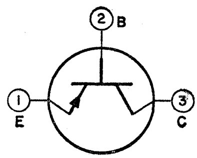
CHARACTERISTICS

Base-to-Emitter Voltage (with collector-to-emitter volts = −7 and collector ma = −5)	−0.35 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −7 and emitter current = 0)	−10 *max*	μa
In Common-Base Circuit		
Collector-to-Base Capacitance (with collector-to-base volts = −7)	5 *max*	pf
In Common-Emitter Circuit		
Forward Current-Transfer Ratio (with collector-to-emitter volts = −7 and collector ma = −5)	20 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = −7 and collector ma = −5)	20 *min*	Mc

TRANSISTOR

2N644

Germanium p-n-p type used in high-speed current-switching computer circuits in which high gain-bandwidth product is a primary design requirement. JEDEC No. TO-9 package; outline 9, Outlines Section. This type is identical with type 2N643 except for the following items:

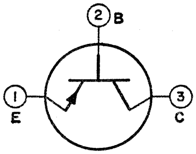


CHARACTERISTICS

In Common-Emitter Circuit

Gain-Bandwidth Product (with collector-to-emitter volts = −7 and collector ma = −5)	40 *min*	Mc

TRANSISTOR



2N645

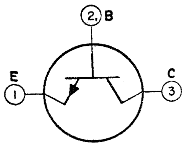
Germanium p-n-p type used in high-speed current-switching computer circuits in which high gain-bandwidth product is a primary design requirement. JEDEC No. TO-9 package; outline 9, Outlines Section. This type is identical with type 2N643 except for the following item:

CHARACTERISTICS

In Common-Emitter Circuit

Gain-Bandwidth Product (with collector-to-emitter volts = −7 and collector ma = −5)	60 *min*	Mc

TRANSISTOR



2N647

Germanium n-p-n type used in large-signal audio-frequency amplifier applications. It is designed especially for use with its p-n-p counterpart, RCA-2N217, in class B complementary-symmetry power-output stages of compact, transformerless, battery-operated portable radio receivers, phonographs, and audio amplifiers operating at battery-supply voltages up to 9 volts. This type can also be used in conventional class B push-pull and class A audio-amplifier circuits. JEDEC No. TO-1 package; outline 4, Outlines Section.

MAXIMUM RATINGS

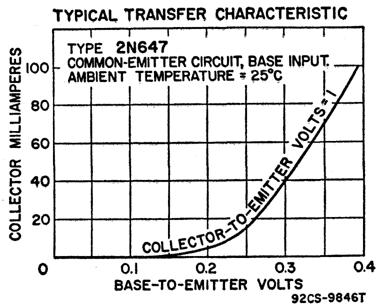
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE	25 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	volts
COLLECTOR CURRENT:		
Peak	100 *max*	ma
DC	50 *max*	ma
EMITTER CURRENT:		
Peak	−100 *max*	ma
DC	−50 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 25°C	100 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	20 *max*	mw
AMBIENT TEMPERATURE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

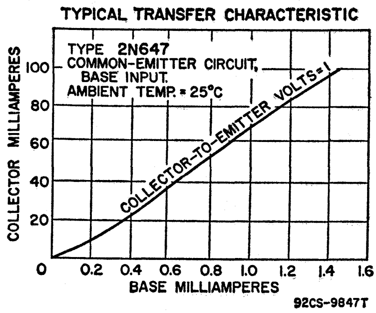
CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = 25 and emitter current = 0)	14 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 12 and collector current = 0)	14 *max*	μa

In Common-Emitter Circuit

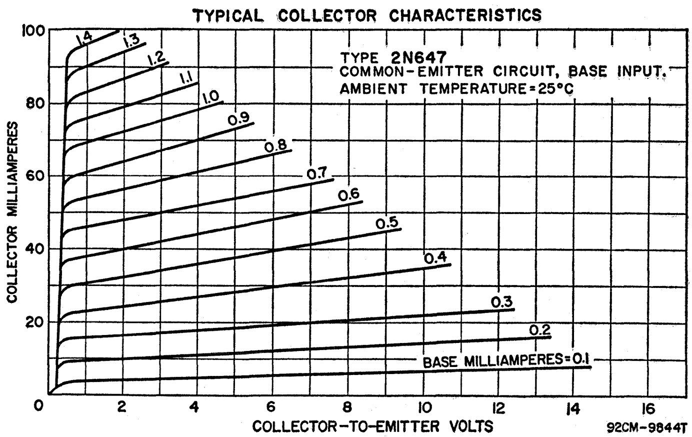
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 1 and collector ma = 50)	70



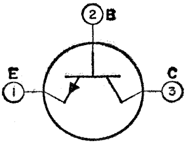


TYPICAL OPERATION IN CLASS B COMPLEMENTARY-SYMMETRY CIRCUIT

DC Collector Supply Voltage	6	volts
DC Collector-to-Emitter Voltage for driver stage	2.3	volts
Zero-Signal DC Base-to-Emitter Voltage for output stage	0.14	volt
Peak Collector Current for each transistor in output stage	70	ma
Zero-Signal DC Collector Current for each transistor (driver and output stage)	1.5	ma
Signal Frequency	1	kc
Input Resistance	1100	ohms
Load Resistance	45	ohms
Power Gain	54	db
Total Harmonic Distortion	10 *max*	per cent
Power Output (with input = 20 millivolts)	100	mw



TRANSISTOR



2N649

Germanium n-p-n type used in large-signal audio-frequency amplifier applications. It is designed especially for use with its p-n-p counterpart, RCA-2N408, in class B complementary-symmetry power-output stages of compact, transformerless, battery-operated portable radio receivers, phonographs, and audio amplifiers operating at battery-supply voltages up to 9 volts. This type can also be used in conventional class B push-pull and class A audio-amplifier circuits. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is identical with type 2N647 except for the following items:

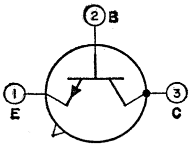
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	20 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	18 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	2.5 *max*	volts

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = 12 and emitter current = 0)	14 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 2.5 and collector current = 0)	14 *max*	μa
In Common-Emitter Circuit		
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 1 and collector ma = 50)	65	

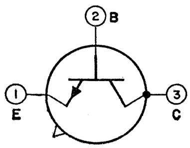
POWER TRANSISTOR



2N656

Silicon n-p-n type used in a wide variety of medium-power switching and amplifier applications in industrial and military equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N497 except that it has a higher dc common-emitter forward current-transfer ratio of 30 to 90.

TRANSISTOR



2N696

Silicon n-p-n type used in high-speed switching applications in data-processing equipment. This type is especially effective under conditions of severe thermal and mechanical stress and other environmental hazards. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

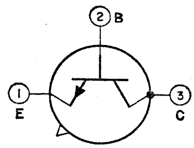
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10 ohms or less)	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	5 *max*	volts
COLLECTOR CURRENT	500 *max*	ma
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	2 *max*	watts
At ambient temperatures up to 25°C	0.6 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.3 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.5 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	1 *max*	μa
In Common-Base Circuit		
Collector-to-Base Capacitance (with collector-to-base volts = 10 and emitter current = 0)	35 *max*	pf
In Common-Emitter Circuit		
DC-Pulse Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 150, pulse duration = 12 milliseconds or less, and duty factor = 0.02 or less)	20 to 60	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 50, and frequency = 20 Mc)	2 *min*	
Gain-Bandwidth Product	80	Mc

TRANSISTOR

2N697



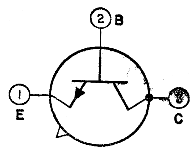
Silicon n-p-n type used in high-speed switching applications in data-processing equipment. This type is especially effective under conditions of severe thermal and mechanical stress and other environmental hazards. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N696 except for the following items:

CHARACTERISTICS

In Common-Emitter Circuit		
DC-Pulse Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 150, pulse duration = 12 milliseconds or less, and duty factor = 0.02 or less)	40 to 120	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 150, and frequency = 20 Mc)	2.5 *min*	
Gain-Bandwidth Product	100	Mc

TRANSISTOR

2N699



Silicon n-p-n type used in a wide variety of small-signal and medium-power applications in industrial and military equipment. It can be used in rf service as an amplifier, mixer, oscillator, and converter; in af service for small-signal and power applications; in switching service for high-speed switching circuits. It features low saturation voltage, high sustaining voltage, and low output capacitance. JEDEC No. TO-5 package; outline 6, Outlines Section. For curves of collector characteristics, refer to type 2N1613.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	120 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance of 10 ohms or less)	80 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	5 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	2 *max*	watts
At ambient temperatures up to 25°C	0.6 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 175	°C
Storage	−65 to 300	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	120 *min*	volts
Collector-to-Emitter Sustaining Voltage (with external base-to-emitter resistance = 10 ohms or less and collector ma = 100)	80 *min*	volts
Base-to-Emitter Saturation Voltage (with collector ma = 150 and emitter ma = 15)	1.3 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 150 and emitter ma = 15)	5 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	2 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 2 and collector current = 0)	100 *max*	μa
Thermal Resistance:		
Junction-to-case	75 *max*	°C/watt
Junction-to-ambient	250 *max*	°C/watt

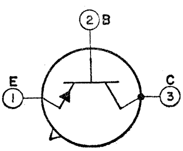
In Common-Base Circuit

Input Resistance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	20 to 30	ohms
With collector-to-base volts = 10 and collector ma = 5	10 *max*	ohms
Output Capacitance (with collector-to-base volts = 10 and emitter ma = 0)	20 *max*	pf
Output Conductance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.1 to 0.5	μmho
With collector-to-base volts = 10 and collector ma = 5	1 *max*	μmho
Small-Signal Open-Circuit Reverse Voltage-Transfer Ratio at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.00025 *max*	
With collector-to-base volts = 10 and collector ma = 5	0.0003 *max*	

In Common-Emitter Circuit

DC-Pulse Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 150, pulse duration = 300 microseconds, and duty factor = 0.02 or less)	40 to 120
Small-Signal Forward Current-Transfer Ratio:	
With collector-to-emitter volts = 5, collector ma = 1, and frequency = 1 kilocycle	35 to 100
With collector-to-emitter volts = 10, collector ma = 5, and frequency = 1 kilocycle	45 *min*
With collector-to-emitter volts = 10, collector ma = 50, and frequency = 20 Mc	2.5 *min*

TRANSISTOR



2N705

Germanium p-n-p type used in high-speed logic-circuit applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−15 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance =10 ohms or less)	−15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−3.5 *max*	volts
COLLECTOR CURRENT	−50 *max*	ma
EMITTER CURRENT	50 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At case temperatures up to 25°C	300 *max*	mw
At ambient or case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	230 *max*	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.4)	−0.44 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.4)	−0.3 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −5 and emitter current = 0)	−3 *max*	μa
Collector Transition Capacitance (with collector-to-base volts = −10, emitter current = 0, and frequency = 1 Mc)	5	pf
Emitter Transition Capacitance (with emitter-to-base volts = −2, collector current = 0, and frequency = 1 Mc)	3.5	pf

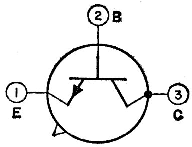
In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −5, collector ma = −10, and frequency = 100 Mc)	3	
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −10)	25 *min*	

TRANSISTORS

2N706
2N706A

Silicon n-p-n types used in high-speed switching applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section.



MAXIMUM RATINGS

	2N706	*2N706A*	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10 ohms)	20 *max*	20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	3 *max*	5 *max*	volts
COLLECTOR CURRENT	—	50 *max*	ma
TRANSISTOR DISSIPATION:			
At ambient temperatures up to 25°C	0.3 *max*	0.3 *max*	watt
At ambient temperatures above 25°C	See curve page 68		
At case temperatures up to 25°C	1 *max*	1 *max*	watt
At case temperature of 100°C	0.5 *max*	1 *max*	watt
TEMPERATURE RANGE:			
Operating (junction) and storage	−65 to 175		°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.9 *max*	0.9 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.6 *max*	0.6 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 15 and emitter current = 0)	0.5 *max*	0.5 *max*	μa

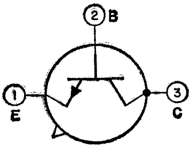
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 10 and emitter current = 0)	6 *max*	—	pf

In Common-Emitter Circuit

	2N706	2N706A
DC-Pulse Forward Current-Transfer Ratio (with dc collector-to-emitter volts = 1, collector ma = 10, pulse duration = 12 milliseconds or less, and duty factor = 0.02 or less)	20 *min*	20 *min*
Small-Signal Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 15, collector ma = 10, and frequency = 100 Mc	2 *min*	—
With collector-to-emitter volts = 10, collector ma = 10, and frequency = 100 Mc	—	2 *min*

TRANSISTOR



Silicon n-p-n type used in very-high-speed switching and high-frequency applications in equipment which requires high reliability and high packaging densities. JEDEC No. TO-18 package; outline 12, Outlines Section.

2N708

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With external base-to-emitter resistance = 10 ohms or less	20 *max*	volts
With base open	15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	5 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	1.2 *max*	watts
At ambient temperatures up to 25°C	0.36 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 200	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	300 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.8 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.4 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 20 and emitter ma = 0)	0.025 *max*	μa

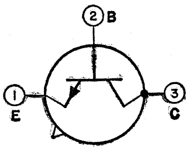
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 10 and emitter current = 0)	6 *max*	pf

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 10, and frequency = 100 Mc)	3 *min*
DC Forward Current-Transfer Ratio:	
With collector-to-emitter volts = 1 and collector ma = 10	30 to 120
With collector-to-emitter volts = 1 and collector ma = 0.5	15 *min*

TRANSISTOR



Silicon n-p-n type used in ultra-high-speed logic-circuit applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section. This type is electrically identical with type 2N2475 except for the following items:

2N709

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 3 and base ma = 0.15)	0.7 to 0.85	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 3 and base ma = 0.15)	0.3 *max*	volt

In Common-Base Circuit

Input Capacitance (with emitter-to-base volts = 0.5, collector current = 0, and frequency = 140 kilocycles)	2 *max*	pf

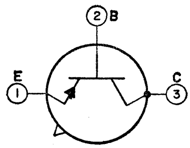
In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 4, collector ma = 5, and frequency = 100 Mc)	6 *min*	
DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 1 and collector ma = 30	15 *min*	
With collector-to-emitter volts = 0.5 and collector ma = 10	20 to 120	

TRANSISTOR

2N710

Germanium p-n-p type used in high-speed logic-circuit applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section. This type is identical with type 2N705 except for the following items:



MAXIMUM RATINGS

EMITTER-TO-BASE VOLTAGE (with collector open)	−2 *max*	volts

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.4)	−0.5 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.4)	−0.5 *max*	volt

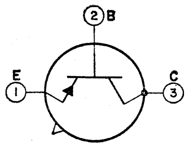
In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.5 and collector ma = −10)	25 *min*	

TRANSISTOR

2N711

Germanium p-n-p type used in high-speed logic-circuit applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section. This type is identical with type 2N705 except for the following items:



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−12 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10 ohms or less)	−12 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma

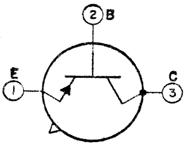
CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.5)	−0.5 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.5)	−0.5 *max*	volt

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −5, collector ma = −10, and frequency = 100 Mc)	2	
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.5 and collector ma = −10)	20 *min*	

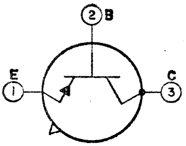
TRANSISTOR



Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-18; outline 12, Outlines Section. This type is electrically identical with type 2N1300.

2N794

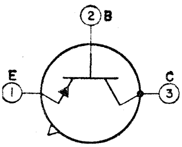
TRANSISTOR



Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section. This type is electrically identical with type 2N1301.

2N795

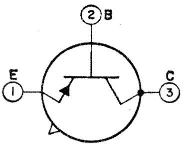
TRANSISTOR



Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section. This type is electrically identical with type 2N1683.

2N796

TRANSISTOR



Germanium p-n-p type used in high-speed switching applications in which high reliability and high packaging densities are required. JEDEC No. TO-18; outline 12, Outlines Section.

2N828

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−15 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10 ohms or less)	−15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−2.5 *max*	volts
COLLECTOR CURRENT	−200 *max*	ma

TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	300 *max*	mw
At ambient temperatures up to 25°C	150 *max*	mw
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	240 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −1)	0.34 to 0.44	volt
Collector-to-Emitter Saturation Voltage:		
With collector ma = −10 and base ma = −1	−0.2 *max*	volt
With collector ma = −50 and base ma = −5	−0.25 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −6 and emitter current = 0)	−3 *max*	μa

In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = −6, emitter current = 0, and frequency = 100 Mc)	6 *max*	pf

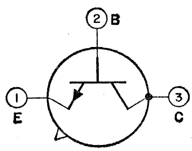
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −10)	25 *min*	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −1, collector ma = −10, and frequency = 100 Mc)	3 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = −1 and collector ma = −10)	300 *min*	Mc

TRANSISTOR

2N834

Silicon n-p-n type used in very-high-speed switching applications in equipment requiring high reliability and high packaging densities. JEDEC No. TO-18 package; outline 12, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base short-circuited to emitter)	30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	5 *max*	volts
COLLECTOR CURRENT	200 *max*	ma
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	1 *max*	watt
At ambient temperatures up to 25°C	0.3 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C
LEAD TEMPERATURE (for 10 seconds maximum)	240 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.9 *max*	volt
Collector-to-Emitter Saturation Voltage:		
With collector ma = 10 and base ma = 1	0.25 *max*	volt
With collector ma = 50 and base ma = 5	0.4 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 20 and emitter current = 0)	0.5 *max*	μa

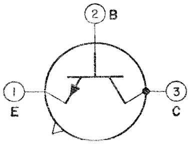
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 10, emitter current = 0, and frequency = 100 Mc)	4 *max*	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 1 and collector ma = 10)	25 *min*	

Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 15, collector ma = 10, and frequency = 100 Mc)	3.5 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = 15, collector ma = 10, and frequency = 100 Mc)	350 *min*	Mc



TRANSISTOR

2N914

Silicon n-p-n type used in high-speed logic-switching and very-high-frequency amplifier applications. JEDEC No. TO-18 package; outline 12, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With external base-to-emitter resistance = 10 ohms or less	20 *max*	volts
With base open	15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	5 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	1.2 *max*	watts
At ambient temperatures up to 25°C	0.36 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 200	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	300 *max*	°C

CHARACTERISTICS

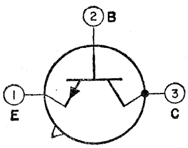
Base-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.7 to 0.8	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 200 and base ma = 20)	0.7 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 20 and emitter current = 0)	0.025 *max*	μa

In Common-Base Circuit

Emitter-to-Base Capacitance (with emitter-to-base volts = −0.5, collector current = 0, and frequency = 140 kilocycles)	9 *max*	pf
Collector-to-Base Capacitance (with collector-to-base volts = 10, emitter ma = 0, and frequency = 140 kilocycles)	6 *max*	pf

In Common-Emitter Circuit

DC-Pulse Forward Current-Transfer Ratio:	
With collector-to-emitter volts = 1 and collector ma = 10	30 to 120
With collector-to-emitter volts = 5 and collector ma = 500	10 *min*
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10 and collector ma = 20)	3 *min*



TRANSISTORS

2N955
2N955A

Germanium n-p-n types used in high-speed logic-circuit applications in data-processing equipment. JEDEC No. TO-18 package; outline 12, Outlines Section.

MAXIMUM RATINGS

	2N955	*2N955A*	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	12 *max*	12 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	8 *max*	8 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	2 *max*	2 *max*	volts

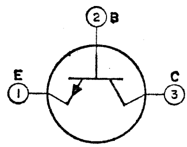
	2N955	2N955A	
COLLECTOR CURRENT	100 *max*	150 *max*	ma
TRANSISTOR DISSIPATION:			
At ambient temperatures up to 25°C	150 *max*	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68		
AMBIENT-TEMPERATURE RANGE:			
Operating and storage	−65 to 100		°C
LEAD TEMPERATURE (for 10 seconds maximum)	230 *max*	230 *max*	°C

CHARACTERISTICS

	2N955	2N955A	
Base-to-Emitter Saturation Voltage (with collector ma = 30 and base ma = 1)	0.3 to 0.6	0.3 to 0.6	volt
Collector-to-Emitter Saturation Voltage:			
With collector ma = 30 and base ma = 1	0.5 *max*	0.3 *max*	volt
With collector ma = 100 and base ma = 5	—	0.6 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 5 and emitter current = 0)	5 *max*	5 *max*	μa
Total Stored Charge (with collector ma = 30 and base ma = 1.5)	125 *max*	65 *max*	pcoul
In Common-Base Circuit			
Input Capacitance (with emitter-to-base volts = 0.5 and collector current = 0)	10 *max*	10 *max*	pf
Output Capacitance (with collector-to-base volts = 5 and emitter current = 0)	6 *max*	6 *max*	pf
In Common-Emitter Circuit			
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 5, collector ma = 20, and frequency = 100 Mc)	10	10	
DC Forward Current-Transfer Ratio:			
With collector-to-emitter volts = 0.5 and collector ma = 30	30 *min*	—	
With collector-to-emitter volts = 0.3 and collector ma = 30	—	30 *min*	

TRANSISTOR

2N1010



Germanium n-p-n type used in low-noise small-signal audio-frequency amplifier applications. It is used in input stages of audio-frequency amplifiers operating from extremely small input signals, such as high-fidelity preamplifiers, tape-recorder amplifiers, microphone preamplifiers, and hearing aids, in which low noise is an important design consideration. JEDEC No. TO-1 package; outline 4, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	10 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE	10 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	10 *max*	volts
COLLECTOR CURRENT	2 *max*	ma
EMITTER CURRENT	−2 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 55°C	20 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 55	°C
Storage	−65 to 85	°C

CHARACTERISTICS

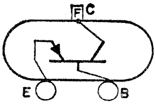
Collector-Cutoff Current (with collector-to-base volts = 10 and emitter current = 0)	10 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 2.5 and collector current = 0)	6 *max*	μa
In Common-Base Circuit		
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 3.5 and collector ma = 0.3)	2	Mc

In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio at 1 kilocycle (with collector-to-emitter volts = 3.5 and collector ma = 0.3)	35	
Noise Figure (with generator resistance = 1000 ohms and integrated noise bandwidth = 15 kilocycles)	5	db

POWER TRANSISTOR

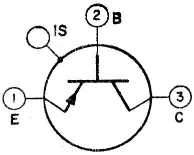
2N1014



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment. Maximum ratings: collector-to-base volts, −100; peak collector amperes, −10; transistor dissipation (at mounting-flange temperature = 25°C), 50 watts; mounting-flange-temperature range (operating), −65 to 100°C. Package is similar to JEDEC No. TO-3; outline 26, Outlines Section, except that maximum case height is 0.72 inch. This type is used principally for renewal purposes.

TRANSISTOR

2N1023



Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. The center lead is internally connected to the metal case to provide integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. For curves of typical collector characteristics and for video-amplifier circuit, refer to type 2N384. JEDEC No. TO-44 package; outline 16, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 0.5)	−40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	240 *max*	mw
At ambient temperatures up to 25°C	120 *max*	mw
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 100	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −50 and emitter current = 0)	−80	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = −0.5)	−80	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−4	μa

Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−1	μa
Thermal Resistance:		
Junction-to-case	0.31 *max*	°C/mw
Junction-to-ambient	0.62 *max*	°C/mw

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and emitter ma = 1.5)	120	Mc
Input Resistance with ac output circuit shorted (with collector-to-base volts = −12, emitter ma = 1.5, and frequency = 50 Mc)	25	ohms
Output Resistance with ac input circuit shorted (with collector-to-base volts = −12, emitter ma = 1.5 and frequency = 50 Mc)	8000	ohms
Collector-to-Base Capacitance (with collector-to-base volts = −12 and emitter current = 0)	2	pf
Power Gain (with collector-to-base volts = −12, emitter ma = 1.5, and frequency = 50 Mc)	21	db

In Common-Emitter Circuit

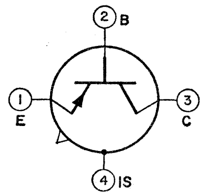
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, emitter ma = 1.5 and frequency = 1 kilocycle)	60	
Input Resistance with ac output circuit shorted (with collector-to-emitter volts = −12, emitter ma = 1.5, and frequency = 30 Mc)	100	ohms
Output Resistance with ac input circuit shorted (with collector-to-emitter volts = −12, emitter ma = −1.5, and frequency = 30 Mc)	8000	ohms
Power Gain (with collector-to-emitter volts = −12, emitter ma = 1.5, and frequency = 30 Mc)	23	db

TYPICAL OPERATION IN VIDEO-AMPLIFIER CIRCUIT

DC Collector-to-Emitter Voltage	−12	volts
DC Emitter Current	5.8	ma
Source Impedance	150	ohms
Capacitive Load	16	pf
Frequency Response	20 cps to 11 Mc	
Pulse Rise Time	0.032	μsec
Voltage Gain	26	db
Maximum Peak-to-Peak Output Voltage	20	volts

TRANSISTOR

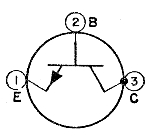
2N1066



Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead is internally connected to the metal case to provide integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N1023.

POWER TRANSISTOR

2N1067



Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-8 package; outline 8, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base short-circuited to emitter	60 *max*	volts
With base open	45 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	volts
COLLECTOR CURRENT	0.5 *max*	ampere
EMITTER CURRENT	−0.5 *max*	ampere
BASE CURRENT	0.2 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	5 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C

CHARACTERISTICS

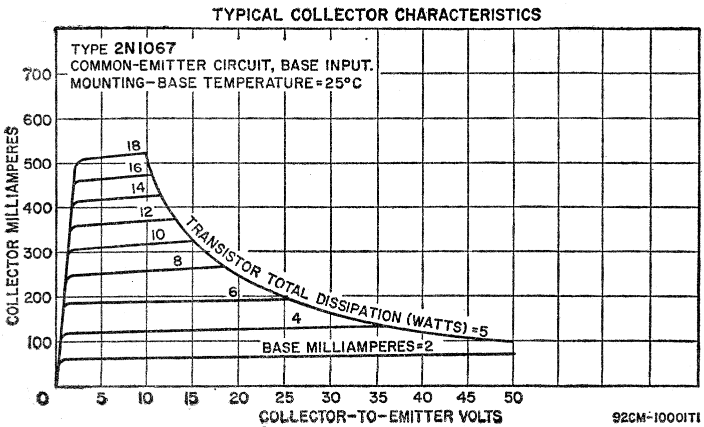
Emitter-to-Base Voltage (with collector-to-emitter volts = 4 and collector ma = 200)	−1.2	volts
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	15	μa
Emitter-Cutoff Current (with emitter-to-base volts = 12 and collector current = 0)	1	μa
Collector Current:		
With collector-to-emitter volts = 60 and base short-circuited to emitter	100	μa
With collector-to-emitter volts = 30 and base open	100	μa
Thermal Resistance:		
Junction-to-case	15	°C/watt
Junction-to-ambient	100 *max*	°C/watt
Thermal Time Constant	8	msec

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1.5	Mc

In Common-Emitter Circuit

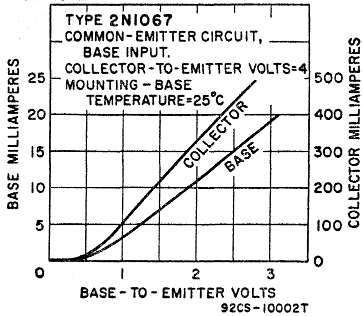
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 200)	35	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 200 and base ma = 20)	3	ohms

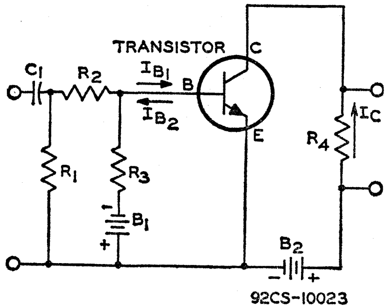


TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT BELOW

DC Collector Supply Voltage (B_2)	12	volts
DC Base Supply Voltage (B_1)	−12	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	200	ma
Turn-On DC Base Current (I_{B1})	20	ma
Turn-Off DC Base Current (I_{B2})	−20	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1.2	μsec
Storage time (t_s)	0.7	μsec
Fall time (t_f)	0.9	μsec

TYPICAL TRANSFER CHARACTERISTICS

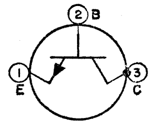




B_1, B_2 = 12 volts
C_1 = 5 μf, electrolytic, 25 volts
R_1 = 51 ohms, 1 watt
R_2 = 280 ohms, 0.5 watt
R_3 = 700 ohms, 1 watt
R_4 = 59 ohms, 2 watts

POWER TRANSISTOR

2N1068



Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-8 package; outline 8, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base short-circuited to emitter	60 *max*	volts
With base open	45 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	volts
COLLECTOR CURRENT	1.5 *max*	amperes
EMITTER CURRENT	−1.5 *max*	amperes
BASE CURRENT	0.5 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	10 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C

CHARACTERISTICS

Emitter-to-Base Voltage (with collector-to-emitter volts = 4 and collector ma = 750)	−1.2	volts
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	15	μa

Emitter-Cutoff Current (with emitter-to-base volts = 12 and collector current = 0)	1	μa
Collector Current:		
With collector-to-emitter volts = 60 and base short-circuited to emitter	100	μa
With collector-to-emitter volts = 30 and base open	100	μa
Thermal Resistance:		
Junction-to-case	7.5	°C/watt
Junction-to-ambient	100 *max*	°C/watt
Thermal Time Constant	8	msec

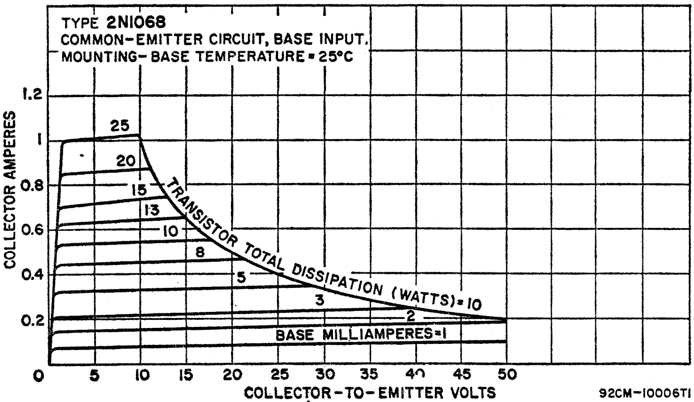
In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1.5	Mc

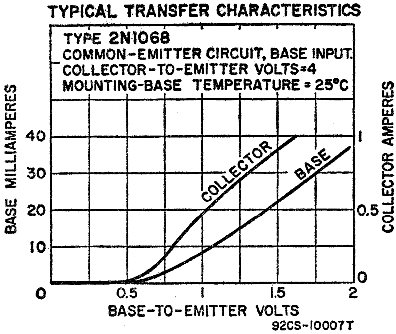
In Common-Emitter Circuit

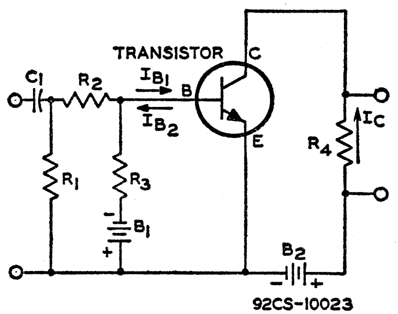
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 750)	38	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 750 and base ma = 20)	3	ohms

TYPICAL COLLECTOR CHARACTERISTICS



TYPICAL TRANSFER CHARACTERISTICS





B_1, B_2 = 12 volts
C_1 = 5 μf, electrolytic, 25 volts
R_1 = 51 ohms, 1 watt
R_2 = 100 ohms, 0.5 watt
R_3 = 320 ohms, 1 watt
R_4 = 15.9 ohms, 2 watts

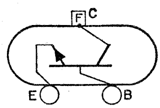
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ABOVE

DC Collector Supply Voltage (B_2)	12	volts
DC Base Supply Voltage (B_1)	−12	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	750	ma

Turn-On DC Base Current (I_{B1})	50	ma
Turn-Off DC Base Current (I_{B2})	−50	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_c)	1.6	μsec
Storage time (t_s)	1	μsec
Fall time (t_f)	1.8	μsec

POWER TRANSISTOR

2N1069



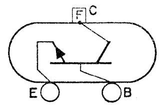
Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-3 package; outline 5, Outlines Section. This type is identical with type 2N1070 except for the following:

CHARACTERISTICS

Emitter-to-Base Voltage (with collector-to-emitter volts = 4 and collector amperes = 1.5)	−1.7	volts
In Common-Emitter Circuit		
DC Collector-to-Emitter Saturation Resistance (with collector amperes = 1.5 and base ma = 300)	0.7	ohm

POWER TRANSISTOR

2N1070



Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-3 package; outline 5, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base short-circuited to emitter	60 *max*	volts
With base open	45 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	9 *max*	volts
COLLECTOR CURRENT	4 *max*	amperes
EMITTER CURRENT	−4 *max*	amperes
BASE CURRENT	1.3 *max*	amperes
TRANSISTOR DISSIPATION:		
At mounting-flange temperatures up to 25°C	50 *max*	watts
At mounting-flange temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C

CHARACTERISTICS

Emitter-to-Base Voltage (with collector-to-emitter volts = 4 and collector amperes = 1.5)	−1.1	volts

Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	25	μa
Emitter-Cutoff Current (with emitter-to-base volts = 9 and collector current = 0)	1	μa
Collector Current:		
With collector-to-emitter volts = 60 and base short-circuited to emitter	200	μa
With collector-to-emitter volts = 45 and base open	200	μa
Thermal Resistance:		
Junction-to-mounting-flange	1	°C/watt
Thermal Time Constant	10	msec

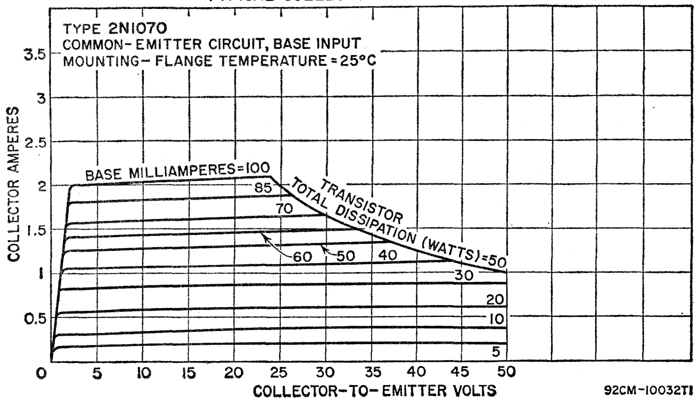
In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 12 and collector ma = 100)	1.2	Mc

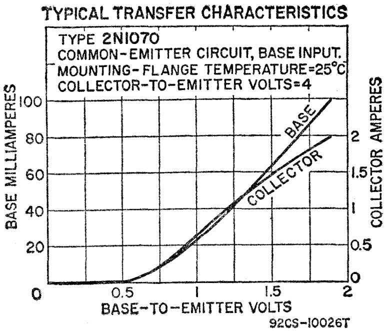
In Common-Emitter Circuit

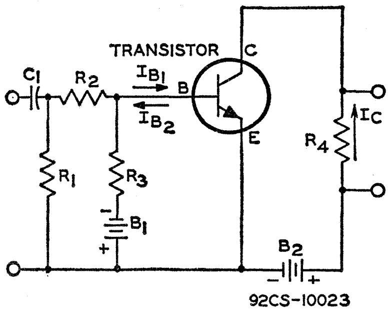
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector amperes = 1.5)	20	
DC Collector-to-Emitter Saturation Resistance (with collector amperes = 1.5 and base ma = 1.5)	0.4	ohm

TYPICAL COLLECTOR CHARACTERISTICS



TYPICAL TRANSFER CHARACTERISTICS





B_1, B_2 = 12 volts
C_1 = 5μf, electrolytic, 25 volts
R_1 = 51 ohms, 1 watt
R_2 = 10 ohms, 0.5 watt
R_3 = 75 ohms, 1 watt
R_4 = 7.5 ohms, 2 watts

TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ABOVE

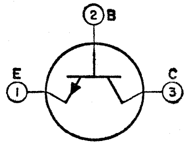
DC Collector Supply Voltage (B_2)	12	volts
DC Base Supply Voltage (B_1)	−12	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	1.5	amperes
Turn-On DC Base Current (I_{B1})	200	ma

Turn-Off DC Base Current (I_{B2})	−200	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1.8	μsec
Storage time (t_s)	0.8	μsec
Fall time (t_f)	1.4	μsec

TRANSISTOR

2N1090

Germanium n-p-n type used in high-current, medium-speed switching circuits in electronic computers. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base-to-emitter volts = −1	18 *max*	volts
With base open	15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	20 *max*	volts
COLLECTOR CURRENT	400 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C

CHARACTERISTICS

Base-to-Emitter Voltage:		
With collector ma = 20 and base ma = 0.67	0.4 *max*	volt
With collector ma = 200 and base ma = 10	1.5 *max*	volts
Collector-to-Emitter Saturation Voltage:		
With collector ma = 20 and base ma = 0.67	0.2 *max*	volt
With collector ma = 200 and base ma = 10	0.3 max	volt
Collector-Cutoff Current (with collector-to-base volts = 12 and emitter current = 0)	8 *max*	μa
Stored Base Charge (with collector ma = 20 and base ma = 1.33)	1600 *max*	pcoul

In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 6 and emitter current = 0)	25 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 6 and emitter ma = −1)	5 *min*	Mc

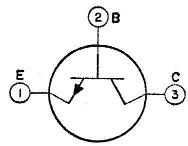
In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 0.2 and collector ma = 20	30 *min*	
With collector-to-emitter volts = 0.3 and collector ma = 200	20 *min*	

TRANSISTOR

2N1091

Germanium n-p-n type used in high-current, medium-speed switching circuits in electronic computers. JEDEC No. TO-5 package; outline 6, Outlines Section. Maximum ratings for this type are the same as for type 2N1090 except for the following items:



MAXIMUM RATINGS

COLLECTOR-TO-EMITTER VOLTAGE:		
With base-to-emitter volts = −1	15 *max*	volts
With base open	12 *max*	volts

CHARACTERISTICS

Base-to-Emitter Voltage:		
With collector ma = 20 and base ma = 0.5	0.35 *max*	volt
With collector ma = 200 and base ma = 6.7	1.1 *max*	volts

Collector-to-Emitter Saturation Voltage:		
With collector ma = 20 and base ma = 0.5	0.2 *max*	volt
With collector ma = 200 and base ma = 6.7	0.3 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 12 and emitter current = 0)	8 *max*	μa
Stored Base Charge (with collector ma = 20 and base ma = 1)	1000 *max*	pcoul

In Common-Base Circuit

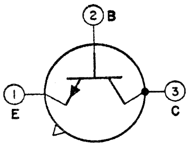
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 6 and emitter ma = −1)	10 *min*	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 6 and emitter current = 0)	25 *max*	pf

In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 0.2 and collector ma = 20	40 *min*	
With collector-to-emitter volts = 0.3 and collector ma = 200	30 *min*	

POWER TRANSISTOR

2N1092



Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base short-circuited to emitter	60 *max*	volts
With base open	30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	volts
COLLECTOR CURRENT	0.5 *max*	ampere
EMITTER CURRENT	−0.5 *max*	ampere
BASE CURRENT	0.2 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	2 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C

CHARACTERISTICS

Emitter-to-Base Voltage (with collector-to-emitter volts = 4 and collector ma = 200)	−1.2	volts
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	15	μa
Emitter-Cutoff Current (with emitter-to-base volts = 12 and collector current = 0)	1	μa
Collector Current:		
With collector-to-emitter volts = 60 and base short-circuited to emitter	100	μa
With collector-to-emitter volts = 30 and base open	100	μa
Thermal Resistance:		
Junction-to-case	35	°C/watt
Junction-to-ambient	225 *max*	°C/watt
Thermal Time Constant	8	msec

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1.5	Mc

In Common-Emitter Circuit

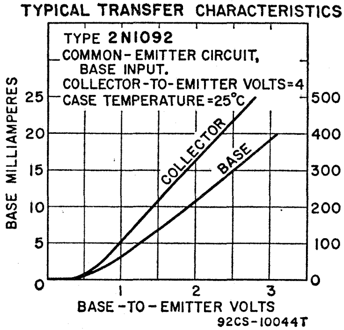
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 200)	35	

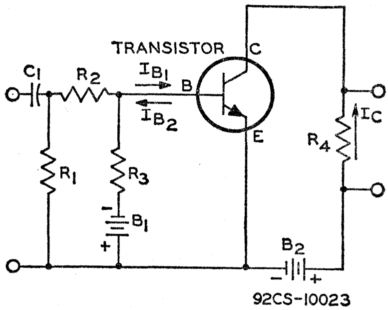
DC Collector-to-Emitter Saturation Resistance (with collector ma = 200 and base ma = 20)	3	ohms

TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT BELOW

DC Collector Supply Voltage (B_2)	12	volts
DC Base Supply Voltage (B_1)	—12	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	200	ma
Turn-On DC Base Current (I_{B1})	20	ma
Turn-Off DC Base Current (I_{B2})	−20	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1.2	μsec
Storage time (t_s)	0.7	μsec
Fall time (t_f)	0.9	μsec

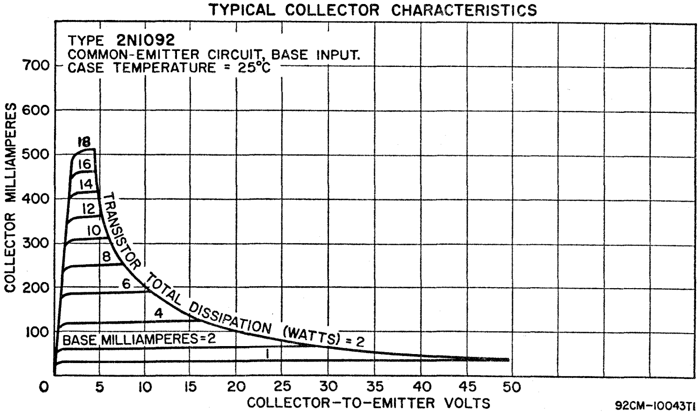
TYPICAL TRANSFER CHARACTERISTICS





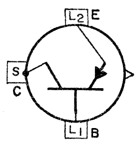
B_1, B_2 = 12 volts
C_1 = 5 μf, electrolytic, 25 volts
R_1 = 51 ohms, 1 watt
R_2 = 280 ohms, 0.5 watt
R_3 = 700 ohms, 1 watt
R_4 = 59 ohms, 2 watts

TYPICAL COLLECTOR CHARACTERISTICS



POWER TRANSISTOR

2N1099



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-

supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N173 except for the following items:

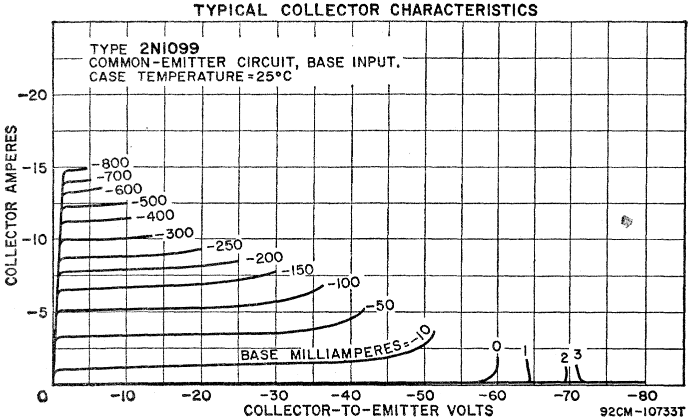
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = 1.5)	−80 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	—40 *max*	volts

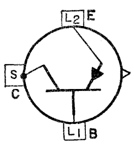
CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to emitter and collector amperes = −0.3	−70 *min*	volts
With base open and collector amperes = −0.3	−60	volts
Collector-to-Emitter Reach-Through Voltage	−80 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −80 and emitter current = 0)	−2	ma

TYPICAL COLLECTOR CHARACTERISTICS



POWER TRANSISTOR



2N1100

Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N174 except for the following items:

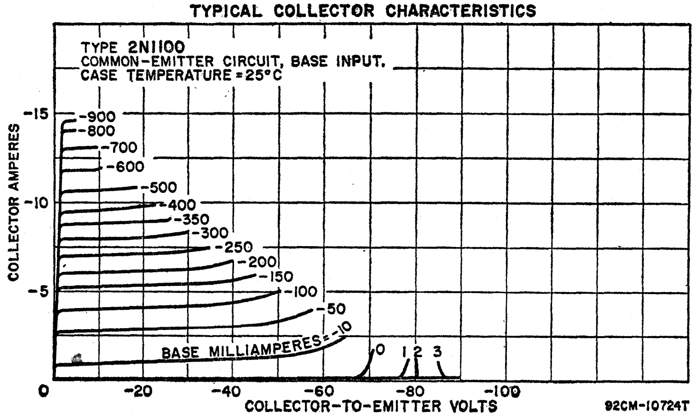
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−100 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−80 *max*	volts

CHARACTERISTICS

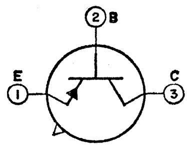
Collector-to-Emitter Breakdown Voltage (with base short-circuited to emitter and collector amperes = −0.3)	−80 *min*	volts
Emitter-to-Base Voltage (with collector-to-base volts = −100 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Reach-Through Voltage	−100 *min*	volts
Emitter-Cutoff Current (with emitter-to-base volts = −80 and collector current = 0)	−1	ma
Collector-Cutoff Current (with collector-to-base volts = −100 and emitter current = 0)	−2	ma

TYPICAL COLLECTOR CHARACTERISTICS



TRANSISTOR

2N1169



Germanium n-p-n bidirectional type used in medium-speed switching circuits in data-processing equipment. This type is designed so that the emitter can also function as a collector and the collector can also function as an emitter. It is especially useful in bidirectional switching, core-driver, and ac-signal relay circuits. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base-to-emitter volts = −1	20 *max*	volts
With base open	18 *max*	volts
COLLECTOR CURRENT	±400 *max*	ma
EMITTER CURRENT	±400 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = 200 and base ma = 10)	1.5 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 200 and base ma = 10)	0.3 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 12 and emitter open)	10 *max*	μa

In Common-Base Circuit

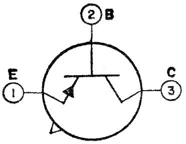
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 6 and collector ma = 1)	4.5 *min*	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 6 and collector current = 0)	19	pf

In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = 0.3 and collector ma = 200)	20 *min*	

TRANSISTOR

2N1170



Germanium n-p-n bidirectional type used in medium-speed switching circuits in data-processing equipment. This type is designed so that the emitter can also function as a collector and the collector can also function as an emitter. It is particularly useful in bidirectional switching, core-driver, and ac-signal relay circuits. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1169 except for the following items:

MAXIMUM RATINGS

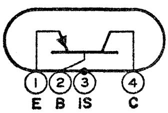
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base-to-emitter volts = −1	39 *max*	volts
With base open	20 *max*	volts

CHARACTERISTICS

Collector-Cutoff Current (with collector-to-base volts = 12 and emitter open)	8 *max*	μa

TRANSISTOR

2N1177



Germanium p-n-p type used in radio-frequency amplifier applications in FM and AM/FM radio receivers. In a typical FM tuner operating at 100 megacycles, this type can provide a power gain of 14 db. JEDEC No. TO-45 package; outline 17, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	23 *max*	mw

AMBIENT-TEMPERATURE RANGE:

Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with emitter-to-base volts = −0.5 and collector μa = −50)	−30 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−12 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −1 and collector current = 0)	−12 *max*	μa

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.99	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = −1)	140	Mc

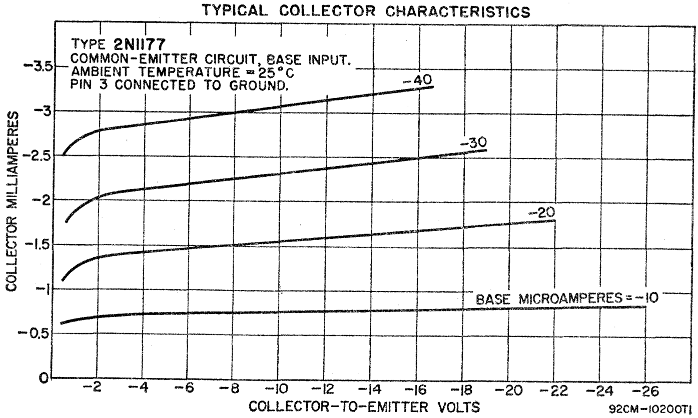
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	100	

TYPICAL OPERATION

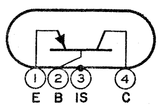
DC Collector-to-Base Voltage	−12	volts
DC Collector Current	−1.5	ma
Signal Frequency	100	Mc
Input Resistance (with ac output circuit shorted)	45	ohms
Output Resistance (with ac input circuit shorted)	3800	ohms
Extrinsic Transconductance	24250	μmhos
Collector-to-Base Output Capacitance	2	pf
Maximum Available Power Gain	14	db

TYPICAL COLLECTOR CHARACTERISTICS



TRANSISTOR

2N1178



Germanium p-n-p type used in radio-frequency oscillator applications in FM and AM/FM radio receivers. In local-oscillator service at a frequency above the incoming rf signal, this type can supply an rf mixer stage with required oscillator-injection voltage for optimum mixing throughout the FM band.

JEDEC No. TO-45 package; outline 17, Outlines Section. This type is identical with type 2N1177 except for the following items:

CHARACTERISTICS

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.976	

In Common-Emitter Circuit

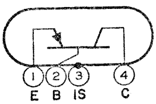
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	40	

TYPICAL OPERATION

DC Collector-to-Base Voltage	−11	volts
Collector Current	−2.5	ma
Signal Frequency	110.7	Mc
Extrinsic Transconductance	21800	µmhos
Collector-to-Base Output Capacitance	2	pf

TRANSISTOR

2N1179



Germanium p-n-p type used in radio-frequency mixer applications in FM and AM/FM radio receivers. In a typical FM tuner operating at 100 megacycles, this type can provide a conversion power gain of 17 db. JEDEC No. TO-45 package; outline 17, Outlines Section. This type is identical with type 2N1177 except for the following items:

CHARACTERISTICS

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.988	Mc

In Common-Emitter Circuit

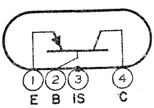
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	80	

TYPICAL OPERATION

DC Collector-to-Base Voltage	−12	volts
DC Collector Current	−0.8	ma
Signal Frequency	100	Mc
Input Resistance (with ac output circuit shorted)	40	ohms
Output Resistance (with ac input circuit shorted and intermediate frequency = 10.7 Mc)	90000	ohms
RMS Base-to-Emitter Oscillator Injection Voltage	125	mv
Extrinsic Conversion Transconductance	7500	µmhos
Collector-to-Base Output Capacitance	2	pf
Maximum Available Conversion Power Gain	17	db

TRANSISTOR

2N1180



Germanium p-n-p type used in intermediate-frequency amplifier applications in FM and AM/FM radio receivers. In a three-stage 10.7-megacycle if amplifier circuit, this type can provide a useful power gain of 65 db with neutralization or 57 db without neutralization. JEDEC No. TO-45 package;

outline 17, Outlines Section. This type is identical with type 2N1177 except for the following items:

MAXIMUM RATINGS

EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt

CHARACTERISTICS

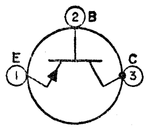
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−12 *max*	μa
In Common-Base Circuit		
Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.988	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = −1)	100	Mc
In Common-Emitter Circuit		
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	80	

TYPICAL OPERATION

DC Collector-to-Emitter Voltage		−12	volts
DC Collector Current		−1.5	ma
Signal Frequency		10.7	Mc
Input Resistance (with ac output circuit shorted)		325	ohms
Output Resistance (with ac input circuit shorted)		24000	ohms
Extrinsic Transconductance		40250	μmhos
Collector-to-Base Output Capacitance		2	pf
Maximum Power Gain:			
	Single Stage	*Three Stages*	
Available	35	35	db
Useful:			
In neutralized circuit	23	21.6	db
In unneutralized circuit	20	19	db

POWER TRANSISTORS

2N1183
2N1183A
2N1183B



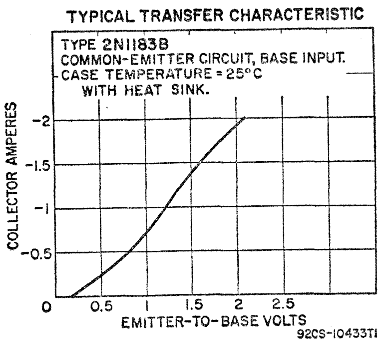
Germanium p-n-p types used in intermediate-power switching and low-frequency amplifier applications in industrial and military equipment. They are used in power switching, dc-to-dc converters, choppers, solenoid drivers, and relay controls; in oscillator, regulator, and pulse-amplifier circuits; and as class A or class B amplifiers for servo and linear amplifier applications. JEDEC No. TO-8 package; outline 8, Outlines Section.

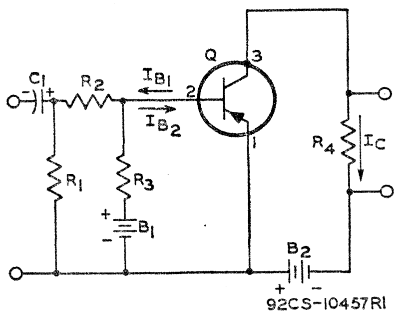
MAXIMUM RATINGS

	2N1183	*2N1183A*	*2N1183B*	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−45 *max*	−60 *max*	−80 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:				
With emitter-to-base volts = −1.2	−45 *max*	−60 *max*	−80 *max*	volts
With base short-circuited to emitter	−35 *max*	−50 *max*	−60 *max*	volts
With base open	−20 *max*	−30 *max*	−40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−20 *max*	−20 *max*	−20 *max*	volts
COLLECTOR CURRENT	−3 *max*	−3 *max*	−3 *max*	amperes
EMITTER CURRENT	3.5 *max*	3.5 *max*	3.5 *max*	amperes
BASE CURRENT	−0.5 *max*	−0.5 *max*	−0.5 *max*	ampere
TRANSISTOR DISSIPATION:				
At case temperatures up to 25°C	7.5 *max*	7.5 *max*	7.5 *max*	watts
At ambient temperatures up to 25°C	1 *max*	1 *max*	1 *max*	watt
At case or ambient temperatures above 25°C		See curve page 68		
TEMPERATURE RANGE:				
Operating (junction) and storage		−65 to 100		

CHARACTERISTICS

	2N1183	*2N1183A*	*2N1183B*	
Collector-to-Emitter Breakdown Voltage:				
With emitter-to-base volts = −1.2 and collector ma = −0.25	−45 *min*	−60 *min*	−80 *min*	volts
With base short-circuited to emitter and collector ma = −50	−35 *min*	−50 *min*	−60 *min*	volts
With base open and collector ma = −50	−20 *min*	−30 *min*	−40 *min*	volts
Emitter-to-Base Voltage (with collector-to-emitter volts = −2 and collector ma = −400)	1.5 *max*	1.5 *max*	1.5 *max*	volts
Collector-Cutoff Current:				
With collector-to-base volts = −1.5 and emitter current = 0	−30 *max*	−30 *max*	−30 *max*	μa
With collector-to-base volts = −45 and emitter current = 0	−250 *max*	—	—	μa
With collector-to-base volts = −60 and emitter current = 0	—	−250 *max*	—	μa
With collector-to-base volts = −80 and emitter current = 0	—	—	−250 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −20 and collector current = 0)	−100 *max*	−100 *max*	−100 *max*	μa
Collector Saturation Resistance (with collector ma = −400 and base ma = −40)	1.25 *max*	1.25 *max*	1.25 *max*	ohms
Thermal Resistance:				
Junction-to-base	10 *max*	10 *max*	10 *max*	°C/watt
Junction-to-ambient	75 *max*	75 *max*	75 *max*	°C/watt
In Common-Base Circuit				
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	500 *min*	500 *min*	500 *min*	kc
In Common-Emitter Circuit				
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2 and collector ma = −400)	20 to 60	20 to 60	20 to 60	



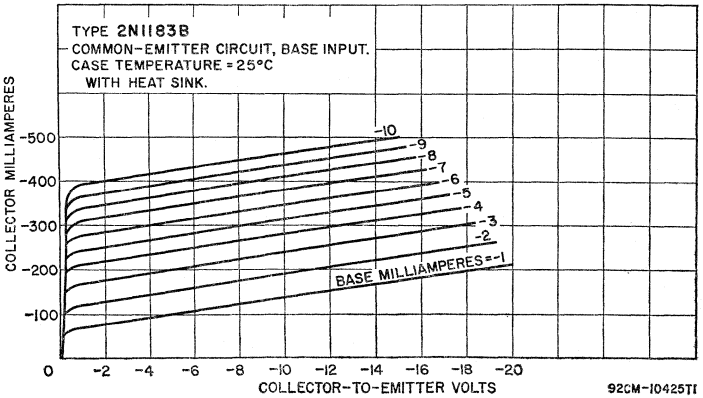


B_1, B_2 = 12 volts
C_1 = 10 μf, electrolytic, 25 volts
R_1 = 51 ohms, 2 watts
R_2 = 120 ohms, 2 watts
R_3 = 230 ohms, 1 watt
R_4 = 29.5 ohms, 5 watts

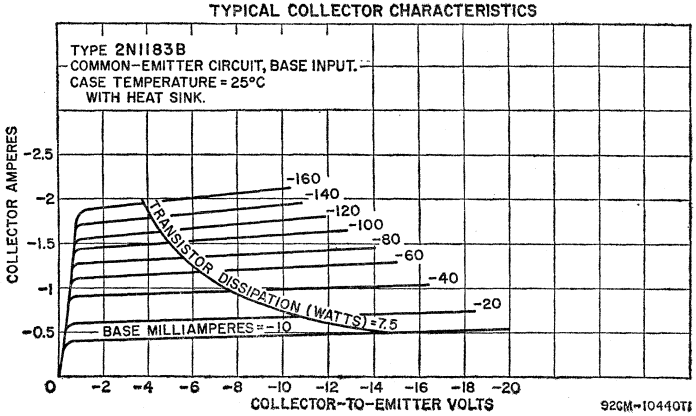
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ABOVE

DC Collector Supply Voltage (B_2)	−12	volts
DC Base Supply Voltage (B_1)	12	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	−400	ma
Turn-on DC Base Current (I_{B1})	−40	ma
Turn-off DC Base Current (I_{B2})	40	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	2	μsec
Storage time (t_s)	1.8	μsec
Fall time (t_f)	1.4	μsec

TYPICAL COLLECTOR CHARACTERISTICS

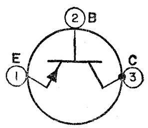


TYPICAL COLLECTOR CHARACTERISTICS



POWER TRANSISTORS

2N1184
2N1184A
2N1184B



Germanium p-n-p types used in intermediate-power switching and low-frequency amplifier applications in industrial and military equipment. They are used in power switching, dc-to-dc converters, choppers, solenoid drivers, and relay controls; in oscillator, regulator, and pulse-amplifier circuits; and as class A or class B amplifiers for servo and linear amplifier applications. JEDEC No.

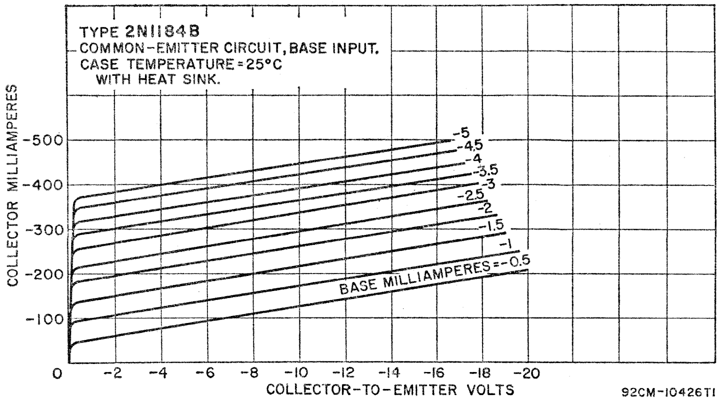
TO-8 package; outline 8, Outlines Section. These types are identical with types 2N1183, 2N1183A and 2N1183B, respectively, except for the following items:

CHARACTERISTICS

In Common-Emitter Circuit

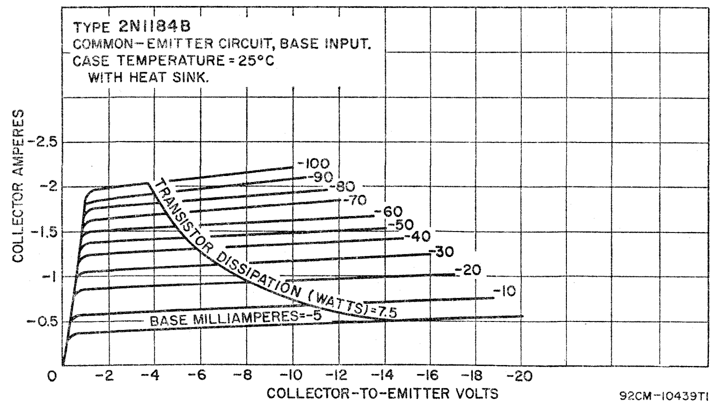
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2 and collector ma = −400) .... 40 to 120

TYPICAL COLLECTOR CHARACTERISTICS



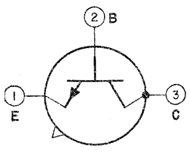
92CM-10426T1

TYPICAL COLLECTOR CHARACTERISTICS



92CM-10439T1

THYRISTOR



Germanium p-n-p type used as a high-speed bistable switching transistor in electronic computers, telephone switchboards, and automatic control switches. JEDEC No. TO-5 package; outline 6, Outlines Section.

2N1213

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 0.3)	−25 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma
COLLECTOR DISSIPATION:		
At ambient temperatures up to 50°C	75 *max*	mw
At ambient temperature of 55°C	60 *max*	mw
At ambient temperature of 71°C	25 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Collector-Breakdown Voltage (with collector μa = −20 and emitter current = 0)	−70	volts
Emitter-Breakdown Voltage (with emitter μa = −100 and collector current = 0)	−2	volts
Base-to-Emitter Voltage for "turn-on"	−0.4	volt
Collector-to-Emitter Voltage (with collector ma = −100)	−0.5	volt
Forward Base Current for "turn-on"	−0.25	ma
Reverse Base Current for "turn-off" (with collector ma = −10)	1.5	ma
Collector Sustaining Current (with base current = 0)	−4.5	ma
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−3	μa

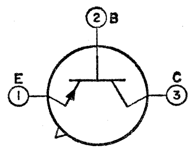
TYPICAL OPERATION IN COMMON-EMITTER FLIP-FLOP CIRCUIT

Collector Supply Voltage	−12	volts
Collector Current (thyristor "on")	−10	ma
Switching Time:		
Delay time	5	nsec
Rise time	15	nsec
Storage time	50	nsec
Fall time	60	nsec

THYRISTOR

2N1214

Germanium p-n-p type used as a high-speed bistable switching transistor in electronic computers, telephone switchboards, and automatic control switches. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1213 except for the following items:



CHARACTERISTICS

Forward Base Current for "turn-on"	−0.5	ma
Reverse Base Current for "turn-off" (with collector ma −20)	6	ma
Collector Sustaining Current (with base current = 0)	−9.5	ma

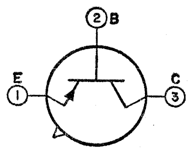
TYPICAL OPERATION IN COMMON-EMITTER FLIP-FLOP CIRCUIT

Collector Current (thyristor "on")	−20	ma
Switching Time:		
Delay time	6	nsec
Fall time	50	nsec

THYRISTOR

2N1215

Germanium p-n-p type used as a high-speed bistable switching transistor in electronic computers, telephone switchboards, and automatic control switches. JEDEC No. TO-5 package; outline 6, Outlines Section. This type



is identical with type 2N1213 except for the following items:

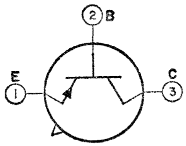
CHARACTERISTICS

Forward Base Current for "turn-on"	−0.5	ma
Reverse Base Current for "turn-off" (with collector ma = −30)	6.5	ma
Collector Sustaining Current (with base current = 0)	−19	ma

TYPICAL OPERATION IN COMMON-EMITTER FLIP-FLOP CIRCUIT

Collector Current (thyristor "on")	−30	ma
Switching Time:		
Delay time	6	nsec
Storage time	35	nsec
Fall time	30	nsec

THYRISTOR



2N1216

Germanium p-n-p type used as a high-speed bistable switching transistor in electronic computers, telephone switchboards, and automatic control switches. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1213 except for the following items:

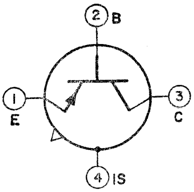
CHARACTERISTICS

Forward Base Current for "turn-on"	−0.5	ma
Collector Sustaining Current (with base current = 0)	−12	ma

TYPICAL OPERATION IN COMMON-EMITTER BISTABLE SWITCHING CIRCUIT

Collector Supply Voltage	−12	volts
Collector Current (thyristor "on")	−50	ma
Switching Time:		
Delay time	7	nsec
Rise time	20	nsec

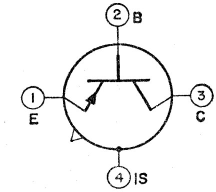
TRANSISTOR



2N1224

Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N274.

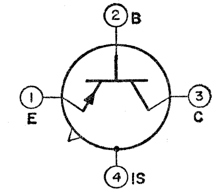
TRANSISTOR



2N1225

Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N384.

TRANSISTOR



2N1226

Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N274 except for the following items:

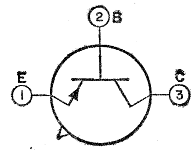
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 0.5)	−60 *max*	volts

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −50 and emitter current = 0)	−100	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = −0.5)	−100	volts

TRANSISTOR



2N1300

Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

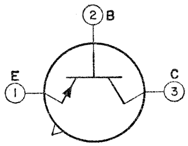
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−13 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−12 *max*	volts

EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −40 and base ma = −1)	−0.4 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −6 and emitter open)	−3 *max*	μa
Total Stored Charge (with collector ma = −10 and base ma = −1)	400 *max*	pcoul
In Common-Base Circuit		
Collector Capacitance (with collector-to-base volts = −6 and emitter current = 0)	12 *max*	pf
In Common-Emitter Circuit		
Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −10)	30 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = −3 and collector ma = −10)	25 *min*	Mc

TRANSISTOR



2N1301

Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. Maximum ratings for this type are the same as for type 2N1300 except for the following items:

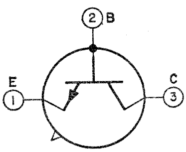
MAXIMUM RATINGS

EMITTER-TO-BASE VOLTAGE (with collector open)	−4 *max*	volts

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −40 and base ma = −1)	−0.6 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −6 and emitter current = 0)	−3 *max*	μa
Total Stored Charge:		
With collector ma = −10 and base ma = −0.4	325 *max*	pcoul
With collector ma = −40 and base ma = −1.6	800 *max*	pcoul
In Common-Base Circuit		
Collector Capacitance (with collector-to-base volts = −6 and emitter open)	12 *max*	pf
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −0.3 and collector ma = −10	30 *min*	
With collector-to-emitter volts = −0.5 and collector ma = −40	40 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = −3 and collector ma = −10)	35 *min*	Mc

TRANSISTOR



2N1302

Germanium n-p-n type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	25 *max*	volts
COLLECTOR CURRENT	300 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 85	°C
Storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	230 *max*	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = 10 and base ma = 0.5)	0.15 to 0.4	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 0.5)	0.2 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 25 and emitter current = 0)	6 *max*	μa

In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 5 and emitter current = 0)	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 5 and emitter ma = 1)	3 *min*	Mc

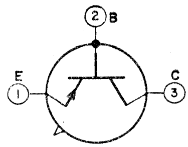
In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 1 and collector ma = 10	20 *min*	
With collector-to-emitter volts = 0.35 and collector ma = 200	10 *min*	

TRANSISTOR

2N1303

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−25 *max*	volts
COLLECTOR CURRENT	−300 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 85	°C
Storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	230 *max*	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.5)	−0.15 to −0.4	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.5)	−0.2 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −25 and emitter current = 0)	−6 *max*	μa

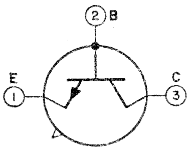
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = −5 and emitter current = 0)	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	3 *min*	Mc

In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −1 and collector ma = −10	20 *min*	
With collector-to-emitter volts = −0.35 and collector ma = −200	10 *min*	

TRANSISTOR



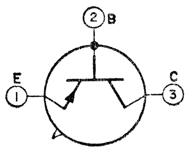
Germanium n-p-n type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1302 except for the following:

2N1304

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = 10 and base ma = 0.5)	0.15 to 0.35	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 0.25)	0.2 *max*	volt
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 5 and emitter ma = 1)	5 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 1 and collector ma = 10	40 to 200	
With collector-to-emitter volts = 0.35 and collector ma = 200	15 *min*	

TRANSISTOR



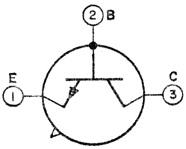
Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1303 except for the following:

2N1305

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.5)	−0.15 to −0.35	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.25)	−0.2 *max*	volt
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	5 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −10 and collector ma = −10	40 to 200	
With collector-to-emitter volts = −0.35 and collector ma = −200	15 *min*	

TRANSISTOR



Germanium n-p-n type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1302 except for the following:

2N1306

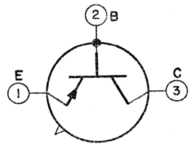
CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = 10 and base ma = 0.5)	0.15 to 0.35	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 0.17)	0.2 *max*	volt
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 5 and emitter ma = 1)	10 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 1 and collector ma = 10	60 to 300	
With collector-to-emitter volts = 0.35 and collector ma = 200	20 *min*	

TRANSISTOR

2N1307

Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1303 except for the following:



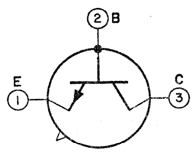
CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.5)	−0.15 to −0.35	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.17)	−0.2 *max*	volt
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	10 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −1 and collector ma = −10	60 to 300	
With collector-to-emitter volts = −0.35 and collector ma = −200	20 *min*	

TRANSISTOR

2N1308

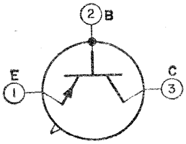
Germanium n-p-n type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1302 except for the following:



CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = 10 and base ma = 0.5)	0.15 to 0.35	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 0.13)	0.2 *max*	volt
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 5 and emitter ma = 1)	15 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 1 and collector ma = 10	80 *min*	
With collector-to-emitter volts = 0.35 and collector ma = 200	20 *min*	

TRANSISTOR



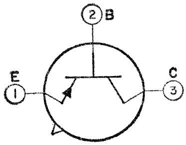
Germanium p-n-p type used in medium-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1303 except for the following:

2N1309

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.5)	−0.15 to −0.35	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −0.13)	−0.2 *max*	volt
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −5 and emitter ma = 1)	15 *min*	Mc
In Common-Emitter Circuit		
Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −1 and collector ma = −10	80 *min*	
With collector-to-emitter volts = −0.35 and collector ma = −200	20 *min*	

TRANSISTOR



Germanium p-n-p bidirectional type used in medium-speed switching circuits in data-processing equipment. This type is designed so that the emitter can also function as a collector and the collector can also function as an emitter. It is especially useful in bidirectional switching, core-driver, and ac-signal relay circuits. JEDEC No. TO-5 package; outline 6, Outlines Section.

2N1319

MAXIMUM RATINGS

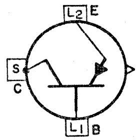
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−20 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = 1)	−20 *max*	volts
COLLECTOR CURRENT	±400 *max*	ma
EMITTER CURRENT	±400 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperature of 55°C	35 *max*	mw
At ambient temperature of 71°C	10 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −400 and base ma = −26.7)	−1.5 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = −400 and base ma = −26.7)	−0.3 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−6 *max*	μa
In Common-Base Circuit		
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and emitter ma = 1)	3 *min*	Mc
Collector-to-Base Capacitance (with collector-to-base volts = −6 and emitter current = 0)	30 *max*	pf
In Common-Emitter Circuit		
Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.3 and collector ma = −400)	15 *min*	

POWER TRANSISTOR

2N1358



Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N174 except for the following items:

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage:		
With base short-circuited to emitter and collector amperes = −0.3	−70 *min*	volts
With base open and collector amperes = −0.3	−40 *min*	volts
Base-to-Emitter Voltage:		
With collector-to-emitter volts = −2 and collector amperes = −5	−0.65	volt
With collector-to-base volts = −2 and collector amperes = −1.2	−0.35	volt
Emitter-to-Base Voltage (with collector-to-base volts = −80 and emitter current = 0)	−0.15	volt
Emitter-Cutoff Current (with emitter-to-base volts = −60 and collector current = 0)	−1	ma
Collector-Cutoff Current (with collector-to-base volts = −2 and emitter current = 0)	−100	μa

In Common-Base Circuit

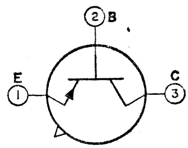
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector amperes = −1)	100	kc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −2 and collector amperes = −1.2	55	
With collector-to-emitter volts = −2 and collector amperes = −5	35	

TRANSISTOR

2N1384



Germanium p-n-p type used in high-speed switching circuits in electronic computers. JEDEC No. TO-11 package; outline 10, Outlines Section.

MAXIMUM RATINGS

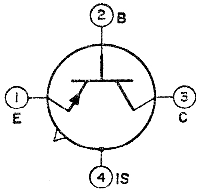
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−500 *max*	ma
EMITTER CURRENT	500 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	240 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −200 and base ma = −10)	−0.9 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −3 and emitter current = 0)	−8 *max*	μa
Stored Base Charge (with collector ma = −10 and base ma = −1)	800 *max*	pcoul

In Common-Emitter Circuit

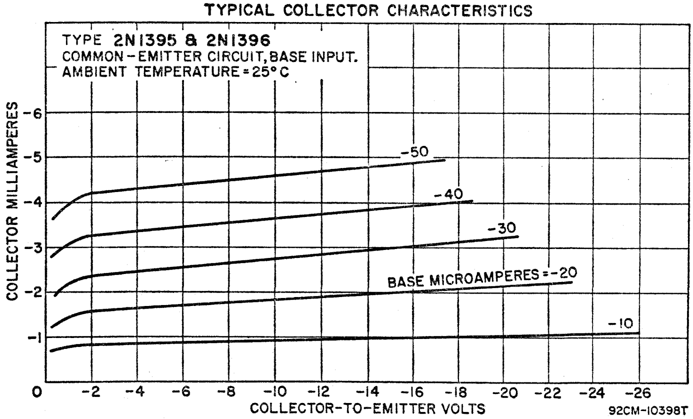
Forward Current-Transfer Ratio (with collector-to-emitter volts = −0.5 and collector ma = −200)....	20 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = −3 and collector ma = −10)........	20 *min*	Mc

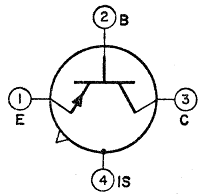


TRANSISTOR

2N1395

Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N274 except for the collector-characteristic curves shown below and a higher common-emitter small-signal forward current-transfer ratio of 90.





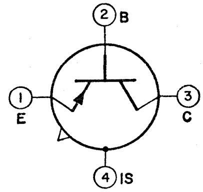
TRANSISTOR

2N1396

Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N384 except for the collector-characteristic curves, which are the same as for type 2N1395, and a higher common-emitter small-signal forward current-transfer ratio of 90.

TRANSISTOR

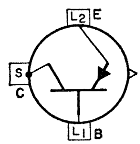
2N1397



Germanium p-n-p type used in rf and if amplifier circuits; oscillator, mixer, and converter circuits; and low-level video-amplifier circuits in industrial and military equipment. It is used in the design of rf circuits having high input-circuit efficiency, excellent operating stability, good automatic-gain-control capabilities over a wide range of input-signal levels, and good signal-to-noise ratio. The drift-field construction provides low base resistance and collector-transition capacitance, and improves performance at high frequencies. A fourth lead internally connected to the metal case provides integral shielding which minimizes interlead capacitance and coupling to adjacent circuit components. JEDEC No. TO-33 package; outline 13, Outlines Section. This type is electrically identical with type 2N1023 except for the collector-characteristic curves, which are the same as for type 2N1395, and a higher common-emitter small-signal forward current-transfer ratio of 90.

POWER TRANSISTOR

2N1412



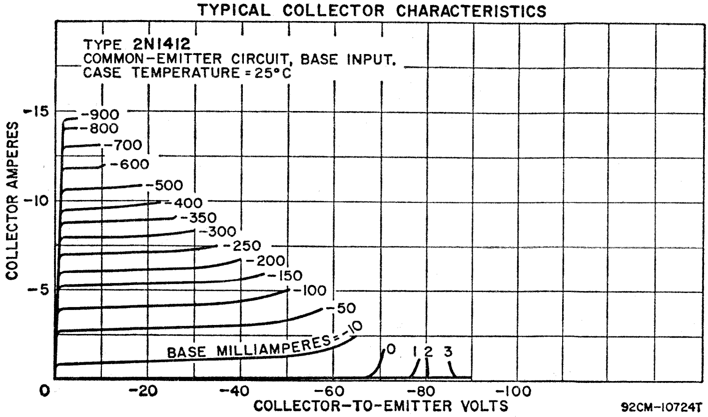
Germanium p-n-p type used in a wide variety of switching and amplifier applications in industrial and military equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, voltage- and current-regulating, dc-to-dc converter, inverter, power-supply, and relay- and solenoid-actuating circuits; and in low-frequency oscillator and audio-amplifier service. This type is designed to provide satisfactory performance under extreme environmental conditions of temperature, moisture, and altitude; it is stud-mounted to provide positive heat-sink contact, and has a cold-weld seal to insure reliable performance under severe environmental conditions. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N174 except for the following items:

MAXIMUM RATINGS

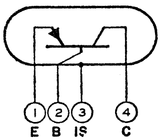
COLLECTOR-TO-BASE VOLTAGE (with emitter-to-base volts = −1.5)	−100 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−60 *max*	volts

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with base short-circuited to emitter and collector amperes = −0.3)	−80 *min*	volts
Emitter-to-Base Voltage (with collector-to-base volts = −80 and emitter current = 0)	−1 *max*	volt
Collector-to-Emitter Reach-Through Voltage	−100 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −100 and emitter current = 0)	−2	ma



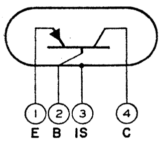
TRANSISTOR



2N1425

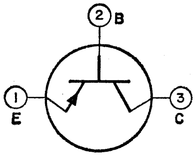
Germanium p-n-p type used in intermediate-frequency amplifier applications in battery-operated AM portable radio receivers. Maximum ratings: collector-to-base volts, −24; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This type is used principally for renewal purposes.

TRANSISTOR



2N1426

Germanium p-n-p type used in converter (mixer-oscillator) applications in battery-operated AM portable radio receivers. Maximum ratings: collector-to-base volts, −24; collector ma, −10; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. JEDEC No. TO-7 package; outline 7, Outlines Section. This type is used principally for renewal purposes.



TRANSISTOR

2N1450

Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-9; outline 9, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt

COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	120 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

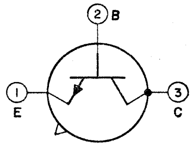
Base-to-Emitter Voltage (with collector ma = −10 and base ma = −0.5)	−0.6 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −10 and base ma = −1)	−0.25 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −7 and emitter current = 0)	−10 *max*	μa

In Common-Emitter Circuit

Forward Current-Transfer Ratio (with collector-to-emitter volts = −1 and collector ma = −10)	20 *min*	

POWER TRANSISTOR

2N1479



Silicon n-p-n type used in a wide variety of medium-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1482 except for the following:

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts

CHARACTERISTICS

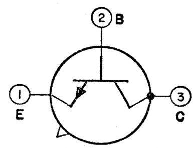
Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 50 and base current = 0)	40 *min*	volts

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 400)	20 to 60	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 200 and base ma = 20)	7 *max*	ohms

POWER TRANSISTOR

2N1480



Silicon n-p-n type used in a wide variety of medium-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class

A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1482 except for the following items:

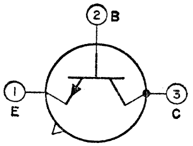
CHARACTERISTICS

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 200)	20 to 60	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 200 and base ma = 20)	7 *max*	ohms

POWER TRANSISTOR

2N1481



Silicon n-p-n type used in a wide variety of medium-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1482 except for the following items:

MAXIMUM RATINGS

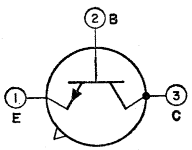
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 50 and base current = 0)	40 *min*	volts

POWER TRANSISTOR

2N1482



Silicon n-p-n type used in a wide variety of medium-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	100 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	100 *max*	volts
With base open	55 *max*	volts

EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	volts
COLLECTOR CURRENT	1.5 *max*	amperes
EMITTER CURRENT	−1.75 *max*	amperes
BASE CURRENT	1 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	5 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and Storage	−65 to 200	°C

CHARACTERISTICS

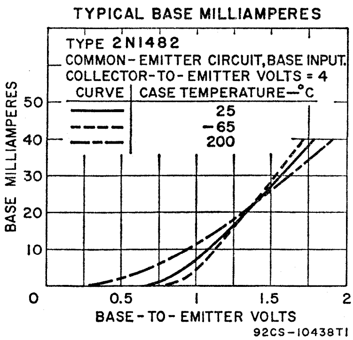
Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	100 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 50 and base current = 0)	55 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector ma = 200)	3 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	10 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 12 and collector current = 0)	10 *max*	μa
Thermal Resistance:		
Junction-to-case	35 *max*	°C/watt
Junction-to-ambient	200 *max*	°C/watt
Thermal Time Constant	10	msec

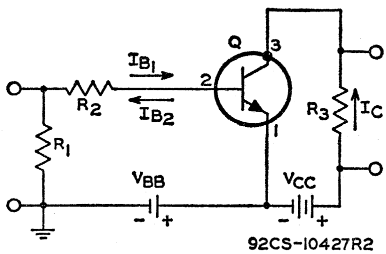
In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1.5	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	150	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 400)	35 to 100	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 5)	50	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 200 and base ma = 10)	7 *max*	ohms

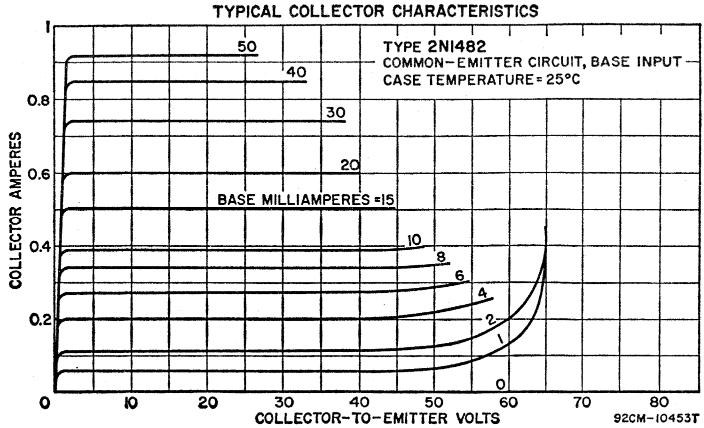




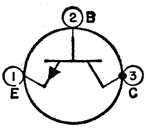
V_{BB} = 8.5 volts
V_{CC} = 12 volts
R_1 = 50 ohms, 1 watt
R_2 = 700 ohms, 1 watt
R_3 = 59 ohms, 2 watts

TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ABOVE

DC Collector Supply Voltage (V_{CC})	12	volts
DC Base Supply Voltage (V_{BB})	−8.5	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	200	ma
Turn-On DC Base Current (I_{B1})	20	ma
Turn-Off DC Base Current (I_{B2})	−8.5	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1	μsec
Storage time (t_s)	0.6	μsec
Fall time (t_f)	1	μsec



POWER TRANSISTOR



2N1483

Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-8 package; outline 8, Outlines Section. This type is identical with type 2N1486 except for the following:

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts

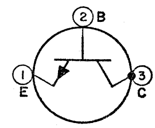
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 750)	20 to 60	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 750 and base ma = 75)	2.67 *max*	ohms

POWER TRANSISTOR

2N1484

Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-8 package; outline 8, Outlines Section. This type is identical with type 2N1486 except for the following:



CHARACTERISTICS

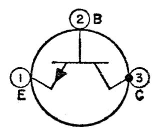
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 750)	20 to 60	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 750 and base ma = 75)	2.67 *max*	ohms

POWER TRANSISTOR

2N1485

Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-8 package; outline 8, Outlines Section. This type is identical with type 2N1486 except for the following:



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts

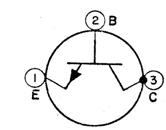
CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts

POWER TRANSISTOR

2N1486

Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as



a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-8 package; outline 8, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	100 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	100 *max*	volts
With base open	55 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	volts
COLLECTOR CURRENT	3 *max*	amperes
EMITTER CURRENT	−3.5 *max*	amperes
BASE CURRENT	1.5 *max*	amperes
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	25 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	100 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	55 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector ma = 750)	3.5 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	15 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 12 and collector current = 0)	15 *max*	μa
Thermal Resistance:		
Junction-to-case	7 *max*	°C/watt
Junction-to-ambient	100 *max*	°C/watt
Thermal Time Constant	10	msec

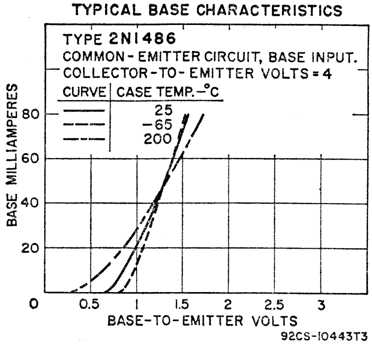
In Common-Base Circuit

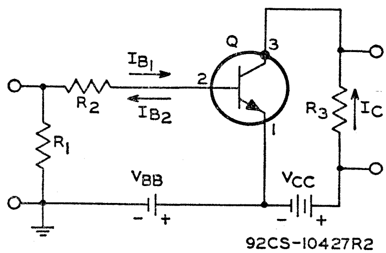
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1.25	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	175	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 750)	35 to 100	
Collector-to-Emitter Saturation Resistance (with collector ma = 750 and base ma = 40)	1 *max*	ohm

TYPICAL BASE CHARACTERISTICS



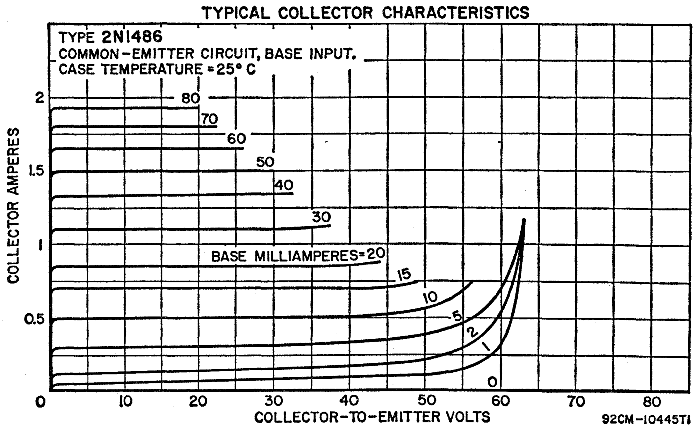


V_{BB} = 8.5 volts
V_{CC} = 12 volts
R_1 = 50 ohms, 1 watt
R_2 = 220 ohms, 1 watt
R_3 = 15.9 ohms, 2 watts

TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ABOVE

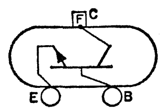
DC Collector Supply Voltage (V_{CC})	12	volts
DC Base Supply Voltage (V_{BB})	−8.5	volts

Generator Resistance	50	ohms
On DC Collector Current (I_c)	750	ma
Turn-On DC Base Current (I_{B1})	65	ma
Turn-Off DC Base Current (I_{B2})	−35	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise Time (t_r)	1	μsec
Storage time (t_s)	0.8	μsec
Fall time (t_f)	1.1	μsec



POWER TRANSISTOR

2N1487



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section. This type is identical with type 2N1490 except for the following:

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts

CHARACTERISTICS

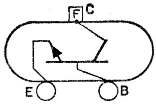
Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.5)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector amperes = 1.5)	15 to 45	
DC Collector-to-Emitter Saturation Resistance (with collector amperes = 1.5 and base ma = 300)	2 *max*	ohms

POWER TRANSISTOR

2N1488



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section. This type is identical with type 2N1490 except for the following:

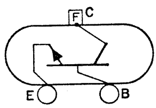
CHARACTERISTICS

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector amperes = 1.5)	15 to 45	
DC Collector-to-Emitter Saturation Resistance (with collector amperes = 1.5 and base ma = 300)	2 *max*	ohms

POWER TRANSISTOR

2N1489



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section. This type is identical with type 2N1490 except for the following:

MAXIMUM RATINGS

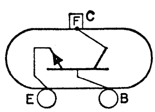
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.5)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts

POWER TRANSISTOR

2N1490



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	100 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	100 *max*	volts
With base open	55 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	10 *max*	volts
COLLECTOR CURRENT	6 *max*	amperes
EMITTER CURRENT	−8 *max*	amperes
BASE CURRENT	3 *max*	amperes
TRANSISTOR DISSIPATION:		
At mounting-flange temperatures up to 25°C	75 *max*	watts
At mounting-flange temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C

CHARACTERISTICS

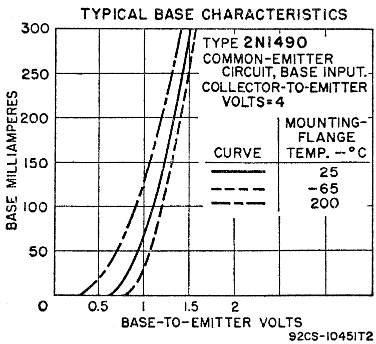
Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.5)	100 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	55 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector amperes = 1.5)	3.5 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	25 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 10 and collector current = 0)	25 *max*	μa
Thermal Resistance:		
Junction-to-mounting-flange	2.33 *max*	°C/watt
Thermal Time Constant	12	msec

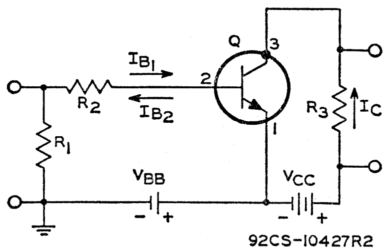
In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 12 and collector ma = 100)	1	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	200	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector amperes = 1.5)	25 to 75	
Collector-to-Emitter Saturation Resistance (with collector amperes = 1.5 and base ma = 300)	0.67 *max*	ohm





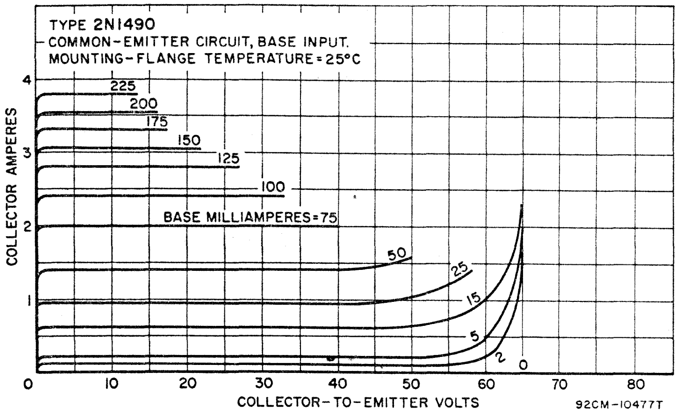
V_{BB} = 8.5 volts
V_{CC} = 12 volts
R_1 = 50 ohms, 1 watt
R_2 = 30 ohms, 1 watt
R_3 = 7.8 ohms, 2 watts

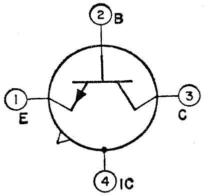
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ABOVE

DC Collector Supply Voltage (V_{CC})	12	volts
DC Base Supply Voltage (V_{BB})	−8.5	volts

Generator Resistance	50	ohms
On DC Collector Current (I_C)	1.5	ma
Turn-On DC Base Current (I_{B1})	300	ma
Turn-Off DC Base Current (I_{B2})	−150	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1	μsec
Storage time (t_s)	1	μsec
Fall time (t_f)	1.2	μsec

TYPICAL COLLECTOR CHARACTERISTICS





TRANSISTOR

2N1491

Silicon n-p-n type used in a wide variety of high-frequency and vhf applications in industrial and military equipment. It is used in large-signal power-amplifier, video-amplifier, oscillator, and mixer circuits over a wide temperature range. This type can also be used in switching service in circuits requiring transistors having high voltage, current, and dissipation values. JEDEC No. TO-12 package; outline 11, Outlines Section. This type is identical with type 2N1493 except for the following items:

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	30 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = 0.5)	30 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	1 *max*	volt

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	30 *min*	volts

In Common-Base Circuit

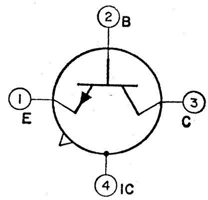
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 30 and collector ma = 15)	250	Mc

In Common-Emitter Circuit

Power Gain at 70 Mc (with collector-to-base volts = 20, emitter ma = −15, and power output = 10 mw)	15	db

TRANSISTOR

2N1492



Silicon n-p-n type used in a wide variety of high-frequency and vhf applications in industrial and military equipment. It is used in large-signal power-amplifier, video-amplifier, oscillator, and mixer circuits over a wide temperature range. This type can also be used in switching service in circuits requiring transistors having high voltage, current, and dissipation values. JEDEC No. TO-12 package; outline 11, Outlines Section. This type is identical with type 2N1493 except for the following items:

MAXIMUM RATINGS

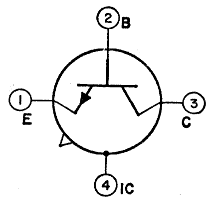
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = 0.5)	60 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	2 *max*	volts

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	60 *min*	volts
In Common-Base Circuit		
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 30 and collector ma = 15)	275	Mc
In Common-Emitter Circuit		
Power Gain at 70 Mc (with collector-to-base volts = 30, emitter ma = −15, and power output = 100 mw)	15	db

TRANSISTOR

2N1493



Silicon n-p-n type used in a wide variety of high-frequency and vhf applications in industrial and military equipment. It is used in large-signal power-amplifier, video-amplifier, oscillator, and mixer circuits over a wide temperature range. This type can also be used in switching service in circuits requiring transistors having high voltage, current, and dissipation values. JEDEC No. TO-12 package; outline 11, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	100 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = 0.5)	100 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	4.5 *max*	volts
COLLECTOR CURRENT	50 *max*	ma
EMITTER CURRENT	−50 *max*	ma
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	3 *max*	watts
At ambient temperatures up to 25°C	0.5 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 175	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	100 *min*	volts

Emitter-Cutoff Current (with emitter-to-base volts = 0.5 and collector current = 0)	100 *max*	μa
Collector-Cutoff Current (with collector-to-base volts = 12 and emitter current = 0)	10 *max*	μa
Thermal Resistance: Junction-to-case	50 *max*	°C/watt

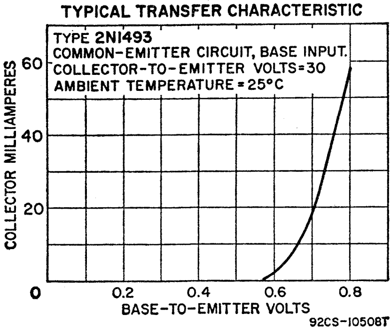
In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 30 and collector ma = 15)	300	Mc
Collector-to-Base-and-Stem Capacitance (with collector-to-base volts = 30 and emitter current = 0)	5 *max*	pf

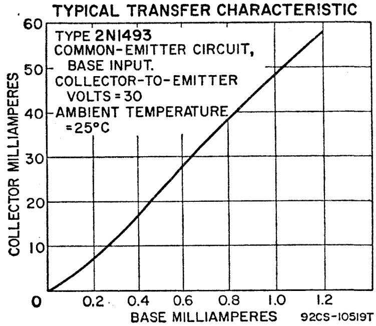
In Common-Emitter Circuit

Small-Signal Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 20, collector ma = 15, and frequency = 1 kilocycle	50	
With collector-to-emitter volts = 30, collector ma = 15, and frequency = 100 Mc	1.8	
Power Gain at 70 Mc:		
With collector-to-base volts = 20, emitter ma = −15, and power output = 10 mw	16	db
With collector-to-base volts = 30, emitter ma = −15, and power output = 100 mw	16	db
With collector-to-base volts = 50, emitter ma = −25, and power output = 500 mw	12	db

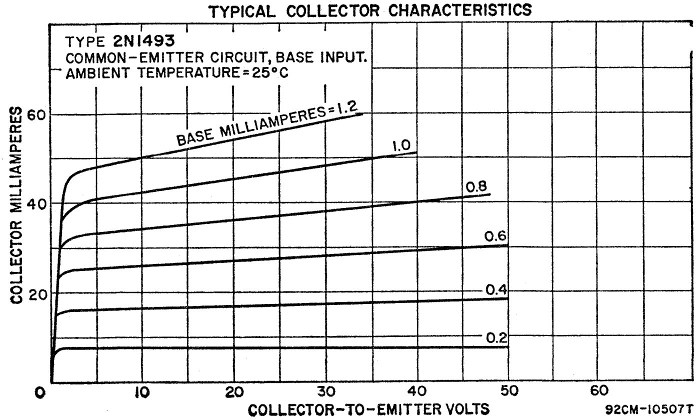
TYPICAL TRANSFER CHARACTERISTIC



TYPICAL TRANSFER CHARACTERISTIC

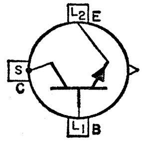


TYPICAL COLLECTOR CHARACTERISTICS



POWER TRANSISTOR

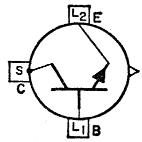
2N1511



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. This type is stud-mounted to provide positive heat-sink contact and has a cold-weld seal. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is electrically identical with type 2N1487.

POWER TRANSISTOR

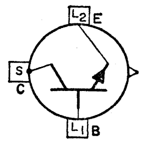
2N1512



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. This type is stud-mounted to provide positive heat-sink contact and has a cold-weld seal. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is electrically identical with type 2N1488.

POWER TRANSISTOR

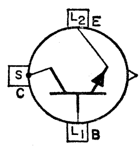
2N1513



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. This type is stud-mounted to provide positive heat-sink contact and has a cold-weld seal. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is electrically identical with type 2N1489.

POWER TRANSISTOR

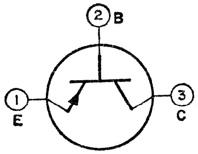
2N1514



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high temperature performance. This type is stud-mounted to provide positive heat-sink contact and has a cold-weld seal. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is electrically identical with type 2N1490.

TRANSISTOR

2N1524



Germanium p-n-p type used in intermediate-frequency amplifier applications in battery-operated AM portable radio receivers. In a common-emitter circuit, this type is capable of providing a maximum power gain of 33 db with neutralization or 30.2 db without neutralization. JEDEC No. TO-1 package; outline 4, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−24 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	35 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

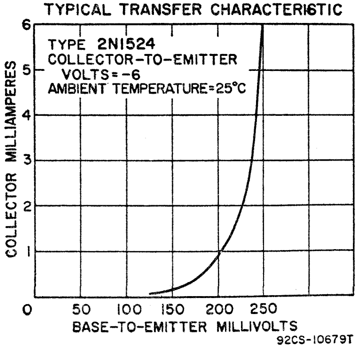
CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with emitter-to-base volts = −0.5 and collector μa = −50)	−24 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−16 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−16 *max*	μa
Thermal Resistance:		
Junction-to-ambient	0.4	°C/mw

In Common-Base Circuit

Small-Signal Forward Current-Transfer-Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.983	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	33	Mc

TYPICAL TRANSFER CHARACTERISTIC



In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle) 60

TYPICAL OPERATION IN SINGLE-STAGE 455-KC AMPLIFIER CIRCUIT

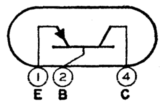
DC Collector-Supply Voltage	−6	−9	−12	volts
DC Collector-to-Emitter Voltage	−5.7	−8.5	−11	volts
Collector Current	−1	−1	−1	ma
Input Resistance	1300	1350	1550	ohms
Output Resistance	0.31	0.415	0.525	megohm
Collector-to-Base Capacitance	2.2	2.1	2	pf
Maximum Power Gain	51	52.4	54.4	db
Useful Power Gain:				
In neutralized circuit	33	33	33	db
In unneutralized circuit	29.7	30	30.2	db

TYPICAL OPERATION IN TWO-STAGE 455-KC AMPLIFIER CIRCUIT

DC Collector-Supply Voltage	−6	−6	−9	−9	−12	−12	volts
DC Collector-to-Emitter Voltage	−5.7	−5.7	−8.5	−8.5	−11	−11	volts
Collector Current	−1	−0.65	−1	−0.65	−1	−0.65	ma
Input Resistance	1300	2100	1350	2200	1550	2500	ohms
Output Resistance	0.31	0.49	0.415	0.65	0.525	0.82	megohm
Collector-to-Base Capacitance	2.2	2.2	2.1	2.1	2	2	pf
Maximum Power Gain	50.9	51.3	52.4	52.8	54	54.3	db
Useful Power Gain:							
In neutralized circuit	31.2	30	31.2	30	31.2	30	db
In unneutralized circuit	28.1	26.6	28.2	26.7	28.3	26.8	db

TRANSISTOR

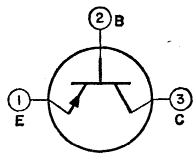
2N1525



Germanium p-n-p type used in intermediate-frequency amplifier applications in battery-operated AM portable radio receivers. In a common-emitter circuit, this type is capable of providing a maximum power gain of 33 db with neutralization or 30.2 db without neutralization. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is electrically identical with type 2N1524.

TRANSISTOR

2N1526



Germanium p-n-p type used in converter (mixer-oscillator) applications in battery-operated portable radio receivers. In a common-emitter circuit, this type is capable of providing a useful conversion power gain of 34.5 db. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is identical with type 2N1524 except for the following items:

CHARACTERISTICS

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle) 0.992

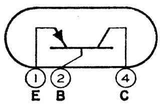
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle) 130

TYPICAL OPERATION IN SELF-EXCITED 1.5-MC CONVERTER CIRCUIT

DC Collector-Supply Voltage	−6	−9	−12	volts
DC Collector-to-Emitter Voltage	−5	−8	−11	volts
DC Collector Current	−0.65	−0.65	−0.65	ma
Input Resistance	1850	1950	2150	ohms
Output Resistance	0.19	0.28	0.48	megohm
RMS Base-to-Emitter Oscillator-Injection Voltage	100	100	100	mv
Conversion Power Gain:				
Maximum available	44.2	46.1	48.9	db
Useful	34.2	34.5	35.8	db

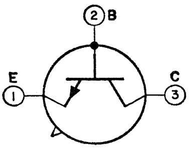
TRANSISTOR



2N1527

Germanium p-n-p type used in converter (mixer-oscillator) applications in battery-operated AM portable radio receivers. In a common-emitter circuit, this type is capable of providing a useful conversion power gain of 34.5 db. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is electrically identical with type 2N1526.

TRANSISTORS



2N1605
2N1605A

Germanium n-p-n types used in medium-speed switching applications in data-processing equipment. These transistors are n-p-n complements of the p-n-p types 2N404 and 2N404A. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

	2N1605	*2N1605A*	
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	40 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base-to-emitter volts = −1)	24 *max*	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	12 *max*	12 *max*	volts
COLLECTOR CURRENT	100 *max*	100 *max*	ma
EMITTER CURRENT	−100 *max*	−100 *max*	ma
TRANSISTOR DISSIPATION:			
At ambient temperatures up to 25°C	150 *max*	200 *max*	mw
At ambient temperatures above 25°C	See curve page 68		
AMBIENT TEMPERATURE RANGE:			
Operating and storage	−65 to 100	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	235 *max*	°C

CHARACTERISTICS

	2N1605	*2N1605A*	
Collector-to-Emitter Saturation Voltage:			
With collector ma = 12 and base ma = 0.4	0.15 *max*	0.15 *max*	volt
With collector ma = 24 and base ma = 1	0.2 *max*	0.2 *max*	volt
Base-to-Emitter Voltage:			
With collector ma = 12 and base ma = 0.4	0.35 *max*	0.35 *max*	volt
With collector ma = 24 and base ma = 1	0.4 *max*	0.4 *max*	volt
Collector-Cutoff Current:			
With collector-to-base volts = 12 and emitter current = 0	5 *max*	—	μa
With collector-to-base volts = 40 and emitter current = 0	—	10 *max*	μa
Total Stored Charge (with collector-to-base volts = 5.25, collector ma = 10, and base ma = 1)	1400	1400 *max*	pcoul

In Common-Base Circuit

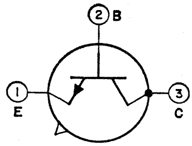
	2N1605	2N1605A	
Collector-to-Base Capacitance (with collector-to-base volts = 6 and collector current = 0)	20 *max*	20 *max*	pf
Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 6 and emitter current = 1)	4 *min*	4 *min*	Mc

In Common-Emitter Circuit

Forward Current-Transfer Ratio:			
With collector-to-emitter volts = 0.15 and collector ma = 12	30 *min*	30 *min*	
With collector-to-emitter volts = 0.2 and collector ma = 24	24 *min*	24 *min*	
With collector-to-emitter volts = 0.25 and collector ma = 20	40 *min*	40 *min*	

TRANSISTOR

2N1613



Silicon n-p-n type used in a wide variety of small-signal and medium-power applications in industrial and military equipment. It can be used in rf service as an amplifier, mixer, oscillator, and converter; in af service for small- and large-signal driver and power applications; in switching service for high-speed switching circuits requiring transistors having high voltage, high dissipation, high pulse beta, low output capacitance, and exceptionally low noise and leakage characteristics. JEDEC No. TO-5 package; outline 6, Outlines Section. For curve of typical transfer characteristics, refer to type 2N2102.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	75 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10 ohms or less)	50 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	7 *max*	volts
COLLECTOR CURRENT	1 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	3 *max*	watts
At ambient temperatures up to 25°C	0.8 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 200	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	75 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.25 and collector current = 0)	7 *min*	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.1)	75 *min*	volts
Collector-to-Emitter Sustaining Voltage (with external base-to-emitter resistance = 10 ohms or less and collector ma = 100)	50 *min*	volts
Base-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.3 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.5 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	0.01 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 5 and collector current = 0)	0.01 *max*	μa
Thermal Resistance:		
Junction-to-case	58.3 *max*	°C/watt
Junction to ambient	219 *max*	°C/watt

In Common-Base Circuit

Input Resistance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	24 to 34	ohms
With collector-to-base volts = 10 and collector ma = 5	4 to 8	ohms

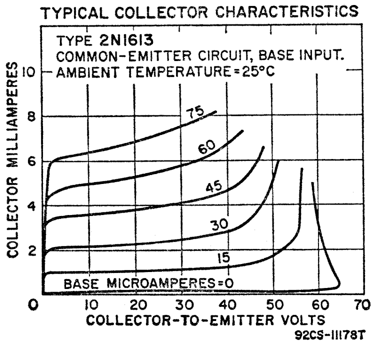
Input Capacitance (with emitter-to-base volts = 0.5 and collector current = 0)	80 *max*	pf
Output Capacitance (with collector-to-base volts = 10 and emitter current = 0)	25 *max*	pf
Output Conductance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.1 to 0.5	μmho
With collector-to-base volts = 10 and collector ma = 5	0.1 to 1	μmho
Small-Signal Open-Circuit Reverse Voltage-Transfer Ratio at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.0003 *max*	
With collector-to-base volts = 10 and collector ma = 5	0.0003 *max*	

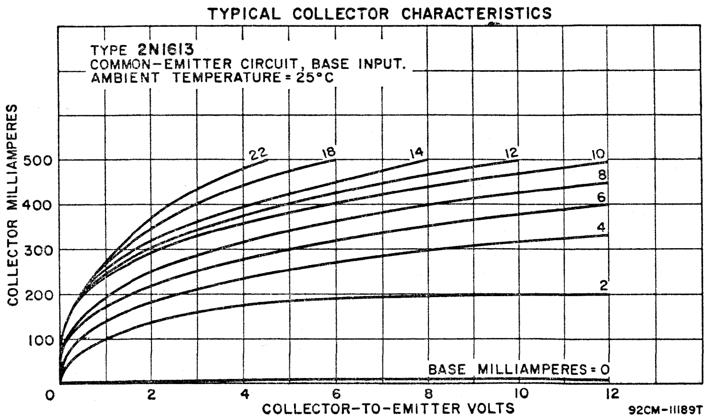
In Common-Emitter Circuit

DC-Pulse Forward Current-Transfer Ratio:*		
With collector-to-emitter volts = 10 and collector ma = 150	40 to 120	
With collector-to-emitter volts = 10 and collector ma = 500	20 *min*	
DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 10 and collector ma = 0.1	20 *min*	
With collector-to-emitter volts = 10 and collector ma = 10	35 *min*	
Small-Signal Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 5, collector ma = 1, and frequency = 1 kilocycle	30 to 100	
With collector-to-emitter volts = 10, collector ma = 5, and frequency = 1 kilocycle	35 to 150	
With collector-to-emitter volts = 10, collector ma = 50, and frequency = 20 Mc	3 *min*	
Noise Figure (with collector-to-emitter volts = 10, collector ma = 0.3, generator resistance = 1000 ohms, circuit bandwidth = 15 kilocycles, and signal frequency = 1 kilocycle)	12 *max*	db
Total Switching Time† (delay time plus rise time plus fall time)	30 *max*	nsec

* Pulse duration = 300 μsec; duty factor = 0.018.

† Refer to type 2N2102 for *Total-Switching-Time Measurement Circuit.*

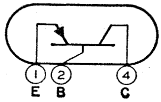




TRANSISTOR

2N1631

Germanium p-n-p type used in radio-frequency amplifier applications in battery-operated AM portable radio receivers. In an unneutralized rf amplifier circuit, this type can provide a power gain of 25.6 db at 1.5 megacycles. JEDEC No. TO-40 package; outline 15, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−34 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	35 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

CHARACTERISTICS

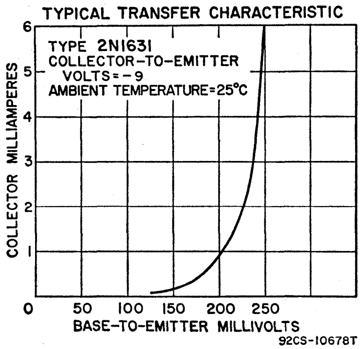
Collector-to-Base Breakdown Voltage (with collector μa = −50 and emitter current = 0)	−34 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−16 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−16 *max*	μa
Thermal Resistance:		
Junction-to-ambient	0.4 *max*	°C/mw

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.987	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = −1)	45	Mc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	80	

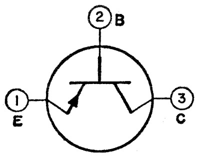


TYPICAL OPERATION

DC Collector-Supply Voltage	−6	−9	−12	volts
DC Collector-to-Emitter Voltage	−5.7	−8.5	−11	volts
DC Collector Current	−1	−1	−1	ma
Signal Frequency	1.5	1.5	1.5	Mc

Input Resistance (with ac output circuit shorted)	520	750	1000	ohms
Output Resistance (with ac input circuit shorted)	0.065	0.11	0.18	megohm
Extrinsic Transconductance	36000	36000	36000	µmhos
Collector-to-Base Capacitance	2.2	2.1	2	pf
Maximum Power Gain	40.4	44.3	47.7	db
Useful Power Gain:				
In unneutralized circuit	25.3	25.5	25.6	db

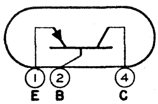
TRANSISTOR



2N1632

Germanium p-n-p type used in radio-frequency amplifier applications in battery-operated AM portable radio receivers. In an unneutralized rf amplifier circuit, this type can provide a power gain of 25.6 db at 1.5 megacycles. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N1631.

TRANSISTOR



2N1633

Germanium p-n-p type used in intermediate-frequency amplifier applications in battery-operated AM portable radio receivers. In a 455-kilocycle intermediate-frequency amplifier circuit, this type can provide a useful power gain of 36.7 db with neutralization or 31.4 db without neutralization. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is identical with type 2N1631 except for the following items:

CHARACTERISTICS

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.986	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = −1)	40	Mc

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	75	

TYPICAL OPERATION IN SINGLE-STAGE 455-KC AMPLIFIER CIRCUIT

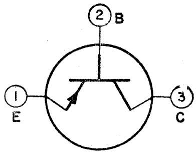
DC Collector-Supply Voltage	−6	−9	−12	volts
DC Collector-to-Emitter Voltage	−5.7	−8.5	−11	volts
DC Collector Current	−1	−1	−1	ma
Input Resistance (with ac output circuit shorted)	1500	1550	1800	ohms
Output Resistance (with ac input circuit shorted)	0.35	0.475	0.6	megohm
Collector-to-Base Capacitance	2.2	2.1	2	pf
Maximum Power Gain	52.6	53.8	55.7	db
Maximum Useful Power Gain:				
In neutralized circuit	36.7	36.7	36.7	db
In unneutralized circuit	31.2	31.3	31.4	db

TYPICAL OPERATION IN TWO-STAGE 455-KC AMPLIFIER CIRCUIT

DC Collector-Supply Voltage	−6	−6	−9	−9	−12	−12	volts
DC Collector-to-Emitter Voltage	−5.7	−5.7	−8.5	−8.5	−11	−11	volts
DC Collector Current	−0.5	−1	−0.5	−1	−0.5	−1	ma
Input Resistance (with ac output circuit shorted)	2800	1500	3000	1550	3400	1800	ohms
Output Resistance (with ac input circuit shorted)	0.7	0.35	0.9	0.475	1.2	0.6	megohms
Collector-to-Base Capacitance	2.2	2.2	2.1	2.1	2	2	pf
Maximum Power Gain	52.2	52.6	53.3	53.8	55.6	55.7	db

TRANSISTOR

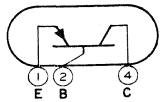
2N1634



Germanium p-n-p type used in intermediate-frequency amplifier applications in battery-operated AM portable radio receivers. In a 455-kilocycle intermediate-frequency amplifier circuit, this type can provide a useful power gain of 36.7 db with neutralization or 31.4 db without neutralization. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N1633.

TRANSISTOR

2N1635



Germanium p-n-p type used in converter (mixer-oscillator) applications in battery-operated AM portable radio receivers. In a common-emitter circuit, this type is capable of providing a useful power gain of 36 db. JEDEC No. TO-40 package; outline 15, Outlines Section. This type is identical with type 2N1633 except for the following items:

CHARACTERISTICS

In Common-Base Circuit

Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.986	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = 1)	45	Mc

In Common-Emitter Circuit

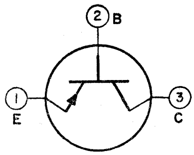
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12, collector ma = −1, and frequency = 1 kilocycle)	75	

TYPICAL OPERATION IN SELF-EXCITED 1-MC CONVERTER CIRCUIT

DC Collector-Supply Voltage	−9	volts
DC Collector-to-Emitter Voltage	−8.5	volts
DC Collector Current	−0.65	ma
Input Resistance	2000	ohms
Output Resistance	0.3	megohm
RMS Base-to-Emitter Oscillator-Injection Voltage	100	mv
Conversion Power Gain	36	db

TRANSISTOR

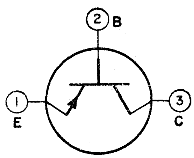
2N1636



Germanium p-n-p type used in converter (mixer-oscillator) applications in battery-operated AM portable radio receivers. In a common-emitter circuit, this type is capable of providing a useful power gain of 36 db. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is electrically identical with type 2N1635.

TRANSISTOR

2N1637



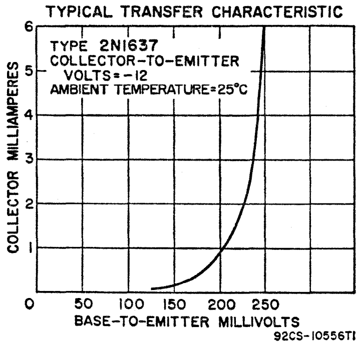
Germanium p-n-p type used in radio-frequency amplifier applications in AM automobile radio receivers. In an unneutralized circuit, this type is capable of providing a useful power gain of 25.6 db at 1 megacycle. JEDEC No. TO-1 package; outline 4, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−34 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1.5 *max*	volts
COLLECTOR CURRENT	−10 *max*	ma
EMITTER CURRENT	10 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	80 *max*	mw
At ambient temperature of 55°C	50 *max*	mw
At ambient temperature of 71°C	35 *max*	mw
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 71	°C
Storage	−65 to 85	°C

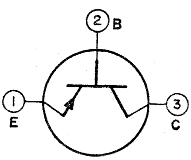
CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector μa = −50 and emitter current = 0)	−34 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−5 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −1.5 and collector current = 0)	−15 *max*	μa
Thermal Resistance:		
Junction-to-ambient	0.4 *max*	°C/mw
In Common-Base Circuit		
Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.987	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = −1)	45	Mc
Collector-to-Base Capacitance	2	pf
In Common-Emitter Circuit		
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12 and collector ma = −1)	80	



TYPICAL OPERATION

DC Collector-to-Emitter Voltage	−5.5	−11.2	volts
DC Collector Current	−1	−1	ma
Signal Frequency	1.5	1.5	Mc
Input Resistance (with ac output circuit shorted)	520	1000	ohms
Output Resistance (with ac input circuit shorted)	0.065	0.18	megohm
Maximum Power Gain	40.4	47.7	db
Maximum Useful Power Gain:			
In unneutralized circuit	25.3	25.6	db



TRANSISTOR

2N1638

Germanium p-n-p type used in 262.5-kilocycle or 455-kilocycle intermediate-frequency amplifier applications in AM automobile radio receivers. In an unneutralized circuit, this type is capable of providing a useful power gain of 36.6 db at 262.5 megacycles. JEDEC No. TO-1 package; outline 4, Outlines Section. This type is identical with type 2N1637 except for the following:

MAXIMUM RATINGS

EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt

CHARACTERISTICS

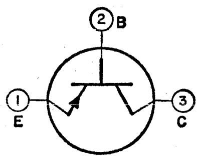
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−7 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−8 *max*	μa
In Common-Base Circuit		
Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.986	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 12 and collector ma = −1)	40	Mc
In Common-Emitter Circuit		
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12 and collector ma = −1)	75	

TYPICAL OPERATION IN SINGLE-STAGE 262.5-KC AMPLIFIER CIRCUIT

DC Collector-to-Emitter Voltage	−5	−11	volts
DC Collector Current	−1.6	−2	ma
Input Resistance	1800	1400	ohms
Output Resistance	0.47	0.72	megohm
Maximum Power Gain	58.6	61.5	db
Useful Power Gain: In unneutralized circuit	35	36.6	db

TRANSISTOR

2N1639



Germanium p-n-p type used in converter (mixer-oscillator) applications in AM automobile radio receivers. In an unneutralized circuit, this type can provide a useful conversion power gain of 37 db at 1.5 megacycles. JEDEC No. TO-1 package; outlines 4, Outlines Section. This type is identical with type 2N1637 except for the following items:

MAXIMUM RATINGS

EMITTER-TO-BASE VOLTAGE (with collector open)	−0.5 *max*	volt

CHARACTERISTICS

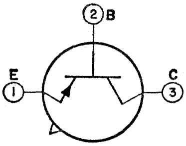
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−7	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−8	μa
In Common-Base Circuit		
Small-Signal Forward Current-Transfer Ratio (with collector-to-base volts = −12, collector ma = −1, and frequency = 1 kilocycle)	0.986	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −12 and collector ma = −1)	45	Mc
In Common-Emitter Circuit		
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −12 and collector ma = −1)	75	

TYPICAL OPERATION

DC Collector-to-Emitter Voltage	−5	−11	volts
DC Collector Current	−0.65	−0.65	ma
Signal Frequency	1.5	1.5	Mc

Input Resistance	1850	2200	ohms
Output Resistance at 252.5 kilocycles	0.1	0.2	megohm
RMS Base-to-Emitter Oscillator-Injection Voltage	100	100	mv
Useful Conversion Power Gain	35.4	37	db

TRANSISTOR



Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.

2N1683

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−13 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−12 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−4 *max*	volts
COLLECTOR CURRENT	−100 *max*	ma
EMITTER CURRENT	100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −40 and base ma = −1)	−0.6 *max*	volt
Collector-Cutoff Current (with collector volts = −6 and emitter current = 0)	−3 *max*	μa
Total Stored Charge:		
With collector ma = −10 and base ma = −0.4	160 *max*	pcoul
With collector ma = −40 and base ma = −1.6	410 *max*	pcoul

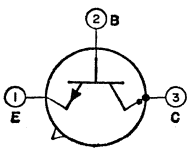
In Common-Base Circuit

Collector Capacitance (with collector-to-base volts = −6 and emitter current = 0)	12 *max*	pf

In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −0.3 and collector ma = −10	50 *min*	
With collector-to-emitter volts = −0.5 and collector ma = −40	50 *min*	
Gain-Bandwidth Product (with collector-to-emitter volts = −3 and collector ma = −10)	50 *min*	Mc

POWER TRANSISTOR



Silicon n-p-n type used in a wide variety of switching and amplifier applications in industrial equipment. It is used in power switching, dc-to-dc converter, inverter, chopper, and relay-control circuits; in oscillator, voltage- and current-regulator circuits; and in dc and servo amplifier circuits. JEDEC No. TO-5 package; outline 6, Outlines Section.

2N1700

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts
EMITTER-TO-BASE VOLTAGE	6 *max*	volts
COLLECTOR CURRENT	1 *max*	ampere
BASE CURRENT	0.75 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	5 *max*	watts
At case temperatures above 25°C	See curve page 68	

TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

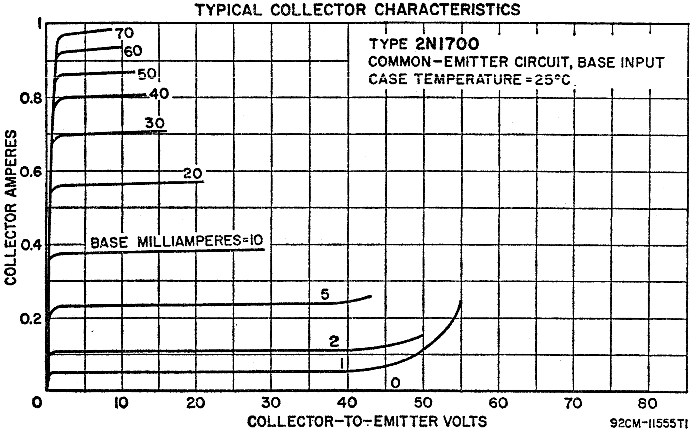
Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.5)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 50 and base current = 0)	40 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector ma = 100)	2 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	75 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 6 and collector current = 0)	25 *max*	μa
Thermal Resistance:		
Junction-to-case	35 *max*	°C/watt
Junction-to-ambient	200 *max*	°C/watt
Thermal Time Constant	10	msec

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1.2	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	150	pf

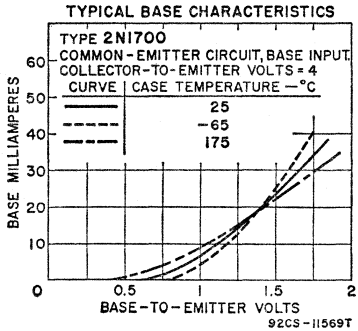
In Common-Emitter Circuit

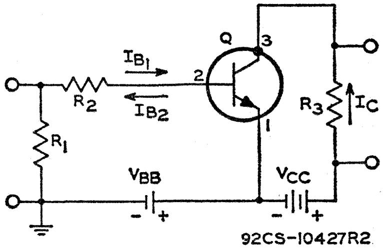
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 100)	20 to 80	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 5)	40	
DC Collector-to-Emitter Saturation Resistance (with collector ma = 100 and base ma = 10)	10 *max*	ohms



TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT ON NEXT PAGE

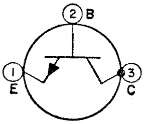
DC Collector Supply Voltage (V_{CC})	12	volts
DC Base Supply Voltage (V_{BB})	−8.5	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	200	ma
Turn-On DC Base Current (I_{B1})	20	ma
Turn-Off DC Base Current (I_{B2})	−8.5	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1	μsec
Storage time (t_s)	0.6	μsec
Fall time (t_f)	1	μsec





V_{BB} = 8.5 volts
V_{CC} = 12 volts
R_1 = 50 ohms, 1 watt
R_2 = 700 ohms, 1 watt
R_3 = 59 ohms, 2 watts

POWER TRANSISTOR



2N1701

Silicon n-p-n type used in a wide variety of switching and amplifier applications in industrial equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, and relay-control circuits; in oscillator, voltage- and current-regulator circuits; and in dc and servo amplifier circuits. JEDEC No. TO-8 package; outline 8, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	6 *max*	volts
COLLECTOR CURRENT	2.5 *max*	amperes
BASE CURRENT	1 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	25 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.75)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector ma = 300)	3 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	100 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 6 and collector current = 0)	50 *max*	μa
Thermal Resistance:		
Junction-to-case	7 *max*	°C/watt
Junction-to-ambient	100 *max*	°C/watt
Thermal Time Constant	10	msec

In Common-Base Circuit

Small-Signal Forward Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	175	pf

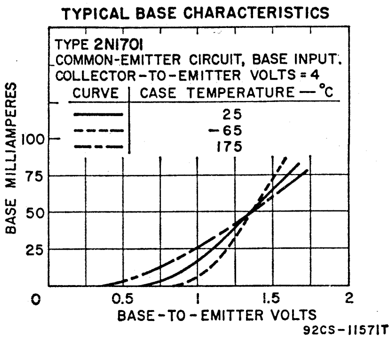
In Common-Emitter Circuit

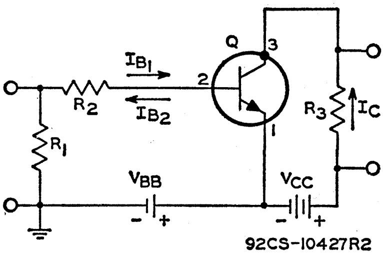
DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 300)	20 to 80	

DC Collector-to-Emitter Saturation Resistance (with collector ma = 300 and base ma = 30)	5 *max*	ohms

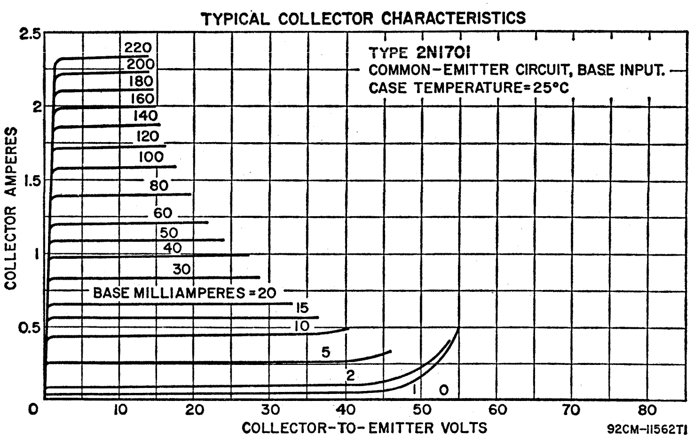
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT BELOW

DC Collector Supply Voltage (V_{CC})	12	volts
DC Base Supply Voltage (V_{BB})	−8.5	volts
Generator Resistance	50	ohms
On DC Collector Current (I_C)	750	ma
Turn-On DC Base Current (I_{B1})	20	ma
Turn-Off DC Base Current (I_{B2})	−8.5	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1	μsec
Storage time (t_s)	0.8	μsec
Fall time (t_f)	1.1	μsec



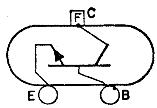


V_{BB} = 8.5 volts
V_{CC} = 12 volts
R_1 = 50 ohms, 1 watt
R_2 = 220 ohms, 1 watt
R_3 = 15.9 ohms, 2 watts



POWER TRANSISTOR

2N1702



Silicon n-p-n type used in a wide variety of switching and amplifier applications in industrial equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, and relay-control circuits; in oscillator, voltage- and current-regulator circuits; and in dc and servo amplifier circuits. Package is similar to JEDEC No. TO-3; outline 23, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	6 *max*	volts
COLLECTOR CURRENT	5 *max*	amperes
BASE CURRENT	2.5 *max*	amperes
TRANSISTOR DISSIPATION:		
At mounting-flange temperatures up to 25°C	75 *max*	watts
At mounting-flange temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 1)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector ma = 800)	4 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	200 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 6 and collector current = 0)	100 *max*	μa
Thermal Resistance:		
Junction-to-mounting-flange	2.33 *max*	°C/watt
Thermal Time Constant	12	msec

In Common-Base Circuit

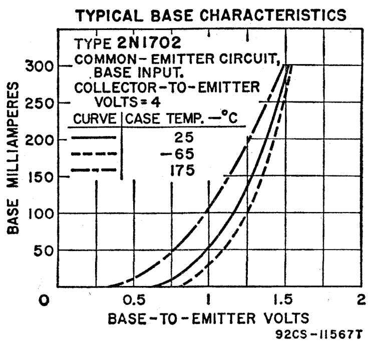
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = 28 and collector ma = 5)	1	Mc
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	200	pf

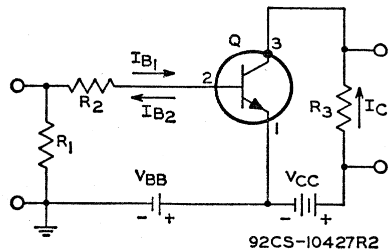
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 800)	15 to 60	
Collector-to-Emitter Saturation Resistance (with collector ma = 800 and base ma = 80)	4 *max*	ohms

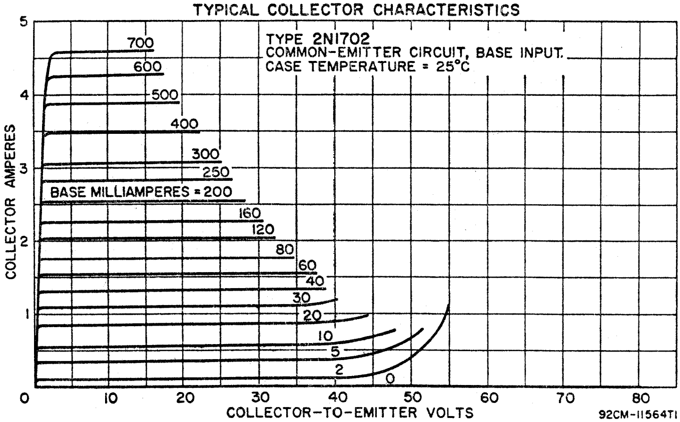
TYPICAL OPERATION IN POWER-SWITCHING CIRCUIT BELOW

DC Collector Supply Voltage (V_{CC})	12	volts
DC Base Supply Voltage (V_{BB})	−8.5	volts
Generator Resistance	50	ohms
On DC Collector Current (I_c)	1.5	amperes
Turn-On DC Base Current (I_{B1})	300	ma
Turn-Off DC Base Current (I_{B2})	−150	ma
Switching Time:		
Delay time (t_d)	0.2	μsec
Rise time (t_r)	1	μsec
Storage time (t_s)	1	μsec
Fall time (t_f)	1.2	μsec



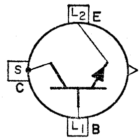


V_{BB} = 8.5 volts
V_{CC} = 12 volts
R_1 = 50 ohms, 1 watt
R_2 = 30 ohms, 1 watt
R_3 = 7.8 ohms, 2 watts



POWER TRANSISTOR

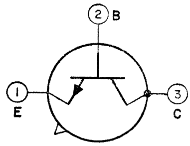
2N1703



Silicon n-p-n type used in a wide variety of switching and amplifier applications in industrial equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, and relay-control circuits; in oscillator, voltage- and current-regulator circuits; and in dc and servo amplifier circuits. This type is stud-mounted to provide positive heat-sink contact and has a cold-weld seal. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is electrically identical with type 2N1702.

TRANSISTOR

2N1708



Silicon n-p-n type used in very-high-speed applications in equipments which require high reliability and high packaging densities. JEDEC No. TO-46 package; outline 18, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 1000 ohms and load resistance = 100 ohms)	20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	3 *max*	volts
COLLECTOR CURRENT	0.2 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	1 *max*	watt
At ambient temperatures up to 25°C	0.3 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 175	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.7 to 0.9	volt
Collector-to-Emitter Saturation Voltage:		
With collector ma = 10 and base ma = 1	0.22 *max*	volt
With collector ma = 50 and base ma = 5	0.35 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 15 and emitter current = 0)	0.025 *max*	μa

In Common-Base Circuit

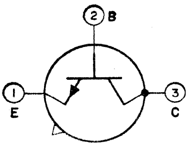
Collector-to-Base Capacitance (with collector-to-base volts = 10, emitter current = 0, and frequency = 140 kilocycles)	6 *max*	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 1 and collector ma = 10)	20 *min*	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 10, and frequency = 100 Mc)	2 *min*	

TRANSISTOR

2N1711



Silicon n-p-n type used in a wide variety of small-signal and medium-power applications in industrial and military equipment. It can be used in rf service as an amplifier, mixer, oscillator, and converter; in af service for small- and large-signal driver and power applications. It features low saturation voltage, high sustaining voltage, high dissipation, high pulse beta, low output capacitance, and exceptionally low noise and leakage characteristics. JEDEC No. TO-5 package; outline 6, Outlines Section. For curves of transfer characteristics, refer to type 2N2102.

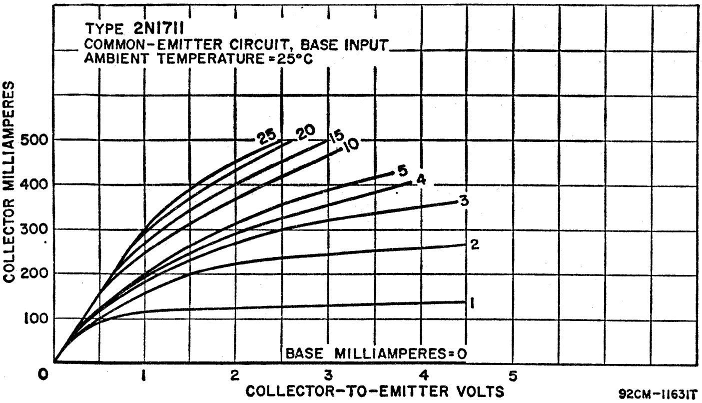
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	75 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 10 ohms or less)	50 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	7 *max*	volts
COLLECTOR CURRENT	1 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	3 *max*	watts
At ambient temperatures up to 25°C	0.8 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 200	°C
Storage	−65 to 300	°C

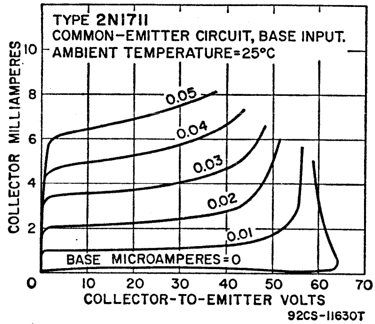
CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	75 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.1 and collector current = 0)	7 *min*	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.1)	75 *min*	volts
Collector-to-Emitter Sustaining Voltage (with external base to-emitter resistance = 10 ohms or less and pulse collector ma = 100)	50 *min*	volts
Base-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.3 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.5 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	0.01 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 5 and collector current = 0)	0.005 *max*	μa
Thermal Resistance:		
Junction-to-case	58.3 *max*	°C/watt
Junction-to-ambient	219 *max*	°C/watt

TYPICAL COLLECTOR CHARACTERISTICS



TYPICAL COLLECTOR CHARACTERISTICS



In Common-Base Circuit

Input Resistance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	24 to 34	ohms
With collector-to-base volts = 10 and collector ma = 5	4 to 8	ohms
Input Capacitance (with emitter-to-base volts = 0.5 and collector current = 0)	80 *max*	pf
Output Capacitance (with collector-to-base volts = 10 and emitter current = 0)	25 *max*	pf
Output Conductance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.1 to 0.5	μmho
With collector-to-base volts = 10 and collector ma = 5	0.1 to 1	μmho
Small-Signal Open-Circuit Reverse Voltage-Transfer Ratio at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.0005 *max*	
With collector-to-base volts = 10 and collector ma = 5	0.0005 *max*	

In Common-Emitter Circuit

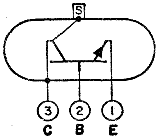
DC-Pulse Forward Current-Transfer Ratio:*	
With collector-to-emitter volts = 10 and collector ma = 10	75 *min*
With collector-to-emitter volts = 10 and collector ma = 150	100 to 300
With collector-to-emitter volts = 10 and collector ma = 500	40 *min*
DC Forward Current-Transfer Ratio:	
With collector-to-emitter volts = 10 and collector ma = 0.01	20 *min*
With collector-to-emitter volts = 10 and collector ma = 0.1	35 *min*
Small-Signal Forward Current-Transfer Ratio:	
With collector-to-emitter volts = 5, collector ma = 1, and frequency = 1 kilocycle	50 to 200
With collector-to-emitter volts = 10, collector ma = 5, and frequency = 1 kilocycle	70 to 300
With collector-to-emitter volts = 10, collector ma = 50, and frequency = 20 megacycles	3.5 *min*

Noise Figure (with collector-to-emitter volts = 10, collector ma = 0.3, generator resistance = 510 ohms, circuit bandwidth = 1 cycle, and signal frequency = 1 kilocycle)	8 *max*	db

* Pulse duration = 300 μsec, duty factor = 0.018.

POWER TRANSISTOR

2N1768



Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial equipment requiring transistors having high voltage, current, and dissipation values. It is used in power switching, dc-to-dc converter, inverter, chopper, and relay actuating circuits; in voltage- and current-regulator circuits; and in dc and servo amplifier circuits. This type has an offset pedestal, stud-mount arrangement which provides positive heat-sink contact. Outline 19, Outlines Section. This type is electrically identical with type 2N1486 except for the following items:

MAXIMUM RATINGS

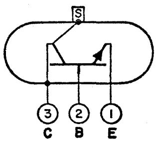
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	40 *max*	watts
At case temperatures above 25°C	See curve page 68	
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.25)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 100 and base current = 0)	40 *min*	volts
Thermal Resistance:		
Junction-to-case	4.375 *max*	°C/watt
Junction-to-ambient	175 *max*	°C/watt

POWER TRANSISTOR

2N1769



Silicon n-p-n type used in a wide variety of intermediate-power switching and amplifier applications in industrial equipment requiring transistors having high voltage, current, and dissipation values. It is used in power-switching, dc-to-dc converter, inverter, chopper, and relay actuating circuits; in voltage- and current-regulator circuits; and in dc and servo amplifier circuits. This type has an offset pedestal, stud-mount arrangement which provides positive heat-sink contact. Outline 19, Outlines Section. This type is identical with type 2N1486 except for the following items:

MAXIMUM RATINGS

TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	40 *max*	watts
At case temperatures above 25°C	See curve page 68	
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

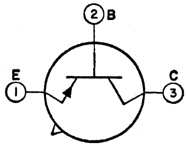
CHARACTERISTICS

Thermal Resistance:		
Junction-to-case	4.375 *max*	°C/watt
Junction-to-ambient	175 *max*	°C/watt

TRANSISTOR

2N1853

Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−18 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−6 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−2 *max*	volts
COLLECTOR CURRENT	−100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
EMITTER-TO-BASE DISSIPATION (under breakdown condition with reverse bias):		
At ambient temperatures up to 25°C	25 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−55 to 85	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −6 and base ma = −0.2)	−0.4 *max*	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −6 and base ma = −0.2)	−0.2 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −15 and emitter current = 0)	−4.2 *max*	μa

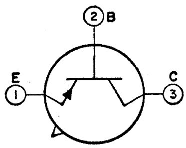
In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter volts = −1, collector current = 0, and base ma = −0.2	30 to 400	
With collector-to-emitter volts = 0.4, collector ma = −6, and base current = 0	30 *min*	

TRANSISTOR

2N1854

Germanium p-n-p type used in high-speed switching applications in data-processing equipment. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N1853 except for the following:



CHARACTERISTICS

Base-to-Emitter Voltage (with collector ma = −20 and base ma = −0.5)	−0.8 *max*	volt
Collector-to-Emitter Saturation Voltage:		
With collector ma = −20 and base ma = −0.66	−0.25 *max*	volt
With collector ma = −20 and base ma = −0.5	−0.3 *max*	volt

In Common-Base Circuit

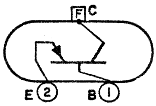
Output Capacitance (with collector-to-base volts = −10, emitter current = 0, and frequency = 140 kilocycles)	12 *max*	pf

In Common-Emitter Circuit

Forward Current-Transfer Ratio:		
With collector-to-emitter voltage = −0.5 and collector ma = −20	40 *min*	
With collector-to-emitter voltage = −0.75 and collector ma = −100	25 *min*	
With collector-to-emitter voltage = −1 and collector ma = −50	400 *max*	
Gain-Bandwidth Product (with collector-to-emitter volts = −1 and collector ma = −10)	40 *min*	Mc

POWER TRANSISTOR

2N1905

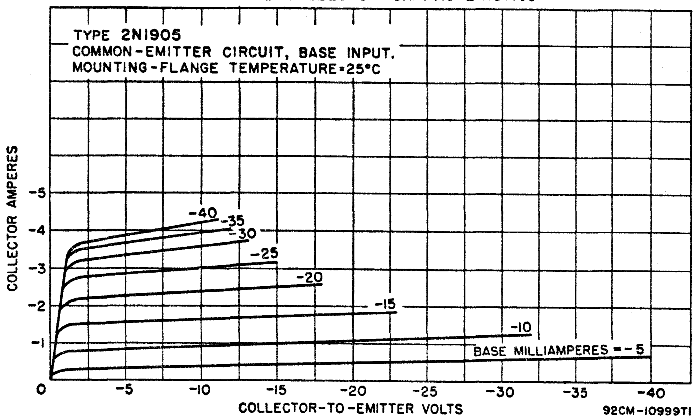


Germanium p-n-p type used in a wide variety of switching and amplifier applications. It is used as a high-power high-speed switch in dc-to-dc converters, inverters, and computers for data-processing equipments; and in ultrasonic oscillators and large-signal wide-band linear amplifiers. Package is similar to JEDEC No. TO-3; outline 24, Outlines Section. This type is identical with type 2N1906 except for typical operation and the following items:

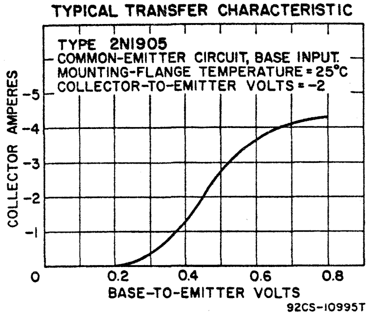
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−40 *max*	volts

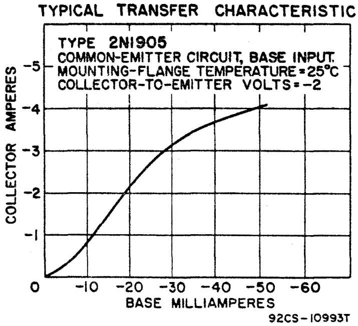
TYPICAL COLLECTOR CHARACTERISTICS



TYPICAL TRANSFER CHARACTERISTIC



TYPICAL TRANSFER CHARACTERISTIC



CHARACTERISTICS

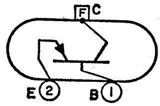
Collector-to-Base Breakdown Voltage (with collector ma = −10 and emitter current = 0)	−60 *min*	volts
Collector-to-Emitter Breakdown Voltage (with collector ma = −100 and base current = 0)	−40 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = −2 and collector ma = −1000)	−0.38	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −1000 and base ma = −50)	−0.3	volt

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2 and collector ma = −1000)	50	
DC Forward Conductance (with collector-to-emitter volts = −2 and collector ma = −1000)	4	mhos

POWER TRANSISTOR

2N1906



Germanium p-n-p type used in a wide variety of switching and amplifier applications. It is used as a high-power high-speed switch in dc-to-dc converters, inverters, and computers for data-processing equipment; and in ultrasonic oscillators and large-signal wide-band linear amplifiers. Package is similar to JEDEC No. TO-3; outline 24, Outlines Section.

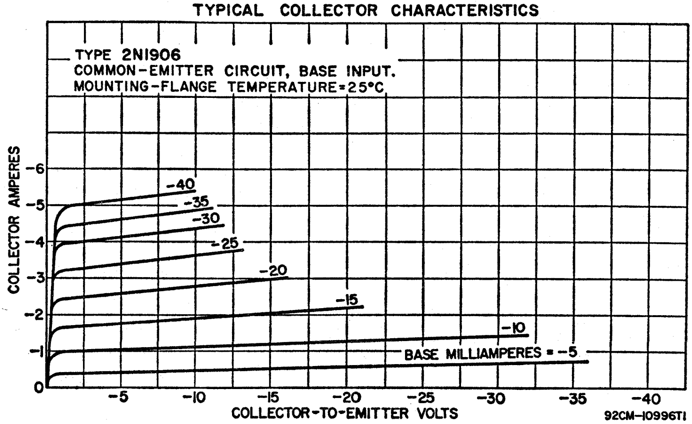
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−100 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−10 *max*	amperes
BASE CURRENT	−3 *max*	amperes
TRANSISTOR DISSIPATION:		
For mounting-flange temperatures up to 25°C	50 *max*	watts
For mounting-flange temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−55 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = −10 and emitter current = 0)	100 *min*	volts
Collector-to-Emitter Breakdown Voltage (with collector ma = −100 and base current = 0)	40 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = −5 and collector current = 0)	1 *min*	volt
Base-to-Emitter Voltage (with collector-to-emitter volts = −2 and collector ma = −5000)	−0.6	volt
Collector-to-Emitter Saturation Voltage (with collector ma = −5000 and base ma = −250)	−0.75	volt
Collector-Cutoff Current (with collector-to-base volts = −40 and emitter current = 0)	−150	μa

TYPICAL COLLECTOR CHARACTERISTICS



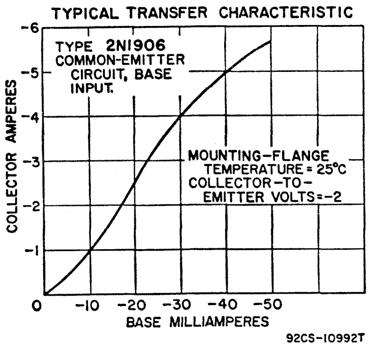
Collector-Cutoff Saturation Current (with collector-to-base volts = −0.5 and emitter current = 0)	−65	μa
Emitter-Cutoff Current (with emitter-to-base volts = −0.5 and collector current = 0)	−1	ma
Thermal Resistance: Junction-to-mounting flange	1.5 *max*	°C/watt

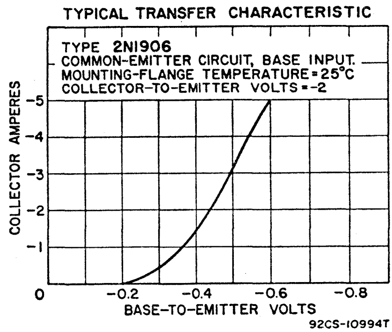
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −2 and collector ma = −5000)	125	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = −5 and collector ma = −500)	75	kc
Gain-Bandwidth Product (with collector-to-emitter volts = −5 and collector ma = −500)	7.5	Mc
DC Forward Conductance (with collector-to-emitter volts = −2 and collector ma = −5000)	8.3	mhos

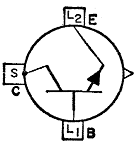
TYPICAL OPERATION IN "ON-OFF" POWER-SWITCHING CIRCUIT

DC Collector-Supply Voltage	5	12.5	12.5	volts
On DC Collector Current	−1	−2.5	−5	amperes
Turn-On DC Base Current	—	−0.25	−0.25	ampere
Turn-Off DC Base Current	—	0.25	0.25	ampere
Pulse-Generator Open-Circuit Voltage	2	—	—	volts
Base-Bias Resistor	75	5	5	ohms
"Speed-Up" Capacitor	0.1	—	—	μf
Load Resistor	5	5	2.5	ohms
Generator Impedance	5	5	5	ohms
Switching Time:				
Delay time	0.1	0.1	0.1	μsec
Rise time	0.1	0.4	0.9	μsec
Storage time	1	7	7	μsec
Fall time	0.6	1	2	μsec





POWER TRANSISTOR



2N2015

Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-36 package; outline 14, Outlines Section. This type is identical with type 2N2016 except for the following:

MAXIMUM RATINGS

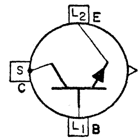
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	100 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	50 *max*	volts

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector amperes = 2)	100 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector amperes = 0.2 and base current = 0)	50 *min*	volts

POWER TRANSISTOR

2N2016



Silicon n-p-n type used in a wide variety of high-power switching and amplifier applications in industrial and military equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, solenoid and relay control circuits; in oscillator, regulator, and pulse-amplifier circuits; and as a class A or class B push-pull audio and servo amplifier. It features low saturation resistance, high current and power dissipation, high beta at high current, and excellent high-temperature performance. JEDEC No. TO-36 package; outline 14, Outlines Section.

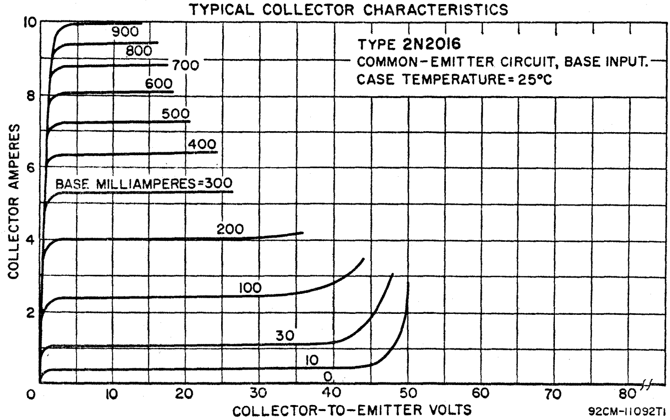
MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	130 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	65 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	10 *max*	volts
COLLECTOR CURRENT	10 *max*	amperes
EMITTER CURRENT	−13 *max*	amperes
BASE CURRENT	6 *max*	amperes
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	150 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Voltage (with emitter-to-base volts = 1.5 and collector amperes = 2)	130 *max*	volts
Collector-to-Emitter Sustaining Voltage (with collector amperes = 0.2 and base current = 0)	65 *max*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector amperes = 5)	2.2 *max*	volts

TYPICAL COLLECTOR CHARACTERISTICS



Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	50 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 10 and collector current = 0)	50 *max*	μa
Thermal Resistance:		
Junction-to-case	1.17 *max*	°C/watt
Thermal Time Constant	30	msec

In Common-Base Circuit

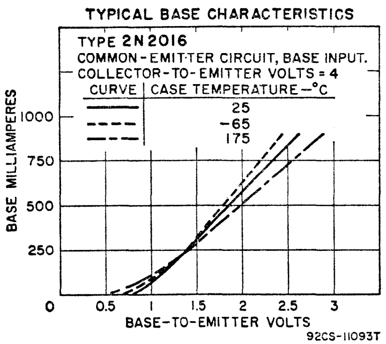
Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	400	pf

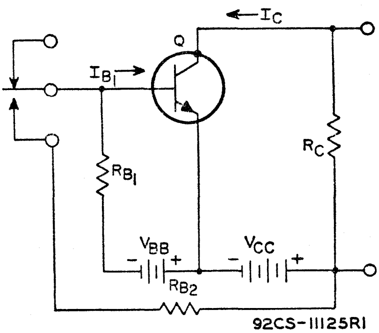
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 4 and collector amperes = 5	15 to 50	
With collector-to-emitter volts = 4 and collector amperes = 10	7.5 *min*	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency	25	kc
DC Collector-to-Emitter Saturation Resistance (with collector amperes = 5 and base amperes = 0.5)	0.25	ohm

TYPICAL OPERATION IN PULSE-RESPONSE TEST CIRCUIT BELOW

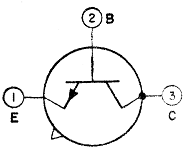
DC Collector-Supply Voltage (V_{CC})	24	volts
DC Base-Supply Voltage (V_{BB})	−6	volts
On DC Collector Current (I_C)	10	amperes
Turn-On DC Base Current (I_{B1})	2	amperes
Base-Circuit Resistance (R_{B1} or R_{B2})	10	ohms
Collector-Circuit Resistance (R_C)	2	ohms
Switching Time:		
On time (Delay time t_d plus rise time t_r)	4	μsec
Off time (Storage time t_s plus fall time t_f)	7	μsec





TRANSISTOR

2N2102

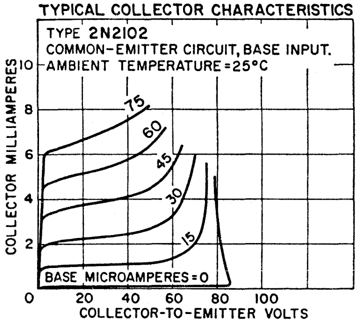


Silicon n-p-n type used in a wide variety of small-signal and medium-power applications in industrial and military equipment. It can be used in rf service as an amplifier, mixer, oscillator, and converter; in af service for small- and large-signal driver and power applications; in switching service for high-speed switching circuits requiring transistors having high voltage and current values. It features low saturation voltage, high sustaining voltage, high dissipation, high pulse beta, low output capacitance, and exceptionally low noise and leakage characteristics. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

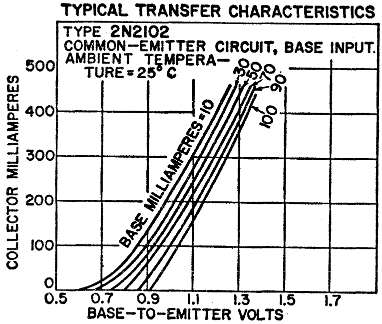
COLLECTOR-TO-BASE VOLTAGE (with emitter open)	120 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With external base-to-emitter resistance = 10 ohms or less	80 *max*	volts
With base open	65 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	7 *max*	volts
COLLECTOR CURRENT	1 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	5 *max*	watts
At ambient temperatures up to 25°C	1 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 200	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	300 *max*	°C

TYPICAL COLLECTOR CHARACTERISTICS



92CS-11175T

TYPICAL TRANSFER CHARACTERISTICS



92CS-11185T

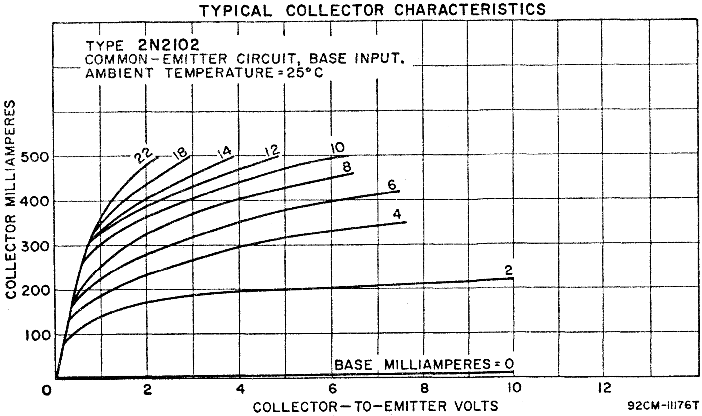
CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	120 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.1 and collector current = 0)	7 *min*	volts
Collector-to-Emitter Reach-Through Voltage (with emitter-to-base volts = 1.5 and collector ma = 0.1)	120 *min*	volts
Collector-to-Emitter Sustaining Voltage:		
With external base-to-emitter resistance = 10 ohms or less and collector ma = 100	80 *min*	volts
With collector ma = 100 and base current = 0	65 *min*	volts
Base-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.1 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	0.5 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	0.002 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 5 and collector current = 0)	0.002 *max*	μa
Thermal Resistance:		
Junction-to-case	35 *max*	°C/watt
Junction-to-ambient	175 *max*	°C/watt

In Common-Base Circuit

Input Resistance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	24 to 34	ohms
With collector-to-base volts = 10 and collector ma = 5	4 to 8	ohms
Input Capacitance (with emitter-to-base volts = 0.5 and collector current = 0)	80 *max*	pf
Output Capacitance (with collector-to-base volts = 10 and emitter current = 0)	15 *max*	pf
Output Conductance at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.1 to 0.5	μmho
With collector-to-base volts = 10 and collector ma = 5	0.1 to 1	μmho
Small-Signal Open-Circuit Reverse Voltage-Transfer Ratio at 1 kilocycle:		
With collector-to-base volts = 5 and collector ma = 1	0.0003 *max*	
With collector-to-base volts = 10 and collector ma = 5	0.0003 *max*	

TYPICAL COLLECTOR CHARACTERISTICS

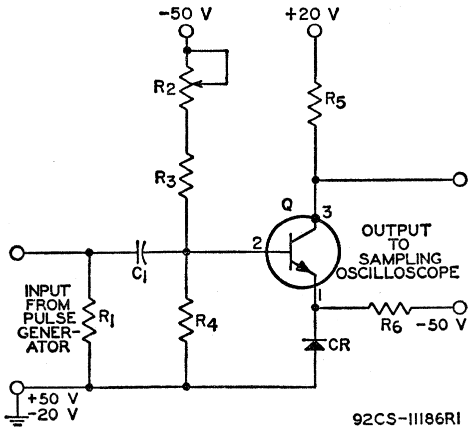


n Common-Emitter Circuit

DC-Pulse Forward Current-Transfer Ratio:*		
With collector-to-emitter volts = 10 and collector ma = 150	40 to 120	
With collector-to-emitter volts = 10 and collector ma = 500	25 *min*	
With collector-to-emitter volts = 10 and collector ma = 1000	10 *min*	
DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 10 and collector ma = 0.01	10 *min*	
With collector-to-emitter volts = 10 and collector ma = 0.1	20 *min*	
With collector-to-emitter volts = 10 and collector ma = 10	35 *min*	
Small-Signal Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 5, collector ma = 1, and frequency = 1 kilocycle	30 to 100	
With collector-to-emitter volts = 10, collector ma = 5, and frequency = 1 kilocycle	35 to 150	
With collector-to-emitter volts = 10, collector ma = 50, and frequency = 20 Mc	3 *min*	
Noise Figure (with collector-to-emitter volts = 10, collector ma = 0.3, generator resistance = 1000 ohms, circuit bandwidth = 15 kilocycles, and signal frequency = 1 kilocycle)	6 *max*	db
Total Switching Time† (delay time plus rise time plus fall time)	30 *max*	nsec

* Pulse duration = 300 μsec, duty factor = 0.018.

† See *Total-Switching-Time Measurement Circuit below.*

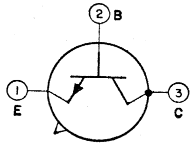


C_1 = 0.01 μf
R_1, R_4 = 100 ohms
R_2 = 1000 ohms
R_3 = 4700 ohms
R_5 = 40 ohms
R_6 = 1000 ohms, 5 watts

TRANSISTOR

2N2205

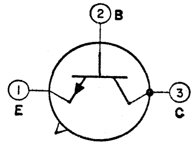
Silicon n-p-n type used in very-high-speed switching applications in equipments which require high reliability and high packaging densities. JEDEC No. TO-18 package; outline 12, Outlines Section. This type is electrically identical with type 2N1708.



TRANSISTOR

2N2206

Silicon n-p-n type used in very-high-speed switching applications in equipments which require high reliability and high packaging densities. JEDEC No. TO-46 package; outline 18, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with external base-to-emitter resistance = 1000 ohms and load resistance = 100 ohms)	20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	3 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	1 *max*	watt
At ambient temperatures up to 25°C	0.3 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operation (junction)	−65 to 175	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 10 and base ma = 1)	0.7 to 0.9	volt
Collector-to-Emitter Saturation Voltage:		
With collector ma = 10 and base ma = 1	0.22 *max*	volt
With collector ma = 50 and base ma = 5	0.35 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 15 and emitter current = 0)	0.025 *max*	μa

In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 10, emitter current = 0, and frequency = 140 kilocycles)	6 *max*	pf

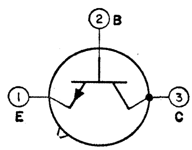
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 1 and collector ma = 10)	40 to 120	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 10, and frequency = 100 Mc)	2 *min*	

TRANSISTOR

2N2270

Silicon n-p-n type used in a wide variety of small-signal and medium-power applications in industrial and military equipment. It can be used in rf service as an amplifier, mixer, oscillator and converter; in af service in small-signal and power applications. It features low output capacitance and exceptionally low noise and leakage characteristics. JEDEC No. TO-5 package; outline 6, Outlines Section. For curve of collector characteristics, refer to type 2N2102.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE		
With external base-to-emitter resistance = 10 ohms or less	60 *max*	volts
With base open	45 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	7 *max*	volts
COLLECTOR CURRENT	1 *max*	ampere
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	5 *max*	watts
At ambient temperatures up to 25°C	1 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C
LEAD TEMPERATURE (for 10 seconds maximum)	255 *max*	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	60 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.1 and collector current = 0)	7 *min*	volts
Collector-to-Emitter Sustaining Voltage:		
With external base-to-emitter resistance = 10 ohms or less and pulse collector ma = 100*	60 *min*	volts
With pulse collector ma = 100* and base current = 0	45 *min*	volts
Base-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	1.2 *max*	volts
Collector-to-Emitter Saturation Voltage (with collector ma = 150 and base ma = 15)	0.9 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 60 and emitter current = 0)	0.1 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 5 and collector current = 0)	0.1 *max*	μa
Thermal Resistance:		
Junction-to-case	35 *max*	°C/watt
Junction-to-ambient	175 *max*	°C/watt

In Common-Base Circuit

Input Capacitance (with emitter-to-base volts = 0.5 and collector current = 0)	80 *max*	pf
Output Capacitance (with collector-to-base volts = 10 and emitter current = 0)	15 *max*	pf

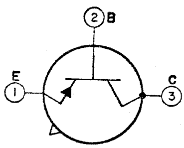
In Common-Emitter Circuit

DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 10 and pulse collector ma* = 150	50 to 200	
With collector-to-emitter volts = 10 and collector ma = 1	35 *min*	
Small-Signal Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 10, collector ma = 5, and frequency = 1 kilocycle	30 to 180	
With collector-to-emitter volts = 10, collector ma = 50, and frequency = 20 Mc	3 *min*	
Noise Figure (with collector-to-emitter volts = 10, collector ma = 0.3, generator resistance = 1000 ohms, circuit bandwidth = 15 kilocycles, and signal frequency = 1 kilocycle)	6 *max*	db

* Pulse duration = 300 μsec, duty factor = 0.018.

TRANSISTOR

2N2273



Germanium p-n-p type used for low-power radio-frequency amplifier applications in the vhf range in industrial and military equipment. JEDEC No. TO-18 package; outline 12, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	−15 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−1 *max*	volt
COLLECTOR CURRENT	−100 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	100 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 100	°C

LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	−25 *min*	volts
Collector-to-Emitter Breakdown Voltage (with collector ma = 0.1 and base current = 0)	−15 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.1 and collector current = 0)	−1 *min*	volt
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−10 *max*	μa

In Common-Base Circuit

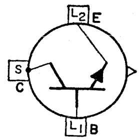
Output Capacitance (with collector-to-base volts = −10, emitter current = 0, and frequency = 140 kilocycles)	3.5 *max*	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = −10 and collector ma = −1)	20 to 150	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = −6, collector ma = −1, and frequency = 10 Mc)	20 to 28	
Base Spreading Resistance (with collector-to-emitter volts = −10, collector ma = −1, and frequency = 250 Mc)	250	ohms
High-Frequency Input Impedance (with collector-to-emitter volts = −9, collector ma = −1, and frequency = 250 Mc)	50 to 250	ohms
Small-Signal Power Gain (with collector-to-emitter volts = −9, collector ma = −1, and frequency = 30 Mc)	10 *min*	db

POWER TRANSISTOR

2N2338



Silicon n-p-n type used in a wide variety of switching and amplifier applications in industrial equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, and relay-control circuits; in oscillator, voltage- and current-regulator circuits; and in dc and servo amplifier circuits. JEDEC No. TO-36 package; outline 14, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With emitter-to-base volts = 1.5	60 *max*	volts
With base open	40 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	6 *max*	volts
COLLECTOR CURRENT	7.5 *max*	amperes
BASE CURRENT	5 *max*	amperes
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	150 *max*	watts
At case temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 200	°C

CHARACTERISTICS

Collector-to-Emitter Breakdown Voltage (with emitter-to-base volts = 1.5 and collector ma = 2)	60 *min*	volts
Collector-to-Emitter Sustaining Voltage (with collector ma = 200 and base current = 0)	40 *min*	volts
Base-to-Emitter Voltage (with collector-to-emitter volts = 4 and collector ma = 3000)	3 *max*	volts
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	200 *max*	μa
Emitter-Cutoff Current (with emitter-to-base volts = 6 and collector current = 0)	100 *max*	μa
Thermal Resistance:		
Junction-to-case	1.17 *max*	°C/watt
Thermal Time Constant	30	msec

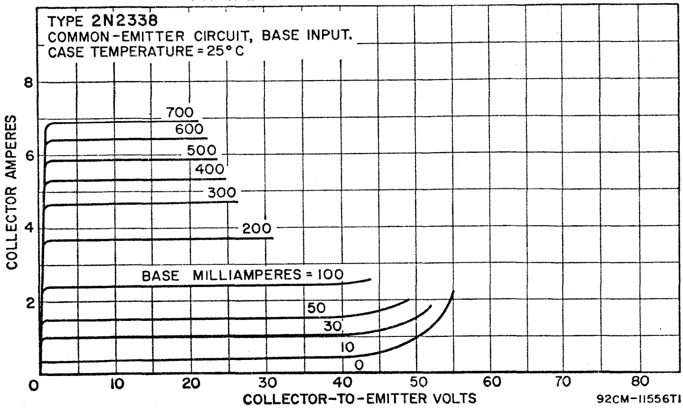
In Common-Base Circuit

Collector-to-Base Capacitance (with collector-to-base volts = 40 and emitter current = 0)	400	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 4 and collector ma = 3000)	15 to 60	
Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-emitter volts = 4 and collector ma = 5)	20	kc
Collector-to-Emitter Saturation Resistance (with collector ma = 3000 and base ma = 300)	0.5 *max*	ohm

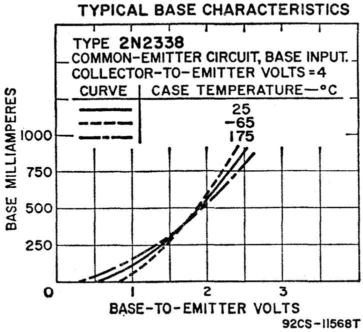
TYPICAL COLLECTOR CHARACTERISTICS

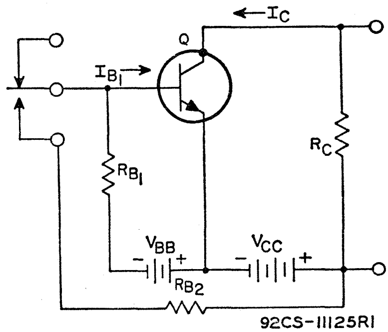


TYPICAL OPERATION IN PULSE-RESPONSE TEST CIRCUIT BELOW

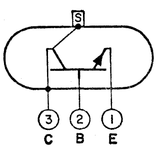
DC Collector Supply Voltage (V_{CC})	24	volts
DC Base Supply Voltage (V_{BB})	−6	volts
On DC Collector Current (I_C)	10	amperes
Turn-On DC Base Current (I_{B1})	2	amperes
Base-Circuit Resistance (R_{B1} or R_{B2})	10	ohms
Collector-Circuit Resistance (R_C)	2	ohms
Switching Time:		
On time (Delay time t_d plus rise time t_r)	4	μsec
Off time (Storage time t_s plus fall time t_f)	7	μsec

TYPICAL BASE CHARACTERISTICS





POWER TRANSISTOR



2N2339

Silicon n-p-n type used in a wide variety of switching and amplifier applications in industrial equipment. It is used in power-switching, dc-to-dc converter, inverter, chopper, and relay-control circuits; in oscillator, voltage- and current-regulator circuits; and in dc and servo amplifier circuits. This type has an offset pedestal, stud-mount arrangement which provides positive heat-sink contact. Outline 19, Outlines Section. This type is electrically identical with type 2N1701 except for the following items:

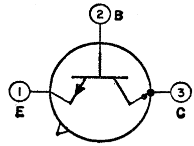
MAXIMUM RATINGS

TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	40 *max*	watts
At case temperatures above 25°C	See curve page 68	
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

TRANSISTOR

2N2475

Silicon n-p-n type used in ultra-high-speed logic-circuit applications in data-processing equipment. Package is similar to JEDEC No. TO-18; outline 27, Outlines Section.



MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	15 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	6 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	4 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 100°C	500* *max*	mw
At ambient temperatures up to 25°C	300 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Storage	−65 to 300	°C
Operating (junction)	−65 to 200	°C
LEAD TEMPERATURE (for 10 seconds maximum)	300 *max*	°C

* This rating must be reduced by 5 mw per °C for case temperatures above 100°C.

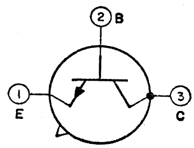
CHARACTERISTICS

Base-to-Emitter Saturation Voltage (with collector ma = 20 and base ma = 0.66)	0.8 to 1.0	volt
Collector-to-Emitter Saturation Voltage (with collector ma = 20 and base ma = 0.66)	0.4 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 5 and emitter current = 0)	0.05 *max*	μa
In Common-Base Circuit		
Output Capacitance (with collector-to-base volts = 5, emitter current = 0, and frequency = 140 kilocycles)	3 *max*	pf
Input Capacitance (with emitter-to-base volts = 0.5, collector current = 0, and frequency = 140 kilocycles)	2.5 *max*	pf
In Common-Emitter Circuit		
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 2, collector ma = 20, and frequency = 100 Mc)	6 *min*	
DC Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 0.3 and collector ma = 1	20 *min*	
With collector-to-emitter volts = 0.5 and collector ma = 50	20 *min*	
With collector-to-emitter volts = 0.4 and collector ma = 20	30 to 150	

TRANSISTOR

2N2476

Silicon n-p-n type used in core-driving and line-driving applications requiring exceptionally fast switching speeds at high currents. JEDEC No. TO-5 package; outline 6, Outlines Section. This type is identical with type 2N2477 except for the following items:



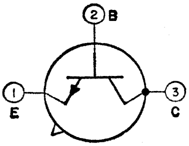
CHARACTERISTICS

Collector-to-Emitter Saturation Voltage:		
With collector ma = 150 and base ma = 7.5	0.4 *max*	volt
With collector ma = 500 and base ma = 50	0.75 *max*	volt
Base-to-Emitter Voltage (with collector ma = 150 and base ma = 7.5)	1 *max*	volt

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 0.4 and collector ma = 150)	20 *min*	

TRANSISTOR



2N2477

Silicon n-p-n type used in core-driving and line-driving applications requiring exceptionally fast switching speeds at high currents. JEDEC No. TO-5 package; outline 6, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	60 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	20 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	5 *max*	volts
TRANSISTOR DISSIPATION:		
At case temperatures up to 25°C	2 *max*	watts
At ambient temperatures up to 25°C	0.6 *max*	watt
At case or ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction)	−65 to 200	°C
Storage	−65 to 300	°C
LEAD TEMPERATURE (for 10 seconds maximum)	300 *max*	°C

CHARACTERISTICS

Collector-to-Emitter Saturation Voltage:		
With collector ma = 150 and base ma = 3.75	0.4 *max*	volt
With collector ma = 500 and base ma = 50	0.65 *max*	volt
Base-to-Emitter Voltage (with collector ma = 150 and base ma = 3.75)	0.95 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = 30 and emitter current = 0)	0.2 *max*	μa

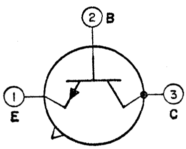
In Common-Base Circuit

Output Capacitance (with collector-to-base volts = 10, emitter current = 0, and frequency = 140 kilocycles)	10 *max*	pf

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 0.4 and collector ma = 150)	40 *min*	
Small-Signal Forward Current-Transfer Ratio (with collector-to-emitter volts = 10, collector ma = 50, and frequency = 100 Mc)	2.5 *min*	

TRANSISTOR



2N2482

Germanium n-p-n type used for low-power radio-frequency amplifier applications in the vhf range in industrial and military equipment. JEDEC No. TO-18 package; outline 12, Outlines Section.

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	20 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with base open)	12 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	3 *max*	volts
COLLECTOR CURRENT	100 *max*	ma

TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
TEMPERATURE RANGE:		
Operating (junction) and storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Collector-to-Base Breakdown Voltage (with collector ma = 0.1 and emitter current = 0)	20 *min*	volts
Collector-to-Emitter Breakdown Voltage (with collector ma = 0.1 and base short-circuited to emitter)	15 *min*	volts
Emitter-to-Base Breakdown Voltage (with emitter ma = 0.1 and collector current = 0)	3 *min*	volts
Collector-Cutoff Current (with collector-to-base volts = 6 and emitter current = 0)	5 *max*	μa

In Common-Base Circuit

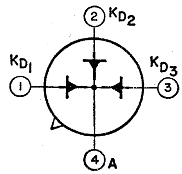
Output Capacitance (with collector-to-base volts = 6, emitter current = 0, and frequency = 140 kilocycles)	4.5 *max*	pf
Collector-to-Base Time Constant (with collector-to-base volts = 6, collector ma = 2, and frequency = 31.9 Mc)	0.3 *max*	μsec

In Common-Emitter Circuit

DC Forward Current-Transfer Ratio (with collector-to-emitter volts = 6 and collector ma = 2)	25 to 200	
Small-Signal Forward Current-Transfer Ratio:		
With collector-to-emitter volts = 6, collector ma = 2, and frequency = 1 kilocycle	15 to 175	
With collector-to-emitter volts = 10, collector ma = 10, and frequency = 100 Mc	10	
With collector-to-emitter volts = 1.7, collector ma = 85, and frequency =100 Mc	3 *min*	
Base Spreading Resistance (with collector-to-emitter volts = 6, collector ma = 10, and frequency = 250 Mc)	30	ohms
Noise Figure:		
With collector-to-emitter volts = 6, collector ma = 2, and frequency = 30 Mc	5	db
With collector-to-emitter volts = 6, collector ma = 2, and frequency = 100 Mc	6	db
Small-Signal Power Gain:		
With collector-to-emitter volts = 6, collector ma = 2, and frequency = 30 Mc	25	db
With collector-to-emitter volts = 6, collector ma = 2, and frequency = 100 Mc	12	db
With collector-to-emitter volts = 12, collector ma = 10, and frequency = 200 Mc	8	db
Power Output as Class A Amplifier (with collector-to-emitter volts = 12, collector ma = 30, signal input = 6.5 mw, and frequency = 70 Mc)	150	mw

TRIPLE DIODE

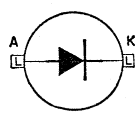
3DG001



Hermetically sealed germanium type used in high-speed switching service in electronic data-processing systems. It is used primarily in high-speed "AND" gates and "OR" gates in computer logic circuits. Advanced transistor-type diffusion techniques assure high switching speeds and a high degree of uniformity of characteristics between diode units. Package has the same dimensions as JEDEC No. TO-33; outline 13, Outlines Section. Diode units are identical with those of type 2DG001.

SILICON RECTIFIER

CR101



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 1200 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	1200 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	1440 *max*	volts
RMS SUPPLY VOLTAGE	840 *max*	volts
DC BLOCKING VOLTAGE	1200 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60 °C	850 *max*	ma

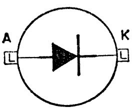
CHARACTERISTICS

Maximum Forward Voltage Drop*	1.2	volts
Shunt Capacitance:		
Maximum	600	pf
Minimum	350	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR102



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 2000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	2000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	2400 *max*	volts
RMS SUPPLY VOLTAGE	1400 *max*	volts
DC BLOCKING VOLTAGE	2000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60°C	825 *max*	ma

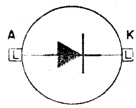
CHARACTERISTICS

Maximum Forward Voltage Drop*	2.4	volts
Shunt Capacitance:		
Maximum	320	pf
Minimum	175	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60 °C.

SILICON RECTIFIER

CR103



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 3000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	3000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	3600 *max*	volts
RMS SUPPLY VOLTAGE	2100 *max*	volts
DC BLOCKING VOLTAGE	3000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60 °C	725 *max*	ma

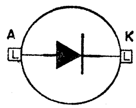
CHARACTERISTICS

Maximum Forward Voltage Drop*	3	volts
Shunt Capacitance:		
Maximum	250	pf
Minimum	140	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60 °C.

SILICON RECTIFIER

CR104



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 4000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	4000 *max*	volts

TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds duration):		
At ambient temperatures from 60 to 125°C	4800 *max*	volts
RMS SUPPLY VOLTAGE	2800 *max*	volts
DC BLOCKING VOLTAGE	4000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60°C	625 *max*	ma

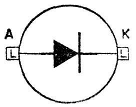
CHARACTERISTICS

Maximum Forward Voltage Drop*	4.2	volts
Shunt Capacitance:		
Maximum	175	pf
Minimum	100	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60 °C.

SILICON RECTIFIER

CR105



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 5000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	5000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	6000 *max*	volts
RMS SUPPLY VOLTAGE	3500 *max*	volts
DC BLOCKING VOLTAGE	5000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60 °C	625 *max*	ma

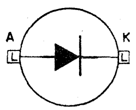
CHARACTERISTICS

Maximum Forward Voltage Drop*	4.8	volts
Shunt Capacitance:		
Maximum	160	pf
Minimum	85	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60 °C.

SILICON RECTIFIER

CR106



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 6000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	6000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	7200 *max*	volts
RMS SUPPLY VOLTAGE	4200 *max*	volts
DC BLOCKING VOLTAGE	6000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60 °C	575 *max*	ma

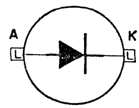
CHARACTERISTICS

Maximum Forward Voltage Drop*	6	volts
Shunt Capacitance:		
Maximum	125	pf
Minimum	70	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60 °C.

SILICON RECTIFIER

CR107



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 7000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	7000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	8400 *max*	volts
RMS SUPPLY VOLTAGE	4900 *max*	volts
DC BLOCKING VOLTAGE	7000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60°C	550 *max*	ma

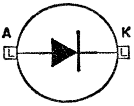
CHARACTERISTICS

Maximum Forward Voltage Drop*	7.2	volts
Shunt Capacitance:		
Maximum	105	pf
Minimum	60	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR108



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 8000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	8000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	9600 *max*	volts
RMS SUPPLY VOLTAGE	5600 *max*	volts
DC BLOCKING VOLTAGE	8000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures of 60°C	550 *max*	ma

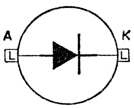
CHARACTERISTICS

Maximum Forward Voltage Drop*	7.8	volts
Shunt Capacitance:		
Maximum	100	pf
Minimum	55	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR109



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 9000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section. This type is identical with type CR110 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	9000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	10800 *max*	volts

RMS SUPPLY VOLTAGE	6300 *max*	volts
DC BLOCKING VOLTAGE	9000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60°C	550 *max*	ma

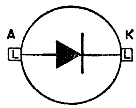
CHARACTERISTICS

Maximum Forward Voltage Drop*	9	volts
Shunt Capacitance:		
Maximum	90	pf
Minimum	45	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR110



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 10,000 volts. This type consists of series-connected silicon rectifier cells shunted by a voltage-equalizing network and molded into a compact, rugged case of insulating material. The integral resistance-capacitance network equalizes the reverse voltage across the rectifier cells under both steady-state and transient conditions. The case has external mounting slots to eliminate the possibility of high-voltage breakdown. Permanent, molded-in markings identify the type number, polarity, and maximum peak-reverse-voltage rating. This type is designed to meet stringent environmental and mechanical specifications. Outline 29, Outlines Section.

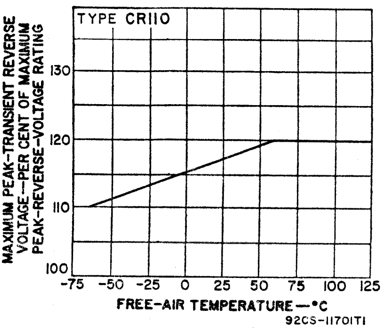
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

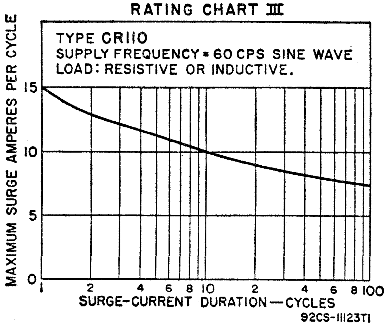
PEAK REVERSE VOLTAGE	10000 *max*	volts
TRANSIENT REVERSE VOLTAGE (non-repetitive, for duration of 5 microseconds maximum):		
At ambient temperatures from 60 to 125°C	12000 *max*	volts
At ambient temperatures up to 60°C	See Rating Chart I	
RMS SUPPLY VOLTAGE	7000 *max*	volts
DC BLOCKING VOLTAGE	10000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60°C	550 *max*	ma
At ambient temperatures above 60°C	See Rating Chart II	
PEAK RECURRENT CURRENT	5 *max*	amperes
SURGE CURRENT†:		
For one-half cycle, sine wave	15 *max*	amperes
For one or more cycles	See Rating Chart III	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 125	°C

† Superimposed on device operating within maximum voltage, current, and temperature ratings; may be repeated after sufficient time has elapsed for the device to return to the presurge thermal-equilibrium conditions.

RATING CHART I



RATING CHART III

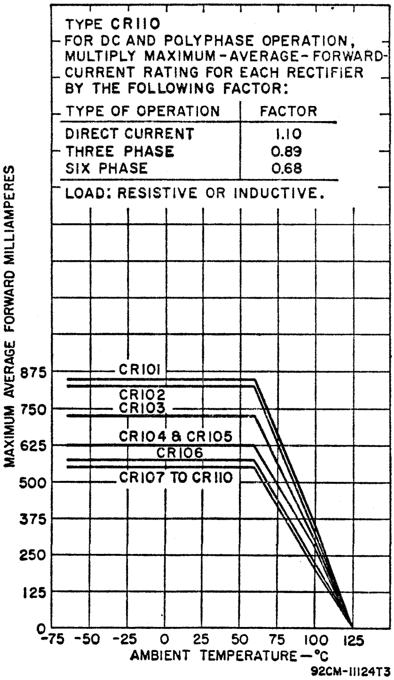


CHARACTERISTICS

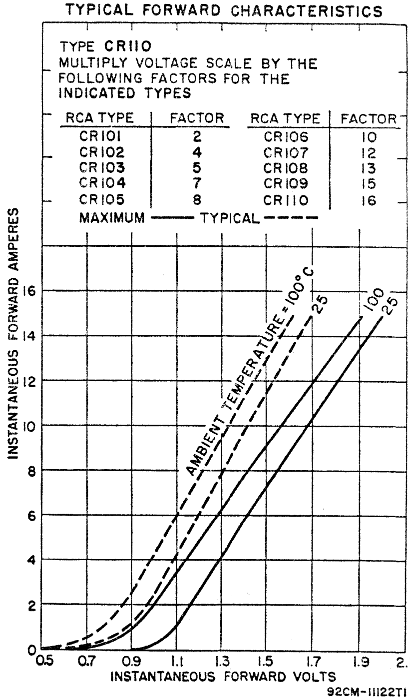
Maximum Forward Voltage Drop*	9.6	volts
Instantaneous Forward Voltage Drop	See Instantaneous Forward Characteristics Curve	
Maximum Reverse Current:		
Dynamic*	0.3	ma
Static‡	0.6	ma
Shunt Capacitance:		
Maximum	80	pf
Minimum	40	pf

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.
‡ DC value at maximum peak reverse voltage, average forward current = 0, and any temperature within the temperature range from −65 to 125°C.

RATING CHART II

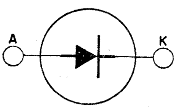


TYPICAL FORWARD CHARACTERISTICS



SILICON RECTIFIER

CR201



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 1500 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical, environmental, and mechanical specifications. Outline 30, Outlines Section. This type is identical with type CR212 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	1500 *max*	volts
RMS SUPPLY VOLTAGE	1060 *max*	volts
DC BLOCKING VOLTAGE	1500 *max*	volts

CHARACTERISTICS

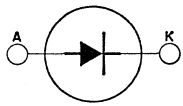
Maximum Forward Voltage Drop*	1.8	volts

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR203

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 3000 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical, environmental, and mechanical specifications. Outline 30, Outlines Section. This type is identical with type CR212 except for the following items:



MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	3000 *max*	volts
RMS SUPPLY VOLTAGE	2120 *max*	volts
DC BLOCKING VOLTAGE	3000 *max*	volts

CHARACTERISTICS

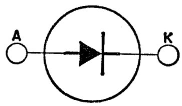
Maximum Forward Voltage Drop*	3	volts

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR204

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 4500 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical, environmental, and mechanical specifications. Outline 30, Outlines Section. This type is identical with type CR212 except for the following items:



MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	4500 *max*	volts
RMS SUPPLY VOLTAGE	3180 *max*	volts
DC BLOCKING VOLTAGE	4500 *max*	volts

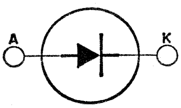
CHARACTERISTICS

Maximum Forward Voltage Drop*	3.6	volts

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR206



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 6000 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical, environmental, and mechanical specifications. Outline 30, Outlines Section. This type is identical with type CR212 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	6000 *max*	volts
RMS SUPPLY VOLTAGE	4240 *max*	volts
DC BLOCKING VOLTAGE	6000 *max*	volts

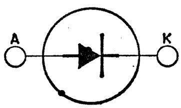
CHARACTERISTICS

Maximum Forward Voltage Drop*	6	volts

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR208



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 8000 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical, environmental, and mechanical specifications. Outline 30, Outlines Section. This type is identical with type CR212 except for the following items:

MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	8000 *max*	volts
RMS SUPPLY VOLTAGE	5650 *max*	volts
DC BLOCKING VOLTAGE	8000 *max*	volts

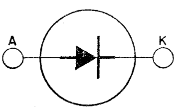
CHARACTERISTICS

Maximum Forward Voltage Drop*	6	volts

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.

SILICON RECTIFIER

CR210



Hermetically sealed type used in power-supply applications at peak reverse voltages up to 10,000 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical, environmental, and mechanical specifications. Outline 30, Outlines Section. This type is identical with type CR212 except for the following items:

MAXIMUM RATINGS

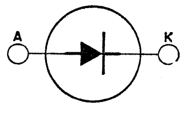
For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

PEAK REVERSE VOLTAGE	10000 *max*	volts
RMS SUPPLY VOLTAGE	7070 *max*	volts
DC BLOCKING VOLTAGE	10000 *max*	volts

SILICON RECTIFIER

CR212

Hermetically sealed type used in power-supply applications at peak reverse voltages up to 12,000 volts. This type consists of series-connected, matched silicon rectifier cells molded into a compact, rugged case of insulating material. The matched cells assure equalization of internal voltages under both steady-state and transient conditions. This type is designed to meet stringent electrical environmental, and mechanical specifications. Outline 30, Outlines Section.



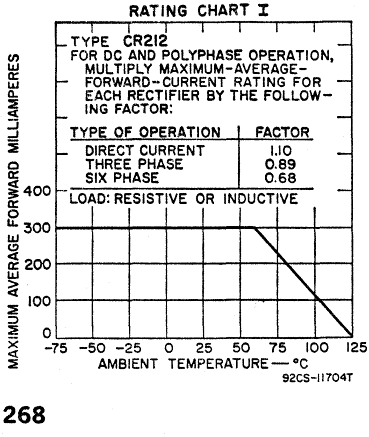
MAXIMUM RATINGS

For power-supply frequency of 60 cps, single-phase operation, with resistive or inductive load

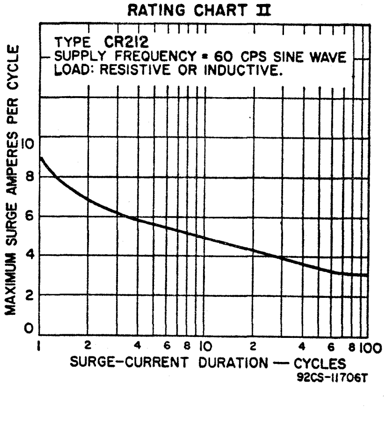
PEAK REVERSE VOLTAGE	12000 *max*	volts
RMS SUPPLY VOLTAGE	8480 *max*	volts
DC BLOCKING VOLTAGE	12000 *max*	volts
AVERAGE FORWARD CURRENT:		
At ambient temperatures up to 60°C	300 *max*	ma
At ambient temperatures above 60°C	See Rating Chart I	
PEAK RECURRENT CURRENT	3 *max*	amperes
SURGE CURRENT‡:		
For one-half cycle, sine wave	9 *max*	amperes
For one or more cycles	See Rating Chart II	
AMBIENT-TEMPERATURE RANGE:		
Operating and storage	−65 to 125	°C

‡ Superimposed on device operating within maximum voltage, current, and temperature ratings; may be repeated after sufficient time has elapsed for the device to return to the presurge thermal-equilibrium conditions.

RATING CHART I



RATING CHART II

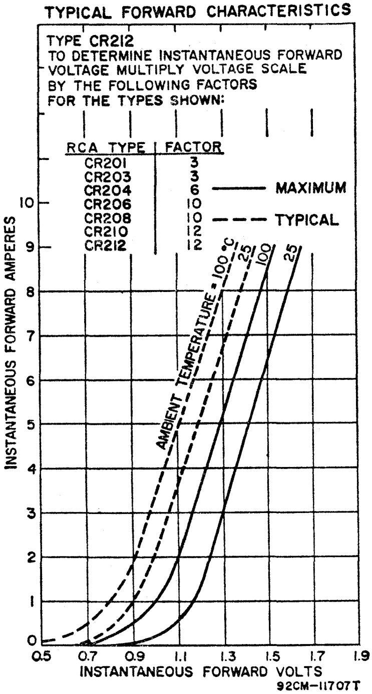


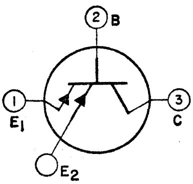
CHARACTERISTICS

Maximum Forward Voltage Drop*	7.2	volts
Instantaneous Forward Voltage Drop	See Curve Below	
Maximum Reverse Current:		
Dynamic†	0.1	ma
Static▲ (at ambient temperature = 25°C)	0.01	ma
Static▲ (at ambient temperature = 100°C)	2	ma

* Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 60°C.
† Average value for one complete cycle at maximum peak reverse voltage, maximum average forward current, and ambient temperature = 100°C.
▲ DC value at maximum peak reverse voltage and average forward current = 0.

TYPICAL FORWARD CHARACTERISTICS



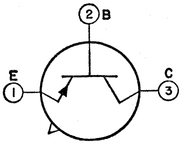


TRANSISTOR

3746

Germanium p-n-p type with two emitters used in a wide variety of applications requiring control of an output current by signals from two sources. It is used in mixer-oscillator circuits in superheterodyne receivers, mixer-amplifier circuits, and switching circuits. Maximum ratings: collector-to-base volts, −34; collector ma, −20; transistor dissipation, 80 milliwatts; ambient-temperature range (operating), −65 to 71°C. The center lead is the connection for emitter No. 2. JEDEC No. TO-44 package; outline 16, Outlines Section. This is a DISCONTINUED type listed for reference only.

TRANSISTOR



Germanium p-n-p type used in critical switching applications in data-processing equipment. This premium type features excellent stability, reliability, and rugged construction. JEDEC No. TO-5 package; outline 6, Outlines Section.

3907/ 2N404

MAXIMUM RATINGS

COLLECTOR-TO-BASE VOLTAGE (with emitter open)	−25 *max*	volts
COLLECTOR-TO-EMITTER VOLTAGE (with emitter-to-base volts = −1)	−24 *max*	volts
EMITTER-TO-BASE VOLTAGE (with collector open)	−12 *max*	volts
COLLECTOR CURRENT	−200 *max*	ma
EMITTER CURRENT	200 *max*	ma
TRANSISTOR DISSIPATION:		
At ambient temperatures up to 25°C	150 *max*	mw
At ambient temperatures above 25°C	See curve page 68	
AMBIENT-TEMPERATURE RANGE:		
Operating	−65 to 85	°C
Storage	−65 to 100	°C
LEAD TEMPERATURE (for 10 seconds maximum)	235 *max*	°C

CHARACTERISTICS

Base-to-Emitter Saturation Voltage:		
With collector ma = −12 and base ma = −0.4	−0.35 *max*	volt
With collector ma = −24 and base ma = −1	−0.4 *max*	volt
Collector-to-Emitter Saturation Voltage:		
With collector ma = −12 and base ma = −0.4	−0.15 *max*	volt
With collector ma = −24 and base ma = −1	−0.2 *max*	volt
Collector-Cutoff Current (with collector-to-base volts = −12 and emitter current = 0)	−5 *max*	μa
Stored Base Charge (with collector ma = −10 and base ma = −1)	1400 *max*	pcoul

In Common-Base Circuit

Small-Signal Forward-Current-Transfer-Ratio Cutoff Frequency (with collector-to-base volts = −6 and collector ma = −1)	4 *min*	Mc
Output Capacitance (with collector-to-base volts = −6 and emitter current = 0)	20 *max*	pf
Input Capacitance (with emitter-to-base volts = −6 and collector current = 0)	20 *max*	pf

In Common-Emitter Circuit

Forward Current-Transfer Ratio:	
With collector-to-emitter volts = −0.15 and collector ma = −12	30 *min*
With collector-to-emitter volts = −0.2 and collector ma = −24	24 *min*

PHOTOJUNCTION CELLS

(Germanium p-n alloy; S-14 spectral response)

RCA TYPE	MAXIMUM RATINGS			CHARACTERISTICS AT 25°C				
	DC Volts Between Terminals	Power Dissipation (watts)	Ambient Temperature Range (°C)	DC Volts Between Terminals	Radiant (A/w)	Sensitivity Luminous (A/lm)	Illumination (μa/fc)	Maximum Dark Current (μa)
7467	50	0.03	—40 to 50	45	0.52	0.014	0.7	35

PHOTOVOLTAIC CELLS

(Silicon n-on-p type)*

RCA TYPE	CHARACTERISTICS AT 28± 3°C			MAX. DIMENSIONS		SENSITIVE AREA (AVERAGE)		
	Minimum Current (ma)	Minimum Power Output (mw)	Minimum Efficiency (per cent)	Length (inches)	Width (inches)	Length (inches)	Width (inches)	Area (sq. in.)
4800	89	40	10.5	0.791	0.791	0.742	0.782	0.58
4801	40	18	10.0	0.396	0.791	0.351	0.782	0.274

Wavelength of maximum response is 8800 ± 500 angstroms; approximate spectral range is 4750 to 10750 angstroms. Characteristics are measured with incident radiant power of 100 milliwatts per square centimeter and load resistor adjusted to obtain 0.45 volt.

PHOTOCONDUCTIVE CELLS

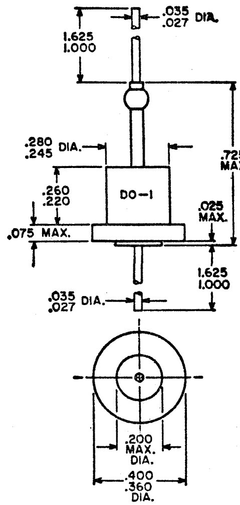
(Cadmium sulfide; S-15 spectral response except as noted)

RCA TYPE	MAXIMUM RATINGS				CHARACTERISTICS AT 25°C			
	DC Volts Between Terminals	Power Dissipation (watts)	Photocurrent (ma)	Ambient Temperature (°C)	Volts Between Terminals	Illumination (fc)	Photocurrent (ma)	Maximum Decay Current (μa)
4402	200	0.05	5	60	12(dc)	10	1.6–3.5	12
4403	250	0.3	50	60	50(ac)	1	7–16	78
4404	250	0.3	50	60	50(ac)	1	2.5–5	40
4413	110	0.05	5	60	12(dc)	10	1–2.75	12
4423	250	0.2	20	60	12(dc)	10	2–8	10
4424	110	0.2	50	60	12(dc)	1	3.6–14.5	80
4425	110	0.2	50	60	12(dc)	1	3–9	35
4442	600	0.3	50	65	50(ac)	1	2.5–5	40
4447	250	0.3	50	60	50(ac)	1	2.5–4.5	40
4448	250	0.3	50	60	50(ac)	1	1.5–4	40
6694A*	150	0.03	—	70	90(dc)	30	0.057–0.65	0.1
7163	250	0.3	50	60	50(ac)	1	1–3	40
7412	200	0.05	1	60	12(dc)	1	0.065–0.275	1
7536	200	0.05	1	60	12(dc)	1	0.065–0.275	1

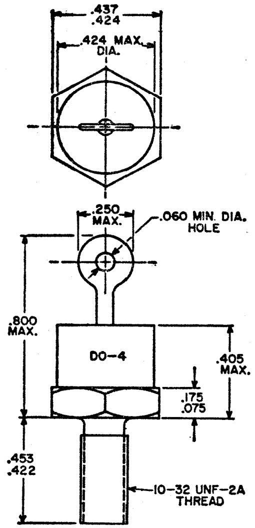
*This type has an S-12 spectral response.

OUTLINES

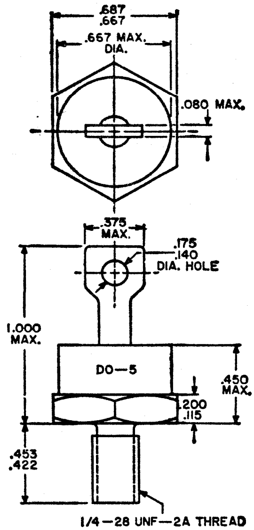
All measurements in inches.



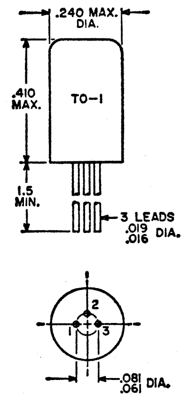
-1-



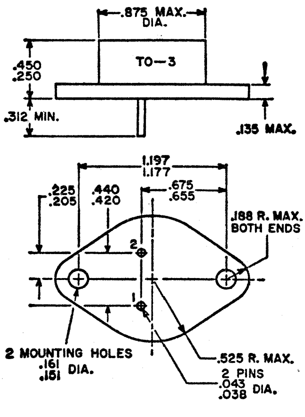
-2-



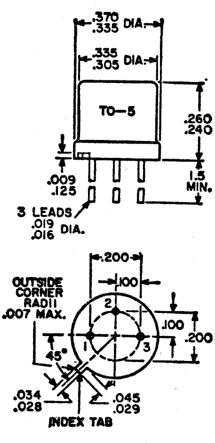
-3-



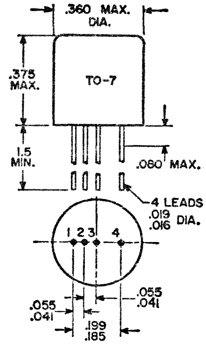
-4-



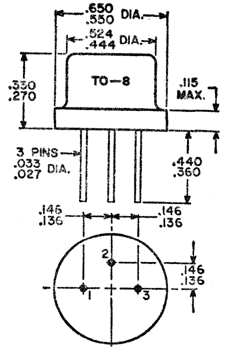
-5-



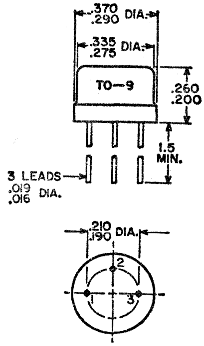
-6-



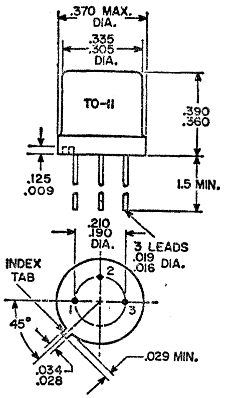
-7-



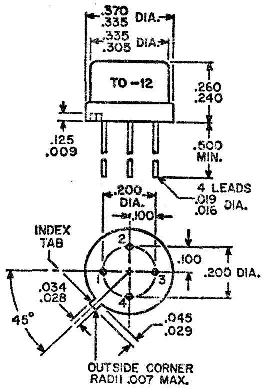
-8-



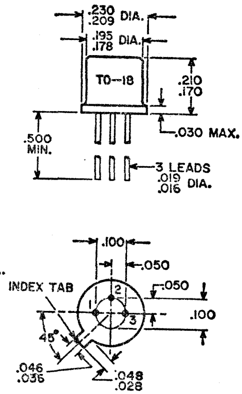
-9-



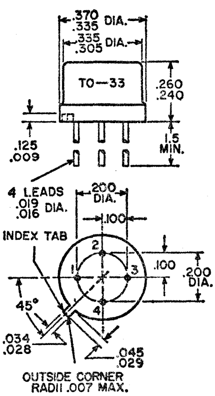
-10-



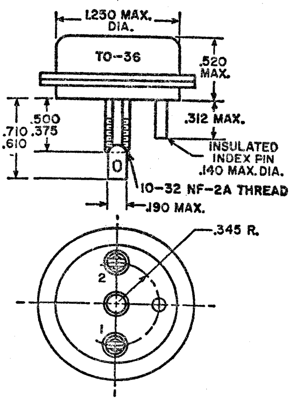
-11-



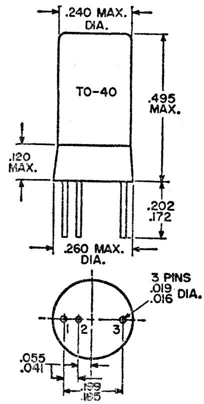
-12-



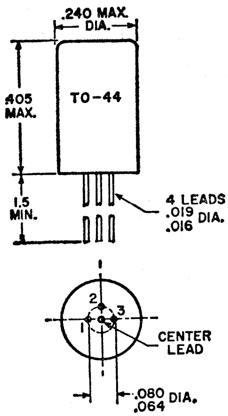
-13-



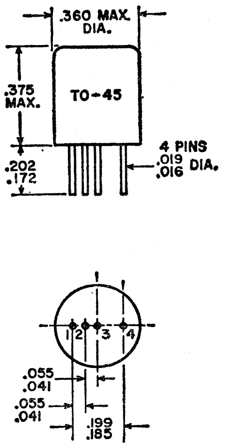
-14-



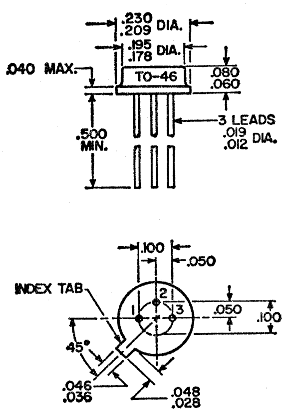
-15-



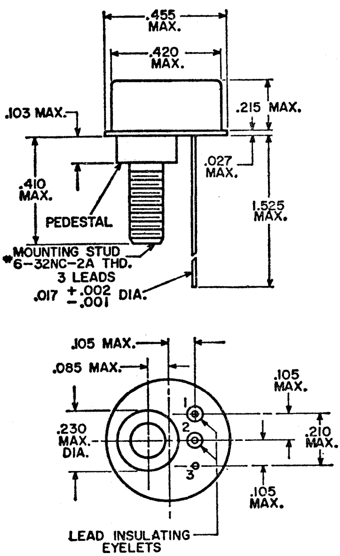
– 16 –



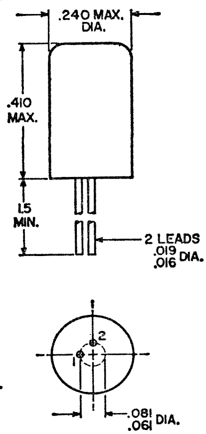
– 17 –



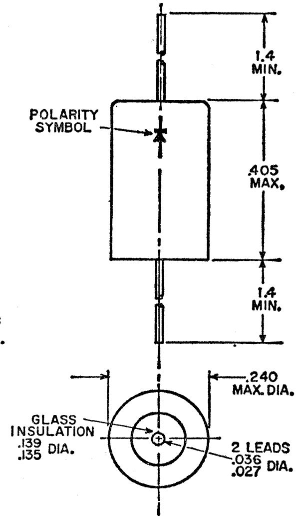
– 18 –



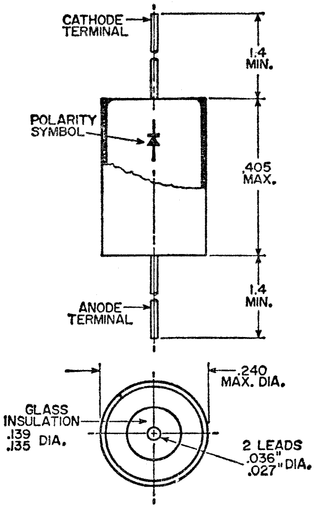
– 19 –



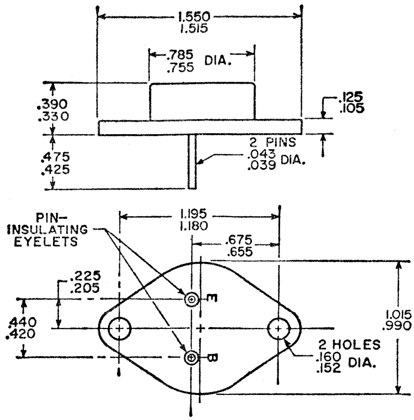
– 20 –



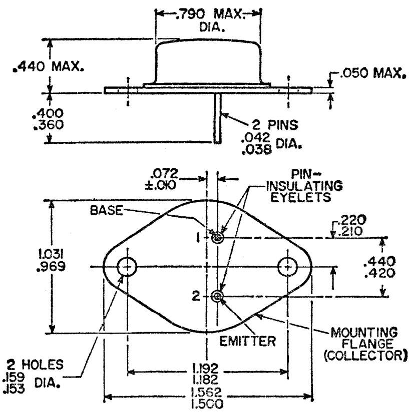
– 21 –


CATHODE TERMINAL
1.4 MIN.
POLARITY SYMBOL
.405 MAX.
1.4 MIN.
ANODE TERMINAL
.240 MAX. DIA.
GLASS INSULATION
.139 .135 DIA.
2 LEADS .036" .027" DIA.

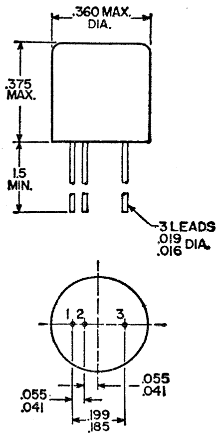
– 22


1.550 1.515
.785 .755 DIA.
.390 .330
.125 .105
2 PINS .043 .039 DIA.
.475 .425
PIN-INSULATING EYELETS
1.195 1.180
.675 .655
.225 .205
E
.440 .420
B
1.015 .990
2 HOLES .160 .152 DIA.

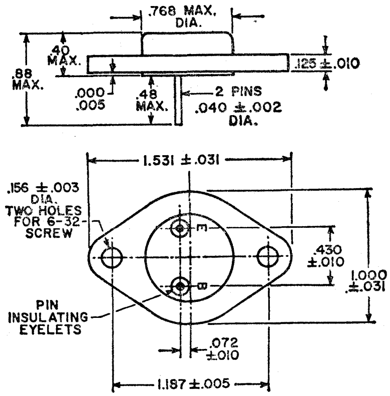
– 23 –


.790 MAX. DIA.
.440 MAX.
.050 MAX.
.400 .360
2 PINS .042 .038 DIA.
.072 ±.010
PIN-INSULATING EYELETS
BASE
.220 .210
1
1.031 .969
.440 .420
2
EMITTER
MOUNTING FLANGE (COLLECTOR)
2 HOLES .159 .153 DIA.
1.192 1.182
1.562 1.500

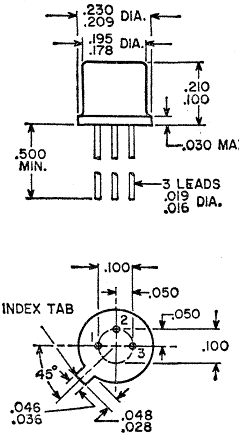
– 24 –


.360 MAX. DIA.
.375 MAX.
1.5 MIN.
3 LEADS .019 .016 DIA.
1 2 3
.055 .041
.055 .041
.199 .185

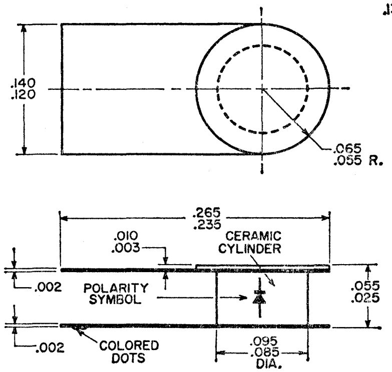
– 25 –



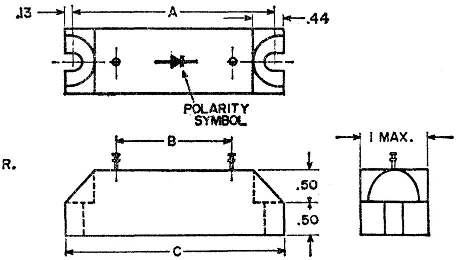
– 26 –



– 27 –

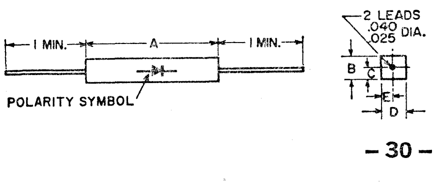


– 28 –



TYPE	DIMENSIONS—INCHES A	B	C
CR101	2-3/8	1-1/8	2-1/8
CR102	2-3/8	1-1/8	2-1/8
CR103	2-3/8	1-1/8	2-1/8
CR104	3-1/4	1-3/4	3
CR105	3-1/4	1-3/4	3
CR106	4-1/2	3-1/4	4-1/4
CR107	4-1/2	3-1/4	4-1/4
CR108	4-1/2	3-1/4	4-1/4
CR109	5-1/2	4	5-1/4
CR110	5-1/2	4	5-1/4

– 29 –



TYPE	DIMENSIONS—INCHES A	B	C	D	E
CR201	2	3/8	3/16	3/8	3/16
CR203	3-1/2	3/8	3/16	3/8	3/16
CR204	4-1/2	3/8	3/16	3/8	3/16
CR206	3-1/2	3/8	3/16	3/4	3/8
CR208	3-1/2	3/8	3/16	3/4	3/8
CR210	4-1/2	3/8	3/16	3/4	3/8
CR212	4-1/2	3/8	3/16	3/4	3/8

– 30 –

CIRCUITS

THE CIRCUITS in this section illustrate some of the more important applications of RCA semiconductor devices; they are not necessarily examples of commercial practice. These circuits have been conservatively designed and are capable of excellent performance. Electrical specifications are given for circuit components to assist those interested in home construction. Layouts and mechanical details are omitted because they vary widely with the requirements of individual set builders and with the sizes and shapes of the components employed.

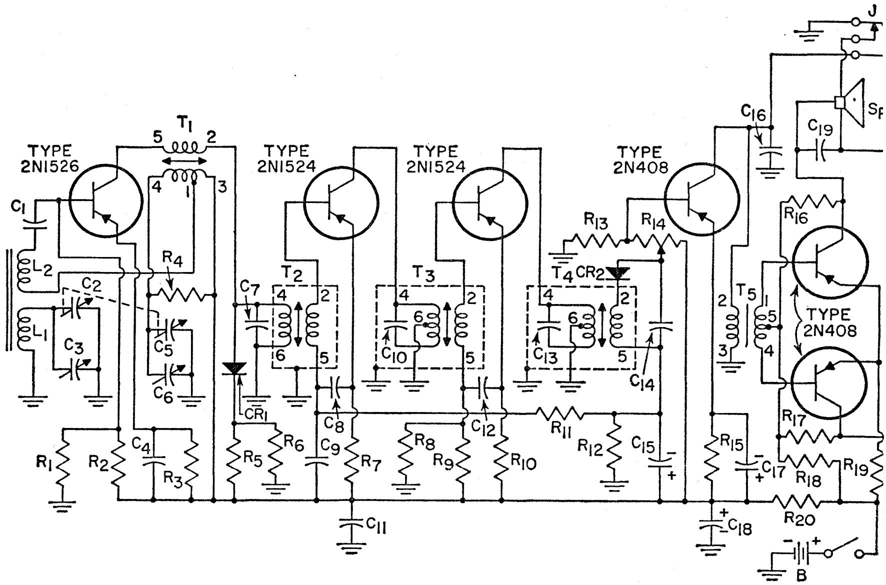
Performance of these circuits depends as much on the quality of the components selected and the care employed in layout and construction as on the circuits themselves. Good signal reproduction from receivers and amplifiers requires the use of good-quality speakers, transformers, chokes and input sources (microphones, phonograph pickups, etc.).

Coils for the receiver circuits may be purchased at local parts dealers by specifying the characteristics required: for rf coils, the circuit position (antenna or interstage), tuning range desired, and tuning capacitances employed; for if coils or transformers, the intermediate frequency, circuit position (1st if, 2nd if, etc.), and, in some cases, the associated transistor types; for oscillator coils, the receiver tuning range, intermediate frequency, type of converter transistor, and type of winding (tapped or transformer-coupled).

The voltage ratings specified for capacitors are the minimum dc working voltages required. Paper, mica, or ceramic capacitors having higher voltage ratings than those specified may be used except insofar as the physical sizes of such capacitors may affect equipment layout. However, if electrolytic capacitors having substantially higher voltage ratings than those specified are used, they may not "form" completely at the operating voltage, with the result that the effective capacitances of such units may be below their rated value. The wattage ratings specified for resistors assume methods of construction that provide adequate ventilation; compact installations having poor ventilation may require resistors of higher wattage ratings.

Information on the characteristics and application features of each transistor or silicon rectifier will be found in the TECHNICAL DATA SECTION. This information will prove of assistance in understanding and utilizing the circuits.

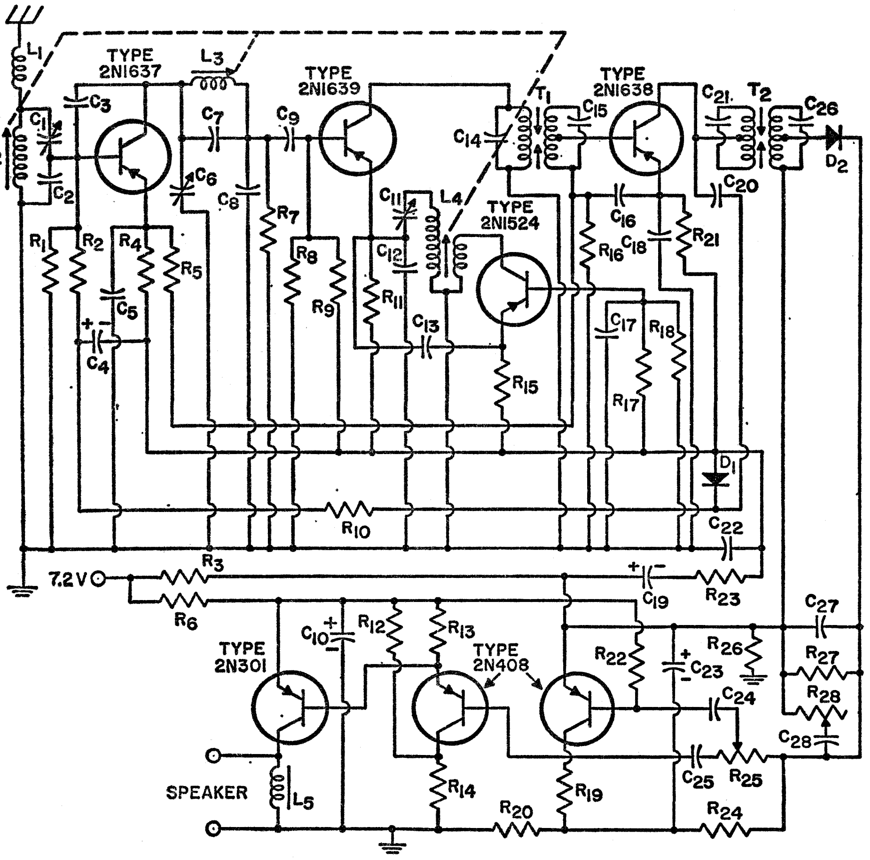
10-1 PORTABLE RADIO RECEIVER



B = 6 volts, RCA VS334
C_1 = 0.022 μf, ceramic, 100 v.
C_2 C_5 = ganged tuning capacitors; C_2, 5.5–128.6 pf; C_5, 4.5–87.5 pf; RCA Stock No. 110757 or equivalent.
C_3 C_6 = trimmer, 1.5–16.5 pf (supplied with C_2 or C_5)
C_4 = 0.01 μf, ceramic, 100 v.
C_7 = 680 pf, mica, $\pm 5\%$, 500 v.
C_8 = 0.05 μf, ceramic, 100 v.
C_9 C_{14} = 0.03 μf, ceramic, 50 v.
C_{10} = supplied with T_3
C_{11} C_{12} = 0.05 μf, ceramic, 100 v.
C_{13} = supplied with T_4
C_{15} = 10 μf, electrolytic, 15 v.
C_{16} = 0.004 μf, ceramic, 100 v.
C_{17} C_{18} = 100 μf, electrolytic, 10 v.
C_{19} = 0.33 μf, plastic, 50 v.
CR_1 CR_2 = crystal diode, RCA Stock No. 101615 or equivalent
J = earphone jacks
L_1 L_2 = antenna assembly ferrite, RCA Stock No. 110750 or equivalent
R_1 = 15000 ohms, 0.5 watt
R_2 = 4700 ohms, 0.5 watt
R_3 = 2200 ohms, 0.5 watt
R_4 = 820000 ohms, 0.5 watt
R_5 = 12000 ohms, 0.5 watt
R_6 = 820 ohms, 0.5 watt
R_7 = 330 ohms, 0.5 watt
R_8 = 6800 ohms, 0.5 watt
R_9 = 1000 ohms, 0.5 watt
R_{10} = 470 ohms, 0.5 watt
R_{11} = 1000 ohms, 0.5 watt
R_{12} = 100000 ohms, 0.5 watt
R_{13} = 22000 ohms, 0.5 watt
R_{14} = volume control, potentiometer, 2500 ohms
R_{15} = 220 ohms, 0.5 watt
R_{16} R_{17} = 10000 ohms, 0.5 watt
R_{18} = 150 ohms, 0.5 watt
R_{19} = 5.6 ohms, 0.5 watt
R_{20} = 82 ohms, 0.5 watt
SP = speaker, 130-ohm voice coil; RCA Stock No. 110565 or equivalent
T_1 = oscillator coil, RCA 110069 or equivalent
T_2 = 1st if transformer, RCA 110758 or equivalent
T_3 = 2nd if transformer, RCA 110759 or equivalent
T_4 = 3rd if transformer, RCA 110760 or equivalent
T_5 = driver transformer, RCA 110575 or equivalent

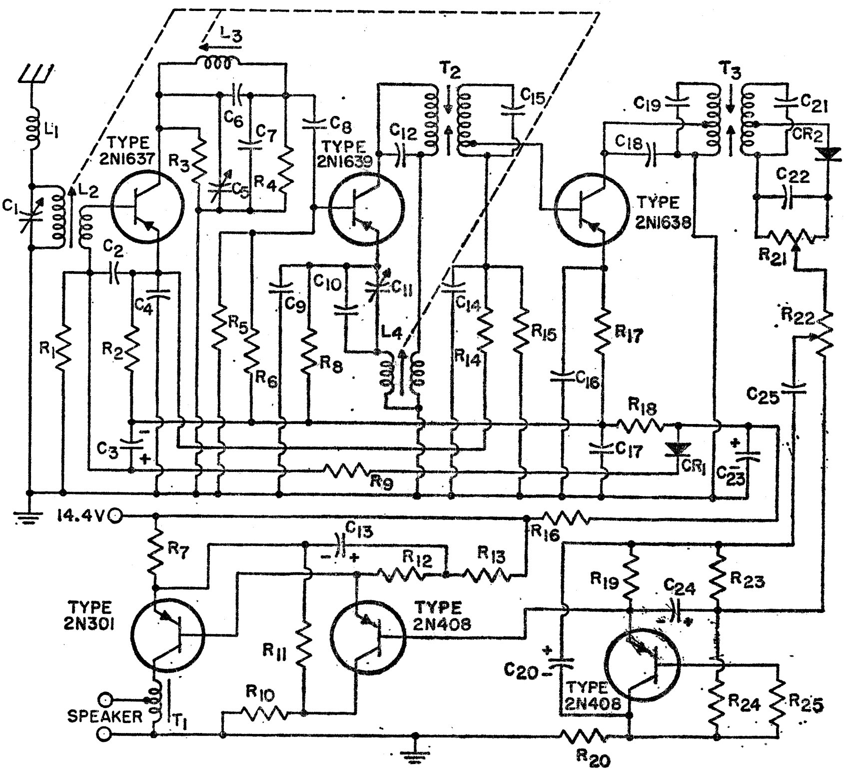
NOTE: For classrooms and other instruction purposes, a radio receiver similar to the above is available in the form of a Dynamic Demonstrator Kit, RCA WE-93A(K)

10-2 6-VOLT AUTOMOBILE RADIO



C_1 = 5-80 pf, variable trimmer
C_2 = 820 pf, mica, 100 v.
C_3 = 2 pf, mica, 100 v.
C_4 C_{23} = 25 μf, electrolytic, 6 v.
C_5 C_9 C_{13} C_{16} C_{17} C_{18} = 0.05 μf, ceramic disc
C_6 C_{11} = 100-580 pf, variable trimmer
C_7 = 270 pf, mica
C_8 = 0.005 μf, ceramic disc
C_{10} C_{22} = 50 μf, electrolytic, 6 v.
C_{12} = 0.0047 μf, ceramic disc
C_{14} C_{15} = supplied with T_1
C_{19} = 500 μf, electrolytic, 3 v.
C_{20} = 180 pf, mica, 100 v.
C_{21} C_{26} = supplied with T_2
C_{24} C_{25} = 1 μf, ceramic disc, 3 v.
C_{27} = 0.04 μf, ceramic disc, 25 v.
C_{28} = 0.5 μf, ceramic disc, 25 v.
D_1 D_2 = 1N295
L_1 = 5 μf, rf choke
L_2 L_3 L_4 = tuner assembly; manufactured by F. W. Sickles Co. and Radio Condenser Corp.
L_2 = antenna coil; variable inductor tuned with 110 pf; frequency range 535 to 1610 kc; Q = 65 at 1610 kc
L_3 = rf coil; variable inductor tuned with 600 pf; frequency range 535 to 1610 kc; Q = 65 at 1610 kc.
L_4 = oscillator transformer; primary, variable inductor tuned with 470 pf; frequency range 797 to 1872 kc; Q = 65 at 1872 kc; secondary, 30 turns
L_5 = output choke; 20 mh; 1 ampere, 0.5 ohm max.
R_1 = 82000 ohms, 0.5 watt
R_2 = 2200 ohms, 0.5 watt
R_3 = 33 ohms, 0.5 watt
R_4 R_{21} = 330 ohms, 0.5 watt
R_5 R_{10} = 5600 ohms, 0.5 watt
R_6 = 0.33 ohm, 1 watt
R_7 = 180 ohms, 0.5 watt
R_8 = 10000 ohms, 0.5 watt
R_9 = 1500 ohms, 0.5 watt
R_{11} R_{22} = 1000 ohms, 0.5 watt
R_{12} R_{13} R_{14} = 68 ohms, 0.5 watt
R_{15} = 820 ohms, 0.5 watt
R_{16} = 47000 ohms, 0.5 watt
R_{17} = 1800 ohms, 0.5 watt
R_{18} = 8200 ohms, 0.5 watt
R_{19} R_{26} = 1200 ohms, 0.5 watt
R_{20} R_{27} = 3300 ohms, 0.5 watt
R_{23} = 120 ohms, 0.5 watt
R_{24} = 100000 ohms, 0.5 watt
R_{25} = volume control, potentiometer, 100000 ohms
R_{28} = tone control, potentiometer, 10000 ohms
T_1 = if transformer, Radio Industries No. E010173, Automatic Manufacturing Co. No. E2740097 AX, or equivalent.
T_2 = if transformer, Radio Industries No. E010174, Automatic Manufacturing Co. No. E2740097 BX, or equivalent

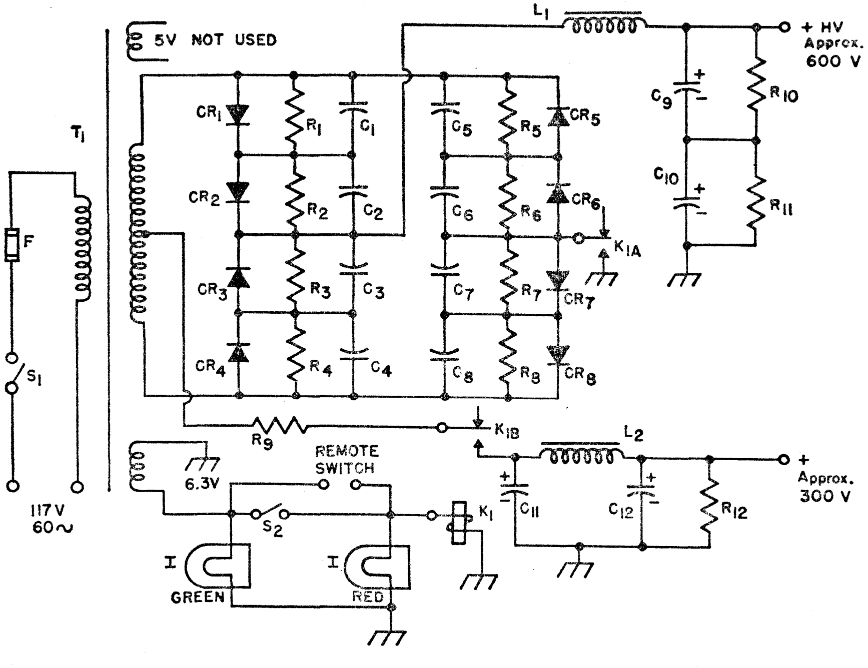
10-3 12-VOLT AUTOMOBILE RADIO



C_1 = 5-80 pf, trimmer
C_2 = 2.2 μf, 3v.
C_3 = 25 μf, electrolytic, 3 v.
C_4 C_8 C_{12} C_{16} C_{17} C_{25} = 0.5 μf, ceramic disc, 25 v.
C_5 C_{11} = 100-580 pf, trimmer
C_6 = 270 pf, mica, 100 v.
C_7 = 0.005 μf, ceramic disc, 25 v.
C_9 = 0.0075 μf, ceramic disc, 25 v.
C_{10} = 180 μμf, ceramic, N-750, negative temperature coefficient
C_{12} C_{15} = supplied with T_2
C_{13} = 500 μf, electrolytic, 3 v.
C_{18} = 120 pf, mica, 100 v.
C_{19} C_{21} = supplied with T_3
C_{20} = 50 μf, electrolytic, 6 v.
C_{22} = 0.02 μf, ceramic disc, 25 v.
C_{23} = 100 μf, electrolytic, 15 v.
C_{24} = 100 μf, electrolytic, 3 v.
CR_1, CR_2 = 1N295
L_1 = 5 μh, rf choke
L_2 L_3 L_4 = tuner assembly; manufactured by F. W. Sickles Co., and Radio Condenser Corp.
L_2 = antenna transformer; primary, variable inductor tuned with 110 pf; frequency range 535 to 1610 kc; Q = 65 at 1610 kc; secondary, 10 turns
L_3 = rf coil; variable inductor tuned with 600 pf; frequency range 535 to 1610 kc; Q = 65 at 1610 kc.
L_4 = oscillator transformer; primary, variable inductor tuned with 470 pf; frequency range 797 to 1872 kc; Q = 65 at 1872 kc; secondary, 30 turns.
R_1 = 82000 ohms, 0.5 watt
R_2 = 560 ohms, 0.5 watt
R_3 = 15000 ohms, 0.5 watt
R_4 = 180 ohms, 0.5 watt
R_5 = 56000 ohms, 0.5 watt
R_6 R_{20} = 4700 ohms
R_7 = 3.3 ohms, 1 watt
R_8 = 1500 ohms, 0.5 watt
R_9 = 8200 ohms, 0.5 watt
R_{10} = 220 ohms, 0.5 watt
R_{11} = 82 ohms, 0.5 watt
R_{12} = 120 ohms, 0.5 watt
R_{13} = 68 ohms, 0.5 watt
R_{14} = 5600 ohms, 0.5 watt
R_{15} = 100000 ohms, 0.5 watt
R_{16} = 680 ohms, 0.5 watt
R_{17} = 470 ohms, 0.5 watt
R_{18} = 100 ohms, 0.5 watt
R_{19} = 1200 ohms, 0.5 watt
R_{21} = volume control, potentiometer, 2500 ohms
R_{22} = tone control, potentiometer, 1000 ohms
R_{23} R_{25} = 3300 ohms, 0.5 watt
R_{24} = 33000 ohms, 0.5 watt
T_1 = output transformer; primary impedance, 20 ohms at 500 ma dc; secondary impedance, 4 ohms to match impedance of voice coil; Columbus Process Co. No. 5383, or equivalent
T_2 = if transformer, Radio Industries No. E014127, Automatic Manufacturing Co. No. E2742208AX, or equivalent
T_3 = if transformer, Radio Industries No. E014128, Automatic Manufacturing Co. No. E2742208BX, or equivalent

10-4 POWER SUPPLY FOR AMATEUR TRANSMITTER

600 Volts; 300 Volts; Total Current 330 Milliamperes (Intermittent Duty)

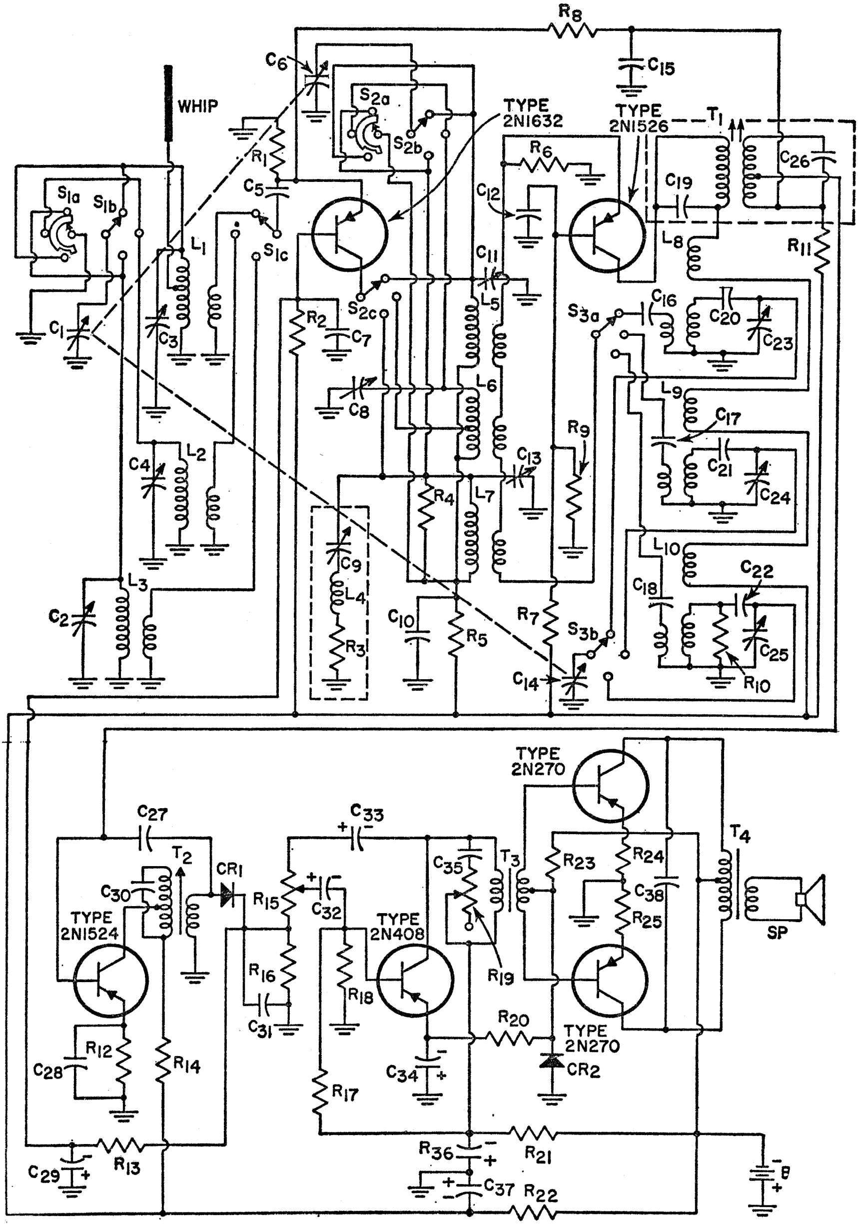


C_1 C_2 C_3 C_4 C_5 C_6 C_7 C_8 = 0.001 μf, ceramic disc, 1000 v.
C_9 C_{10} C_{11} C_{12} = 40 μf, electrolytic, 450 v.
CR_1 CR_2 CR_3 CR_4 CR_5 CR_6 CR_7 CR_8 = RCA-1N2864
I = indicator lamp

K_1 = relay; Potter and Brumfield KA11AY or equiv.
L_1 = 2.8 henries, 300 ma; Stancor C-2334 or equiv.
L_2 = 4 henries, 175 ma; Stancor C-1410 or equiv.
R_1 R_2 R_3 R_4 R_5 R_6 R_7 R_8 = 100000 ohms, 0.5 watt

R_9 = 47 ohms, 1 watt
R_{10} R_{11} = 15000 ohms, 10 watts
R_{12} = 47000 ohms, 2 watts
S_1 S_2 = toggle switch, single-pole single-throw
T = power transformer; Stancor P-8166 or equiv.

10-5 THREE-BAND RADIO RECEIVER



10-5 THREE-BAND RADIO RECEIVER (cont'd)

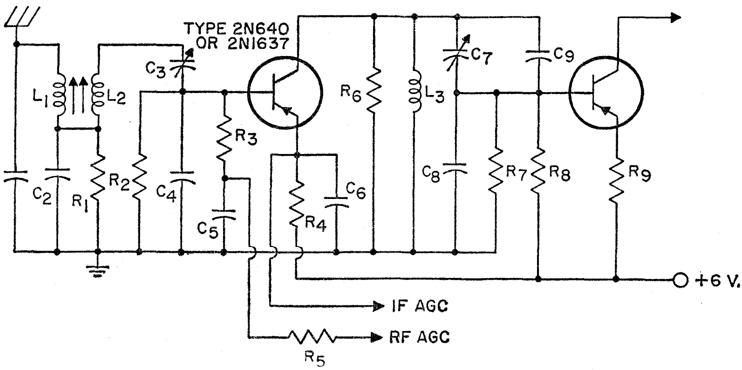
B = 9 volts
C_1 C_6 C_{14} = variable, 26.1 to 251 pf
C_2 C_3 C_4 C_9 C_{23} C_{24} C_{25} = trimmer, 3-35 pf, Arco 403, or equivalent
C_5 = 0.25 μf, ceramic disc
C_7 C_{10} C_{15} C_{28} = 0.05 μf, ceramic disc
C_8 C_{11} C_{13} = trimmer, 1.5-20 pf, Arco 402, or equivalent
C_{12} C_{38} = 0.01 μf, ceramic disc
C_{16} = 0.0005 μf, ceramic disc
C_{17} C_{18} C_{31} = 0.02 μf, ceramic disc
C_{19} C_{26} = 350 pf, part of T_1
C_{20} = 900 pf, silver mica
C_{21} = 300 pf, silver mica
C_{22} = 91 pf, silver mica
C_{27} = 10 pf, ceramic disc
C_{29} = 10 μf, 3 volts, electrolytic
C_{30} = 220 pf, ceramic disc, supplied with T_2
C_{32} = 2 μf, 3 volts, electrolytic
C_{33} = 10 μf, 3 volts, electrolytic
C_{34} = 100 μf, 3 volts, electrolytic
C_{35} = 0.04 μf, ceramic disc
C_{36} C_{37} = 100 μf, 10 volts, electrolytic
L_1 = 42 μh at 3100 kc, shortwave antenna coil, Q_0 = 75; turns ratio N_1/N_2, 1.67:1; N_2/N_3, 18:1
L_2 = 380 μh at 1000 kc, broadcast, antenna coil, Q_0 = 184; turns ratio N_1/N_2, 78:1
L_3 = 4600 μh at 270 kc, longwave antenna coil Q_0 = 69; turns ratio N_1/N_3, 91:1
L_4 = 5 μh, part of if trap
L_5 = 34 μh at 3100 kc, shortwave RF coil, Q_0 = 81; turns ratio, N_1/N_3, 87:1
L_6 = 370 μh at 1000 kc, broadcast RF coil, Q_0 = 80; turns ratio, N_1/N_2, 2.5:1; N_2/N_3, 25:1
L_7 = 4200 μh at 270 kc, longwave RF coil, Q_0 = 10; turns ratio N_1/N_3, 91:1 (measured with 100000-ohm shunt)
L_8 = 29 μh at 3550 kc, shortwave oscillator coil, Q_0 = 20; turns ratio N_1/N_2, 25:1, N_1/N_3, 4:1
L_9 = 200 μh at 1455 kc, broadcast oscillator coil, Q_0 = 39; turns ratio N_1/N_2, 29:1, N_1/N_3, 13:1
L_{10} = 1100 μh at 725 kc, longwave oscillator coil, Q_0 = 17; turns ratio N_1/N_2, 21:1, N_1/N_3, 12:1 (measured with 200000-ohm shunt)
R_1 = 270 ohms, 0.5 watt
R_2 = 150000 ohms, 0.5 watt
R_3 = 22000 ohms, 0.5 watt
R_4 = 100000 ohms, 0.5 watt
R_5 = 560 ohms, 0.5 watt
R_6 = 1800 ohms, 0.5 watt
R_7 = 18000 ohms, 0.5 watt
R_8 = 1200 ohms, 0.5 watt
R_9 = 3300 ohms, 0.5 watt
R_{10} = 200000 ohms, 0.5 watt
R_{11} = 47000 ohms, 0.5 watt
R_{12} = 270 ohms, 0.5 watt
R_{13} = 10000 ohms, 0.5 watt
R_{14} = 1000 ohms, 0.5 watt
R_{15} = volume control, 1 megohm, reverse log. taper
R_{16} = 4000 ohms, 0.5 watt
R_{17} = 27000 ohms, 0.5 watt
R_{18} = 4700 ohms, 0.5 watt
R_{19} = tone control, 1 megohm, audio taper
R_{20} = 560 ohms, 0.5 watt
R_{21} = 330 ohms, 0.5 watt
R_{22} = 100 ohms, 0.5 watt
R_{23} = 4.7 ohms, 0.5 watt
R_{24} = 3.9 ohms, 0.5 watt
R_{25} = 3.9 ohms, 0.5 watt
S_{1a}–S_{3b} = three-section wafer switch
S_p = speaker, 3.2 ohms
T_1 = first if transformer (455 kc): double-tuned critical coupling, Automatic Mfg. No. E-2,749,067EX or equivalent
T_2 = second if transformer (455 kc): single-tuned, Automatic Mfg. No. E-2,749,067CX, or equivalent
T_3 = driver transformer: primary 10000 ohms; secondary, 2000 ohms, center tapped; Mid-West Coil and Transformer Co. No. 20AT88, or equivalent
T_4 = output transformer: primary, 250 ohms center tapped; secondary, 3.2 ohms; Mid-West Coil and Transformer Co. No. 20AT86, or equivalent

NOTE 1: Components C9, L4, and R3 make up an if trap in the long-wave band and are used to improve if rejection and signal-to-noise ratio.

NOTE 2: For the antenna and rf coils, N_1 refers to the turns of the primary winding, N_2 to the tapped portion of the primary, and N_3 to the secondary. For the oscillator coils, N_1 refers to the tank winding, N_2 to the emitter winding, and N_3 to the collector winding.

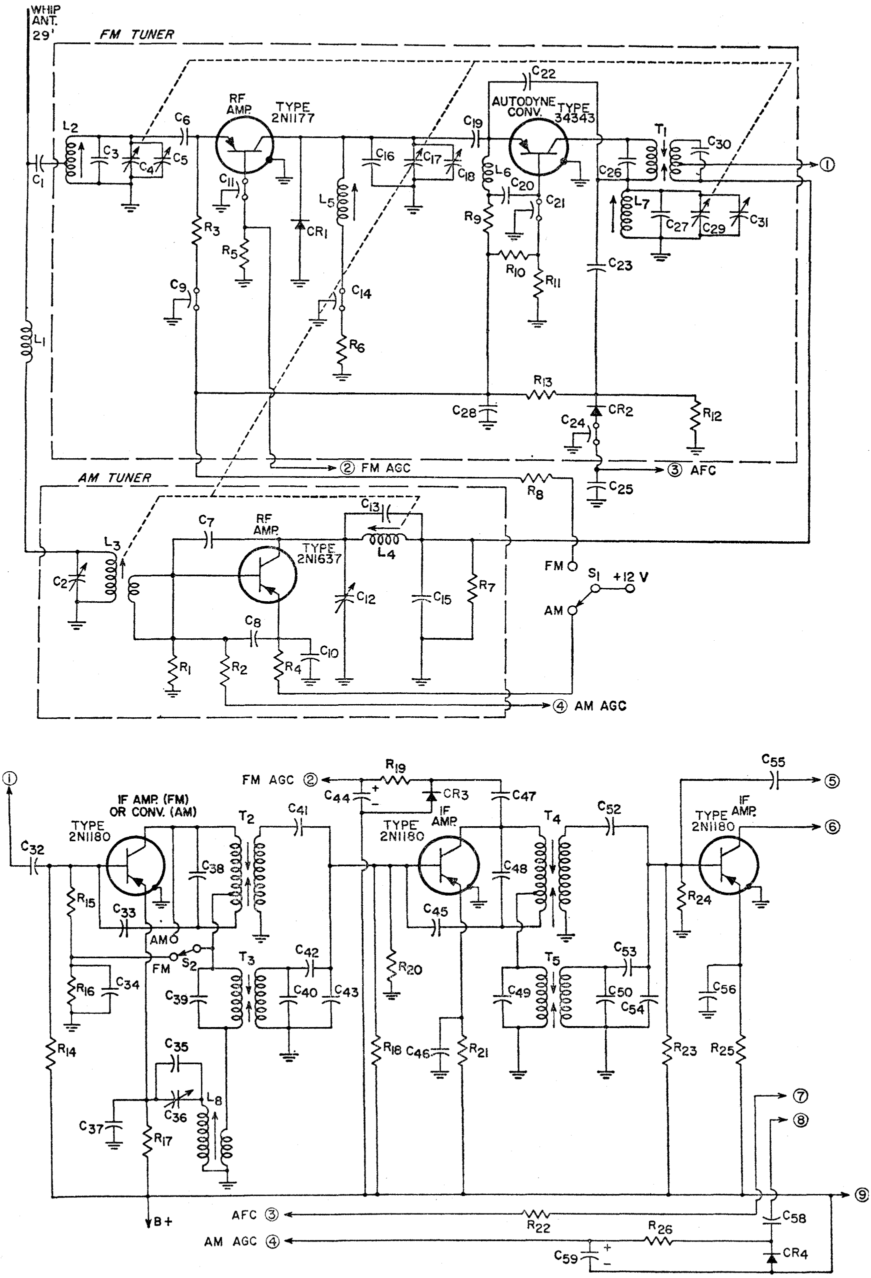
10-6 "FRONT-END" FOR RADIO RECEIVER

With Double-Tuned Antenna and Single-Tuned RF Stage

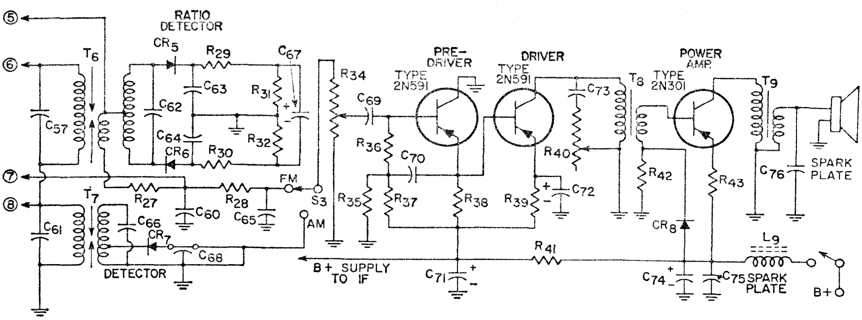


C_1 = 3-50 pf, variable
C_2 = 0.01 μf, ceramic disc, 25v.
C_3 = 30-200 pf, variable
C_4 = 1000 pf, mica
C_5 C_6 = 0.05 μf, ceramic disc, 25 v.
C_7 = 120-450 pf, variable
C_8 = 0.004 μf, ceramic disc, 25 v.
C_9 = 680 pf, mica
L_1 L_2 = antenna coils, variable inductors tuned with 110 pf; frequency range 535 to 1610 kc; Q = 65 at 1610 k, 60 to 65 at 535 kc
L_3 = rf coil; variable inductor tuned with 1000 pf; frequency range 535 to 1610 kc; Q = 65 at 1610 kc.
R_1 R_4 R_5 = 330 ohms, 0.5 watt
R_2 = 82000 ohms, 0.5 watt
R_3 = 2200 ohms, 0.5 watt
R_6 = 6800 ohms, 0.5 watt
R_7 = 10000 ohms, 0.5 watt
R_8 = 1500 ohms, 0.5 watt
R_9 = 1000 ohms, 0.5 watt

10-7 AM/FM AUTOMOBILE RADIO

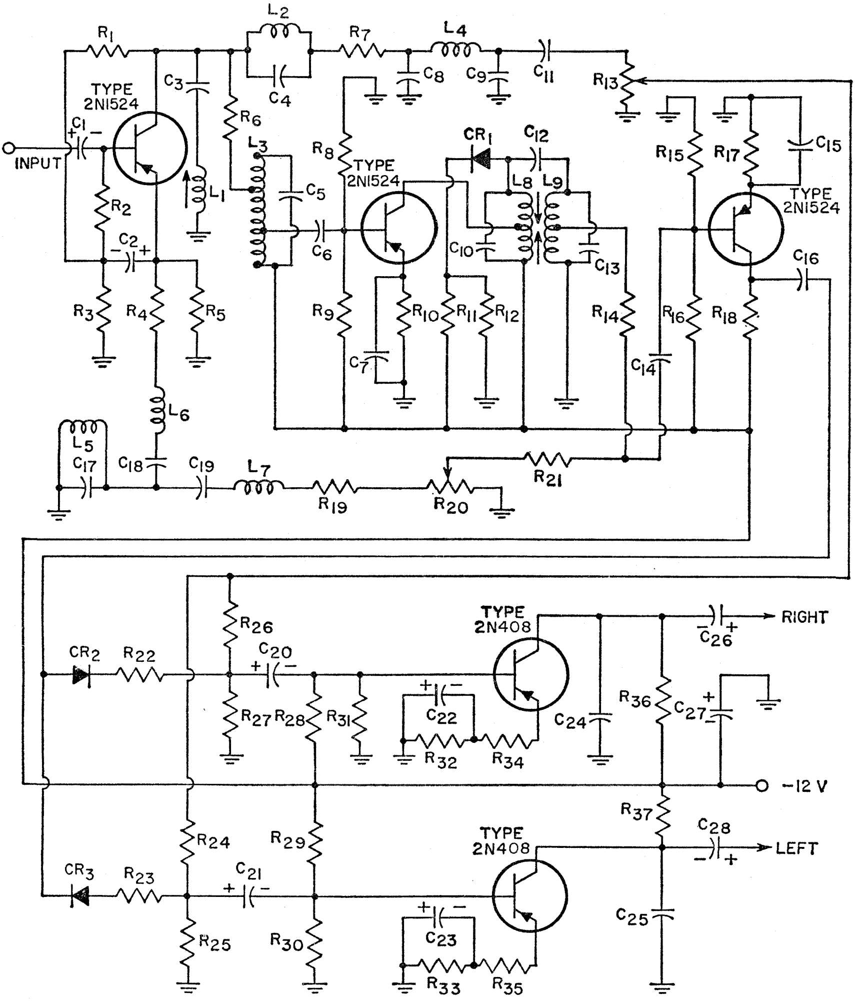


10-7 AM/FM AUTOMOBILE RADIO (cont'd)



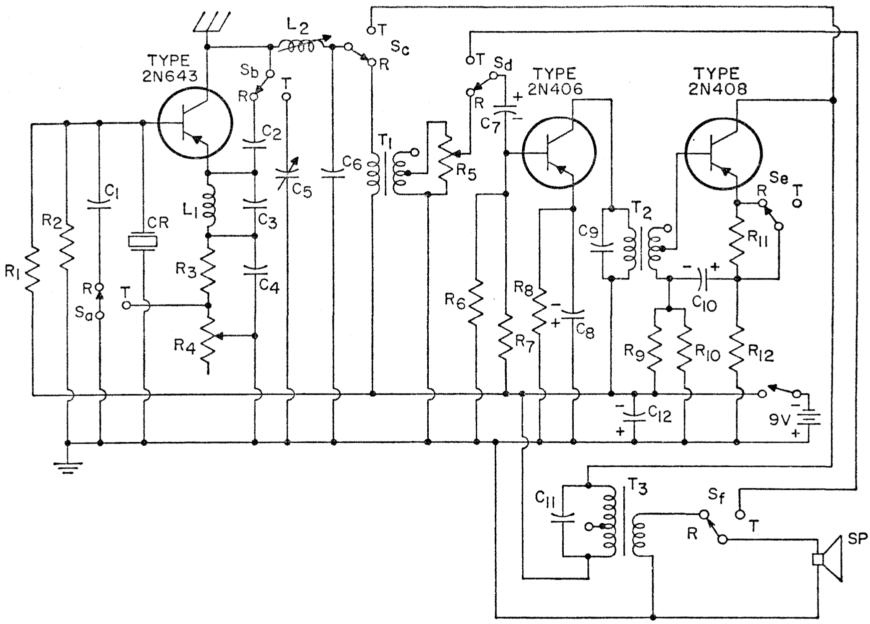
C_1 = 18 pf, ceramic disc, 50 v.
C_2 = 5-80 pf, mica, trimmer
C_3 C_6 C_{19} C_{47} = 5 pf, ceramic disc, 50 v.
C_4 C_{17} C_{29} = 6-21 pf, tuning capacitor
C_5 C_{18} C_{31} = 1-6 pf, mica, trimmer
C_7 = 1.5 pf, ceramic disc, 50 v.
C_8 C_{10} C_{32} C_{46} C_{56} C_{69} C_{73} = 0.05, μf, ceramic disc, 50 v.
C_9 C_{11} C_{14} C_{21} C_{24} C_{68} = 0.002 μf, feedthrough, 50 v.
C_{12} = 55-300 pf, mica, trimmer
C_{13} = 390 pf, ceramic disc, 50 v.
C_{15} = 0.005 μf, ceramic disc, 50 v.
C_{16} C_{23} = 4 pf, ceramic disc, 50 v.
C_{20} = 330 pf, ceramic disc, 50 v.
C_{25} C_{28} C_{34} C_{37} C_{51} C_{60} C_{63} C_{64} = 0.01 μf, ceramic disc, 50 v.
C_{26} C_{30} = part of T_1
C_{27} = 15 pf, ceramic disc, 50 v.
C_{33} C_{45} = 3.3 pf, ceramic disc, 50 v.
C_{35} = 180 pf, N750 ceramic
C_{36} = 80-550 pf, mica, trimmer
C_{38} C_{41} = part of T2
C_{39} C_{40} C_{42} = part of T3
C_{43} C_{54} = 0.001 μf, ceramic disc, 50 v.
C_{44} = 10 μf, electrolytic, 25 v.
C_{48} C_{52} = part of T_4
C_{49} = 1800 pf ±10%, ceramic disc
C_{50} C_{53} = part of T_5
C_{55} = 2 pf, ceramic disc, 50 v.
C_{57} C_{62} = part of T_6
C_{58} = 200 pf, ceramic disc, 50 v.
C_{59} = 20 μf, electrolytic, 25 v.
C_{61} = 1500 pf ±10%, ceramic disc
C_{65} = 0.02 μf, ceramic disc, 50 v.
C_{66} = part of T_7
C_{67} = 10 μf, electrolytic, 3 v.
C_{70} = 2.2 μf, ceramic disc, 3 v.
C_{71} = 200 μf, electrolytic, 25 v.
C_{72} = 100 μf, electrolytic, 25 v.
C_{74} = 500 μf, electrolytic, 25 v.
C_{75} C_{76} = spark plate
CR_1 CR_3 CR_4 CR_7 = diode, 1N295
CR_2 = AFC diode
CR_5 CR_6 = diode, 1N542
CR_8 = diode, 1N1763
L_1 = 6.2 μh, radio-frequency choke
L_2 = antenna coil for FM tuner; 4 turns No. 16 HF on 0.220-inch form, spaced 5/16-inch (approx.); tapped at 1 turn; core "J" material Arnold A1-336 or equiv.
L_3 = antenna coil for AM tuner; variable inductor; tunes with 120 pf over the frequency range from 535 to 1610 kc; Q_0 = 60 at 1610 kc; secondary 8 turns
L_4 = rf coil for AM tuner; variable inductor; tunes with 560 pf over the frequency range from 535 to 1610 kc; Q_0 = 60 at 1610 kc; no secondary
L_5 = rf coil for FM tuner; same as L_2 except has no tap
L_6 = miniature radio-frequency choke, 1 μh (approx.)
L_7 = oscillator coil for FM tuner; 3 turns No. 16 HF on 0.220-inch form, spaced 1/4-inch (approx); core "J" material Arnold A1-336 or equiv.
L_8 = oscillator coil for FM tuner; variable inductor; tunes with 470 pf over the frequency range from 797 to 1872 kc; Q_0 = 45 at 1872 kc; secondary 30 turns
L_9 = filter choke, 125 μh (approx.)
R_1 R_{12} R_{22} = 100000 ohms, 0.5 watt
R_2 R_4 = 560 ohms, 0.5 watt
R_3 = 390 ohms, 0.5 watt
R_5 R_{11} R_{16} = 33000 ohms, 0.5 watt
R_6 R_{27} R_{41} = 180 ohms, 0.5 watt
R_7 = 68 ohms, 0.5 watt
R_8 = 220 ohms, 0.5 watt
R_9 = 680 ohms, 0.5 watt
R_{10} = 4300 ohms, 0.5 watt
R_{13} = 1 megohm, 0.5 watt
R_{14} R_{15} = 10000 ohms, 0.5 watt
R_{17} R_{29} = 1500 ohms, 0.5 watt
R_{18} R_{23} = 2200 ohms, 0.5 watt
R_{19} R_{26} = 5600 ohms, 0.5 watt
R_{20} R_{24} = 18000 ohms, 0.5 watt
R_{21} R_{25} R_{39} = 470 ohms, 0.5 watt
R_{28} = 3900 ohms, 0.5 watt
R_{30} = 1000 ohms, 0.5 watt
R_{31} R_{32} R_{37} = 6800 ohms, 0.5 watt
R_{34} = potentiometer, 100000 ohms, 0.5 watt, audio taper
R_{35} = 62000 ohms, 0.5 watt
R_{36} = 4700 ohms, 0.5 watt
R_{38} = 3300 ohms, 0.5 watt
R_{40} = potentiometer, 250000 ohms, 0.5 watt, audio taper
R_{42} = 270 ohms, 1 watt
R_{43} = 0.47 ohm, 0.5 watt
T_1 = FM if transformer; Radio Industries No. 12224 or Automatic Manufacturing No. E2741353AX or equiv.
T_2 T_4 = FM if transformer; Radio Industries No. 12080R1 or Automatic Manufacturing No. E2741166BX or equiv.
T_3 = AM if transformer; Radio Industries No. 12414 or equiv.
T_5 = AM if transformer; Radio Industries No. 12415 or equiv.
T_6 = ratio-detector transformer; Radio Industries No. 12007R1 or Automatic Manufacturing No. E2741166AB or equiv.
T_7 = AM if transformer; Radio Industries No. 12416 or equiv.
T_8 = driver transformer; primary 8000 ohms at 3 ma dc; secondary 60 ohms; Columbus Process Co. No. X5357 or equiv.
T_9 = output transformer; primary 20 ohms at 700 ma dc; secondary 4 ohms; Columbus Process Co. No. 5383 or equiv.

10-8 FM STEREO MULTIPLEX ADAPTER



C_1 C_{20} C_{21} = 10 μf, electrolytic, 3 v.
C_2 = 100 μf, electrolytic, 3 v.
C_3 = 390 pf, mica
C_4 C_5 = 1000 pf, ceramic disc
C_6 C_{14} C_{16} = 0.05 μf, ceramic disc
C_7 = 1 μf, ceramic disc, 3 v.
C_8 C_9 = 1500 pf, mica
C_{10} C_{13} = 390 pf, ceramic disc
C_{11} = 0.75 μf, mica
C_{12} = 5 pf, mica
C_{15} = 0.47 μf, mica
C_{17} = 2200 pf, ceramic disc
C_{18} C_{19} = 820 pf, mica
C_{22} C_{23} = 50 μf, electrolytic, 3 v.
C_{24} C_{25} = 0.01 μf, mica
C_{26} C_{28} = 10 μf, electrolytic, 12 v.
C_{27} = 100 μf, electrolytic, 12 v.
CR_1 CR_2 CR_3 = 1N295
L_1 L_8 L_9 = 38-kc trap, variable inductor, Automatic Manufacturing Co. No. E2741173BX, or equivalent
L_2 L_3 = 19-kc trap, variable inductor, Automatic Manufacturing Co. No. E2741173AX, or equivalent
L_4 = 100 mh
L_5 = 10 mh
L_6 L_7 = 25 mh
R_1 = 24000 ohms, 0.5 watt
R_2 R_{18} = 3900 ohms, 0.5 watt
R_3 R_4 R_{15} R_{19} R_{21} R_{22} R_{23} R_{36} R_{37} = 4700 ohms, 0.5 watt
R_5 = 330 ohms, 0.5 watt
R_6 = 1500 ohms, 0.5 watt
R_7 = 10000 ohms, 0.5 watt
R_8 R_{30} R_{31} = 5600 ohms, 0.5 watt
R_9 = 68000 ohms, 0.5 watt
R_{10} R_{32} R_{33} = 1000 ohms, 0.5 watt
R_{11} = 1200 ohms, 0.5 watt
R_{12} R_{28} R_{29} = 47000 ohms, 0.5 watt
R_{13} = potentiometer, 10000 ohms, sideband-level control
R_{14} = 1800 ohms, 0.5 watt
R_{16} = 43000 ohms, 0.5 watt
R_{17} = 560 ohms, 0.5 watt
R_{20} = potentiometer, 500 ohms, separation control
R_{24} R_{26} = 75000 ohms, 0.5 watt
R_{25} R_{27} = 2200 ohms, 0.5 watt
R_{35} R_{35} = 47 ohms, 0.5 watt

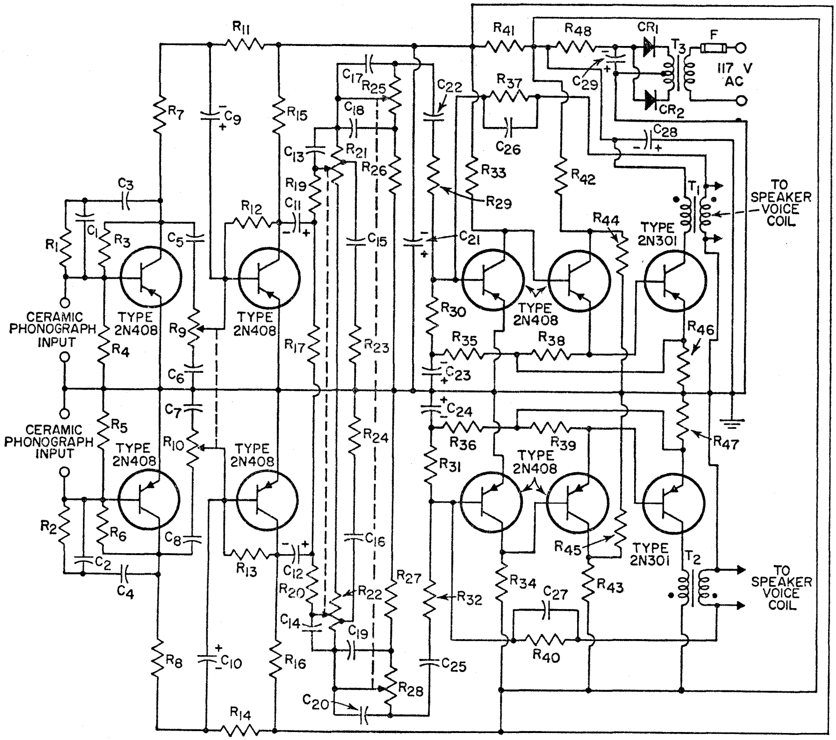
10-9 CITIZENS-BAND TRANSCEIVER



C_1 C_6 C_9 = 0.001 μf, ceramic disc
C_2 C_3 = 27 pf, mica
C_4 = 0.02 μf, ceramic disc
C_5 = 3-35 pf, trimmer
C_7 = 10 μf, electrolytic, 3 v.
C_8 C_{10} = 30 μf, electrolytic, 3 v.
C_{11} = 0.2 μf, ceramic disc
C_{12} = 200 μf, electrolytic, 10 v.
CR = crystal, 27.12 Mc (series resonant mode)
L_1 = 25 μf, radio-frequency choke
L_2 = 9 turns No. 24 enam. close-wound on ¼-inch form, ferrite slug
R_1 = 22000 ohms, 0.5 watt
R_2 = 2200 ohms, 0.5 watt
R_3 = 240 ohms, 0.5 watt
R_4 = regeneration-control potentiometer, 1000 ohms
R_5 = volume-control potentiometer, 5000 ohms
R_6 = 6800 ohms, 0.5 watt
R_7 = 56000 ohms, 0.5 watt
R_8 = 1000 ohms, 0.5 watt
R_9 = 10000 ohms, 0.5 watt
R_{10} = 560 ohms, 0.5 watt
R_{11} = 15 ohms, 0.5 watt
R_{12} = 27 ohms, 0.5 watt
S = receive-transmit switch, six-pole two-position
Sp = speaker, 14-ohm voice coil
T_1 = transformer; primary 10000 ohms; secondary 1000 ohms, center-tapped (one-half secondary used)
T_2 = transformer; primary 20000 ohms; secondary 800 ohms, center-tapped (one-half secondary used)
T_3 = transformer; primary 650 ohms, center-tapped; secondary 16 ohms

10-10 STEREO AMPLIFIER

Output 3 Watts per Channel



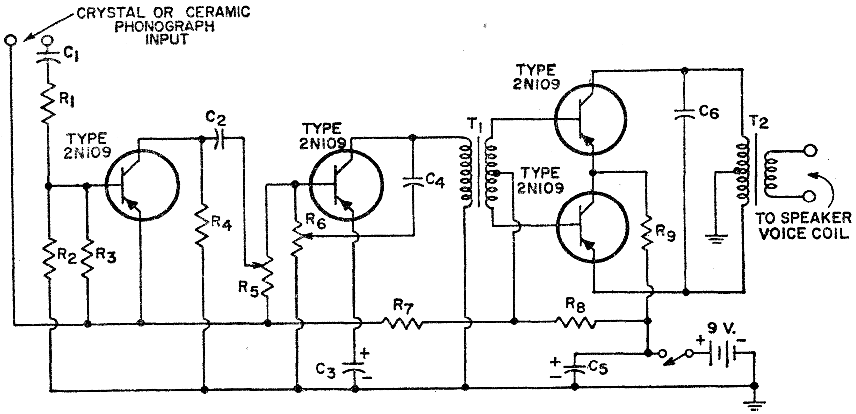
C_1 C_2 C_3 C_4 = 0.02 μf, miniature, 100 v.
C_5 C_8 C_{17} C_{20} = 0.1 μf, miniature, 100 v.
C_6 C_7 = 0.5 μf, miniature, 100 v.
C_9 C_{10} = 6 μf, electrolytic, 6 v.
C_{11} C_{12} = 10 μf, electrolytic, 6 v.
C_{13} C_{14} = 0.001 μf, miniature, 100 v.
C_{15} C_{16} C_{18} C_{19} = 1 μf, miniature, 100 v.
C_{21} = 1000 μf, electrolytic, 10 v.
C_{22} C_{25} = 2.2 μf, ceramic disc, 3 v.
C_{23} C_{24} = 100 μf, electrolytic, 3 v.
C_{26} C_{27} = 12 pf, ceramic disc, 1000 v.
C_{28} = 1000 μf, electrolytic, 15 v.
C_{29} = 1000 μf, electrolytic, 25 v.
F = Fuse, 1A or ¾A, "slo-blo"

R_1 R_2 = 3300 ohms, 0.5 watt
R_3 R_6 = 220000 ohms, 0.5 watt
R_4 R_5 = 10000 ohms, 0.5watt
R_7 R_8 = 1200 ohms, 0.5 watt
R_9 R_{10} = treble-control dual potentiometer, 3000 ohms
R_{11} R_{14} = 2200 ohms, 0.5 watt
R_{12} R_{13} = 56000 ohms, 0.5 watt
R_{15} R_{16} = 1500 ohms, 0.5 watt
R_{17} = balance potentiometer, 2500 ohms
R_{19} R_{20} = 180 ohms, 0.5 watt
R_{21} R_{22} = loudness-control dual potentiometer, 10000 ohms tapped down 3000 ohms
R_{23} R_{24} R_{26} R_{27} = 330 ohms, 0.5 watt
R_{25} R_{28} = bass-control dual potentiometer, 5000 ohms
R_{29} R_{32} = 2200 ohms, 0.5 watt
R_{30} R_{31} = 1800 ohms, 0.5 watt

R_{33} R_{34} = 6800 ohms, 0.5 watt
R_{35} R_{36} = 470 ohms, 0.5 watt
R_{37} R_{40} = 820000 ohms, 0.5 watt
R_{38} R_{39} = 51 ohms, 0.5 watt
R_{41} = 390 ohms, 0.5 watt
R_{42} R_{43} = 220 ohms, 1 watt
R_{44} R_{45} = 68 ohms, 0.5 watt
R_{46} R_{47} = 0.27 ohm, 0.5 watt
R_{48} = 7 ohms, 10 watts
T_1 T_2 = output transformer, 25 ohms to 4 ohms at 400 cps; Midwest Coil and Transformer 20A124 or equiv.
T_3 = power transformer, 117 v. to 48 v., center-tapped (24 v. per winding); Midwest Coil and Transformer 20P21 or equivalent.
NOTE 1: See data on type 2N301 for heat-sink requirements.

10-11 PHONOGRAPH AMPLIFIER

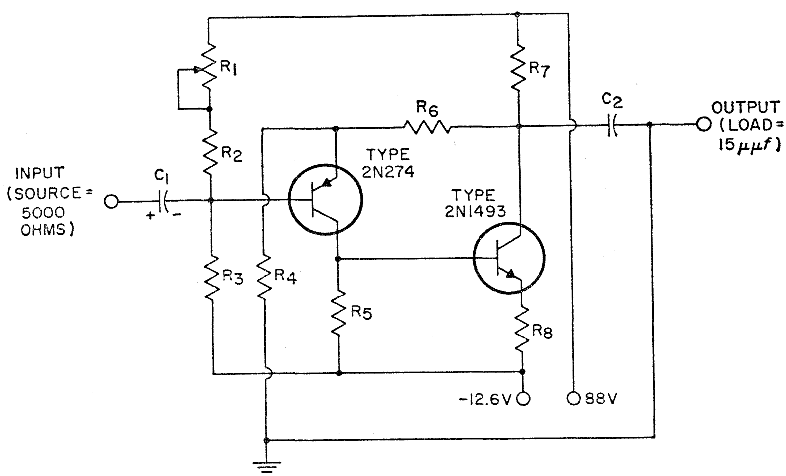
Output 200 mw



C_1 = 0.01 μf, ceramic disc
C_2 = 1 μf, ceramic disc
C_3 C_5 = 50 μf, electrolytic, 12 v.
C_4 = 0.002 μf, ceramic disc
C_6 = 0.04 μf, ceramic disc
R_1 = 1 megohm, 0.5 watt
R_2 = 220000 ohms, 0.5 watt
R_3 = 4700 ohms, 0.5 watt
R_4 = 1500 ohms, 0.5 watt
R_5 = volume-control potentiometer, 5000 ohms, logarithmic audio taper
R_6 = tone-control potentiometer, 100000 ohms, linear taper
R_7 = 680 ohms, 0.5 watt
R_8 = 27 ohms, 0.5 watt
R_9 = 33 ohms, 0.5 watt
T_1 = driver transformer; primary impedance 3000 ohms; secondary impedance (base-to-base) 5000 ohms
T_2 = output transformer; primary impedance (collector-to-collector) 550 ohms; secondary impedance to match speaker voice coil

10-12 VIDEO AMPLIFIER

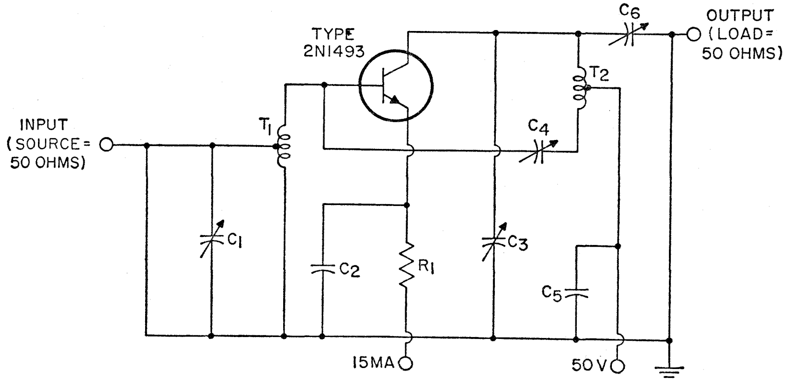
High Input Impedance, Bandwidth 7.5 Mc, Gain 75



C_1 = 10 μf, electrolytic, 15 v.
C_2 = 0.1 μf, paper, 100 v.
R_1 = potentiometer, 25000 ohms (adjust for 40 v. between collector of 2N1493 and ground)
R_2 = 50000 ohms, 1 watt
R_3 R_6 = 10000 ohms, 0.5 watt
R_4 = 100 ohms, 0.5 watt
R_5 = 510 ohms, 0.5 watt
R_7 = 2000 ohms, 1 watt
R_8 = 20 ohms, 0.5 watt

10-13 70-Mc POWER AMPLIFIER

Output 0.5 Watt



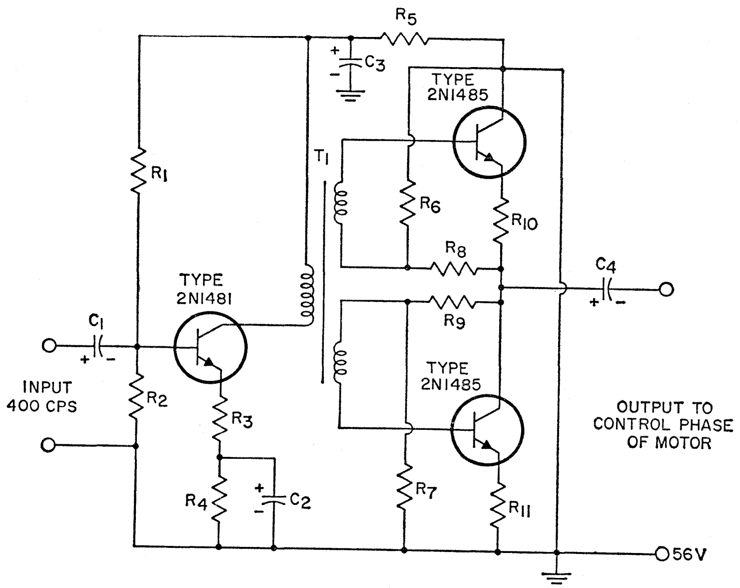
C_1 C_3 C_4 C_6 = 3-20 pf, ceramic trimmer
C_2 C_5 = 0.01 μf, 100 v.
R_1 = 1000 ohms, 2 watts

T_1 = 8 turns No. 24 enam. on General Ceramic Corp. F-303 toroid of Q material, tapped at 1 turn

T_2 = 8 turns No. 24 enam. wound on CTC ⅜-inch ceramic coil form (no slug used), tapped at 2.5 turns

10-14 SERVO AMPLIFIER

Output 6 Watts



C_1 = 10 μf, electrolytic, 15 v.
C_2 = 47 μf, electrolytic, 15 v.
C_3 = 20 μf, electrolytic, 50 v.
C_4 = 500 μf, electrolytic, 50 v.
R_1 = 68000 ohms, 0.5 watt
R_2 = 5600 ohms, 0.5 watt

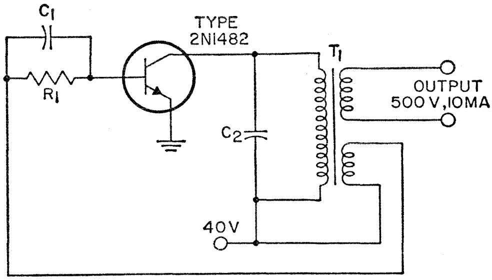
R_3 = 56 ohms, 0.5 watt
R_4 = 560 ohms, 0.5 watt
R_5 = 3300 ohms, 0.5 watt
R_6 R_9 = 18000 ohms, 0.5 watt
R_7 R_8 = 400 ohms, 0.5 watt
R_{10} R_{11} = 4 ohms, 1 watt

T = driver transformer; core material 0.014-inch Magnetic Metals Corp. "Crystalligned" or equiv.; primary 1500 turns; secondary 450 turns, bifilar wound (each section 225 turns)

10-15 28-Kc POWER OSCILLATOR

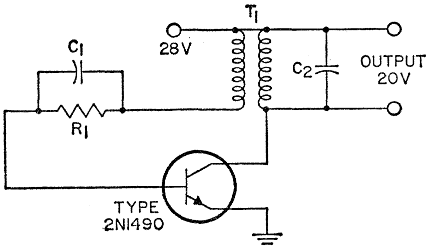
Output 5 Watts

C_1 = 0.1 μf, paper, 50 v.
C_2 = 0.38 μf, paper, 100 v.
R_1 = 3600 ohms, 0.5 watt
T = transformer; primary 40 turns No. 24 enam.; secondary 720 turns No. 36 enam.; feedback 10 turns No. 32 enam.; wound on $\frac{5}{16}$-inch-diameter 455-kilocycle ferrite rod, length 3 inches



10-16 100-Kc POWER OSCILLATOR

Output 10 Watts

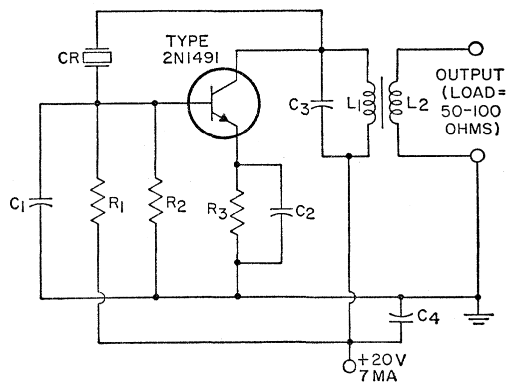


C_1 = 0.1 μf, paper, 50 v.
C_2 = 0.33 μf, paper, 100 v.
R_1 = 510 ohms, 0.5 watt
T = rf transformer; air core; collector winding, 19 turns No. 10 enam.; base winding, 5 turns No. 22 enam.; inside diameter of windings, 0.88 inch; close-wound

10-17 27-Mc CRYSTAL OSCILLATOR

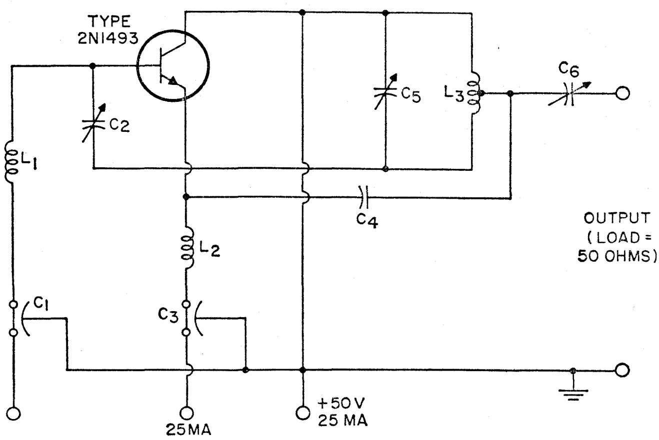
Output 4 mw

C_1 = 20 pf, ceramic disc, 25 v.
C_2 C_4 = 0.01 μf, ceramic disc, 25 v.
C_3 = 22 pf, ceramic disc, 25 v.
CR = crystal, 27 Mc
L_1 = 15 turns No. 22 enam., close-wound on CTC LS5 form (powdered-iron slug)
L_2 = 2 turns No. 18 enam., wound over cold end of L_1
R_1 = 9100 ohms, 0.5 watt
R_2 = 680 ohms, 0.5 watt
R_3 = 200 ohms, 0.5 watt



10-18 70-Mc POWER OSCILLATOR

Output 0.5 Watt

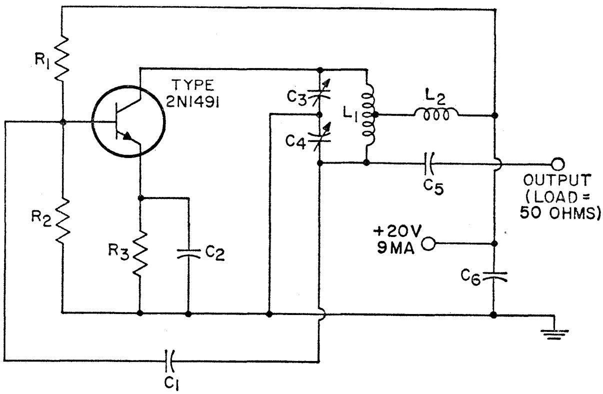


C_1 C_3 = 1500 pf, feed-through, ceramic
C_2 C_6 = 7-100 pf, trimmer, ceramic
C_4 = 0.01 μf, ceramic disc, 25 v.
C_5 = 5-50 pf, trimmer, ceramic
L_1 L_2 = 10 μh, radio-frequency choke
L_3 = 3½ turns No. 14 enam., close-wound on ¾-inch diameter, tapped at 2 turns

10-19 70-Mc COLPITTS OSCILLATOR

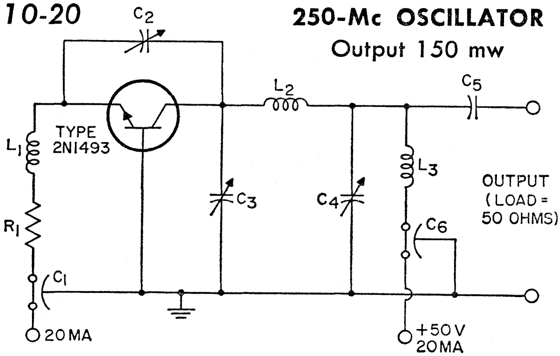
Output 35 mw

C_1 = 18 pf, ceramic disc, 25 v.
C_2 c_6 = 0.01 μf, ceramic disc, 25 v.
C_2 C_6 = 0.01 μf, ceramic disc, 25 v.
C_3 = 5-20 pf, trimmer, ceramic
C_4 = 4-30 pf, trimmer, ceramic
C_5 = 22 pf, ceramic disc, 25 v.
L_1 = 5 turns No. 20 enam., close-wound on CTC-LS5 form (powdered-iron slug), tapped at 3 turns
L_2 = 10 μh, radio-frequency choke
R_1 = 9100 ohms, 0.5 watt
R_2 = 1500 ohms, 0.5 watt
R_3 = 200 ohms, 0.5 watt



10-20 250-Mc OSCILLATOR

Output 150 mw

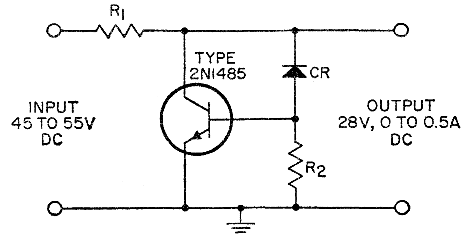


C_1 C_6 = 1000 pf, feedthrough, ceramic
C_2 = 0.6-5.5 pf, trimmer, ceramic
C_3 = 3-15 pf, trimmer, ceramic
C_4 = 4-50 pf, trimmer, ceramic
C_5 = 0.002 μf, paper, 100 v.
L_1 L_3 = 0.82 μh, radio-frequency choke
L_2 = 1 turn No. 14 enam., 1-inch diameter
R_1 = 400 ohms, 0.5 watt

10-21 VOLTAGE REGULATOR, SHUNT TYPE

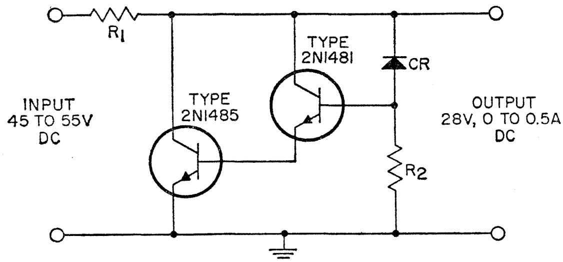
Regulation 1.5%

CR = reference diode, 27 v.
R_1 = 28 ohms, 10 watts (includes source resistance of transformers, rectifiers, etc.)
R_2 = 50 ohms, 0.5 watt



10-22 VOLTAGE REGULATOR, SHUNT TYPE

Regulation 0.5%

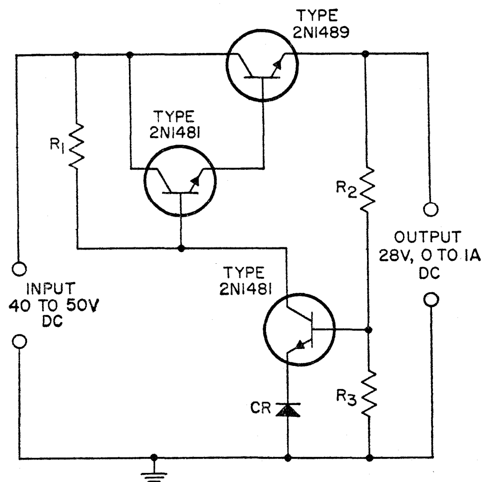


CR = reference diode, 27 v.
R_1 = 28 ohms, 10 watts (includes source resistance of transformers, rectifiers, etc.)
R_2 = 1000 ohms, 0.5 watt

10-23 VOLTAGE REGULATOR, SERIES TYPE

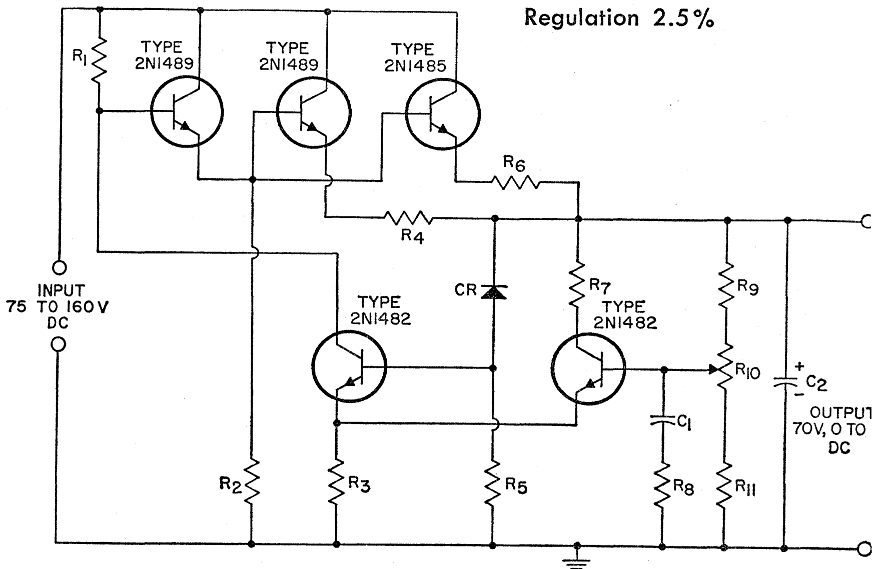
Regulation 3.5%

CR = reference diode, 12 v.
R_1 = 1000 ohms, 1 watt
R_2 = 15000 ohms, 0.5 watt
R_3 = 12000 ohms, 0.5 watt



10-24 VOLTAGE REGULATOR, SERIES TYPE

Regulation 2.5%

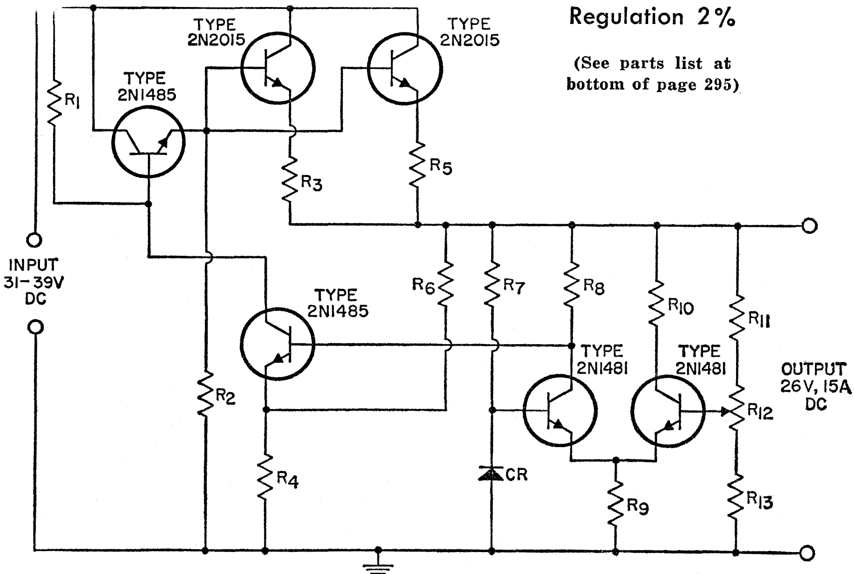


C_1 = 0.5 μf, paper, 50 v.
C_2 = 25 μf, electrolytic, 100 v.
CR = reference diode, 33 v.
R_1 = 620 ohms, 1 watt
R_2 = 20000 ohms, 0.5 watt
R_3 = 1000 ohms, 1 watt
R_4 R_6 = 0.5 ohm, 10 watts
R_5 = 4000 ohms, 0.5 watt
R_7 = 750 ohms, 0.5 watt
R_8 = 100 ohms, 0.5 watt
R_9 = 2500 ohms, 0.5 watt
R_{10} = potentiometer, 1000 ohms, 0.5 watt
R_{11} = 3500 ohms, 0.5 watt

10-25 VOLTAGE REGULATOR, SERIES TYPE

Regulation 2%

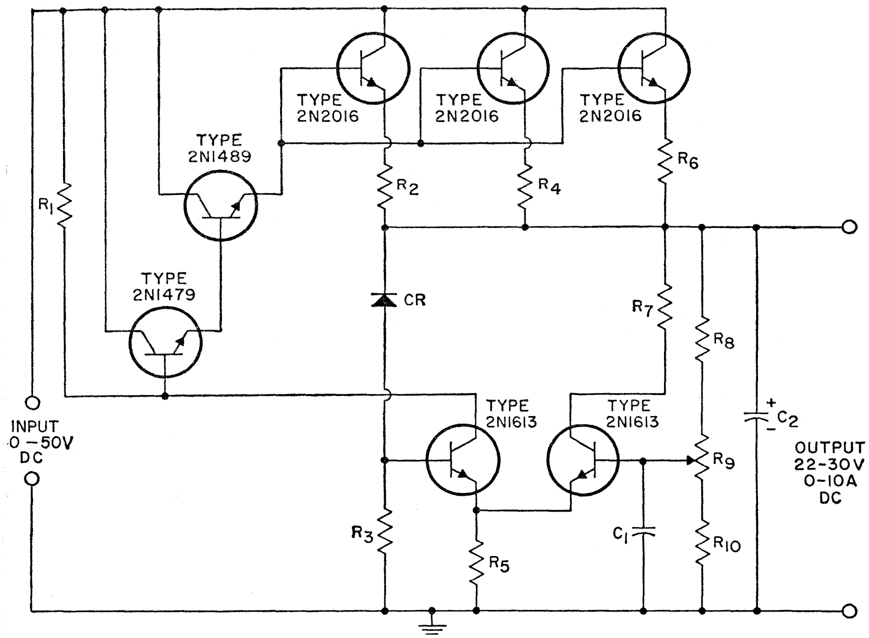
(See parts list at bottom of page 295)



10-26 VOLTAGE REGULATOR, SERIES TYPE

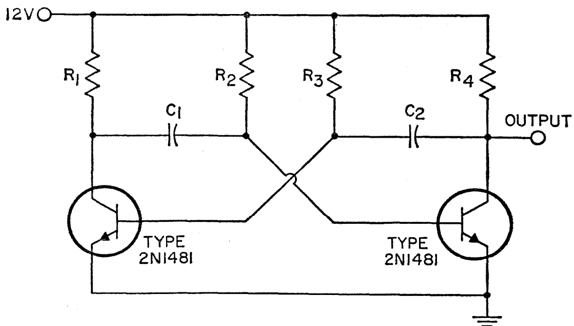
With Adjustable Output

Line Regulation within 1.0% Load Regulation within 0.5%



C_1 = 1 µf, paper, 25 v.
C_2 = 100 µf, electrolytic, 50 v.
CR = reference diode, 12 v.
R_1 = 1200 ohms, 0.5 watt
R_2 R_4 R_6 = 0.1 ohm, 0.5 watt
R_3 = 2000 ohms, 0.5 watt
R_5 = 570 ohms, 0.5 watt
R_7 = 270 ohms, 0.5 watt
R_8 R_{10} = 1000 ohms, 0.5 watt
R_9 = potentiometer, 1000 ohms, 0.5 watt

10-27 ASTABLE MULTIVIBRATOR



C_1 C_2 = 0.01 µf, paper, 25 v.

R_1 R_4 = 60 ohms, 5 watts

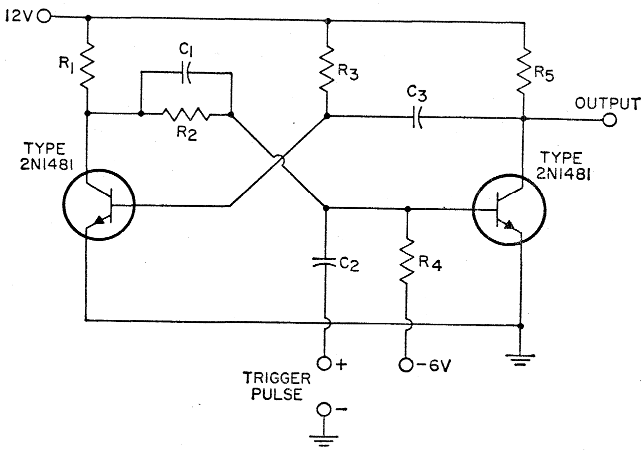
R_2 R_3 = 1000 ohms, 0.5 watt

Parts List for Circuit 10-25:

CR = reference diode, 7.5 v., 100 mw.
R_1 = 225 ohms, 5 watts
R_2 = 10000 ohms, 0.5 watt
R_3 R_5 = 0.075 ohm, 5 watts (cut to measure from resistance wire)
R_4 = 60 ohms, 4 watts
R_6 = 75 ohms, 5 watts
R_7 = 2200 ohms, 0.5 watt
R_8 R_{10} = 500 ohms, 2 watts
R_9 = 120 ohms, 2 watts
R_{11} = 820 ohms, 1 watt
R_{12} = potentiometer, 150 ohms, 0.5 watt
R_{13} = 300 ohms, 1 watt

NOTE: 2N1485 and 2N2015 transistors must be mounted on heat sink of sufficient size to keep the case temperatures below 100°C.

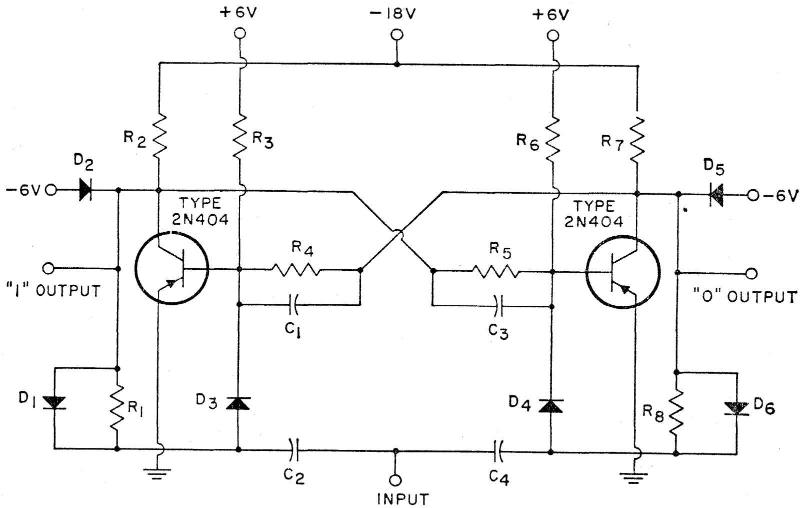
10-28 MONOSTABLE MULTIVIBRATOR



C_1 = 0.005 μf, paper 25 v.
C_2 = 0.05 μf, paper, 25 v.
C_3 = 0.01 μf, paper, 25 v.
R_1 R_5 = 60 ohms, 5 watts
R_2 = 820 ohms, 0.5 watt
R_3 = 1000 ohms, 0.5 watt
R_4 = 5000 ohms, 0.5 watt

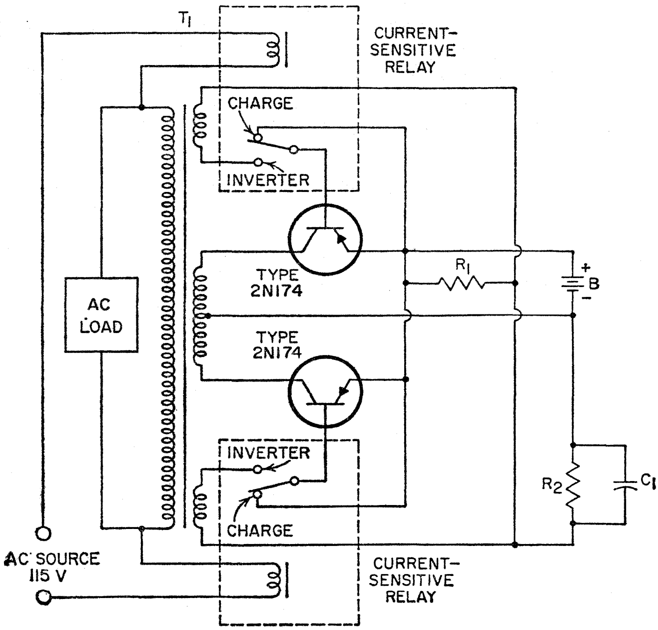
10-29 BISTABLE MULTIVIBRATOR

1-Mc "Flip-Flop"



C_1 C_3 = 180 pf, mica, 24 v.
C_2 C_4 = 430 pf, mica, 24 v.
D_1 D_2 D_3 D_4 D_5 D_6 = diode, 1N126
R_1 R_8 = 5100 ohms, 0.5 watt
R_2 R_7 = 1200 ohms, 0.5 watt
R_3 R_6 = 11000 ohms, 0.5 watt
R_4 R_5 = 2700 ohms, 0.5 watt

10-30 AUTOMATIC INVERTER-CHARGER



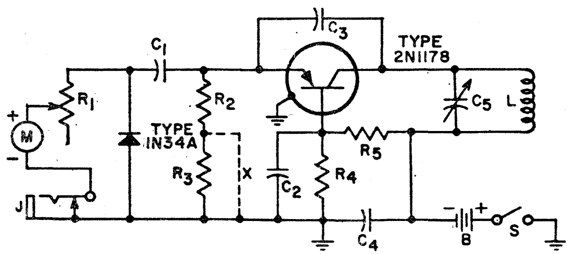
B = storage battery, 12 v.
C_1 = 100 μf, electrolytic, 50 v.
R_1 = 30 ohms, 10 watts
R_2 = 100 ohms, 10 watts
T = transformer; primary, 100 turns; secondary, 20 turns, bifilar wound, center-tapped; charger-inverter windings, 9 turns each; feedback windings, 5 turns each.

10-31 GRID-DIP METER

For Measuring Resonant Frequencies from 3.5 to 100 Mc

B = 13.5 volts, RCA VS304
C_1 = 33 $\mu\mu$f, mica, 50 v.
C_2 = 0.01 μf, paper, 50 v.
C_3 = 5 $\mu\mu$f, mica, 50 v.
C_4 = 0.01 μf, paper, 50 v.
C_5 = variable capacitor, 50 pf (Hammarlund type HF-50 or equivalent)
J = phone jack, normally closed
L = plug-in coil
M = microammeter, 0 to 50 μa (Simpson model 1227 or equivalent)
R_1 = variable resistor, 0-0.25 megohm, 0.5 watt
R_2 = 220 ohms, 0.5 watt
R_3 = 3,000 ohms, 0.5 watt
R_4 = 3,900 ohms, 0.5 watt
R_5 = 39,000 ohms, 0.5 watt
J = jumper, omit for measurements below 45 Mc

NOTE: Wind coils according to the following directions:

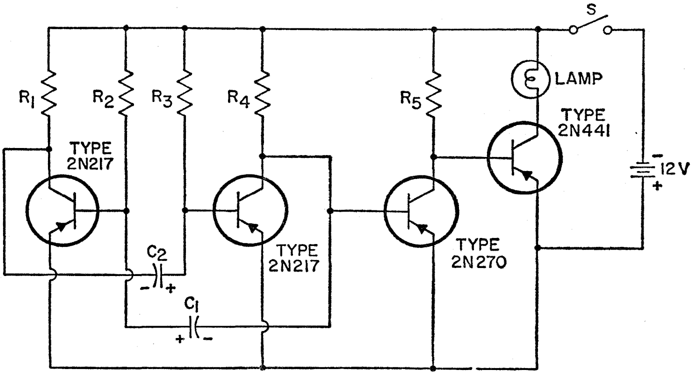


Coil	Freq. Range	Wire Size	No. of Turns
1	3.4-6.9 Mc	#28, enamel	48¼, close wound
2	6.7-13.5 Mc	#24, enamel	22, close wound
3	13-27 Mc	#24, enamel	9⅛, close wound
4	25-47 Mc	#24, enamel	4⅛, close wound
5	46-78 Mc	#24, enamel	1½, close wound
6	74-97 Mc	#16, tinned	hairpin formed, 1⅞ inches long including pins, and ¼ inch wide

Coil forms are Amphenol type 24-5H or equivalent.

10-32 LIGHT FLASHER

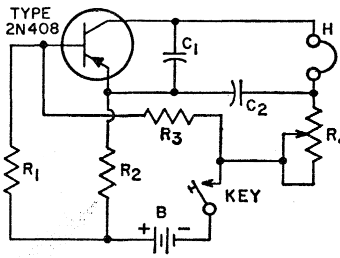
60 Flashes per Minute



C_1 = 25 μf, electrolytic, 12 v.
C_2 = 100 μf, electrolytic, 12 v.
LAMP = bulb, 12 v, 1 ampere
R_1 R_4 = 2000 ohms, 0.5 watt
R_2 R_3 = 100000 ohms, 0.5 watt
R_5 = 120 ohms, 0.5 watt
S = switch

NOTE: C_1 and C_2 may be varied to change flashing rate. Bulbs and other resistive loads handling currents up to one ampere may be used, but inductive loads should not be used.

10-33 CODE-PRACTICE OSCILLATOR



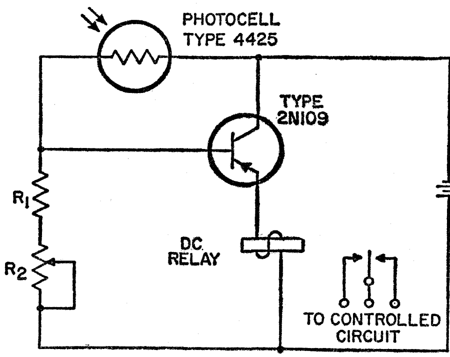
B = 1.5–4.5 v. (One to three series-connected RCA VS036 dry cells may be used, depending upon the volume level desired.)
C_1 C_2 = 0.01 μf, paper, 150 v.
H = Headphone, 2000-ohm, magnetic
R_1 = 2200 ohms, 0.5 watt
R_2 = 27000 ohms, 0.5 watt
R_3 = 3000 ohms, 0.5 watt
R_4 = volume control potentiometer, 50000 ohms, 0.5 watt

10-34 PHOTO-RELAY

Operates with Light Increase

B = 6 volts, RCA VS317
R_1 = 120 ohms, 0.5 watt
R_2 = potentiometer, 5000 ohms; Mallory U-14 or equivalent
Relay = 1000 ohms, 2.3-milliampere operating current; Sigma type 5F or equivalent

NOTE: The relay mounting frame is at armature potential and should be insulated from a common chassis for safety reasons.



INDEX

RCA Technical Publications

Copies of the publications listed below may be obtained from your RCA distributor or from Commercial Engineering, Radio Corporation of America, Somerville, N. J.

Semiconductor Products

● RCA SEMICONDUCTOR PRODUCTS HANDBOOK — HB-10. Two binders, each 7⅜″ L x 5⅝″ W x 2⅞″ D. Contains over 1000 pages of looseleaf data and curves on RCA semiconductor devices such as transistors, silicon rectifiers, and semiconductor diodes. Available on a subscription basis. Price $10.00* including service for first year. Also available with RCA Electron Tube Handbook HB-3 at special combination price of $25.00.*

● RCA SEMICONDUCTOR PRODUCTS GUIDE — 60S16R3 (10⅞″ x 8⅜″) — 12 pages. Contains classification chart, index, and ratings and characteristics on RCA's line of transistors, silicon rectifiers, semiconductor diodes, and photocells. Single copy free on request.

● RCA SILICON POWER TRANSISTORS APPLICATION GUIDE — ICE-215 (10⅞″ x 8⅜″)—28 pages. Describes outstanding features of RCA silicon power transistors and their use in many critical industrial and military applications. Includes construction details, discussion of voltage ratings, thermal stability conditions, and equivalent circuits for power transistors. Price 50 cents.*†

● RCA SILICON VHF TRANSISTORS APPLICATIONS GUIDE—ICE-228 (10⅞″ x 8⅜″)—20 pages. Describes unique capabilities of RCA silicon vhf transistors and their use in critical industrial and military applications up to 300 Mc. Price 50 cents.*†

● TRANSISTORIZED VOLTAGE REGULATORS APPLICATION GUIDE—ICE-254 (10⅞″ x 8⅜″)—12 pages. Describes and discusses transistorized voltage regulators of the series and shunt types. Included are design considerations, step-by-step design procedures, and the solutions to sample design problems. An Appendix contains the derivation of design equations. Price 25 cents.*†

Electron Tubes

● RCA ELECTRON TUBE HANDBOOK —HB-3 (7⅜″ x 5⅝″). Five 2¼-inch-capacity binders. Contains over 5000 pages of looseleaf data and curves on RCA receiving tubes, transmitting tubes, cathode-ray tubes, picture tubes, photocells, phototubes, camera tubes, ignitrons, vacuum gas rectifiers, traveling-wave tubes, premium tubes, pencil tubes, and other miscellaneous types for special applications. Available on subscription basis. Price $20.00* including service for first year. Also available with RCA Semiconductor Products Handbook HB-10 at special combination price of $25.00.*

● RCA RECEIVING TUBE MANUAL——RC-21 (8¼″ x 5⅜″)—480 pages. Contains technical data on 903 receiving tubes and 106 picture tubes for black-and-white and color television. Features tube theory written for the layman, application data for radio and television circuits, new receiving-tube and picture-charts, and several circuits for high-fidelity audio amplifiers. Features lie-flat binding. Price $1.00.*†

● RCA TRANSMITTING TUBES— TT-5 (8¼″ x 5⅜″) — 320 pages. Gives data on over 180 power tubes having plate-input ratings up to 4 kw and on associated rectifier tubes. Provides basic information on generic types, parts and materials, installation and application, and interpretation of data. Contains circuit diagrams for transmitting and industrial applications. Features lie-flat binding. Price $1.00.*†

● RADIOTRON° DESIGNER'S HANDBOOK — 4th Edition (8¾″ x 5½″) —1500 pages. Comprehensive reference covering the design of radio and audio circuits and equipment. Written for the design engineer, student, and experimenter. Contains 1000 illustrations, 2500 references, and cross-referenced index of 7000 entries. Edited by F. Langford-Smith.

● RCA POWER TUBES — PG-101E (10⅞″ x 8⅜″)—46 pages. Technical information on 200 RCA vacuum power tubes, rectifier tubes, thyratrons, and ignitrons. Includes terminal connections. Price 75 cents.*†

● RCA RECEIVING-TYPE TUBES FOR INDUSTRY AND COMMUNICATIONS —RIT 104B (10⅞″ x 8⅜″)—32 pages. Technical information on over 190 RCA "special red" tubes, premium tubes, nuvistors, computer tubes, pencil tubes, glow-discharge tubes, small thyratrons, low-microphonic amplifier tubes, mobile communications tubes, and other special types. Includes socket-connection diagrams. Price 30 cents.*†

● RCA RECEIVING TUBES AND PICTURE TUBES —1275K (10⅞" x 8⅜") —64 pages. New, enlarged, and up-to-date booklet contains classification chart, application guide, characteristics chart, and base and envelope connection diagrams on more than 1050 entertainment receiving tubes and picture tubes. Price 50 cents.*†

● RCA PHOTOSENSITIVE DEVICES AND CATHODE-RAY TUBES — CRPD-105B (10⅞" x 8⅜")—36 pages. Contains technical information on 151 RCA tubes including single-unit, twin-unit, and multiplier phototubes; photocells; camera and image-converter tubes; flying-spot tubes; monitor, projection, transcriber, and view-finder kinescopes; oscillograph and storage tubes. Price 50 cents.*†

● RCA INTERCHANGEABILITY DIRECTORY OF INDUSTRIAL-TYPE ELECTRON TUBES — ID-1020C (10⅞" x 8¾")—16 pages. Lists more than 1450 basic type designations for 18 classes of industrial tube types; shows the RCA Direct Replacement Type or the RCA Similar Type, when available. Price 35 cents.*†

● RCA PHOTOCELLS—ICE-261 (10⅞" x 8⅜")—20 pages. Contains a selection of photocell-circuit diagrams; technical data and characteristic curves of RCA photoconductive, photojunction, and photovoltaic cells; interchangeability information; and supplementary information on tungsten and fluorescent light sources. Price 25 cents.*†

● RCA MAGNETRONS AND TRAVELING-WAVE TUBES — MT-301A (10⅞" x 8⅜") — 48 pages. Operating theory for magnetrons and traveling-wave tubes, application considerations, and techniques for measurement of electrical parameters. Price 60 cents.*†

● RCA PENCIL TUBES — ICE-219 (10⅞" x 8⅜")—28 pages. Contains operating theory for pencil tubes, electrical and mechanical circuit-design considerations, environmental considerations, application considerations, and data for commercial types. Price 50 cents.*†

● RCA CAMERA TUBES — ICE-262 (10⅞" x 8⅜")—24 pages. Includes concise data on all commercially available RCA camera tubes as well as typical curves and information defining the most important characteristics of camera tubes. Also contains cutaway views of a vidicon and image orthicon illustrating construction features. Price 75 cents.*†

● RCA INTERCHANGEABILITY DIRECTORY OF FOREIGN vs. U.S.A. RECEIVING-TYPE ELECTRON TUBES — ICE-197A (8⅜" x 10⅞") — 4 pages. Covers approximately 500 foreign tube types used principally in AM and FM radios, TV receivers, and audio amplifiers. Indicates U.S.A. direct replacement type or similar type if available. Single free copy on request.

Batteries

● RCA BATTERY MANUAL— BDG-111 (10⅞" x 8¾")—64 pages. Contains information on dry cells and batteries [carbon zinc (Leclanché), mercury, and alkaline types]. Includes battery theory and applications, detailed electrical and mechanical characteristics, a classification chart, dimensional outlines, and terminal connections on each battery type. Price 50 cents.*†

● RCA BATTERIES — BAT-134E (10⅞" x 8⅜")—16 pages. Technical data on 160 Leclanché, alkaline, and mercury-type dry batteries for radios, industrial applications, flashlights, lanterns, and for photoflash service. Price 35 cents.*†

● RCA BATTERIES FOR TRANSISTOR APPLICATIONS — TBA-107A (10⅞" x 8⅜")—12 pages. Technical data and curves on 25 RCA Leclanché and mercury-type dry batteries designed for use in applications utilizing transistors. Price 25 cents.*†

Test and Measuring Equipment

INSTRUCTION BOOKLETS —Illustrated instruction booklets, containing specifications, operating and maintenance data, application information, schematic diagrams, and replacement parts lists, are available for all RCA test instruments. Prices for booklets on individual instruments are available on request.

°Trade Mark Reg. U.S. Pat. Off.
*Prices shown apply in U.S.A. and are subject to change without notice.
†Optional List Price.

Reading List

The following list contains a number of references which should prove helpful to those interested in further information on semiconductor theory and applications.

Basic Theory and Application of Transistors TM 11-690, U.S. Govt. Printing Office, 1959.

BETTRIDGE, B. R. *Transistors and Crystal Diodes,* Wehman Bros., 1954.

BRARDI, R. *Transistor Technology,* VOL. III. D. Van Nostrand Co., Inc., 1958.

CALDWELL, W. C. *Practical Transistor Servicing,* Howard W. Sams Co., Inc., 1960.

CARROLL, J. M. *Transistor Circuits and Applications,* McGraw-Hill Book Co., Inc., 1957.

CONTI, T. *Metallic Rectifiers and Crystal Diodes,* John F. Rider, Inc., 1958.

DUNLAP, W. C. *Introduction to Semiconductors,* John Wiley and Sons, Inc., 1957.

EVANS, J. *Fundamental Principles of Transistors,* D. Van Nostrand Company, Inc., 1958.

GREINER, R. A. *Semiconductor Devices and Applications,* McGraw-Hill Book Co., Inc., 1961.

JOYCE, M. V. *Transistor Circuit Analysis,* Addison Wesley Co., Inc., 1961.

HUNTER, L. P. *Handbook of Semiconductor Electronics,* McGraw-Hill Book Co., Inc., 1958.

LEAHRMAN, H. *Transistor Techniques,* Gernsback Library, Inc., 1957.

LINVILL, J. G. *Transistors and Active Circuits,* McGraw-Hill, Inc., 1961.

LO, A. W., et al. *Transistor Electronics,* Prentice-Hall, Inc., 1955.

LURCH, J. *Fundamentals of Electronics,* John Wiley and Sons, Inc., 1960.

MILLMAN, J. *Vacuum Tube and Semiconductor Electronics,* McGraw-Hill Book Co., Inc., 1958.

MUELLER, H. *Introduction to Electrical Engineering,* McGraw-Hill Book Co., Inc., 1957.

PRESSMAN, A. I. *Design of Transistorized Circuits for Digital Computers* John F. Rider, Inc., 1959.

PULLEN, K. A. *Handbook of Transistor Design,* Prentice-Hall, Inc., 1961.

RYDER, J. *Electronic Fundamentals and Applications,* Prentice-Hall, Inc., 1959.

SEELY, J. *Radio Electronics,* McGraw-Hill Book Co., Inc., 1956.

SHEA, R. F. *Transistor Circuit Engineering,* John Wiley and Sons, Inc., 1957.

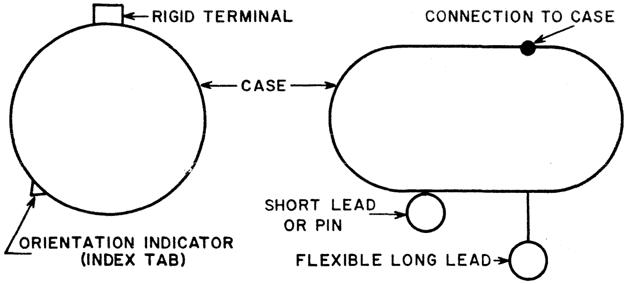
SHOCKLEY, W. *Electrons and Holes in Semiconductors,* D. Van Nostrand Co., 1950.

SHURE, A. *Semiconductors and Transistors,* John F. Rider, Inc., 1961.

TERMAN, J. *Electronics and Radio Engineering,* McGraw-Hill Book Co., Inc., 1955.

TURNER, R. P. *Transistor Circuits,* Gernsback Library, Inc., 1957.

KEY TO TERMINAL DIAGRAMS



A	Anode
B	Base
C	Collector
D_1	Diode Unit No. 1
D_2	Diode Unit No. 2
D_3	Diode Unit No. 3
E	Emitter
F	Mounting Flange
IC	Internal Connection
IS	Interlead Shield
K	Cathode
L	Lug
S	Stud

NOTES:

Elongated case symbol denotes "in-line" arrangement of electrode terminals.

Arrow on case of diodes or emitter lead of transistor diagrams indicates direction of "conventional current flow"; electron current flows in a direction opposite to the arrows.

Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

Contents

RCA
TRANSISTOR
MANUAL

Designed for use by engineers, technicians, educators, students, radio amateurs, hobbyists, and others interested in semiconductor devices and circuits ■

RCA Semiconductor and Materials Division, Somerville, N[illegible] Jersey