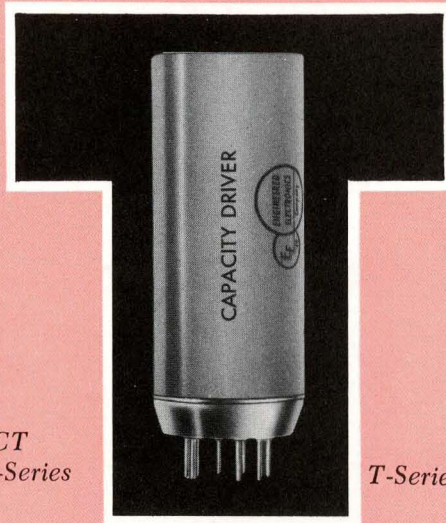




CT
-Series



T-Series

EECO

digital circuit modules

catalog T-113

PRESENTING ONE OF THE MOST COMPREHENSIVE, VERSATILE AND WIDELY PROVEN FAMILIES OF DIGITAL CIRCUIT MODULES EVER CATALOGED.

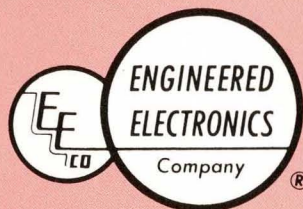


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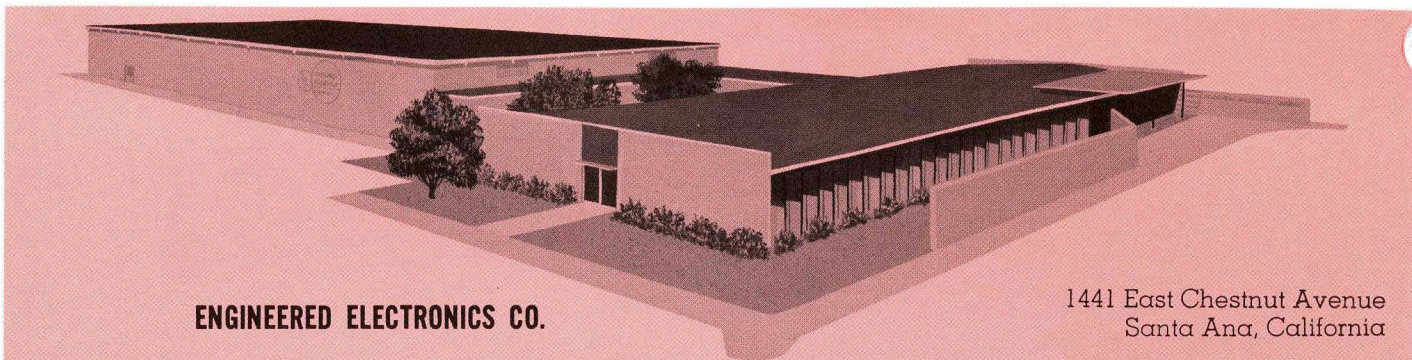
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ABOUT EECO

EECO consists of two autonomous divisions. As family members we share a corporate name — but we live apart and there's a big difference in our operations . . .

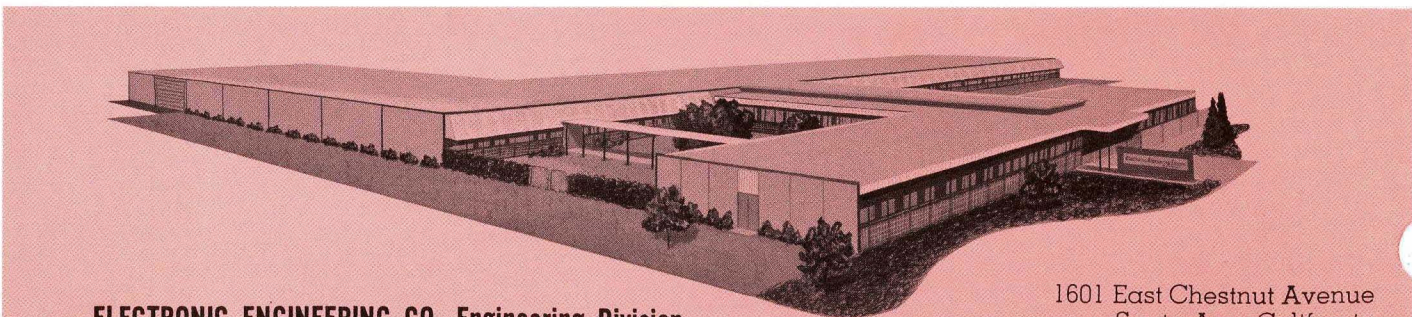


ENGINEERED ELECTRONICS CO.

1441 East Chestnut Avenue
Santa Ana, California

The Engineered Electronics Co. division specializes in the production of efficient digital "building blocks." This specialization assures EECO's customers of advanced circuit module techniques, a maximum variety of available module types, speedy off-the-shelf delivery, and reduced system checkout time.

The mushrooming volume and diversity of electronic systems that use EECO modules is proof of EECO's ability to assure "pre-proven module performance with maximum reliability." In short, EECO's modules eliminate hours of circuit development, testing, correcting and re-testing from a system schedule, with appreciable savings to the system's total cost.



ELECTRONIC ENGINEERING CO., Engineering Division

1601 East Chestnut Avenue
Santa Ana, California

The Engineering Division specializes in digital systems design and development. Typical systems designed and manufactured by the Engineering Division include Data Processing Systems and interface equipment such as Computer Language Translators, Digital

Timing Systems, and Range Instrumentation Systems. In addition, the Engineering Division manufactures standard lines of Punched Tape Programming units, Time Code Generators, and Magnetic Core Memories.

EECO FACILITIES

Strategically located on a 19-acre site in the heart of the new industrial area of Santa Ana, California, the two EECO divisions are housed in modern plants which have 41,000 sq. ft. (Engineering Div.) and 23,000 sq. ft. (Engineered Electronics Co. Div.) of floor space. The Engineered Electronics Co. Division's plant is completely furnished with the latest equipment and facilities for the manufacture of digital circuit modules including a Plastic Chemistry lab for encapsulation research, a Metallographic lab for welding metallurgical studies, and an integrated production line for welding under microscopes.

Also included is a bonded stockroom for Jan Mil parts. Present overall facilities clearance is to Secret and all key personnel have Top Secret clearance.

A complete evaluation of production runs is observed before any circuits are released. Quality-control testing is performed on a 100% basis, with quality control approved and under the cognizance of the U. S. Signal Corps.

Accounting is under the audit of a U. S. Navy Area Audit Office.



EECO T-Series Catalog No. T-113

T-Series modules comprise one of the most comprehensive and widely used families of digital circuit modules ever cataloged. Further, past routes from general plans to successfully operating systems via the famous T-Series provide a wealth of proven solutions and clear alternates that can eliminate days, weeks, and even agonizing months from a new program.

The unusually large quantity of proven circuit types affords unequalled selectivity and critical employment of the most ideal circuits for each specific function.

Finally, T-Series packages are outstanding for conventional type circuits. They provide for good density, most direct system layout and ready accessibility to all components. In some applications, the CT circuit cards offer additional economy using the same, well-proven T-Series circuits.

This catalog, then, offers you fast access to this most proven and widely used family of digital circuit modules. Separate sections enable rapid location of data needed:

INDEX, starting on the next page, shows the location of general family information, information for each circuit type and information on related equipment units.

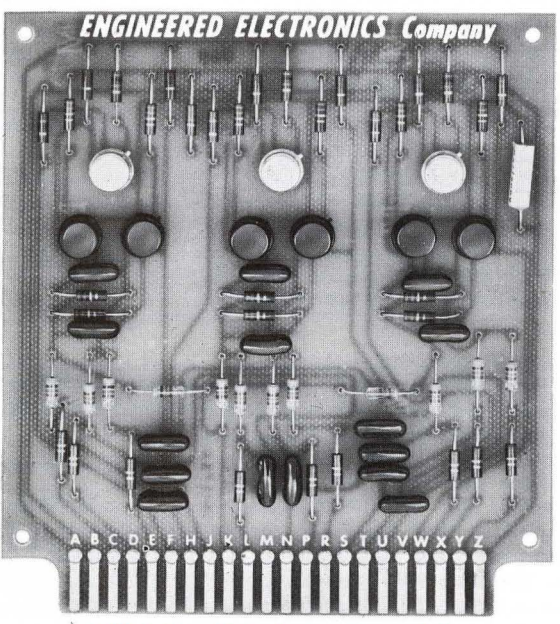
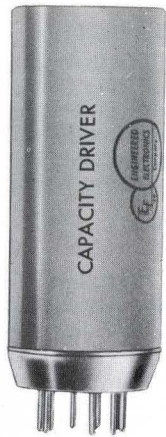
GENERAL FAMILY INFORMATION, starting on page 6, covers specifications, construction, loading procedures, symbol definitions and other material applicable to T- or CT- modules.

CIRCUIT DATA SECTION, begins on page 16. This section covers each module in detail. The units are grouped by circuit type and function and the functional groups are arranged in alphabetical sequence.

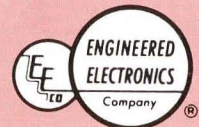
RELATED EQUIPMENT SECTION presents information on digital system breadboard equipment, power supplies, hardware, and panels and chassis. This section begins on page 62.

PRICES and ORDERING INFORMATION are provided on separate sheets in the back of this catalog.

T-Series digital circuit modules



CT-Series digital circuit modules



1441 EAST CHESTNUT AVENUE
SANTA ANA, CALIFORNIA

TEL: 714-547-5651
TWX: 714-531-5522
CABLE: ENGELEX

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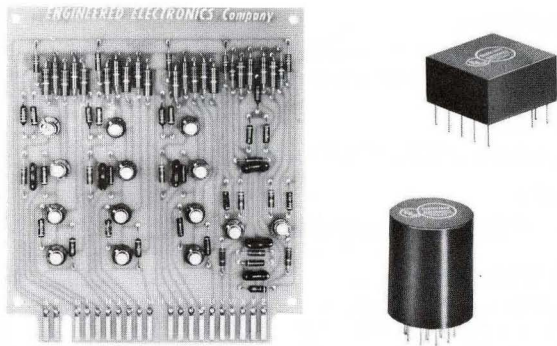
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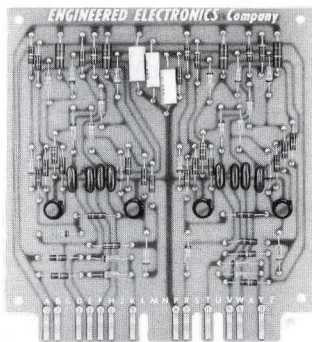


TRANSISTOR UNIVERSAL NOR MODULES (U-SERIES)

This family has four silicon-transistor sub-groups; each sub-group is available in at least one of three package styles. Two of these package styles have all-welded connections and are transfer molded. The third package is a conventional printed-circuit-card configuration.

One 1-megacycle sub-group is available in either of the two welded packages; a cylindrical module which plugs into standard sockets and a rectangular module with self leads for dip-soldering on printed circuit boards. Another 1-megacycle sub-group is packaged on 4½"x5" glass epoxy printed circuit cards which mate with standard connectors.

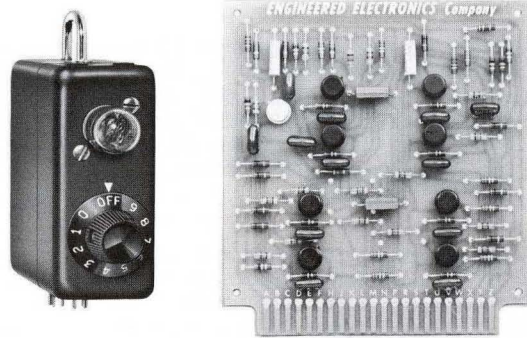
One 10-megacycle sub-group is available in the rectangular welded package only and another 10-megacycle sub-group is available in printed-circuit-card configuration only.



G-SERIES EXTENDED SERVICE DIGITAL CIRCUIT MODULES

The G-Series is a complete family of high quality, low-cost digital circuits on cards. Designed for either synchronous or non-synchronous applications, these units operate at frequencies up to 10 Mpps.

This family consists of four compatible sub-groups of circuits; sub-groups which operate at frequencies up to 10 Mpps, 5 Mpps, 1 Mpps, and 100 Kpps respectively. Each sub-group contains the necessary circuits to provide an attractive price advantage to the system designer... it is not necessary to pay for higher frequency capability than is necessary for each system or portion of a system.



TRANSISTOR DECADE COUNTERS (N-SERIES)

N-Series Plug-In Decade Counters feature high-operating speed, simple power requirements, and three types of read-out. The three types of readout are: (1) a vertical display using ten incandescent lamps, (2) an in-line display using a NIXIE Tube, and (3) a remote projection-type display. All counters in the N-Series family are completely compatible with the T-Series Digital Plug-In Circuits.

These Decade Counters are also available in circuit board form.



MINISIG® INDICATORS (R-SERIES)

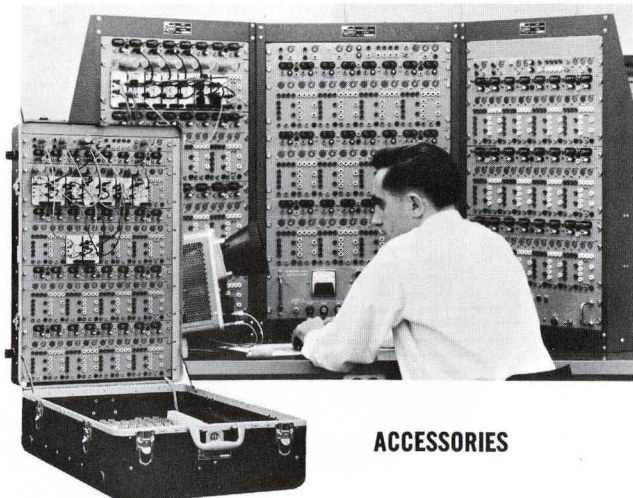
R-Series Minisig Indicators are sensitive indicator devices used to indicate the state of a flip-flop or storage element. Most Minisig indicators incorporate a driver circuit in order to give on-off indications where the signal excursion or power output is too small for direct operation of neon or incandescent lamps, and can, therefore, be used effectively in systems designed for small signal excursions.

These indicators are available in a variety of models including neon-type, filament-type, high-temperature-type, and thyratron-type units. Most models have adjustable operating characteristics controlled by external bias voltage to accommodate a wide range of input signal conditions.



ROTARY THUMBWHEEL SWITCHES AND ASSEMBLIES

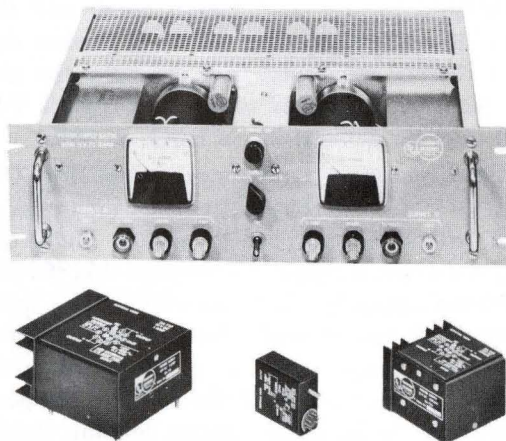
EECoSWITCH Modules are manually operated rotary switches that couple direct readout with coded electrical outputs. A variety of modules provide for decimal, BCD-coded, or other coded outputs. Assemblies of these modules are also available and different models provide either front-mounting or back-mounting and easy module replacement from the back or from the front of the assembly.



ACCESSORIES

System Breadboard Equipment (H-Series) — This integrated system of pre-wired panels is used for rapid breadboarding of electronic assemblies and for classroom training. There are two types of panels... suitcase-enclosed and rack-mounted. Rack-mounted panels can be worked in combinations to breadboard a complete digital system; suitcase-enclosed panels are used to demonstrate small portions of systems. H-Series Breadboards can be used with T, N, U, K, and M Series modules. Plastic Circuit Cards, printed at breadboard scale, facilitate rapid system breadboarding, visualization, and cost estimation. A second kind of System Breadboard Equipment accommodates EECo G-, CT-, and UC-Series circuit cards and can be used at clock frequencies up to 10 Mpps. Features include; 1.) fast set-up of trial circuit combinations, 2.) combinations can be tested at operating frequencies, and 3.) a "stop-action" look at overall logic flow is available at all times.

Transistorized Power Supplies (ZA-Series) — The ZA-Series is a family of 12-volt modular power supplies which provide regulated power for the transistor digital circuit modules. These solid-state power supplies feature low output impedances and excellent regulation. Output current capabilities range from 100 milliamperes to 5 amperes.



Other Related Hardware — As a service to its customers, EECo makes available a large line of circuit-card hardware, sockets, and hold-down hardware for plug-in units, and a variety of styles of chassis. Also, additional accessories for the System Breadboard Equipment such as patch cords, plastic circuit symbol cards, etc., are available at modest cost.

MINIWELD® SYSTEM CIRCUITS (K-and-L SERIES)

Highly developed welding and matrix methods pack up to 40 components into one L-Series module which occupies less than 2.5 cubic inches. There are 152 compatible modules in the L-Series.

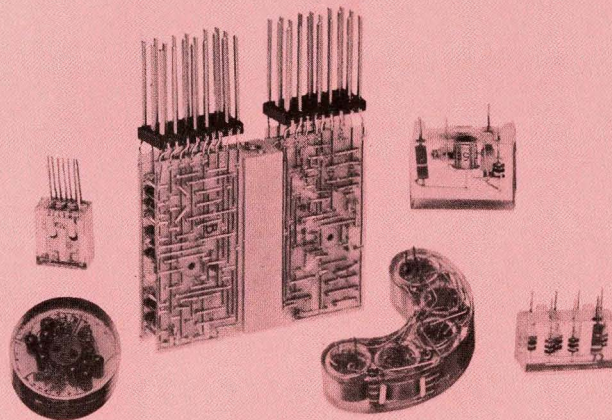
K-Series units are economical breadboard versions of the more-expensive welded L-Series modules. A careful analysis of various systems requirements provided EECo with the ability to generate only 14 types of these K-Series units which enable economical breadboard simulation of all 152 L-Series modules. Use of K-Series units permits breadboarding a complete system or any portion of a system without expensive "prototype system" expense.



SPECIAL AND CUSTOM CIRCUITS

We invite quotation requests to produce special units tailored to your specific needs. Because of our experience in package design and assembly methods, we can produce these specials at a cost favorably comparable to the cost of producing an equal number of standard items. Prices on your special circuits can be estimated within 15% to 25% by comparing your circuits to similar circuits in the EECo catalog. When quotations are requested, or when orders are placed on an "advise-price" basis, the following information is required:

1. Circuit schematic.
2. Bills of Materials with:
 - Transistor, tube, or diode types.
 - Resistor values, tolerances, wattages, and temperature coefficient.
 - Capacitor values, tolerances, voltages, and temperature coefficient.

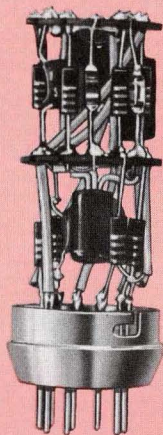


PACKAGING OF CUSTOM WELDED CIRCUITS

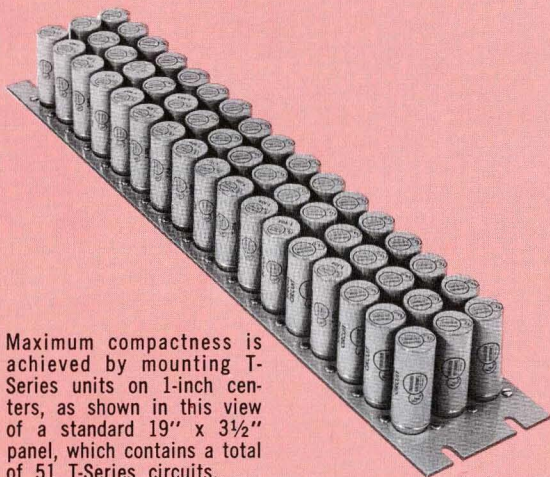
EECo has complete facilities for production packaging of welded circuits. We maintain a staff of packaging engineers, a metallographic lab and a plastic chemistry lab to assist you in custom packaging of your circuits.



Typical T-Series plug-in package, actual size.



Typical T-Series construction details, actual size. (Patent #2986675)



Maximum compactness is achieved by mounting T-Series units on 1-inch centers, as shown in this view of a standard 19" x 3 1/2" panel, which contains a total of 51 T-Series circuits.

T-SERIES transistor circuit plug-in digital modules

general family information

The T-Series is a family of transistorized digital circuits for service in compact systems and equipment.

Featured in the T-Series are:

1. Compatible, standardized signal levels.
2. Consistently conservative electrical specifications.
3. Standard package outline.
4. Simple power requirements.
5. Electrical compatibility with N-Series Decades and R-Series Minisig[®] indicators.
6. Choice of repairable modules, encapsulated modules for industry, and encapsulated modules for military applications.

In general, circuit design is based on *saturated* operation of the transistors involved, except where fully reliable performance can be achieved using *unsaturated* operation. Each circuit design is based on derated specifications for the components used; and the resulting circuit specifications are then further derated to give reserve reliability. (For example, the guaranteed operating frequency range of a typical T-Series circuit may be derated by as much as 50%.)

The usual *operating* temperature range for T-Series circuits is -45°C to $+65^{\circ}\text{C}$, with variations as noted on the individual specification sheets. Many circuits will operate over a range of -54°C to $+71^{\circ}\text{C}$. *Storage* temperature range is -55°C to $+75^{\circ}\text{C}$. The specifications for each circuit apply throughout the operating temperature range, and are guaranteed *minimum* specifications. As a result, if the ambient temperature is stabilized, the frequency range, loading capability, etc., of the circuits involved will generally be improved.

T-Circuits are also available in potted (TE) and circuit-card (CT) forms as well as with military components (TM) or military-equivalent components (TA). Delivery time for these special configurations is determined, to a great degree, by accessibility of parts. However, EECo maintains a bonded stockroom of MIL parts and long-delivery-time problems are rare. Prices for TM, TA, and TE units must be quoted by the factory.

POWER CONNECTIONS

Power connections are standardized throughout the T-Series to the greatest degree consistent with the most effective use of the number of pins available. For standard catalog circuits, the following uniform pin connections are used to simplify buss wiring of sockets:

1. In all cases, **without exception:**
Pin 1 = -12 volts DC
2. In most cases, **with typical exceptions** as noted:
Pin 6 = 12 volt common

EXCEPTIONS:

PNP emitter followers and DC Logic units require both a +12 volt DC and a -12 volt DC supply in contrast to other units, which require -12 volts DC only. On these units:

Pin 6 = +12 volts DC
(Examples: PNP emitter followers T-111, T-112, and T-113; DC Logic units T-404, T-405, T-406, and T-407.)

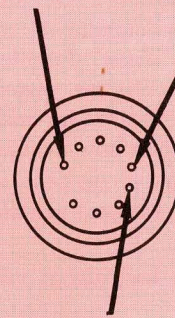
3. In some cases:
Pin 5 = +12 volts DC
(Example: Pulse "And" Gate T-410A.)

PART NUMBERING SYSTEM

T-Series part numbers are coded according to number of connector pins and circuit function. All catalog units have 3-digit part numbers; 4- and 5-digit numbers are used only for special and custom units. The numbering system for T-Series units is as follows:

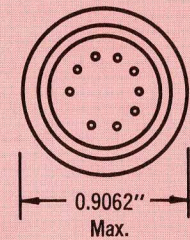
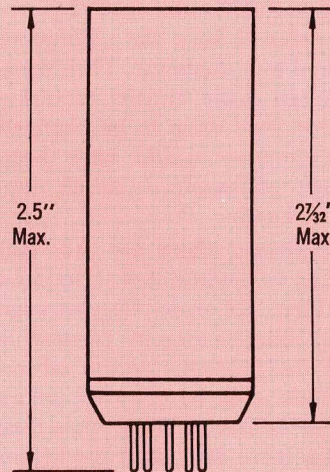
Number	Socket	Circuit Type	Max Oper Freq
T-100	9-pin	Active	250 Kc
T-300	9-pin	Active & Logic	1 Mc
T-400	9-pin	Logic	250 Kc
T-600	13-pin	Active & Logic	250 Kc
T-800	13-pin	Active & Logic	1 Mc
T-900	—	Hardware	—

Pin 1:
-12 volts DC
(ALL Standard units).

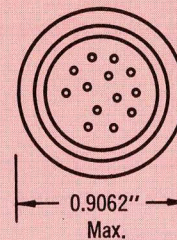


Pin 5:
a. Miscellaneous on most units (set, input, output, tie point, etc.).
b. Unused on some units.
c. +12 volts DC on some units, e.g., Pulse "And" Gate T-410A.
d. 12-volt common on some units, e.g., DC Logic T-407.

Pin 6:
a. 12-volt common on most units.
b. +12 volts DC on some units, e.g., PNP emitter followers and DC Logic units.
c. Signal connection on some units.



End view of typical 9-pin T-Series unit. Mates with standard 9-pin miniature noval socket. Standard miniature tube hold down hardware may be used.



End view of typical 13-pin T-Series unit. Mates with standard 14-pin miniature socket with pin 10 blanked for keyway orientation (EECo Part No. T-937). Standard miniature tube hold down hardware may be used.

OUTLINE DRAWINGS

T-SERIES DESIGN PHILOSOPHY

EECo T-Series circuits are designed to accommodate "worst case" situations where each component can deviate to the limit of its tolerance in the "worst" direction and at extremes of temperature. The circuits are tested at the temperature extremes both in breadboard and final evaluation states to assure that all specifications are met.

The use of ± 12 volts was a matter of decision and compromise. These power levels were selected because of the following advantages:

- A good safety factor for the breakdown voltages of the transistors used.

- A good compromise between high voltage and good signal level, resulting in a good signal-to-noise ratio.

- The low end of aircraft 28 volt supply tolerance is 24 volts (which is easily separable to ± 12 volts). Our units will work on ± 14 volts with only slight changes in specifications.

- The units can work from standard automobile or marine battery voltages.

"True" and "false" levels of -3VDC and -11VDC respectively were selected in order to keep the number of power supply voltages required to a minimum. With these levels, it was possible to design many circuits requiring only one power supply. If one level were to be clamped at 0 volts, more elaborate circuitry would have been necessary and another design philosophy — circuit simplicity — would have been violated.

As with most engineering decisions, there are pros and cons regarding use of saturated vs. unsaturated techniques in the design of our units. First, the major disadvantage of saturated operation is that charge (minority carriers) is stored in the base region of the transistor during saturation and these minority carriers must be removed before the transistor can come out of saturation. This takes time and makes saturated operation more difficult at the higher frequencies. The stored base charge rating of the transistor then becomes a critical parameter. However, advantages of saturated operation are:

- Simplicity of circuit design.

- Well defined voltage levels.

- Fewer parts required than in non-saturating circuits.

- Lower transistor dissipation when conducting.

- Immunity to short stray voltage signals.

- Less dependence on transistor parameters.

For these reasons, most of our T-Series circuits are designed for saturated operation.

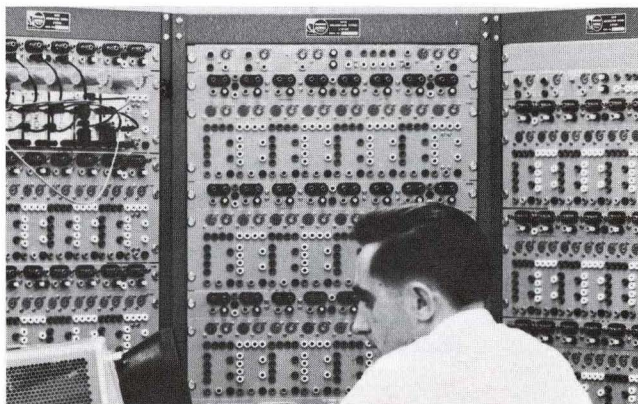
DIGITAL SYSTEMS BREADBOARD KIT

The EECo Breadboard Kit for use with plug-in circuits is a powerful systems-design tool for the engineer, and also is valuable as a training and educational aid. The breadboard panels have the necessary permanent wiring to accommodate any regular circuit and all other circuit interconnections are made by patch cords or plugs. Therefore, no soldering is needed, and experimental arrangements of T-Series units can be quickly set up, changed, or taken down without waste of time or materials.

The breadboarding system is designed around plastic circuit cards with circuit symbols showing input and output connections, power connections, part number, application notes, etc. These cards fit on the panel below sockets for the plug-in units, and match a pattern of banana jacks that are permanently wired to pins on the sockets.

Holes in the circuit cards expose the appropriate socket pin connections. Power connections are made by shorting plugs, which also align the cards with the jack pattern and hold the cards in place. Signal connections are made by patching card-to-card in the circuit line-up being tried.

All T-Series units with pin 1 used for -12 volts, whether 9-pin, 13-pin, or special units, can be used on the breadboard panels.



LOANER POLICY

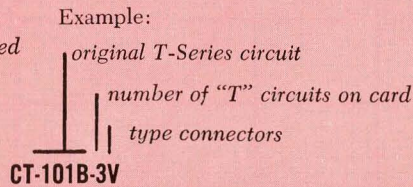
We are prepared to loan you, without obligation, a reasonable quantity of EECo plug-in units for a 30-day trial period.

In order to obtain merchandise on a 30-day loan, send us a purchase order for the required units with a notation on the purchase order that the units are being ordered on a 30-day loan basis. The merchandise will be shipped to you with our regular invoice; terms are net 30 days from date of invoice. When you return the material, please return one copy of our invoice with the material and your account will be credited. You will be charged only for repair of damage to the units caused by misuse, neglect, accident, or improper installation or application. (See our Warranty in the Price List section of this catalog.)

CT NUMBERING SYSTEM

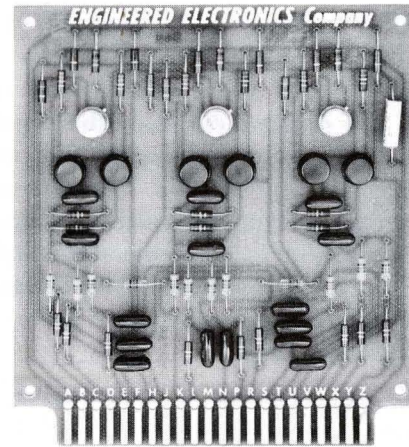
A CT circuit number is the same as the number of its T-Series equivalent. A figure is appended to this figure to indicate the number of "T" circuits on the CT-card. No additional letter is needed for cards with standard tin-plated connectors. A letter is added to indicate other connectors:

V=Varicon
G=Gold-plated
R=Rhodium-plated



CT #	T-SERIES EQUIVALENTS		
CT-101B-3	Three	T-101B	RST Flip-Flops
CT-102A-4	Four	T-102A	T Flip-Flops
CT-104-2	Two	T-104	Multivibrators
CT-106-4	Four	T-106	Squaring Amplifiers
CT-108-2	Two	T-108	Linear Amplifiers
CT-109-4	Four	T-109	Reset Generators
CT-111-9	Nine	T-111	PNP Emitter Followers
CT-114-9	Nine	T-114	NPN Emitter Followers
CT-120-4	Four	T-120	Relay Drivers
CT-121-4	Four	T-121	Relay Drivers
CT-129-4	Four	T-129	Reset Generator
CT-130-3	Three	T-130	Relay Drivers
CT-134-4	Four	T-134	Dual Relay Drivers (8 circuits)
CT-135-4	Four	T-135	Dual Relay Drivers (8 circuits)
CT-136-4	Four	T-136	Dual Inverter (8 circuits)
CT-139-4	Four	T-139	Relay Driver
CT-162-4	Four	T-162	RS Flip-Flops
CT-163-3	Three	T-163	DC Drivers
CT-165-4	Four	T-165	Capacity Drivers
CT-166-4	Four	T-166	One Shot Multivibrators
CT-170-4	Four	T-170	Dual Relay Driver (8 circuits)
CT-171-4	Four	T-171	Dual Relay Driver (8 circuits)
CT-172-4	Four	T-172	Voltage Comparator
CT-302-2	Two	T-302	Capacity Drivers
CT-304-4	Four	T-304	Complementary Symmetry Emitter Followers
CT-306-2	Two	T-306	Squaring Amplifiers
CT-307-4	Four	T-307	Dual Complementary Symmetry Emitter Followers (8 circuits)
CT-411-3	Three	T-411	Pulse "AND" Gates
CT-421A-4	Four	T-421A	Exclusive "OR" Gates
CT-422-4	Four	T-422	Exclusive "OR" Gates
CT-423A-3	Three	T-423A	Dual Exclusive "OR" Gates (6 circuits)
CT-430-4	Four	T-430	Pulse Mixer Amplifiers
CT-434-3	Three	T-434	"AND"/"OR" Gates
CT-437-3	Three	T-437	NOR Gates
CT-439-4	Four	T-439	DCTL "AND" Gates
CT-441-2	Two	T-441	Full Adder
CT-448-2	Two	T-448	Dual Pulse "AND" Gates (4 circuits)
CT-602-2	Two	T-602	Pulse "OR" Gates
CT-605-3	Three	T-605	Shift Register Flip-Flops
CT-606-2	Two	T-606	Shift Register Flip-Flops
CT-610-3	Three	T-610	Shift Register Flip-Flops
CT-628-2	Two	T-628	Code Converter
CT-633-2	Two	T-633	RST Flip-Flops
CT-641-2	Two	T-641	Dual DCTL "AND" Gates (4 circuits)
CT-642-2	Two	T-642	Dual DCTL "OR" Gates (4 circuits)
CT-643-2	Two	T-643	RST Flip-Flops
CT-645-2	Two	T-645	DCTL NOR Gates
CT-650-2	Two	T-650	Dual DCTL "AND" Gates (4 circuits)
CT-651-2	Two	T-651	Dual DCTL "OR" Gates (4 circuits)
CT-801A-2	Two	T-801A	Gated Flip-Flops
CT-802-2	Two	T-802	Dual DCTL "AND" Gates (4 circuits)
CT-805-2	Two	T-805	Dual Exclusive "OR" Gates (4 circuits)

CT-Series Digital Circuit Card Modules



EECO's CT-Series of modules are basically T-Series germanium transistor circuits mounted on circuit cards. They enable additional economy for certain types of installations. These CT-Series circuits are well proved through past T- and CT applications and additionally represent the specific circuits that have proved most efficient in the voluminous T-Series applications.

Specifications for CT modules are identical to the corresponding T-Series modules (See "T-Series Equivalents") except the CT-Series Operating Temperature range is -20°C to $+50^{\circ}\text{C}$, and the power requirements are a multiple of the number of circuits per card.

CT circuits are wired with 2-mil copper bonded to etched $4\text{-}1/2'' \times 5'' \times 1/16''$ epoxy cards. Standard connectors are tin-plated, with optional Varicon, gold-plated, and rhodium-plated connectors available if specified. Card files, guides, connectors, and other hardware available for this series are described in the Related Equipment section of this catalog.

CT-Series modules can be used with card files, card drawers, and other hardware suitable for the $4\text{-}1/2'' \times 5'' \times 1/16''$ cards. The hardware shown in the hardware section of this catalog is specifically recommended and can be ordered from EECO, using the "H" part numbers listed in the Price List section of this catalog. For the convenience of companies supplied directly by the manufacturer, the manufacturers' part numbers are shown (in parenthesis).

LOADING INFORMATION

Individual unit specifications list input load characteristics in terms of arbitrary units, and output drive capabilities in terms of reference curves. This section of the catalog contains these reference curves, an explanation of how to use them, and other significant information to assist the digital system designer. An important point to remember is that these curves were generated for various typical operating frequencies with units operating at room temperature and with system power at 12 volts. Some derating is necessary at extremes of temperature or if system power varies over the specified tolerance.

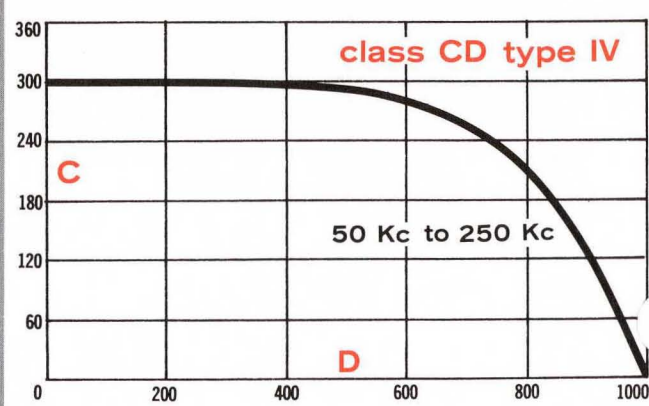
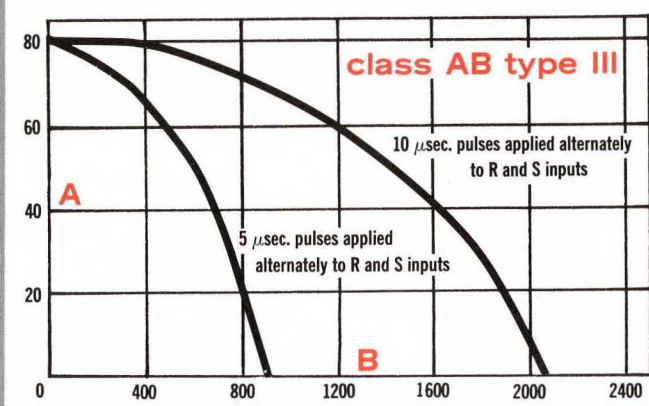
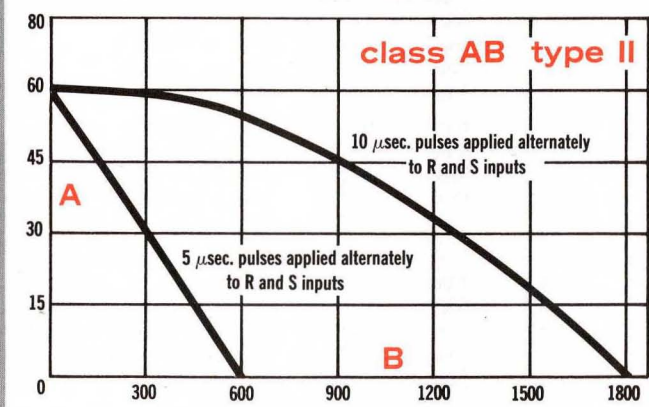
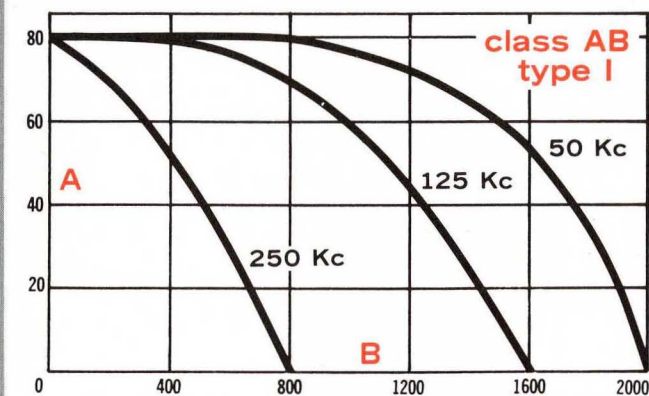
All T-Series circuits, depending on type of output, have one of three types of drive characteristic; AB, CD, or EF. All units with PNP-common-emitter output stages exhibit AB drive characteristics; units with PNP-emitter-follower output stages have CD drive characteristics; and, T-Series units with NPN-emitter-follower output stages have EF output drive characteristics.

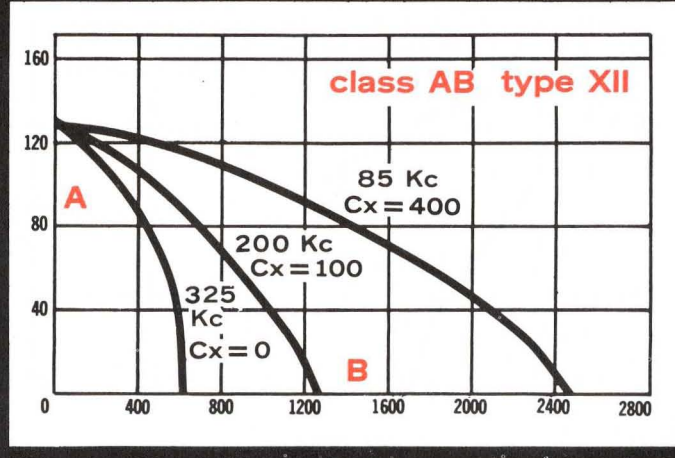
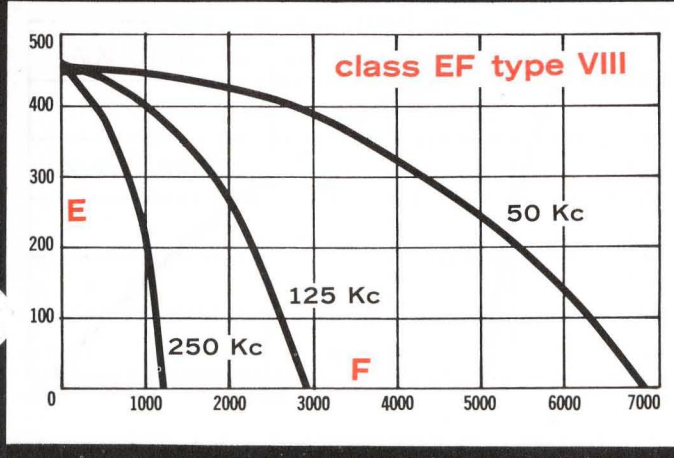
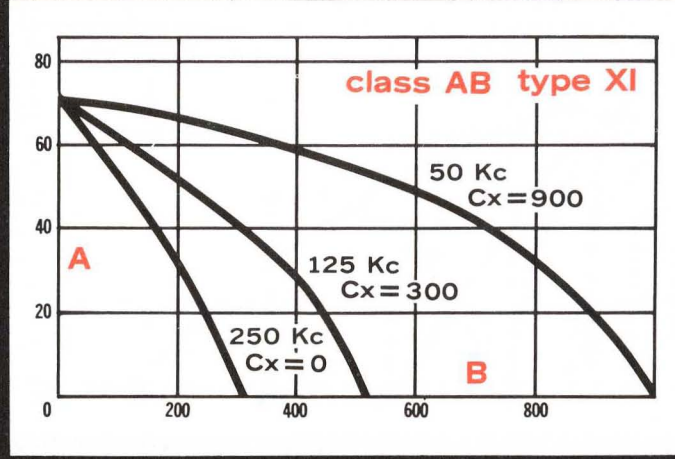
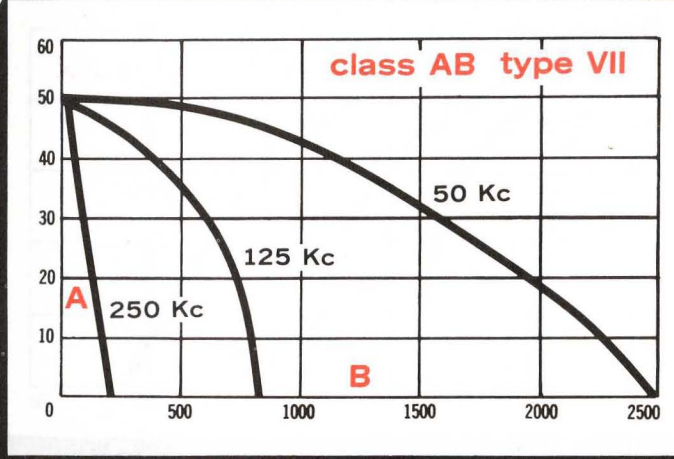
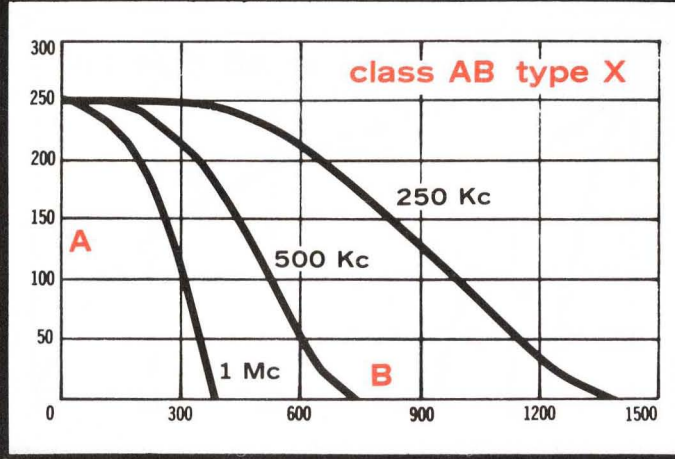
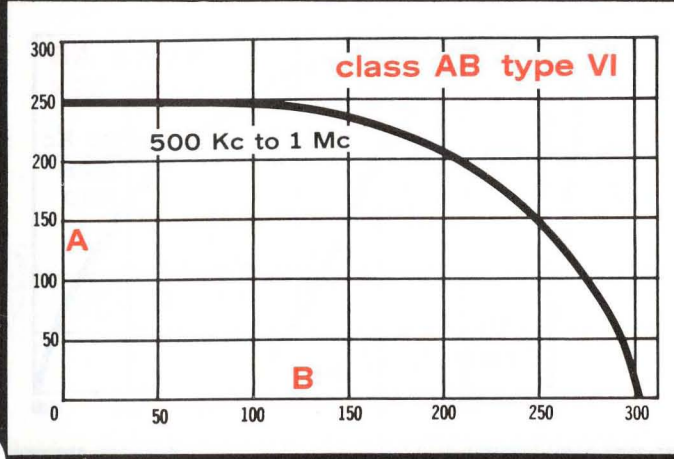
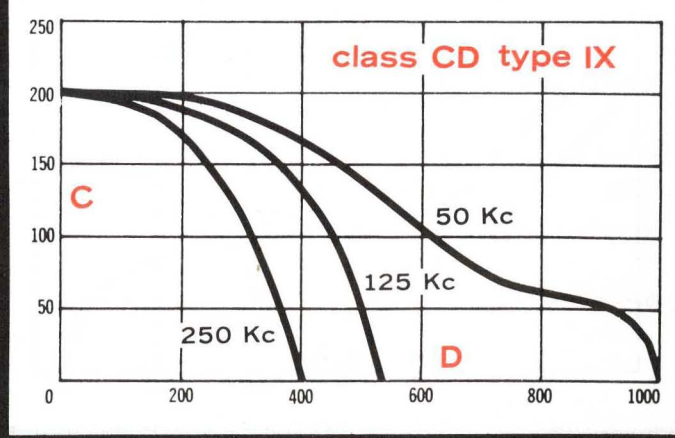
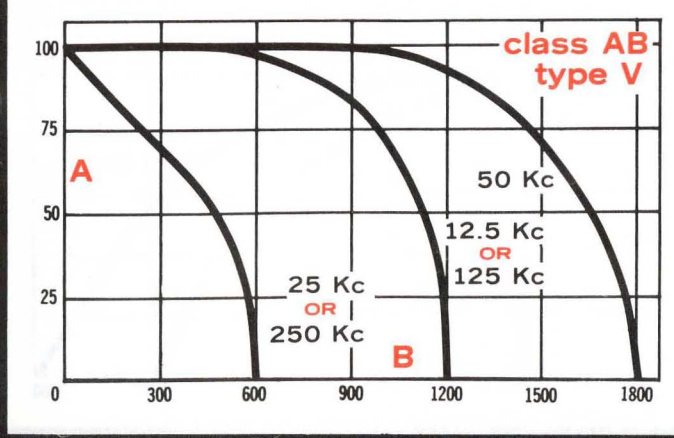
Similarly, T-Series units have three sets of input load characteristics; A & B, C & D, and E & F. **The input characteristic to be used in a given system application depends on the drive characteristic class of the circuit used as a driver.** AB drivers will "see" A and B input characteristics; CD drivers will "see" C and D, etc. If a given type AB driver is to drive a variety of other circuits, then all the A input characteristics of the driven circuits should be added algebraically and all the B characteristics of the driven circuits should, similarly, be added algebraically. The total A's and B's are then located on the reference curve for the driver and, if the AB coordinates are within the maximum shown on the chart, the driver will drive the circuits.

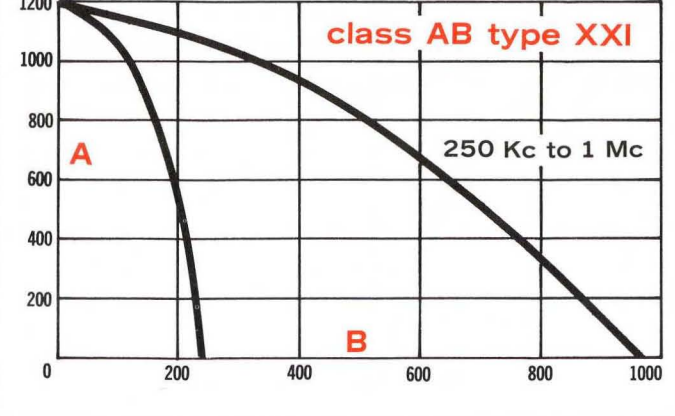
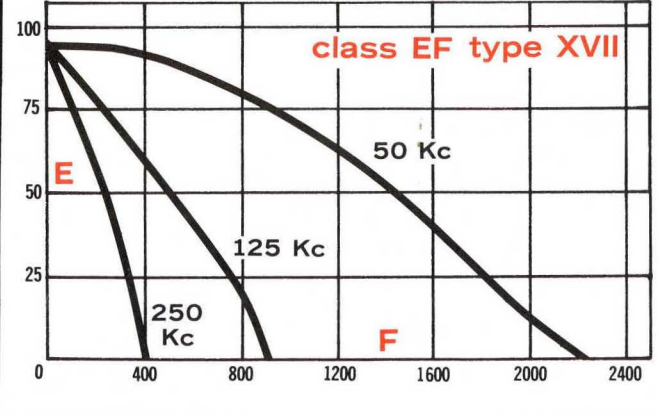
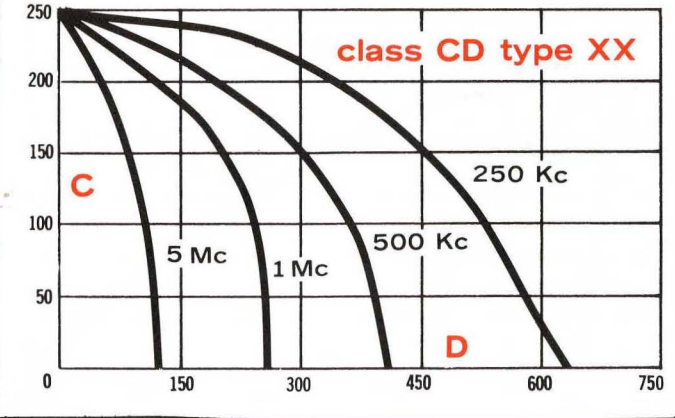
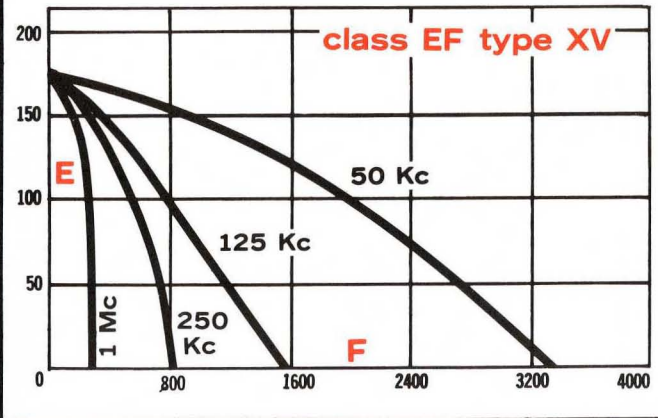
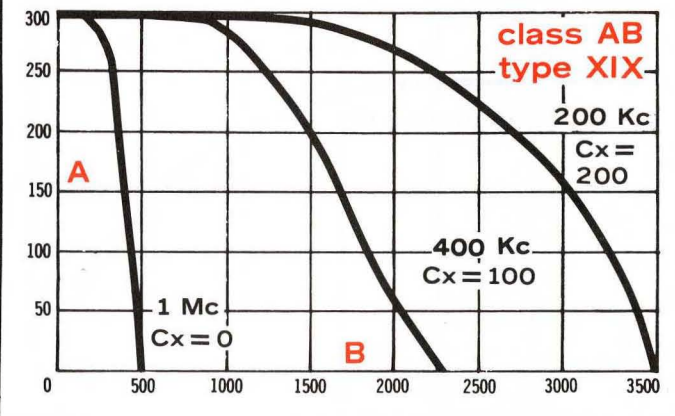
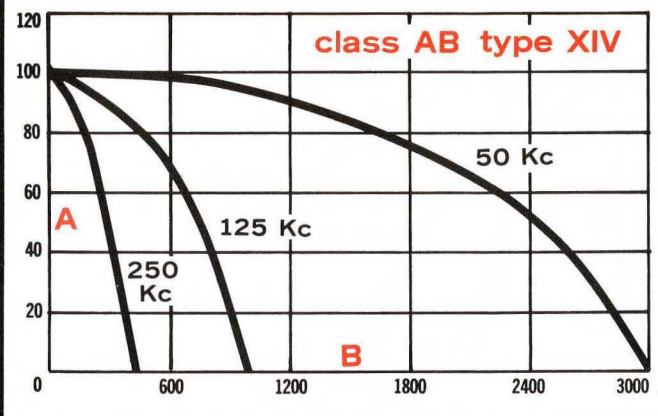
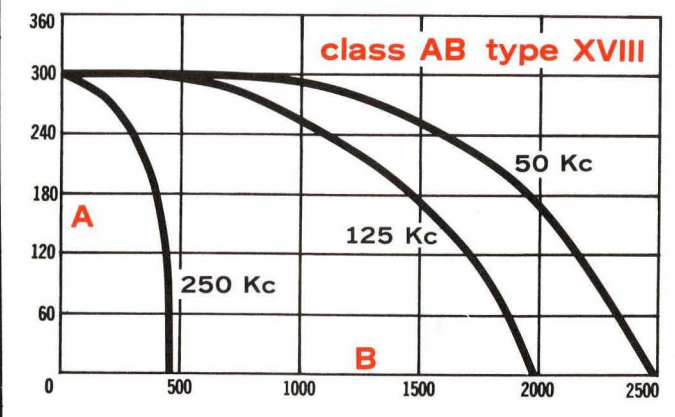
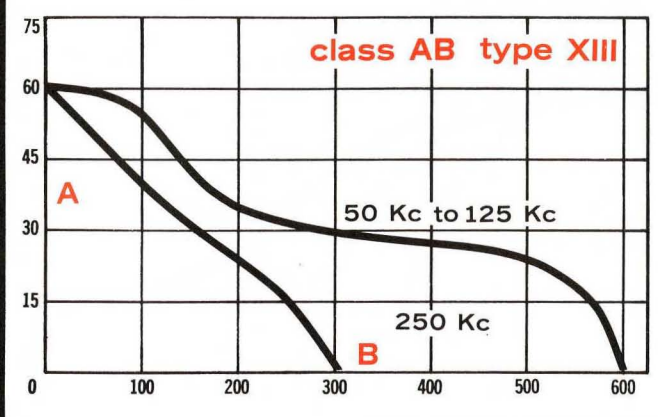
For example, consider the case where a T-101B flip-flop being triggered at 250Kc is to trigger four other T-101B flip-flops. Since the T-101B, in a T mode of operation, is an AB type I driver, the A and B input characteristics of the driven circuits must be summed. A=10 and B=100 for a single T-101B flip-flop, hence four T-101B's represent a total A load of 40 and a total B load of 400. Application of these AB values as coordinates to the drive characteristic curve AB Type I reveals that a T-101B being triggered at 250Kc can reliably trigger four other T-101B's.

Consider another case where a T-109 Reset Generator is to Reset 10 other T-101B Flip-Flops. The T-109 Load Drive Characteristics indicate AB Driver Max. A = 150 and Max. B = 200. The T-101B direct inputs A and B are A = 10 and B = 0, for a single T-101B Flip-Flop; hence, 10 T-101B's represent a total A-load of 100 and a total B-load of 0. The total value of A = 100 is below the maximum A = 150 value called out under the T-109 Load Drive Characteristics; therefore, the T-109 will Reset 10 T-101B's reliably within the specified frequency range.

Circuit loading is also influenced by stray capacitance. In cases where a number of circuits are driven by a common driver, lead length should be kept within reasonable dimensions.







USE OF EMITTER FOLLOWERS

Emitter followers are used to increase the load-driving capability of the drive unit or to provide better circuit isolation between the drive unit and the load unit. PNP emitter followers such as T-111 are generally used to drive DC logic or other resistive loads. When driving capacitive loads (one that has a capacitor in series with its input and therefore requires a pulse to drive it) with PNP emitter followers, connect a 5.6K Ω resistor from the output of the emitter follower to the +12 volt supply. This is done to lower the output impedance of the emitter follower for positive-going signals and, thus, increase its driving ability for positive pulses.

NPN emitter followers such as T-114 are generally used to drive capacitive loads because they have a minimum output impedance for positive pulses or positive-going signals. They are also good for driving control inputs of Pulse "And" gates and control inputs of Shift Registers and Gated flip-flops.

Use of an emitter follower will increase the load-driving capability of a given driver by a factor of 2 to 2.5. Of course this does not apply if the driver already has an integral emitter follower.

EXAMPLES:

Frequency	Drive Unit	Emitter Follower	Permissible Load
250Kc	T-101B	NONE	4 T-102A
250Kc	T-101B	T-114	8 to 10 T-102A
250Kc	T-104	NONE	2 T-106 (Direct Input)
250Kc	T-104	T-111	4 T-106 (Direct Input)

One note of caution: When the emitter follower being driven is, in turn, used to drive DC logic or control inputs of pulse logic, lighter loading is most desirable so that the driving circuit output levels will not be detrimentally lowered in amplitude. Consider, for example, the case where a heavily loaded unit with a 6 volt output and a lightly-loaded unit with an 8 volt output are both connected into the same logic circuit. In this case, it is possible to get an undesired 2 volt pedestal which may trigger succeeding circuits.

Input circuit differentiation can be accomplished in a conventional fashion with a series capacitor and a resistor returned to a bias of proper value to establish the quiescent output voltage. When this is done, care should be taken to keep operating conditions within the maximum signal amplitude allowed.

LOADS ON BOTH OUTPUTS OF FLIP-FLOPS

When the drive unit is a flip-flop without an emitter follower built in on the output, the drive capability shown on the drive characteristic curve is the total combined load that can be driven by both outputs of the flip-flop. This total load can also be driven by either output singly.

USE OF PULSE "AND" GATES

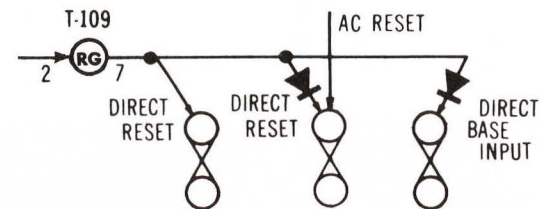
Pulse "And" Gates such as T-410A and T-630 are not recommended as loads for CD drivers because of rise-time deterioration. Additionally, due to low output amplitudes, Pulse "And" Gates are poor driving units and should be used to drive flip-flops only. These flip-flops will then, in turn, have only half of their normal driving ability. For example, the usual permissible load for a T-101B is 4 T-102A's but, when the T-101B is driven by a T-410A, the driving ability of the T-101B is reduced to 2 T-102A's; one-half its normal driving ability.

USE OF RESET GENERATORS

Reset Generator T-109 is used for **direct set** (when this terminal is available) or **direct reset** of flip-flops. With a nominal -3VDC applied at the input of the T-109, the output of the T-109 is approximately 0VDC; the level used for resetting. When a T-109 is connected to direct reset inputs of flip-flops and -3VDC is applied to the T-109, pin-8 outputs of the flip-flops will be held at -3VDC. However, if trigger pulses are applied to the flip-flops while they are being held reset, pulses may appear at the pin-7 outputs and detrimentally trigger subsequent circuits.

When T-109 is used to reset flip-flops at **direct base inputs**, an external diode must be used to isolate the relatively low output impedance of the T-109 from the unit being reset at times other than "reset time." Connect the cathode of the diode to the base input and the anode of the diode to the T-109 output. This diode is internal on units which have direct reset inputs.

If the direct reset input is used in **addition** to the AC reset input, then it is necessary to use an isolating diode between the T-109 output and the AC reset of these units. Otherwise, a pulse at the AC reset input will "see" a low-impedance path through the T-109 and not trigger the flip-flop properly.

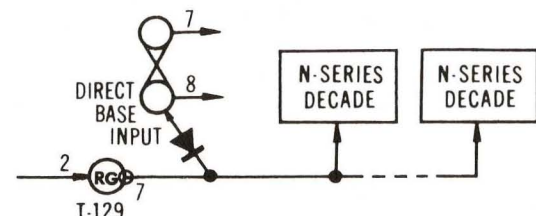


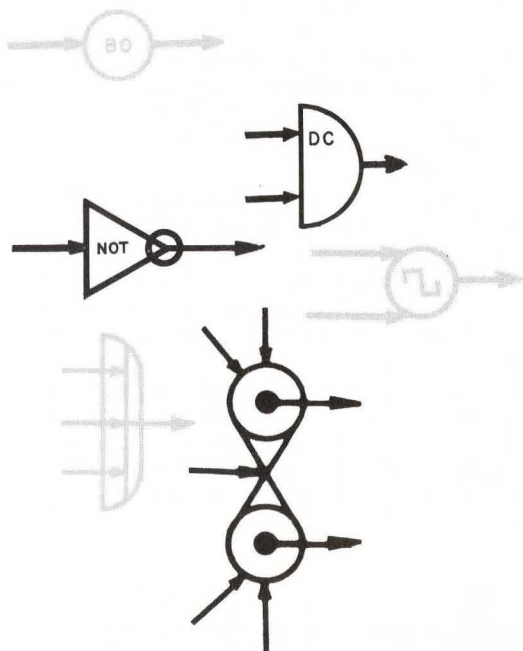
Reset Generator T-129 is designed to reset N-Series Decade Counters; a -3VDC input to T-129 causes approximately -4VDC out of the T-129. This -4VDC is the level used for resetting N-Series units.

CAUTION

When resetting less than 3 decades or less than 10 flip-flops, connect a 1K Ω resistor in series with the output of the T-129. This resistor is necessary to limit the reset current for light loads.

T-129 can also be used to reset flip-flops which have direct base inputs. In this case, connect a diode between the output of the T-129 and the base input of the flip-flop with the cathode of the diode connected to the T-129 (this diode is internal in the decades). Now, a -3VDC input to the Reset Generator causes the pin-7 output of the flip-flop(s) to be held at -3VDC. (Note that this is the opposite of what happens when T-109 is used.) Once again, if trigger pulses are applied to the flip-flop(s) while they are held reset, pulses may result at the pin-8 output and detrimentally trigger succeeding circuits. T-129 will hold N-Series decades reset even with pulses going into the trigger input of the decade but, if the decade has code outputs, the first stage output will show effects similar to those experienced with T-Series units.





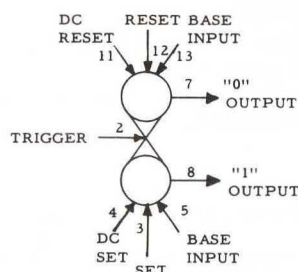
CIRCUIT SYMBOLS

Our system of circuit symbols is designed to provide rapid identification of circuit functions; to show direction of signal flow; and to accommodate combinations of circuit symbols in a logical manner for purposes of indicating internal gating, gradations of drive ability, etc. Use of these symbols will give a full measure of benefits:

1. Engineering sketches made with these symbols are essentially equipment schematics, so design changes are simplified and final drafting is materially speeded up.
2. Technicians familiar with these symbols can expedite their construction and repair work.
3. Draftsmen using these symbols can produce final drawings at reduced cost. (Symbol templates are available as a further drafting aid.)

The following paragraphs define the symbols used in literature and drawings produced by the Engineered Electronics Company. Signal connections to each symbol are numbered to correspond with pin connections on the module. Internal connections can be determined, if desired, by reference to specification sheets in the catalog. Specification sheets are quickly located by referring to circuit symbols and circuit numbers printed next to the circuit schematic.

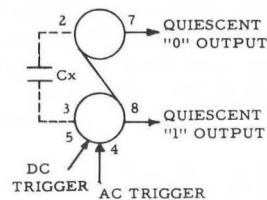
BISTABLE ELEMENTS — Flip-flops are symbolized as shown below. The two circles represent the two active circuit elements. The various inputs enter the symbol in a manner which represents how they affect the circuit. For example, an 8-volt positive-going pulse or voltage step applied to pin 12 resets the flip-flop; the "1" output (pin 8) rises to -3 volts and the "0" output (pin 7) falls to -11 volts. Once the flip-flop is in a reset state, any further reset inputs do not affect the flip-flop. An 8-volt positive-going pulse or voltage step applied to pin 3 sets the flip-flop; the "1" output falls to -11 volts and the "0" output rises to -3 volts. Positive pulses or voltage steps applied to the trigger input (pin 2) cause the pin-7 and pin-8 outputs to change level; if the flip-flop is in a set state, a pulse at pin 2 resets the circuit; if the flip-flop is in a reset state, a pulse at pin 2 sets the circuit.



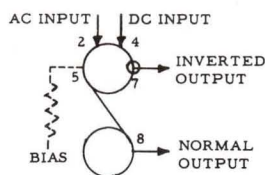
NOTE: Throughout this book, where input signals are identified as "pulse," the signals can be replaced by voltage steps when the input terminal is AC-coupled. In other words, AC-coupled inputs will generally differentiate the input signal.

If a given flip-flop has a direct-coupled input, the input lines are slanted from the left side of the symbol as shown at pin 4 (d-c set) and pin 11 (d-c reset). If a given flip-flop has an input connection direct to the base of one of the flip-flop transistors, the input lines are slanted from the right to the symbol as shown at pins 5 and 13.

MONOSTABLE ELEMENTS — One-Shots and Squaring Amplifiers are symbolized as shown. The two circles again represent the two active circuit elements but only one line joins the circles. In the case of the one-shot, an external capacitor connection is required and is thus shown in dotted lines. The two one-shot outputs are identified in terms of their untriggered state. That is, the pin-8 output rests at -3 volts and the pin-7 output rests at -11 volts. When a trigger pulse is applied at either pin 4 (a-c trigger) or pin 5 (d-c trigger), the pin-8 output falls to -11 volts and the pin-7 output rises to -3 volts for a period of time equal to the RC time constant of the circuit. At the end of this time, both outputs return to their quiescent level.

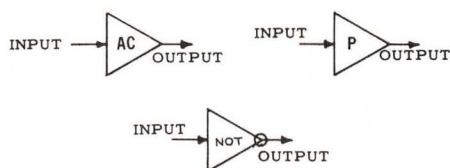


The squaring amplifier is a modified Schmitt trigger circuit which remains in one output state until the input exceeds a trigger level. When this level is exceeded, the circuit rapidly switches to a second output state and remains in this second state until the input voltage falls below the trigger level. Two opposite-state outputs (pin 7 and pin 8) are generated. When the circuit is in an untriggered state,



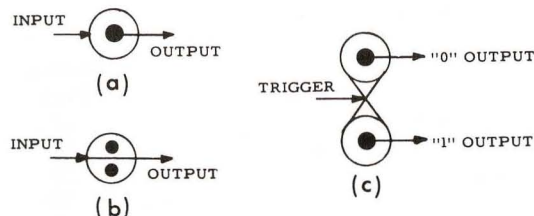
the pin-8 output rests at -11 volts and the pin-7 output rests at -3 volts. When the circuit is triggered by a positive-going voltage, the pin-8 output rises to -3 volts and the pin-7 output falls to -11 volts. The small open circle at output pin 7 represents the fact that this output is essentially an inversion of the pin 2 or pin 4 input. An external bias voltage applied at pin 5 can be used to control the threshold level at which the circuit is triggered and is thus shown in dotted lines.

AMPLIFIERS AND INVERTERS — Amplifiers and Inverters are represented by equilateral triangles pointed in the direction of signal flow. The exact function of any given device is indicated by markings within the triangle. For example, AC indicates an a-c amplifier, P indicates a pulse amplifier, NOT indicates a logic inverter, etc.



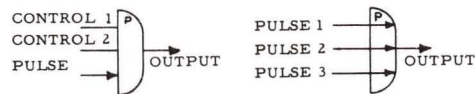
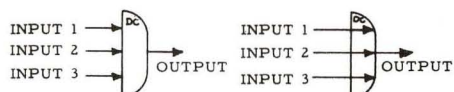
Where applicable, inversion is indicated by a small circle superimposed over the output as shown with the logic inverter symbol.

EMITTER FOLLOWERS — NPN and PNP emitter followers are represented as shown in (a) below. Note that no discrimination is made between the two types. Complementary emitter followers, which are a paralleled combination of NPN and PNP transistors, are symbolized as shown in (b).



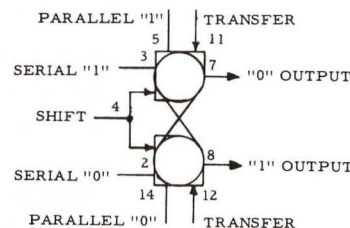
Frequently emitter followers are incorporated as an integral part of a circuit module in order to provide greater drive capability. In this case, the emitter follower symbol is combined with the particular circuit symbol in question. A flip-flop with integral emitter follower outputs is shown in (c) above.

LOGIC ELEMENTS — “Or” and “and” gates are represented by a semi-ellipse. Input signal lines terminate at the major axis of the ellipse to represent an “and” gate and are carried into the symbol terminating at the convex side to represent an “or” gate. Output lines contact the center of the convex side.

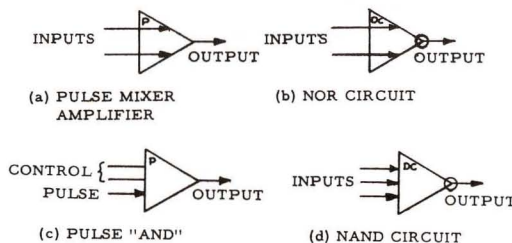


Note that a discrimination is made between d-c gates and pulse gates. The letters DC and P are used to designate the two types of gate and, in addition, control inputs to a pulse “and” gate do not have any arrowheads.

COMBINED SYMBOLS — If a circuit module consists of a combination of basic circuits, the basic symbols are synthesized to show this combination. For example, a gated flip-flop containing 4 integral pulse “and” gates is shown below. These gates are represented by a box enclosing the affected element of the flip-flop. The circuit shown is useful as one element of a shift register where parallel-form data is gated into the register by transfer pulses at pins 11 and 12. If a chain of these flip-flops is used, data from one element can be serially shifted to the next element in the register by shift pulses applied at pin 4.



Another example of combined circuit symbols is the convention used for pulse mixer amplifiers, NOR circuits, pulse “and” gates which contain amplifiers, and NAND circuits. The amplifier symbol is used to represent amplification accomplished by the circuit and the inputs are either terminated at the base of the triangle (“and”) or carried into the triangle (“or”) in a manner similar to that used for logic elements. In the case of NOR (not “or”) and NAND (not “and”) circuits, an open circle is superimposed on the output to represent logic inversion occurring in the circuit.



POWER CONNECTIONS — Power connections are not shown on the circuit symbols. These connections are eliminated for purposes of clarity and simplicity, but may be quickly checked by reference to the specification sheets. In order to simplify bus-wiring of sockets, uniform pin connections are used as previously described, wherever practicable. However, the number of pins required for signal connections varies considerably from unit to unit and, in some cases, the circuit design makes it impossible to reserve pin connections for power. CHECK SCHEMATICS BEFORE WIRING SOCKETS TO AVOID ERRORS AND POSSIBLE DAMAGE TO UNITS.



circuit data section

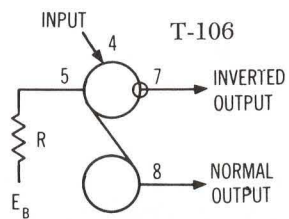
This section contains four specific types of data for each circuit: general description, table of specifications, schematic drawing and symbol.

Units are grouped by circuit type and function and groups are in alphabetical sequence. Location and/or comparison of specific units can be made by the most expedient route for the immediate need: the Table of Contents, which begins on page 2, is arranged according to circuit function and lists key circuit data, such as speed and number of inputs for the Logic Circuits, voltage characteristics for the Relay Drivers, etc. A Cross Index by module number appears on page 3. Finally, the section itself is arranged in alphabetical sequence:

	Starting Page
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Inverters	40
Level Converters	42
Logic Circuits	44
Multivibrators	57
Oscillator	59
Reset Generator	60
Voltage Regulator	61
Bias Supply	61

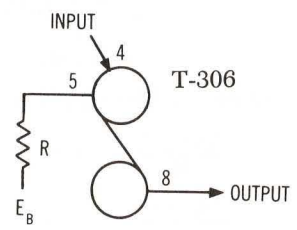
SQUARING AMPLIFIERS

T-106, T-306, T-312



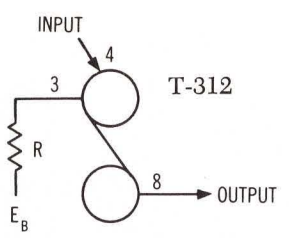
T-106 ONLY

- (1.) $R = \frac{-(E_B + 2.5) \cdot 10}{E_B + 2.5}$
- (2.) $E_1 = \frac{-(E_B + 2) \cdot 10}{R} - 2$
- (3.) $E_2 = \frac{-(E_B + 3) \cdot 10}{R} - 5$
- (4.) When bias supply voltage is positive, the following must be true:
 $1.5 > \frac{(E_B - 9)}{R}$



T-306 ONLY

- (5.) $R = \frac{-(E_B + 3) \cdot 10}{E_B + 6}$
- (6.) $E_1 = \frac{-(E_B + 3) \cdot 10}{R} - 3.5$
- (7.) $E_2 = \frac{-(E_B + 3) \cdot 10}{R} - 8.5$



T-312 ONLY

- (8.) $R = \frac{-(E_B + 3) \cdot 66}{6E_B + 29}$
- (9.) $E_1 = \frac{-(E_B + 2) \cdot 11}{R} - 3$
- (10.) $E_2 = \frac{-(E_B + 3) \cdot 11}{R} - 7$

DESCRIPTION

These units are basically modified Schmitt Trigger circuits which remain in a given output state until the inputs exceed a trigger level. At this time, the circuits rapidly switch to a second output state and remain in this second state until the input signal returns below the trigger level. The trigger level is adjustable by means of a bias voltage applied to pin 5 of T-106 and T-306 and to pin 3 of T-312. For example, in a system using our standard signal levels of -3 and -11 volts, a threshold of -6.5VDC can be established for T-106 by connecting a 47KΩ resistor from pin 5 to +12VDC.

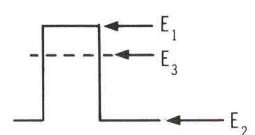
These circuits are typically used for such purposes as waveform restoration, signal level shifting, "Not" circuits, squaring sinusoidal or nonrectangular inputs, pulse amplification and DC level detecting (although they are not as sensitive as T-172 for this latter application).

SIGNAL LEVEL SHIFTING

Squaring Amplifiers T-106 (0 to 250 Kc), T-306 (0 to 5 Mc) and T-312 (0 to 1 Mc) can be used to convert other system signal levels to T-Series voltage levels by applying a suitable bias voltage. This bias voltage adjusts the threshold level of the amplifier to adapt it for use with input signals having minimum amplitudes equal to or greater than the amplitudes called out in unit specifications.

If an input signal is more positive than the most positive level called out and more negative than the most negative level called out, a bias voltage is not required and the units operate around their normal threshold levels. If, however, the input signal excursion does not fall within these limits, a bias voltage is used to select a convenient threshold level. This level should be approximately 1 volt more positive than the mid-point of the input signal for maximum reliability and noise rejection. If the threshold level is to be more negative than -2.5 volts, use a +12-volt bias supply (E_B); if the level is to be more positive than -2.5 volts, use a -12-volt bias supply voltage.

The relationships between bias resistance R (in KΩ), bias supply voltage E_B (in volts), and maximum and minimum input excursions (in volts) are listed in equations (1) through (10) . . . Equations (1) through (4) apply when T-106 is used, equations (5) through (7) apply when T-306 is used, and equations (8) through (10) apply when T-312 is used.



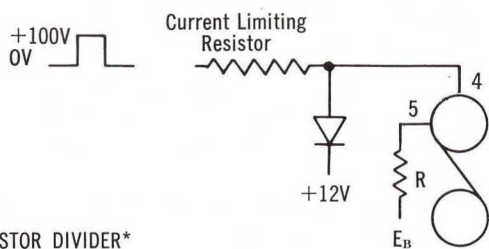
- E₁ = Minimum most-positive excursion of input signal.
- E₂ = Minimum most-negative excursion of input signal.
- E₃ = Threshold Level.

The following paragraphs illustrate two examples of level conversion using Squaring Amplifier T-106.

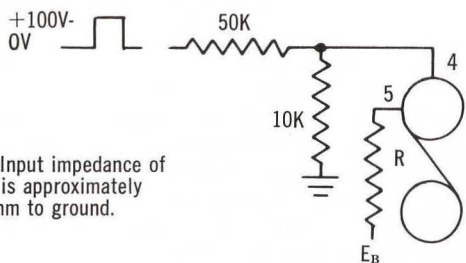
Converting Large Input Signals.

If the input signal has a 20-volt swing or greater, a clamping diode or resistor voltage divider should be used as shown.

DIODE CLAMP



RESISTOR DIVIDER*



*Note: Input impedance of T-106 is approximately 15K-ohm to ground.

In the sample shown, the signal into the T-106 will be approximately 0 volts to +10 volts and a threshold level of +6 volts should be selected. Since the threshold level is more positive than -2.5 volts, a -12-volt bias voltage should be used.

To find the bias resistance (R) required to obtain a threshold of +6 volts, use equation (1):

$$R = - \frac{(E_B + 2.5) 10}{E_s + 2.5} = - \frac{(-12 + 2.5) 10}{6 + 2.5}$$

$$= 11 \text{ K}\Omega. \text{ (Use 12 K resistor)}$$

Check to assure that the signal has enough swing to trigger the T-106. The input signal must swing more positive than E1 and more negative than E2.

$$E_1 = - \frac{(E_B + 2) 10}{R} - 2 = - \frac{(-12 + 2) 10}{12} - 2$$

$$= +6.3 \text{ volts}$$

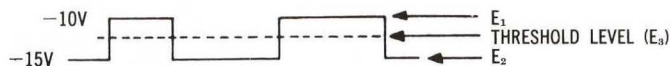
$$E_2 = - \frac{(E_B + 3) 10}{R} - 5 = - \frac{(-12 + 3) 10}{12} - 5$$

$$= +2.5 \text{ volts}$$

Thus, the signal to the T-106 must shift at least from +2.5 volts to +6.3 volts. Since the signal applied swings from 0 v to +10 v, there is more than enough to trigger the T-106.

Converting Small Input Signals.

The same method is used to select bias resistance when small input signals are applied, however, the value of R becomes more critical. For example, assume an input signal which shifts from -15 volts to -10 volts.



Select a threshold level of -11.5 volts (1 volt more positive than the -12.5 volt midpoint of the input signal). Since the threshold level is more negative than -2.5 volts, a +12-volt bias voltage should be used as E_B. Use equation (1) to determine the value of bias resistance required.

$$R = - \frac{(E_B + 2.5) 10}{E_s + 2.5} = - \frac{(+12 + 2.5) 10}{-11.5 + 2.5}$$

$$= 16 \text{ K}\Omega \text{ (Use 15 K resistor)}$$

Using equations (2) and (3), check to assure that the signal excursion is great enough to trigger the T-106.

$$E_1 = - \frac{(E_B + 2) 10}{R} - 2 = - \frac{(12 + 2) 10}{15} - 2$$

$$= -11.3 \text{ volts}$$

$$E_2 = - \frac{(E_B + 3) 10}{R} - 5 = - \frac{(12 + 3) 10}{15} - 5$$

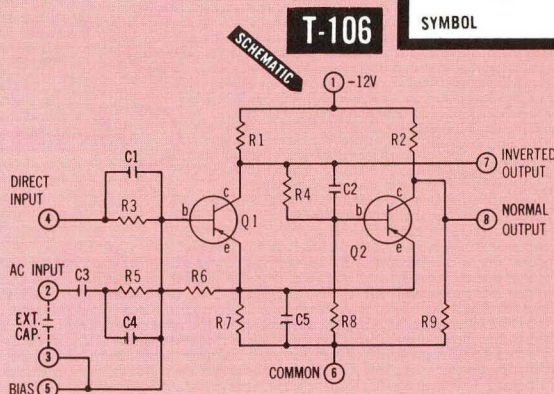
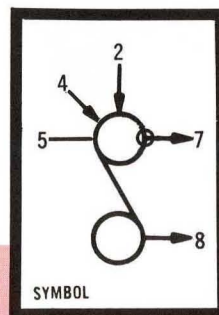
$$= -15 \text{ volts}$$

Since the bias supply is positive, check to see if

$$\frac{E_B - 9}{R} < 1.5$$

$$\frac{12 - 9}{15} < 1.5$$

$$0.2 < 1.5$$



SQUARING AMPLIFIERS	T-106	T-306	T-312
INPUT			
Direct Input			
SIGNAL FREQUENCY RANGE	0 to 500 Kc ††	0 to 5 Mc	0 to 1 Mc
MIN. AMPLITUDE TO CHANGE OUTPUT (level shift)	3V* (—2V to —5V)	5V (—8.5V to —3.5V)	4V (—7V to —3V)
RISE AND FALL TIMES REQUIRED	2 m sec max.	2 m sec max.	0.05 μsec min. 0.3 μsec max.
INPUT LOAD CHARACTERISTICS:			
A, B	25, 100	Pin 3: 65, 0 Pin 4: 40, 100	Pin 2: 0, 400 Pin 4: 50, 400
C, D	45, 150	Pins 3 & 4: 45, 150	Pin 2: 0, 100 Pin 4: 10, 100
E, F	25, 100	Pin 3: 65, 0 Pin 4: 40, 100	Pin 2: 0, 400 Pin 4: 50, 400
AC Input			
SIGNAL FREQUENCY RANGE	50 to 500 Kc † ††	100 Kc to 5 Mc ‡	250 Kc to 1 Mc
TRIGGER AMPLITUDE:			
Minimum	4V P-P	4.5V P-P	3V P-P
Nominal	5V P-P	6V P-P	6V P-P
Maximum	12V P-P	12V P-P	10V P-P
RISE AND FALL TIMES REQUIRED:	†	‡	0.05 μsec min. 1.0 μsec max.
INPUT LOAD CHARACTERISTICS:			
A, B	25, 100	(Pin 2) 35, 0	50, 400
C, D	45, 150	(Pin 2) 45, 150	10, 100
E, F	25, 100	(Pin 2) 35, 0	50, 400
OUTPUT			
AMPLITUDE (level shift)	8V (—11 to —3V)	8V (—11 (±0.5 or —1.0) to —3 (±0.3 or —1.0) V)	8V (—11 (±1.0) to —3 (±1.0) V)
RISE TIME (under typical load)	Pin 8: 0.6 μsec Pin 7: 0.8 μsec	6 to 40 nsec	0.2 μsec max.
LOAD DRIVE CHARACTERISTICS	AB type XIV	CD type XX	AB type X
POWER REQUIRED			
—12 VDC ±10%	5.0 ma	18 ma max.	16 ma max.
OPERATING TEMPERATURE RANGE			
	—45 to +65°C	—55 to +71°C	—55 to +71°C

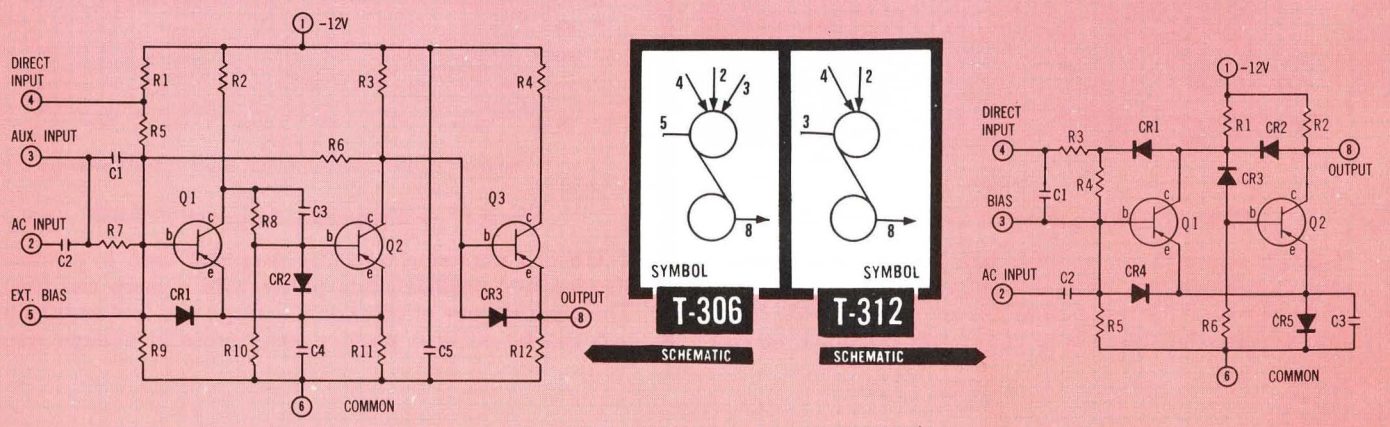
* For 8V level shift from —11 to —3V, connect external 47 KΩ resistor from Pin 5 to +12V supply.

† For sine-wave inputs at frequencies lower than 50 Kc, add external capacitor between pins 2 & 3 as follows:

‡ Low-frequency range can be extended by connecting external capacitor between pins 2 & 3.

†† Operating frequency may be extended to 1 Mc with 6V P-P sine-wave input and emitter-follower buffering on output.

Freq.	Capac.
1 to 5 Kc	0.1 uf
5 to 25 Kc	0.022 uf
25 to 50 Kc	0.0047 uf



AMPLIFIERS

T-108 (LINEAR), T-305 (VIDEO), T-118 (PULSE)

DESCRIPTION

T-108 is a linear amplifier which can be used to amplify low-level input signals to a level usable by T-Series circuits. Inputs can be sine waves, square waves, pulses, or other complex wave forms, provided the frequency components of the signal are within the response range of the amplifier. Input sources include voltage pick-ups, low-level transducers, etc. Chart I illustrates the basic input impedance limits of T-108.

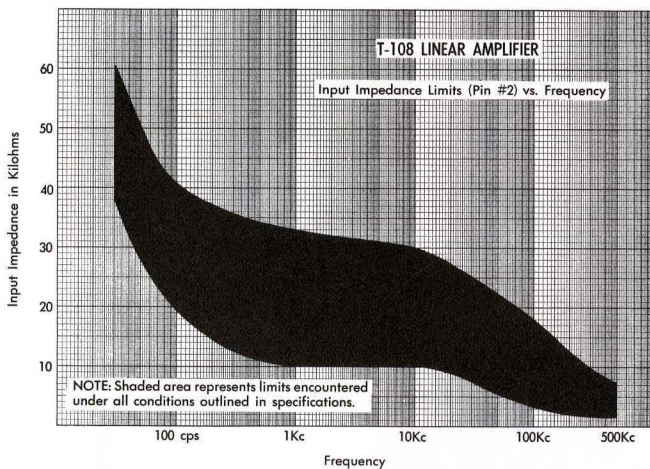


Chart I — Input Impedance Limits of T-108

Three fixed gain settings are selectable by jumpering pins; these gains are X10, X45, and X90 respectively. If no jumper is connected, a gain of X10 is realized. Gains of X45 and X90 are realized when a jumper is connected from pin 3 to pin 5 in the former case and from pin 3 to pin 7 in the latter case. Improved low-frequency response can be achieved by coupling inputs via a large capacitor to the pin-4 input and connecting a large bypass capacitor from pin 3 to pin 6. Chart II illustrates typical frequency response curves for T-108.

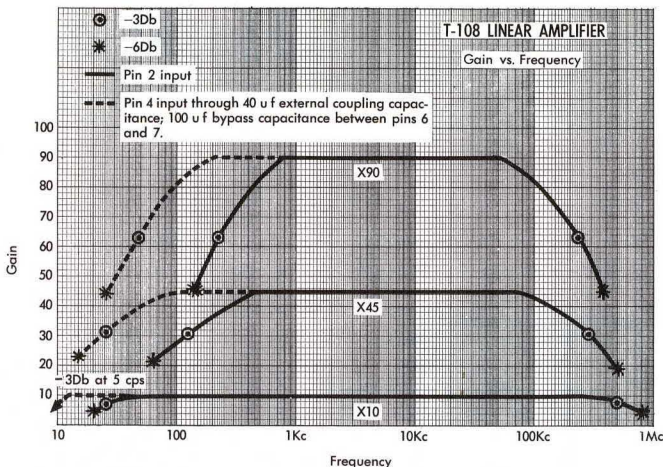


Chart II — Frequency Response of T-108

T-305 is also a linear amplifier but, because its frequency response extends to 10Mc, it is referred to as a video amplifier. Because the response of this amplifier exceeds 10Mc and because the output is in phase with the input, careful

use of RF techniques in external wiring is mandatory. For example, input and output leads should be either shielded or widely separated from one another and as short as possible; power supply leads should be as short as possible and high-frequency by-passed where necessary; ground return should be carefully selected to reduce ground loops to a minimum. Pin 9 should be jumpered to pin 6 by a short piece of straight buss wire directly across the bottom of the socket. The best grounding scheme is to use pin 6 for power supply and input signal ground and pin 9 for output signal ground.

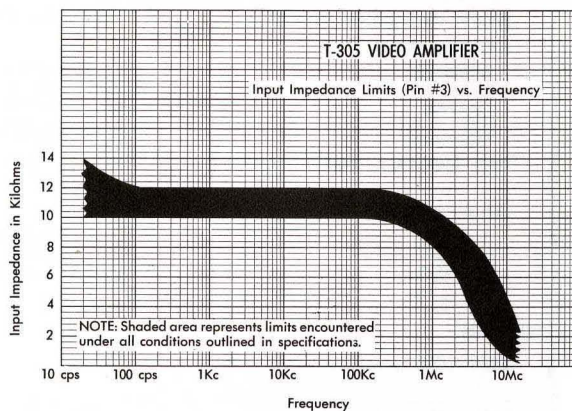


Chart III — Input Impedance Limits of T-305

Three fixed gain settings are also selectable for T-305 by jumpering pins; these gains are X10, X31.6, and X100. When no jumper is connected, a gain of 10 is realized. Gains of 31.6 and 100 are realized when a jumper is connected from pin 4 to pin 7 in the former case and from pin 4 to pin 5 in the latter case. Chart IV presents typical response curves for T-305 at these three gain settings.

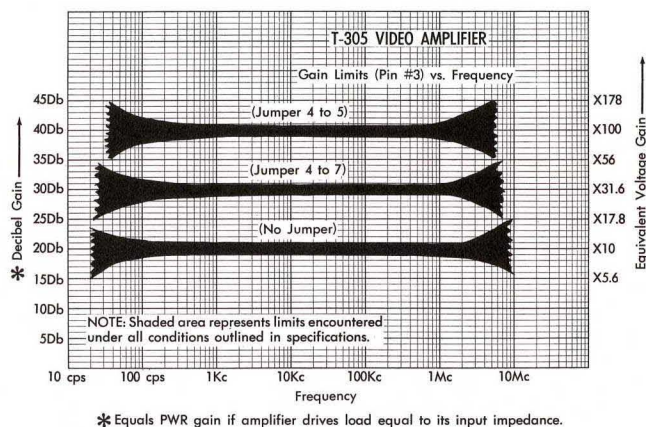


Chart IV — Frequency Response of T-305

T-118 is a transistorized Pulse Amplifier used to produce standardized positive-going pulses with a sharp rise time. The input may be of deteriorated shape and low amplitude and can be either a positive-going pulse or voltage step.

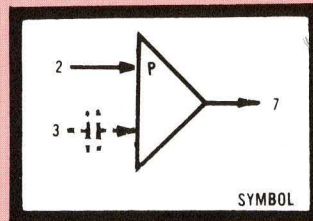
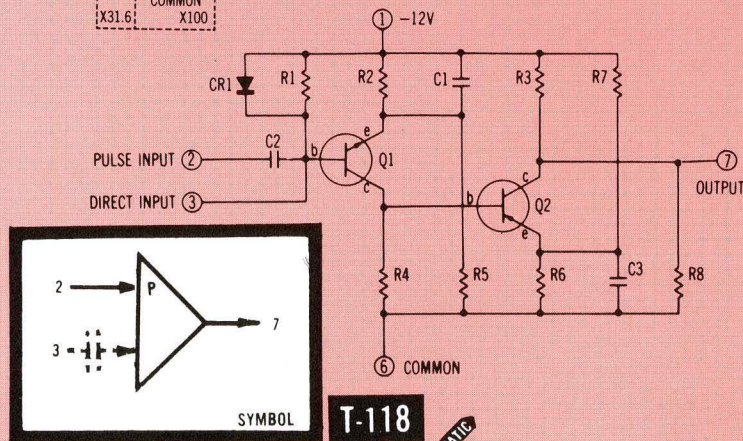
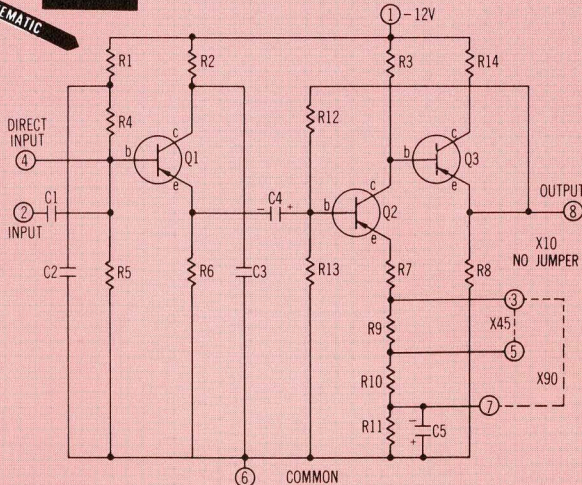
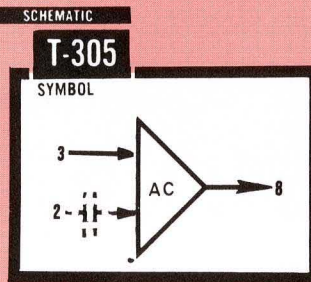
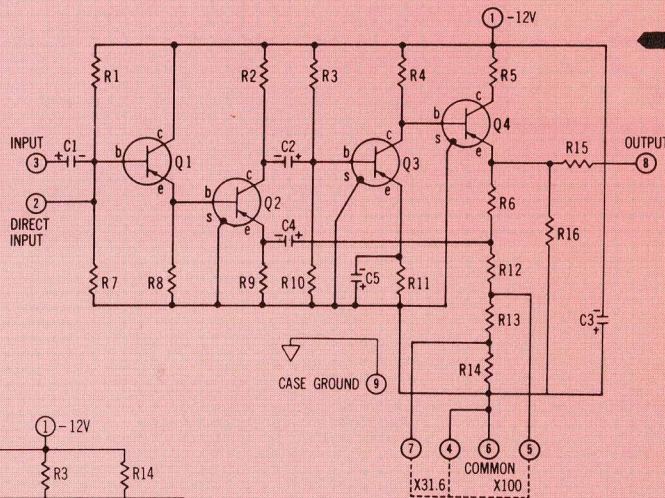
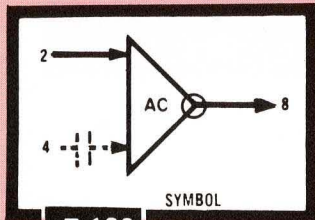
AMPLIFIERS	T-108 Linear Ampl	T-305 Video Ampl	T-118 Pulse Ampl
INPUT			
SIGNAL FREQUENCY RANGE	30 cps to 500 Kc	20 cps to 10 Mc	250 Kc max.
AMPLITUDE: For Linear Operation (depending on gain) Maximum	5 mV to 0.6V 12V P-P†	5 mV to 0.6V 6V P-P*†	@ rise times up to 1 μ sec: 5.5V pulse or step min.
INPUT IMPEDANCE	See Chart I	See Chart III	A = 10, B = 100 C = 20, D = 200 E = 10, F = 100
OUTPUT			
NOMINAL DC LEVEL	-7V	-7V	-11V
AMPLITUDE (undistorted)	6V P-P max.	6V P-P max.	min. 6V P-P pos. pulse
PHASE INVERSION	180°	none	none
GAIN (See Description)	x10, x45, or x90	x10, x31.6, or x100	††
FREQUENCY RESPONSE	See Chart II	See Chart IV	-NA-
RANDOM OUTPUT NOISE	20 mV P-P	50 mV P-P‡	-NA-
OUTPUT IMPEDANCE	1 K Ω nominal	500 Ω max (AC coupled)	-NA-
LOAD DRIVE CHARACTERISTIC	1 T-106	1 T-306 or T-312	AB type XIII
RISE TIME	-NA-	-NA-	0.02 to 0.5 μ sec
PULSE WIDTH	-NA-	-NA-	0.5 to 3.5 μ sec
POWER REQUIRED -12 VDC \pm 10%	2.5 ma	15 ma	2.5 ma quiescent 10 ma peak
OPERATING TEMPERATURE RANGE	-45 to +65°C	-54 to +71°C	-45 to +65°C

* Because of maximum voltage rating on input coupling capacitor, input signal levels at Pin 3 must always remain within the range of -4 to +45V. For signal levels beyond this range, use input Pin 2 and an external coupling capacitor with an adequate voltage rating. DC voltage at Pin 2 is -4.5V (\pm 1.0V).

† Large transients can cause temporary blocking of subsequent low-level inputs.

‡ Gain at X100, input terminated at 1 K Ω , Pin 9 grounded.

†† For signals having poor rise time, use Pin 3 input with an external capacitor of suitable size. The circuit will not respond to inputs of less than 1.5V amplitude regardless of rise time.



VOLTAGE COMPARATOR T-172

DESCRIPTION

T-172 is a voltage comparator designed to detect DC voltage levels in the range of -6 volts to +6 volts. Two inputs are used: a reference voltage and a voltage to be compared with this reference voltage. When the input signal is more positive than the reference voltage, the unit provides a -3-volt output; when the input signal is more negative than the reference voltage, the unit produces a -11-volt output.

T-172 can also be used as a level detector if the reference voltage input is grounded and a Zener diode and resistor network are used to pre-bias the input to the polarity opposite to that of the expected input. Values of resistance used should be as low as possible because source impedance will affect the sensitivity and temperature stability of the unit.

ELECTRICAL SPECIFICATIONS

INPUT:

Signal Frequency Range: 0 to 100Kc. For input frequencies from 100Kc to 250Kc, maximum level shift to cause full excursion of the output is 0.4V ($\pm 0.2V$ with respect to the reference voltage).

Input Signal: When signal is 0.1VDC greater than reference voltage, the output is nominally -3VDC; when signal is 0.1VDC less than reference voltage, the output is nominally -11VDC.

Minimum Input Level Shift to Cause Full Excursion of Output: 0.05VDC (Source impedance must be less than 100 Ω for max. sensitivity.)

OUTPUT:

Amplitude: -3VDC (± 1) = signal exceeds reference voltage, -11VDC (± 1) = reference exceeds signal voltage.

Rise Time: Less than 1 μ sec for an input level shift from 0.5VDC below the reference to 0.5VDC above the reference with a rise time of less than 1 μ sec. Output may not be fast enough to drive trigger-type circuits when input rise time exceeds 1 microsecond. To provide proper rise time, use Squaring Amplifier T-106 at the T-172 output.

Load Drive Characteristics: This is a CD type IX driver.

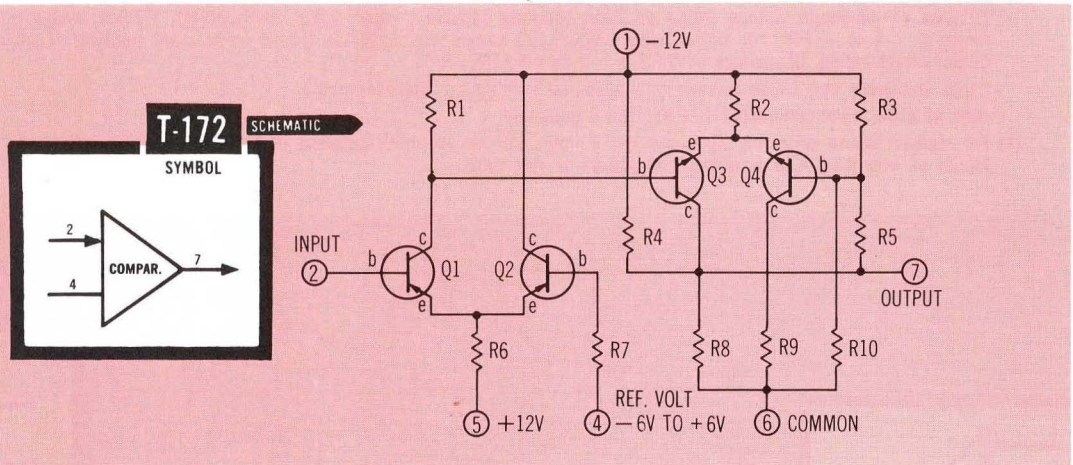
POWER REQUIRED:

-12VDC $\pm 10\%$: 30 ma maximum

+12VDC $\pm 10\%$: 6 ma maximum

Ref. Voltage: typically 0 to $\pm 6VDC$ at 0.2 ma maximum

OPERATING TEMPERATURE RANGE: -54 to +71°C



DESCRIPTION

T-424A can be used as either a Half-Adder or a Half-Subtractor, depending on connection of an external jumper. Outputs, depending on this jumper connection, are Sum or Difference (Pin 7) and Carry or Borrow (Pin 8). Half Adder Mode—The logic equations for a Half Adder are:

$$\begin{aligned} \text{Sum} \quad S &= X\bar{Y} + \bar{X}Y \\ \text{Carry} \quad C &= XY \end{aligned}$$

A Full Adder is formed when a third input, "carry" from the next lowest significant digit, is added to the sum. Therefore, two Half Adders and an "Or" gate are necessary to make up a Full Adder. (See Truth Tables I and II.)

TRUTH TABLE I
Half Adder

(X plus Y = S)

X	0	1	0	1
Y	0	0	1	1
S	0	1	1	0
C	0	0	0	1

TRUTH TABLE II
Full Adder

(X plus Y plus C = S)

X	0	1	0	1	0	1	0	1
Y	0	0	1	1	0	0	1	1
C	0	0	0	0	1	1	1	1
S	0	1	1	0	1	0	0	1
C	0	0	0	1	0	1	1	1

Half Subtractor Mode—A Half subtractor provides Difference (D) and Borrow (B) outputs from two single-digit inputs (X minus Y). The logic equations for a Half Subtractor are:

$$\begin{aligned} \text{Difference} \quad D &= X\bar{Y} + \bar{X}Y \\ \text{Borrow} \quad B &= DY \end{aligned}$$

Full Subtraction is performed when a third input, "borrow" from the next lowest significant digit, is subtracted from (X minus Y). Two Half Subtractors and an "Or" gate are necessary to make up a Full Subtractor. (See Truth Tables III and IV.)

TRUTH TABLE III

Half Subtractor (X minus Y = D)

X	0	1	0	1
Y	0	0	1	1
D	0	1	1	0
B	0	0	1	0

TRUTH TABLE IV

Full Subtractor (X minus Y minus B = D)

X	0	1	0	1	0	1	0	1
Y	0	0	1	1	0	0	1	1
B	0	0	0	0	1	1	1	1
D	0	1	1	0	1	0	0	1
B	0	0	1	0	1	0	1	1

Note that the Sum and Difference equations are exactly alike; either can be formed by an "Exclusive-Or" gate. Carry and Borrow equations have similar form but different inputs. Either can be performed by an "And" gate if one of the inputs is connected to X for addition and to D for subtraction.

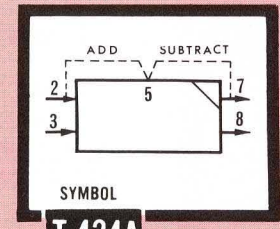
The time delay between input and output signal excursions (measured between half-amplitude points) is 1.5 microseconds maximum for one T-424A, or a total of 2.0 microseconds maximum for two cascaded T-424A units. In order to determine the maximum possible accumulated delay (T in μsec) through N cascaded T-424A units, use one of the following equations:

$$\begin{aligned} \text{if } N \text{ is even: } \quad T &= N \\ \text{if } N \text{ is odd: } \quad T &= N + 0.5 \end{aligned}$$

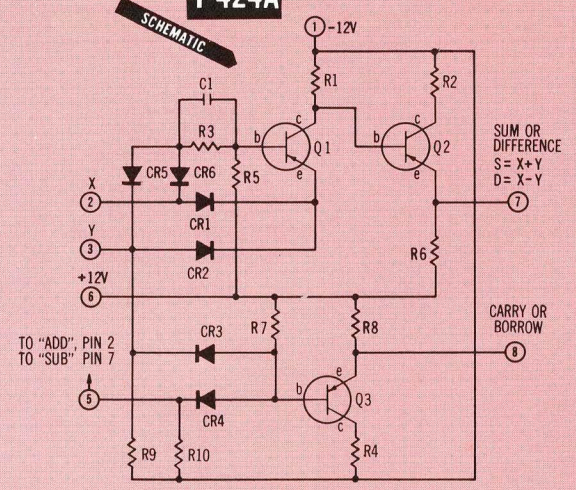
ARITHMETIC CIRCUITS
T-424A, T-441, T-628

ARITHMETIC CIRCUIT	T-424A Half adder/subtractor
INPUT	
SIGNAL FREQUENCY RANGE	0 to 250 Kc
SIGNAL LEVELS (nominal):	
Binary "1"	—3 VDC
Binary "0"	—11 VDC
RISE TIME	0.1 to 1.0 μsec
FALL TIME	0.1 to 2.5 μsec
INPUT LOAD CHARACTERISTICS:	
C, D	120, 0
OUTPUT	
AMPLITUDE (nominal)	—3 VDC = "1", —11 VDC = "0"
RISE TIME (depending on input rise & fall time)	0.1 to 1.0 μsec
LOAD DRIVE CHARACTERISTICS	CD type IX
POWER REQUIRED	
—12 VDC $\pm 10\%$	8 ma
+12 VDC $\pm 10\%$	8 ma
OPERATING TEMPERATURE RANGE	—54 to + 71°C

table continued on next page



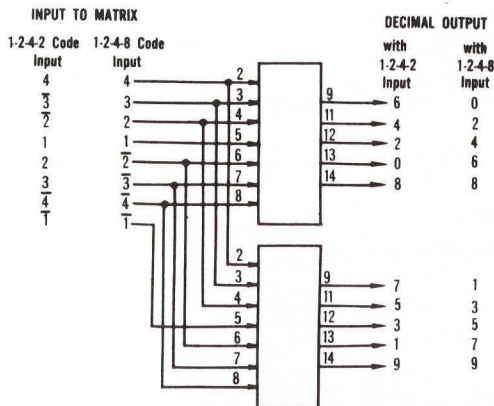
T-424A



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T-628 is basically a code converter intended for use in pairs to convert a 1-2-4-2 or a 1-2-4-8 binary-coded-decimal input to a 10-line decimal output (0-9) for driving relay drivers. The matrix is arranged so that emitter followers are not required on either input or output. Relay Drivers such as T-120, T-121, and T-128 can be loaded on all outputs simultaneously.

NOTE: T-628 cannot be used with the Digital System Breadboard Equipment because pin 9 is wired to ground on the T-927 System Development Panels.

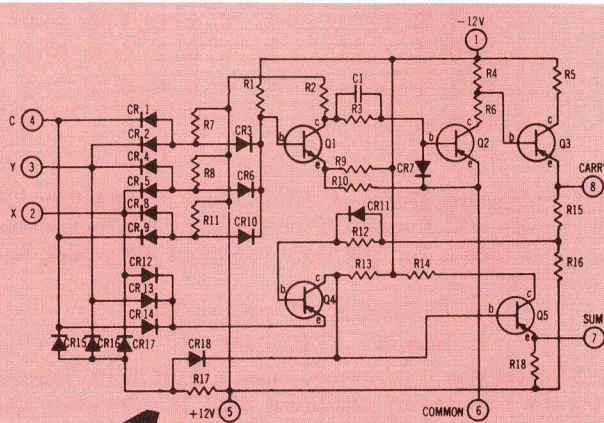


CONNECTIONS NECESSARY FOR CODE CONVERSION

T-441 is a complete Full Adder in one package. Three inputs (one each for the addend X, the augend Y, and a carry C from the previous digit of lower significance) cause Sum and Carry outputs as shown in Truth Table II. A built-in amplifier circuit minimizes level shift and, thus, eliminates need for restoring circuits in the carry propagation path of a system.

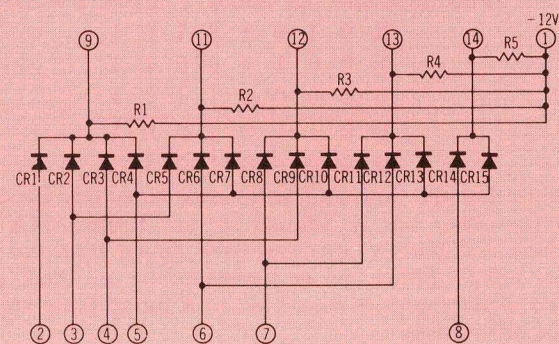
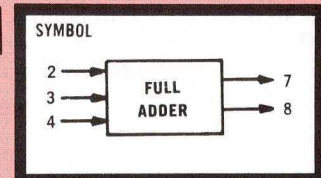
The delay from input to carry output (pin 8) is 1.7 μsec maximum for one T-441 operating under worst-case conditions. However, when two or more T-441 adders are cascaded (pin 8 of one to pin 4 of the next), the delay is approximately N microseconds, where N equals the number of T-441 units cascaded. Because of this delay, a characteristic of all logic circuits, the maximum frequency limit is reduced as the number of cascaded adders increases according to the equation:

$$F_{max} = \frac{1}{3 + N} \text{ (in Mc)}$$



SCHEMATIC

T-441



SCHEMATIC

T-628

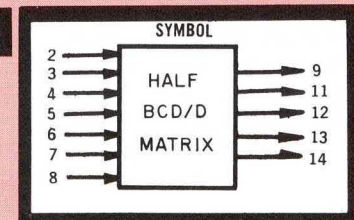


table continued from last page		
ARITHMETIC CIRCUITS	T-441 Full adder	T-628 Half BCD to decimal converter
INPUT		
SIGNAL FREQUENCY RANGE	0 to 250 Kc*	0 to 1 Kc
SIGNAL LEVELS (nominal):		
Binary "1"	-3 VDC	-11 VDC
Binary "0"	-11 VDC	-3 VDC
RISE TIME	0.1 to 1.0 μsec	- NA -
FALL TIME	0.1 to 2.5 μsec	- NA -
INPUT LOAD CHARACTERISTICS:		
A, B		60, 0
C, D	120, 0	140, 0 ★
E, F		60, 0
OUTPUT		
AMPLITUDE (nominal)	-3 VDC = "1", -11 VDC = "0"	-11 VDC = "1", -3 VDC = "0"
RISE TIME (depending on input rise & fall time)	Pin 7: 1.0 μsec max Pin 8: 1.0 μsec max or 20 times better than input (whichever is greater)	- NA -
LOAD DRIVE CHARACTERISTICS	CD type IV	Each output will drive one relay driver such as T-120, T-121, or T-128. ★
POWER REQUIRED		
-12 VDC ±10%	24 ma†	3.6 ma max.
+12 VDC ±10%	13 ma†	none
OPERATING TEMPERATURE RANGE	-54 to +71°C	-45 to +65°C

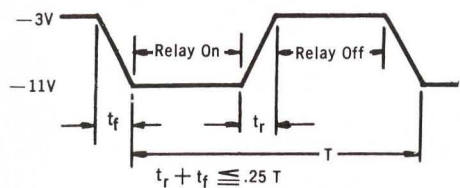
* See equation describing F max in Description.

† Excluding load current.

★ When connected to a driver capable of driving this additional load; i.e., a flip-flop already driving another flip-flop.

RELAY DRIVERS T-120 T-121 T-128 T-130 T-134
T-135 T-139 T-141 T-170 T-171

INPUT WAVEFORM



Absolute maximum value for t_r or t_f = 1 second.

t_f = fall time
 t_r = rise time

NOTE:

When driving non-linear resistive elements such as incandescent lamps, precautions must be taken to never exceed the maximum output current rating of the circuit. When first turned "on" these resistive elements may draw surge currents several times the normal operating current.

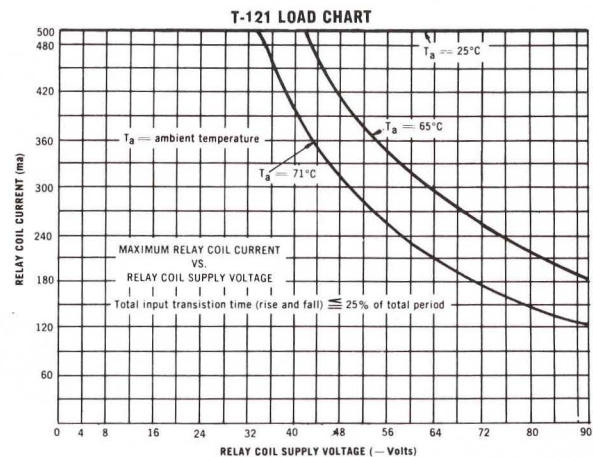
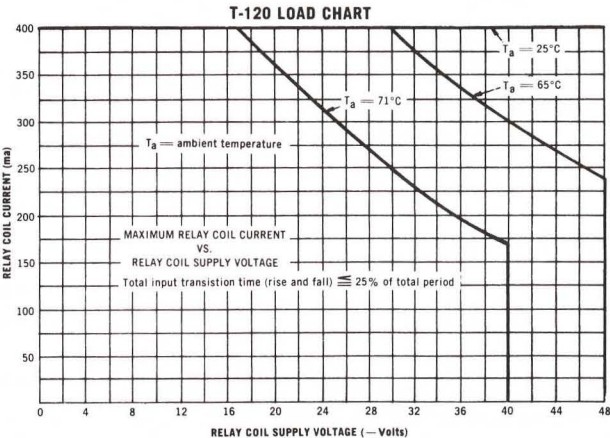
DESCRIPTION

These circuits are basically transistor switches that may be operated directly from the output of other T-Series circuits such as flip-flops, one shots or squaring amplifiers. Input signal levels required are -3VDC and -11VDC. As the specifications show, some units are activated at -3VDC and some are activated at -11VDC. Major variables to consider when selecting one of these units are maximum output current required and the output voltage level to be switched.

The most common application for these units is control of general-purpose relays. However, the units are equally useful for signal inversion and/or level changing. Dual units such as T-134 and T-135 also find use as Reset Generators in systems consisting of admixtures of T-Series and N-Series units.

When used to actuate relays, these units require protection against reverse surge voltages generated by the relay coil. To this end, diode clamping may be used across the coil as shown on the individual schematics. Diode requirements are: (1) Peak forward current = relay "on" current, and (2) peak inverse voltage = relay supply voltage.

RELAY DRIVERS	T-120 -48V 500 ma Relay Driver	T-121 -90V 500 ma Relay Driver	T-128 -30V 500 ma Relay Driver
<i>table continued on next page</i>			
INPUT	††	††	††
SIGNAL FREQUENCY RANGE at max. output current	0 to 1 Kc	0 to 1 Kc	0 to 1 Kc
DC SIGNAL LEVEL TO ACTIVATE	-11V	-11V	-11V
DC SIGNAL LEVEL TO DEACTIVATE	-3V	-3V	-3V
MAX. SIGNAL CURRENT REQUIRED: at -11V, to a positive source	0.1 ma	0.1 ma	0.1 ma
at -3V, to a negative source	0.5 ma	0.5 ma	0.5 ma
MAX. RISE or FALL TIME†	1 sec	1 sec	1 sec
OUTPUT	‡	‡	
MAX. OUTPUT CURRENT	500 ma	500 ma	500 ma
MAX. OUTPUT SUPPLY VOLTAGE	-48V	-90V	-30V
RISE TIME, typical: longest of following:			
Time under max. load	6 μsec	6 μsec	6 μsec
% input fall time	10%	10%	10%
% input rise time			
FALL TIME, typical: longest of following:			
Time under max. load	6 μsec	6 μsec	6 μsec
% input fall time			
% input rise time	10%	10%	10%
CURRENT LEAKAGE through load in "off" condition and at maximum operating temperature:			
typical	1 ma	1 ma	1 ma
maximum	5 ma	5 ma	5 ma
POWER REQUIRED (exclusive of relay current)			
+12V (±10%) at	14 ma	14 ma	14 ma
-12V (±10%) at	30 to 45 ma	30 to 45 ma	30 to 45 ma
RELAY COIL SUPPLY maximum	-48V	-90V	-30V
OPERATING TEMPERATURE RANGE	-54 to +65°C	-54 to +71°C	-54 to +71°C



- ‡ Maximum output current available is dependent on relay voltage used; see load chart.
- †† Max. frequency with relay load depends on relay capabilities
- May be operated up to 71° C for relay voltages up to 40V.
- † The sum of input rise and fall time must not be greater than 25% of total period.

continued on next page

RELAY DRIVERS

table continued from last page

	T-130 —28V, 1 amp. Relay Driver	T-134 —35V 100 ma Relay and indicator Driver* (dual)	T-135 —35V 100 ma Relay and Indicator Driver* (dual)	T-139 +30V 400 ma Relay Driver	T-141 +45V 400 ma Relay Driver	T-170 +35V 100 ma Relay and Indicator Driver (dual)	T-171 +35V 100 ma Relay and Indicator Driver (dual)
INPUT	††	††	††	††	††		
SIGNAL FREQUENCY RANGE at max. output current	0 to 1 Kc	0 to 50 Kc	0 to 50 Kc	0 to 1 Kc	0 to 1 Kc	0 to 50 Kc	0 to 50 Kc
DC SIGNAL LEVEL TO ACTIVATE	—11V	—11V	—3V	—3V	—3V	—11V	—3V
DC SIGNAL LEVEL TO DEACTIVATE	—3V	—3V	—11V	—11V	—11V	—3V	—11V
MAX. SIGNAL CURRENT REQUIRED: at —11V, to a positive source	0.4 ma	0.45 ma	0.2 ma	0.2 ma	0.2 ma	0.2 ma	0.5 ma
at —3V, to a negative source	0.5 ma	0.3 ma	0.5 ma	0.4 ma	0.4 ma	0.5 ma	0.2 ma
MAX. RISE or FALL TIME†	1 sec	1 msec	1 msec	1 sec	1 sec	1 msec	1 μ sec (rise) 2 μ sec (fall)
OUTPUT	•	•	•	•	•	•	•
MAX. OUTPUT CURRENT	1 amp	100 ma	100 ma	400 ma	400 ma	100 ma	100 ma
MAX. OUTPUT SUPPLY VOLTAGE	—30V	—35V	—35V	+30V	+45V	+35V	+35V
RISE TIME, typical: longest of following:							
Time under max. load	13 μ sec	1 μ sec	2 μ sec	6 μ sec	6 μ sec	1 μ sec	1 μ sec
% input fall time	20%	20%		10%	10%	25%	
% input rise time			25%				25%
FALL TIME, typical: longest of following:							
Time under max. load	13 μ sec	1 μ sec	3 μ sec	6 μ sec	6 μ sec	1 μ sec	1 μ sec
% input fall time			10%				25%
% input rise time	10%	20%		10%	10%	25%	
CURRENT LEAKAGE through load in "off" condition and at maximum operating temperature:							
typical	0.6 ma			0.02 ma	0.02 ma		
maximum	3 ma	0.1 ma	0.1 ma	0.3 ma	0.3 ma	0.5 ma	0.5 ma
POWER REQUIRED (exclusive of relay current)							
+12V ($\pm 10\%$) at	20 ma	12 ma	2.5 ma	30 ma max.	30 ma max.	12 ma max.	24 ma
—12V ($\pm 10\%$) at	20 ma	22 ma	14 ma	45 ma max.	45 ma max.	24 ma max.	24 ma
—3V ($\pm 10\%$) at*	110 ma						
RELAY COIL SUPPLY maximum	—30V	—35V	—35V	+30V	+45V	+35V	+35V
OPERATING TEMPERATURE RANGE	—54 to +65°C	—55 to +71°C	—55 to +71°C	—54 to +65°C	—54 to +65°C	—55 to +71°C	—55 to +71°C

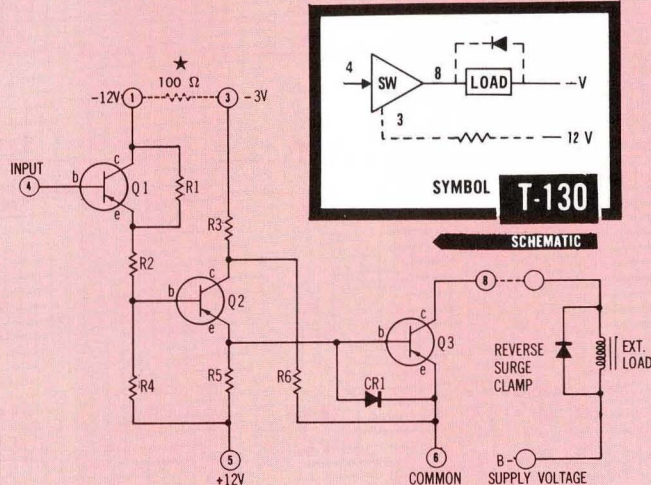
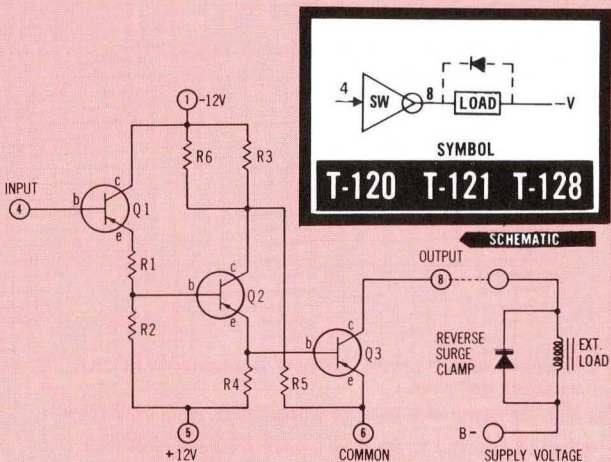
* Can also be converted to reset generator.

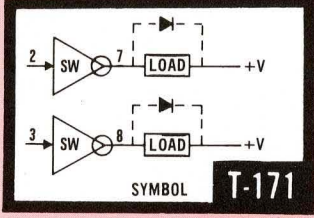
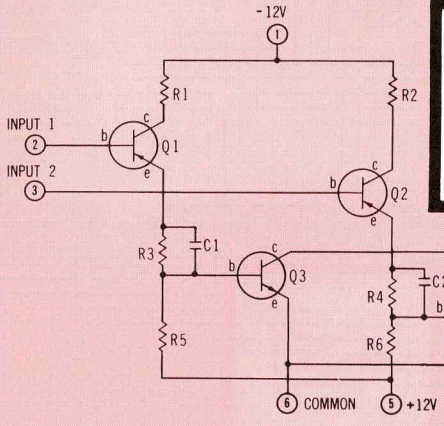
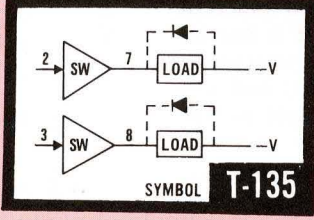
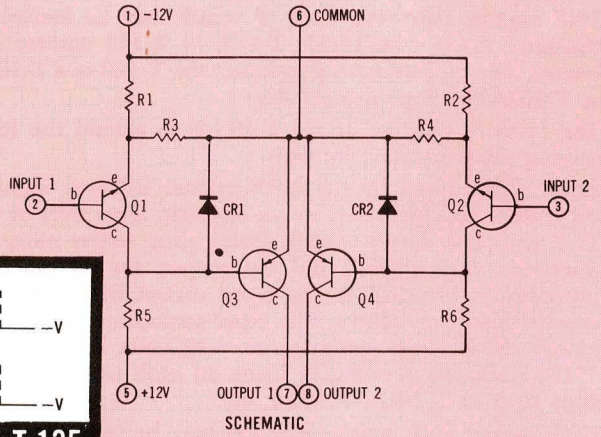
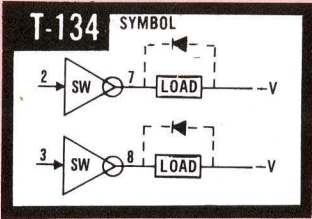
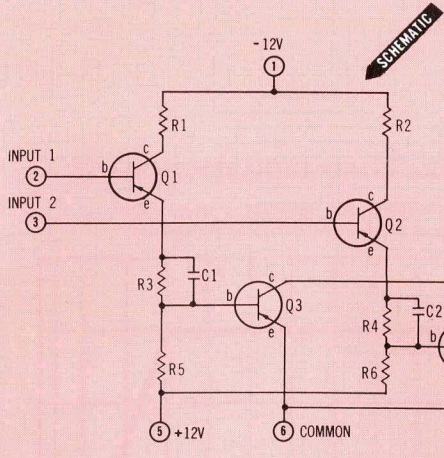
†† Max. frequency with relay load depends on relay capabilities.

† The sum of input rise and fall time must not be greater than 25% of total period.

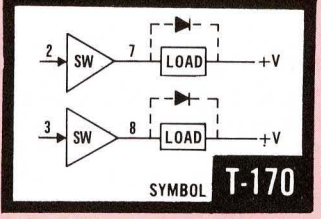
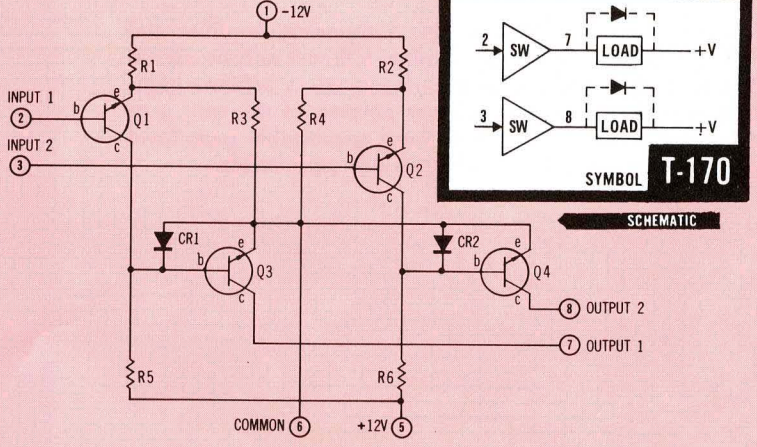
• No derating necessary over voltage and temperature range.

* Can be derived from —12V supply by connecting a 100 Ω , 2 watt resistor between pins 1 and 3.

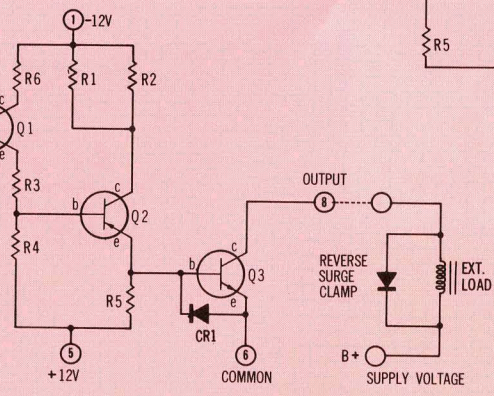
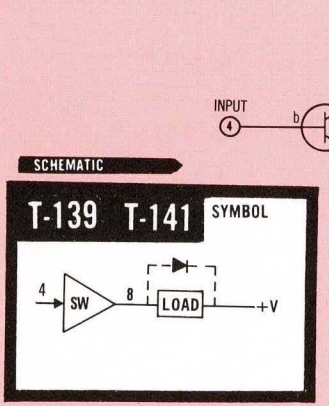




SCHEMATIC



SCHEMATIC



DRIVERS T-163, T-165, T-302

DESCRIPTION

T-163 is a transistorized driver containing five germanium transistors. An NPN emitter follower is used to drive four PNP emitter followers, each of which may be loaded in the same manner as T-111, T-112, or T-113 emitter followers. The typical driving unit into the T-163 is a T-101B or T-102A flip-flop, or equivalent.

The primary purpose of the T-163 is to extend the logic driving capabilities of flip-flops.

Level shift caused by the NPN emitter follower input is very nearly compensated by an opposite level shift at the PNP emitter follower output. Delay time, under most applications, is negligible and the output, for all practical purposes, is identical to the input except that it has increased load capabilities. The input impedance is approximately 20 K ohms minimum to -12 volts DC and two T-163 units are permissible loads on each output of flip-flops such as T-101B, T-102A, etc.

Each output PNP emitter follower may be treated exactly as a T-111 when considering load-driving ability. Maximum load per T-163 may not exceed that of four T-111 emitter followers. Total logic loading for each T-163 is 12 DC "Or" gates, or 16 DC "And" gates, or 32 DCTL "And" or "Or" gates. Thus, T-163 can be used to extend flip-flop fan-out capabilities to 64 "And" or "Or" loads per output.

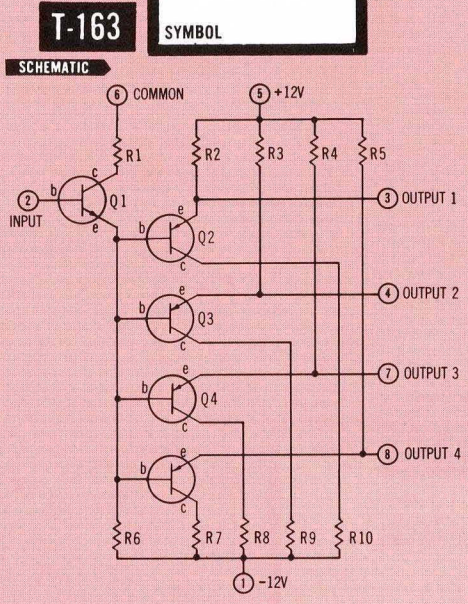
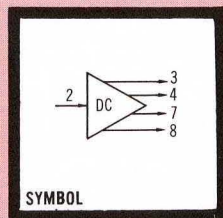
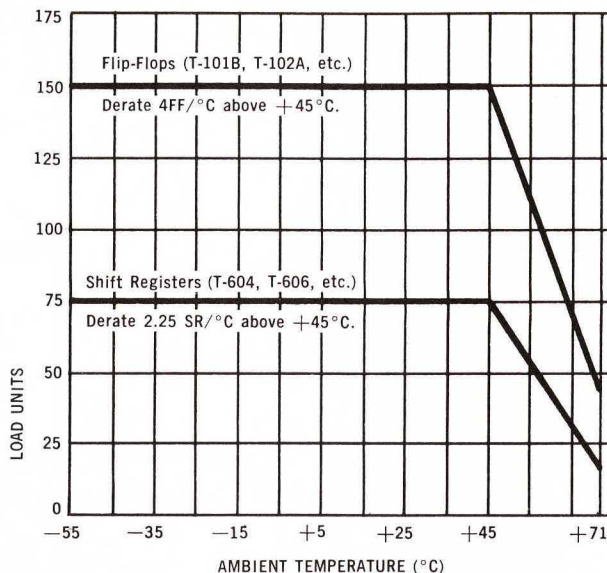
Capacity Driver **T-165** is a transistorized assembly containing three germanium transistors in a pulse amplifier configuration with a low output impedance. The primary purpose of this unit is to drive heavy capacitive loads such as a large number of shift register pulse inputs.

Signal lead length should be as short as possible when driving a large number of units to prevent ringing or overshoot. In addition, signal lead-wire resistance should be kept to a minimum because peak currents as high as 400 ma can be expected when driving the maximum load.

Capacity Driver **T-302** contains a squaring amplifier and a complementary-symmetry emitter-follower output circuit. Anti-saturation techniques are employed to achieve high-frequency response. The primary purpose of this unit is to drive high capacitive loads without appreciable logic level loss or phase shift. DC loading is also permissible.

T-165 — 250Kc LOAD DERATING CHART

(Load can be doubled when frequency is halved within the maximum of 150 Flip-Flops or 75 Shift Registers)



DRIVERS	T-163 D.C. Driver	T-165 Capacity Driver	T-302 Capacity Driver
INPUT			
SIGNAL FREQUENCY RANGE	0 to 250 Kc	0 to 250 Kc	0 to 1 Mc
AMPLITUDE	8V (—11V to —3V shift)	Pulse: 6.5V P-P min.†† 9.0V P-P max.	8V (—11 to —3V shift)
RISE TIME	0.5 to 1.0 μsec	0.5 μsec max.	0.05 to 0.3 μsec
INPUT LOAD CHARACTERISTICS:			
A, B	10, 25	10, 100	50, 150
C, D	15, 150	15, 150	0, 100
E, F	10, 25	10, 100	50, 150
OUTPUT (each output)			
AMPLITUDE	* ‡ approx. equal to input amplitude with: max. loss at —3V level = —0.25V max. loss at —11V level = +0.6V	8.0 to 8.3V P-P pulse depending on frequency	—11V to —3V DC level shift
RISE TIME	equal to input rise time	0.4 μsec max. with maximum loads shown on chart•	0.15 μsec max.•
FALL TIME	equal to input fall time	2.0 μsec max. with maximum loads shown on chart•	0.20 μsec max.•
PULSE WIDTH	depends on input	2.5 μsec max. with maximum loads shown on chart	depends on input
DELAY TIME	0.15 μsec max.	0.6 μsec max. with maximum loads shown on chart	0.15 μsec max.
OUTPUT DRIVE CHARACTERISTICS	CD type IV†	See load chart page 28	20 T-801 or T-301 pulse inputs
POWER REQUIRED			
—12 VDC ±10%	24 ma max.	15.7 ma quiescent, 130 ma max. depending on load	33 ma average
+12 VDC ±10%	15 ma max.	2.5 ma max.	none
OPERATING TEMPERATURE RANGE	—55 to +71°C	—55 to +71°C	—55 to +71°C

* **CAUTION:** Outputs may not be paralleled. Each output must be loaded independent of remaining outputs.

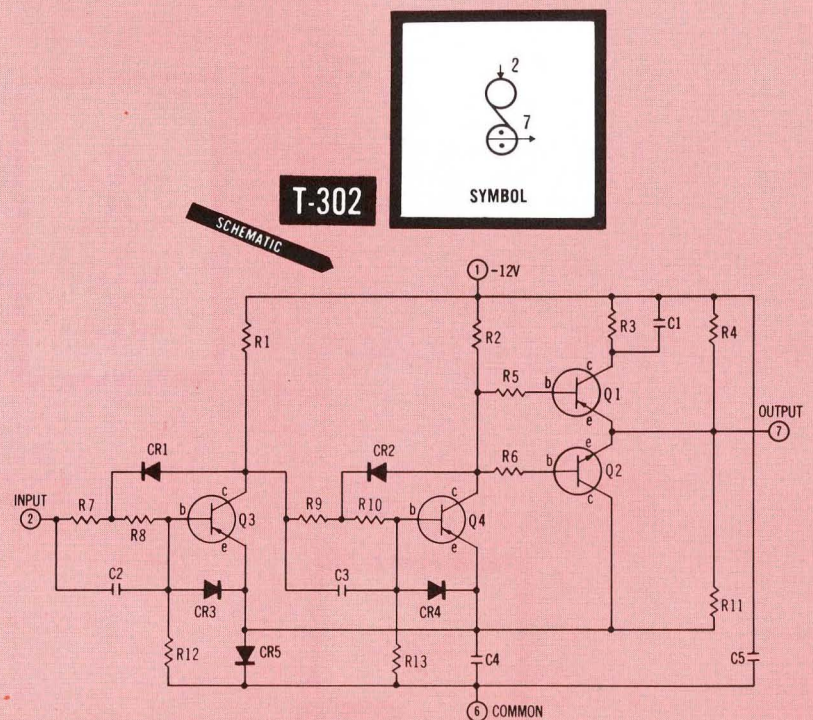
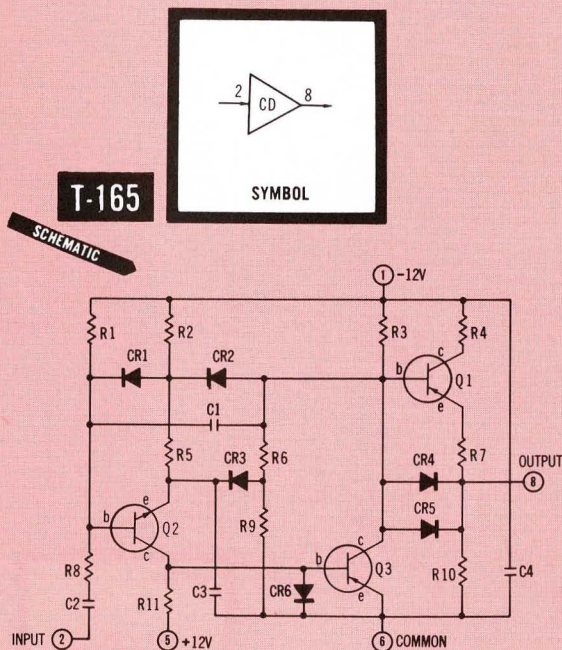
† When operating into a purely capacitive load connect an external 5.6KΩ resistor from output to +12V supply.

‡ Ringing: Under adverse conditions of temperature, supply voltage, and load connections high-frequency ringing may be experienced

at the —3V level with amplitudes slightly exceeding 1V P-P. This is **not** detrimental to 250 Kc operations of T-series units but may be compensated for by inserting a 100 Ω resistor in series with each output pin.

†† Noise Rejection. 1.5V P-P.

- Faster rise and fall times obtainable with lighter loading.



EMITTER FOLLOWERS T-111, T-112, T-113, T-114, T-115, T-116, T-161, T-652, T-304, T-307

DESCRIPTION

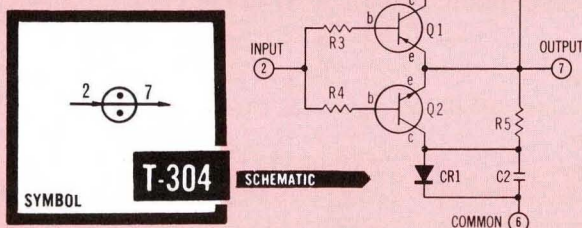
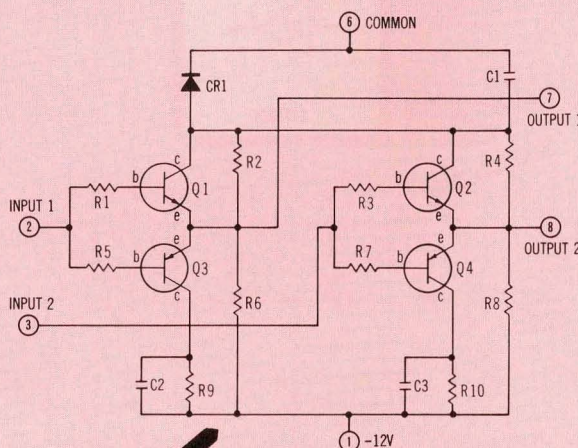
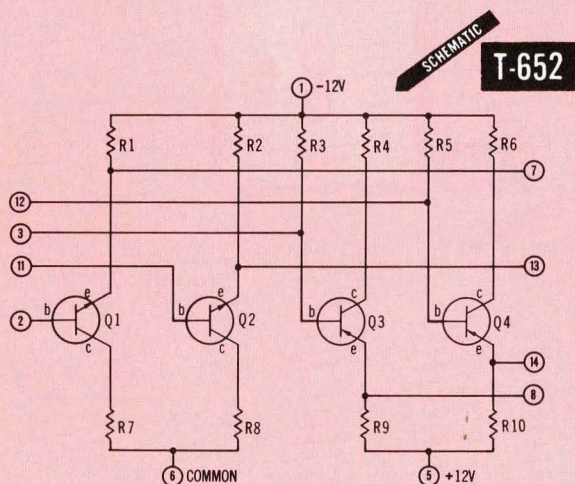
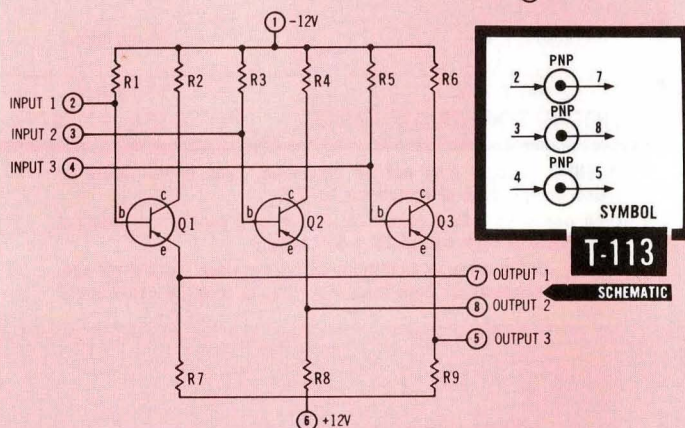
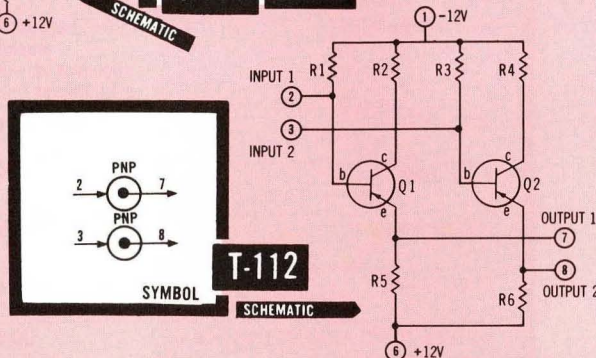
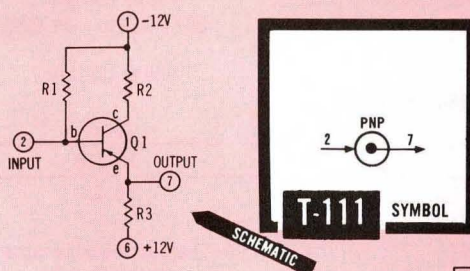
(See "Use of Emitter Followers" in "Family Information" section.)

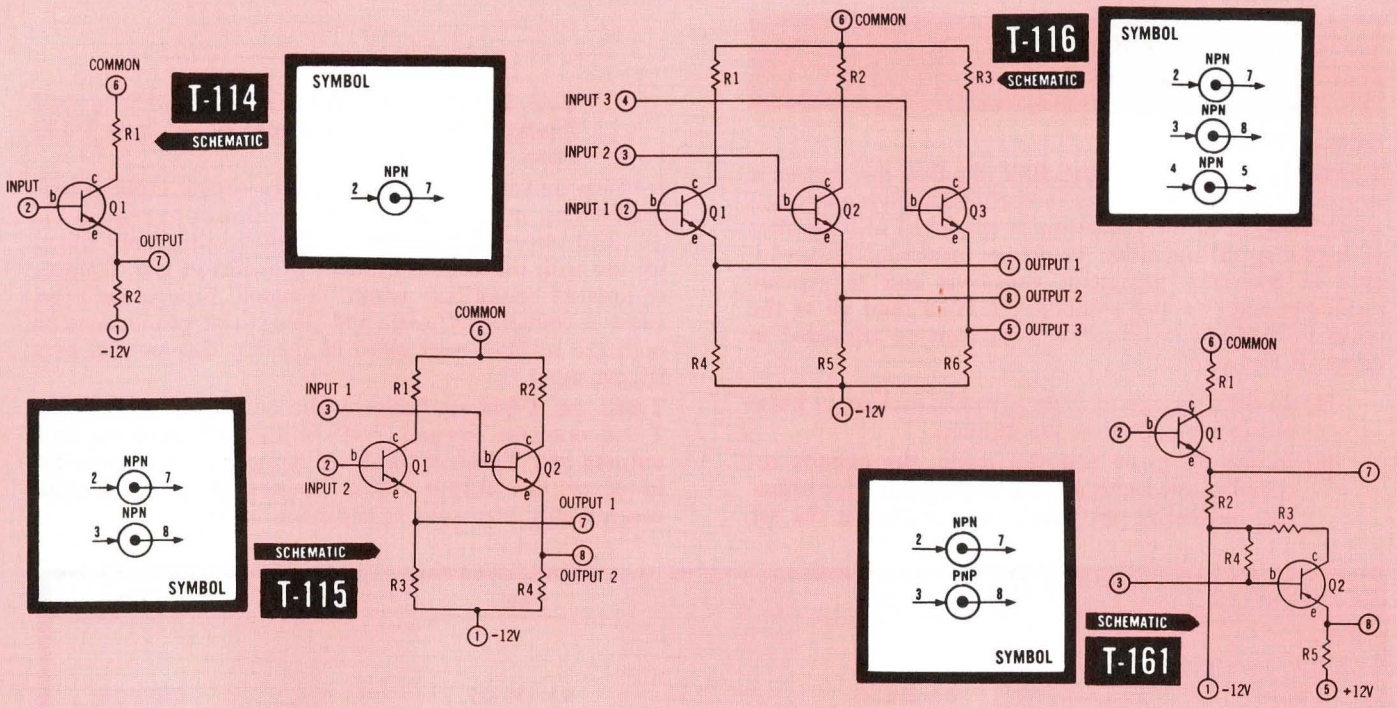
The **T-111**, **T-112**, and **T-113** are arrangements of the same basic PNP emitter follower in single-, dual-, and triple-circuit packages. PNP emitter followers are used principally to increase load-driving ability into resistive loads such as DC Logic. When necessary to operate into a capacitive load, connect a 5.6KΩ resistor from each output to the +12-volt supply.

The **T-114**, **T-115**, and **T-116** are arrangements of the same basic NPN emitter follower in single-, dual-, and triple-circuit packages. NPN emitter followers are used principally to increase load-driving ability into capacitive loads such as flip-flops or one-shots. NPN emitter followers are not recommended for operating into DC Logic.

T-161 is a dual package consisting of a PNP emitter follower (T-111) and an NPN emitter follower (T-114) in one container. **T-652** is a dual T-161. These two units can be used to fill odd requirements for emitter followers in a system. Additionally, these units find service as complementary symmetry emitter followers when the inputs are connected together and the outputs are connected together. Since NPN emitter followers have minimum output impedance for positive-going signals and PNP emitter followers have minimum output impedance for negative-going signals, parallel connection of one of each of these types (a complementary symmetry emitter follower) results in a circuit having a very low output impedance for driving capacitive loads.

T-304 and **T-307** are single and dual versions of a complementary symmetry emitter follower for use at frequencies up to 1Mc.





EMITTER FOLLOWERS	PNP Emitter Followers T-111, T-112 (dual), T-113 (triple)	NPN Emitter Followers T-114, T-115 (dual), T-116 (triple)	PNP/NPN Emitter Followers T-161 T-652	Complementary Emitter Followers T-304, T-307 (dual)
INPUT				
SIGNAL FREQUENCY RANGE	0 to 250 Kc*	0 to 250 Kc*	0 to 250 Kc*	0 to 1 Mc
SIGNAL AMPLITUDE: NORMAL	-11 to -3V level shift	-11 to -3V level shift	-11 to -3V level shift	-11 to -3V level shift
Maximum Pulse	12V P-P†	12V P-P†	12V P-P†	12V P-P†
INPUT LOAD CHARACTERISTICS:				
A, B	10, 25	15, 25	10, 25	5, 50
C, D	15, 50	0, 100	Pins 7 & 13 outputs loaded: 0, 100 Pins 8 & 14 outputs loaded: 15, 50	15, 50
E, F	10, 25	10, 25	10, 25	5, 50
OUTPUT				
AMPLITUDE	input signal amplitude	input signal amplitude	input signal amplitude	input signal amplitude with
LEVEL SHIFT	0.25V positive	0.25V negative	PNP: 0.25V positive NPN: 0.25V negative	level loss from each extreme as follows: T-304 = 0.25V T-307 = 0.4V
RISE TIME	★	0.1 μsec max. deterioration from input signal‡	PNP: ★ NPN: See T-114, T-115, T-116	same as input signal
DRIVE CHARACTERISTICS	CD type IV††	EF type VIII	Pins 7, 13: EF type VIII Pins 8, 14: CD type IV††	1KΩ to ±12V max. res. load 500 pf to com.; max. cap. load
OUTPUT IMPEDANCE:				
Neg.-going signal	150 Ω	1.8 KΩ max.	PNP: 150 Ω NPN: 1.8 KΩ	100 Ω max.
Pos.-going signal	5.6 KΩ max.	150 Ω	PNP: 5.6 KΩ NPN: 150 Ω	100 Ω max.
POWER REQUIRED (each emitter follower)				
-12 VDC ±10%	3.9 to 11 ma depending on load	1 to 7 ma depending on load	T-161: 4.9 to 18 ma depending on load T-652: 9.8 to 36 ma depending on load	T-304: 10 ma max. T-307: 20 ma max.
+12 VDC ±10%	3.9 to 11 ma depending on load	none	T-161: 3.9 to 11 ma depending on load T-652: 7.8 to 22 ma depending on load	none
OPERATING TEMPERATURE RANGE	-45 to +65°C	-54 to +71°C	-45 to +65°C	-55 to +71°C

* Frequency Range extends to 500 Kc with slightly reduced output signal.

† When coupled through a suitable capacitor. The input pin must be biased by a resistor returning to the appropriate bias. This RC network can also be used to convert voltage steps into pulses.

‡ Under maximum capacitive loading, rise-time deterioration will not exceed 0.2 μsec.

†† When operating into pure capacitive load, connect a 5.6 KΩ external resistor from output to +12V supply.

★ For inputs with rise times faster than 0.5 μsec., output is 0.5 μsec. max. For slower input rise time, output rise time equals input rise time.

RST FLIP-FLOPS

T-101B, T-157, T-633, T-643, T-644

DESCRIPTION

T-101B is a general-purpose RST flip-flop for use as a storage or memory device or for frequency division. Saturated operation of the transistors is employed at a sacrifice of higher-speed operation to obtain maximum independence of transistor parameter variations and to provide maximum stability and reliability. T-101B (and all of the other RST flip-flops described here) can be triggered in either of two modes:

- (1) In the T (trigger or binary) mode, each input pulse changes the state of the flip-flop.
- (2) In the RS (reset and set) mode, the circuits respond to **alternate** set and reset pulses; for example, successive set pulses do not disturb the set

state. Direct Reset inputs are for use when several flip-flops are to be reset synchronously by a T-109 Reset Generator.

T-157 is similar to T-101B except the trigger input is buffered by an integral NPN emitter follower to reduce the AC load effect of this circuit. **T-633** is admirably suited for use with the Digital Systems Breadboard and Training equipment (described under "Related Equipment") because it contains DC, AC, and direct base connections on both the set and reset sides of the flip flop as well as a trigger input.

T-643 and **T-644** are basically the same as T-101B except T-643 contains integral PNP emitter followers on both outputs and T-644 contains an integral PNP emitter follower on one output. These emitter followers provide considerably increased load-driving ability.

RST FLIP-FLOPS	T-101B	T-157	T-633	T-643	T-644
INPUT					
SIGNAL FREQUENCY RANGE:					
T Mode	0 to 250 Kc†	0 to 250 Kc	0 to 250 Kc†	0 to 250 Kc †	0 to 250 Kc
RS Mode	0 to 250 Kc*‡	0 to 250 Kc*	0 to 250 Kc* †	0 to 300 Kc*	0 to 250 Kc*
AMPLITUDE (except base inputs)					
Maximum	9V P-P	9V P-P	9V P-P	9V P-P	9V P-P
Minimum (pos-going pulse) @ rise time up to 1.0 μsec)■	6V P-P	6V P-P	6V P-P	6V P-P	6V P-P
AMPLITUDE (base input)	—NA—	—NA—	DC level shift —3.5 to —1.0V	—NA—	—NA—
RISE TIME	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec
INPUT LOAD CHARACTERISTICS:					
TRIGGER inputs:					
A, B	10, 100	5, 50	10, 100	10, 100	10, 100
C, D	16, 150	0, 200	16, 150	16, 150	16, 150
E, F	10, 100	10, 25	10, 100	10, 100	10, 100
AC SET & RESET inputs:					
A, B	20, 100	20, 100	20, 100	20, 100	20, 100
C, D	40, 150	40, 150	40, 150	40, 150	40, 150
E, F	20, 100	20, 100	20, 100	20, 100	20, 100
DIRECT inputs: (Refer to Description)					
A, B	10, 0	10, 0	Direct: 10, 0 Base: 15, 0	10, 0	10, 0
OUTPUT					
AMPLITUDE (nominal DC levels)	—3V = "1", —11V = "0"	—3V = "1", —11V = "0"	—3V = "1", —11V = "0"	—3V = "1", —11V = "0"	—3V = "1", —11V = "0"
RISE TIME (depending on load & input signal)	0.2 to 1.0 μsec	0.2 to 1.0 μsec	0.2 to 1.0 μsec	0.2 to 1.0 μsec	0.2 to 1.0 μsec
FALL TIME	approx. 2.0 μsec	approx. 2.0 μsec	approx. 2.0 μsec	approx. 2.0 μsec	approx. 2.0 μsec
LOAD DRIVE CHARACTERISTICS	††T mode: AB type I RS mode: AB type III	††AB type I	††T mode: AB type I RS mode: AB type III	•CD type IV	•T mode: Pin 7: CD type IV Pin 8: AB type I RS mode: Pin 7: CD type IV Pin 8: AB type III
POWER REQUIRED					
—12 VDC ± 10%	5 ma	9 ma	5 ma	12.8 to 27 ma depending on load	8.9 to 16 ma depending on load
+12 VDC ± 10%	none	none	none	3.9 to 11 ma depending on load	3.9 to 11 ma depending on load
OPERATING TEMPERATURE RANGE					
	—45 to +65°C	—45 to +65°C	—45 to +65°C	—45 to +65°C	—45 to +65°C

* With duty cycle of driving signal for frequencies above 150 Kc reduced to allow 5.0 μsec recovery time on each input.

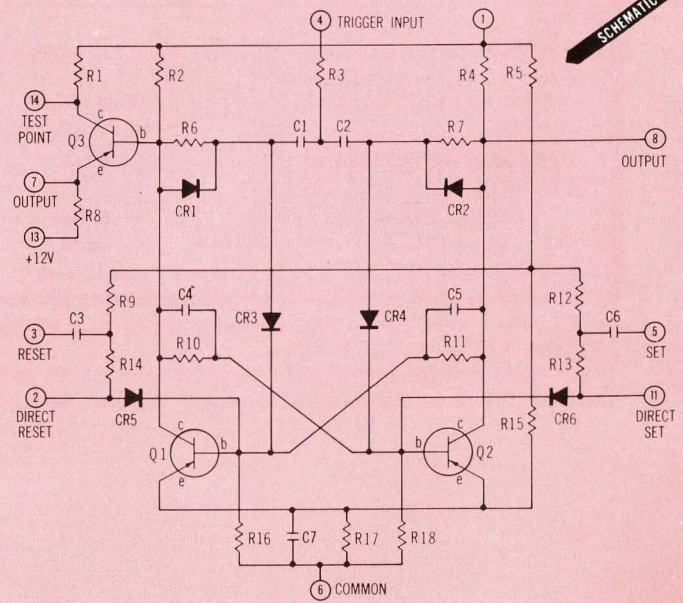
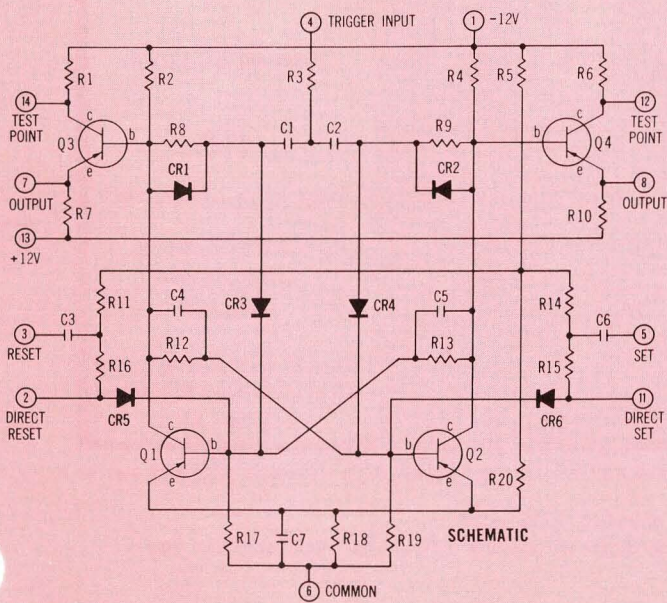
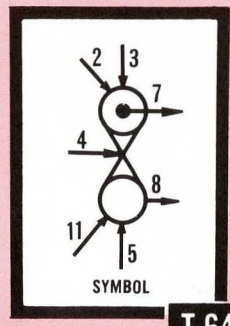
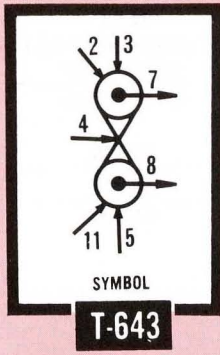
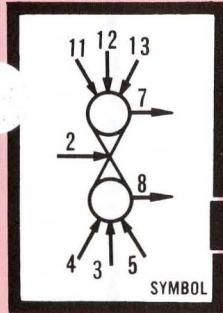
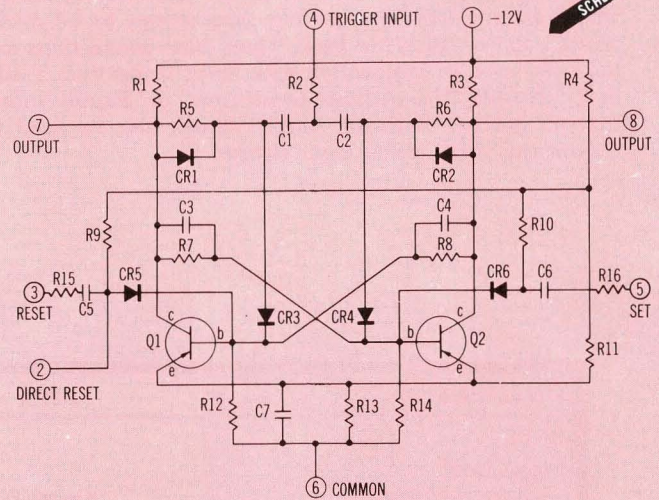
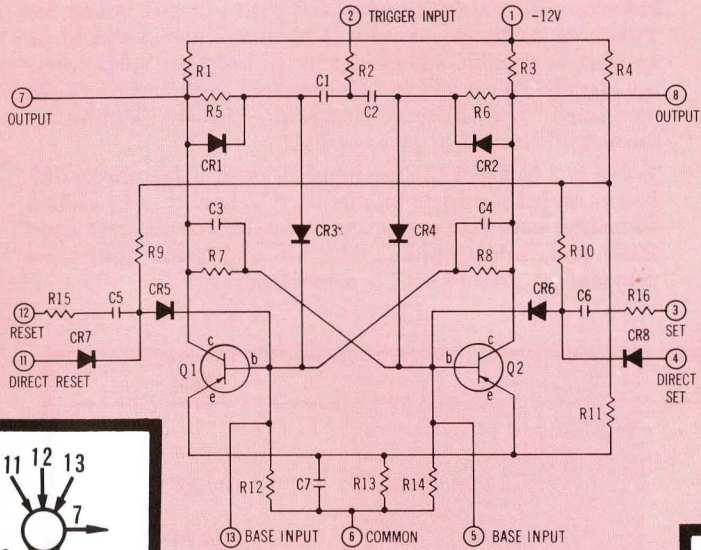
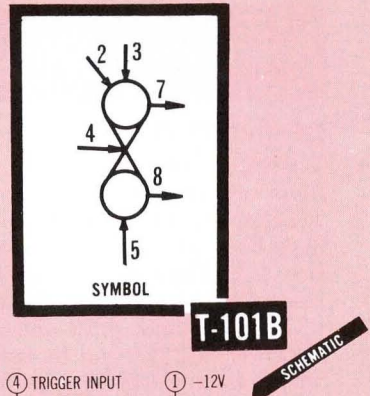
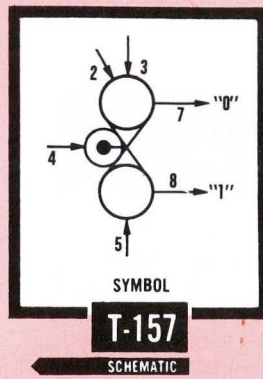
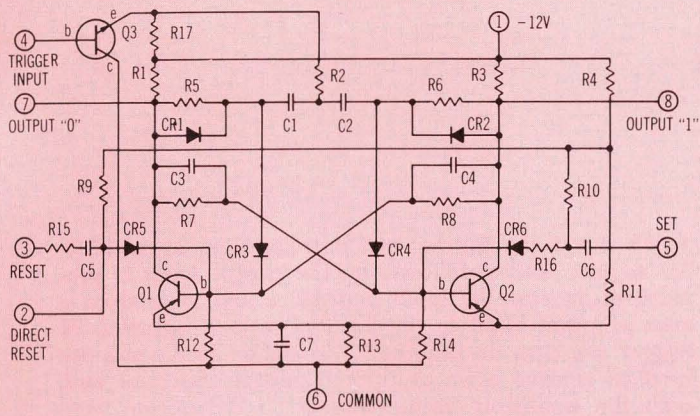
† Range extends to 400 Kc when lightly loaded and with 7V minimum input at 0.4 μsec rise time.

‡ Range extends to 300 Kc with 6.5V minimum input at 1 μsec rise time or faster.

†† Capacitive loading on one output may deteriorate rise time on other output. Rise time can be restored by using emitter follower between flip-flop output and capacitive load.

- When operating into capacitive loads, connect a 5.6 KΩ external resistor from output to +12V supply.

- At faster rise times, less amplitude is required. However, these units will not trigger on 1.5V or less regardless of rise time.



T FLIP-FLOPS T-102A, T-303, T-647

DESCRIPTION

T-102A is used as a storage or memory device and as a frequency divider. It is very similar to RST flip-flop T-101B except that the diode-isolated set and reset inputs have been eliminated and replaced with a direct connection to the base of each transistor. This unit is intended, primarily, to be triggered in the T (trigger or binary) mode where each input pulse changes the state of the flip-flop. However, T-102A can be used in set and reset operation where external circuitry permits connections to be made directly to the transistor base. These base connections are normally used in conjunction with Reset Generators T-109 or T-129 (See "Use of Reset Generators" in "Family Information" section of this catalog) but can also be used in conjunction with pulse logic circuits.

T-303 is a T flip-flop for use at frequencies up to 5Mc. An integral emitter follower on the trigger input is provided to increase the input impedance and to produce a more constant input to the flip flop proper regardless of trigger rise time or amplitude. Saturation techniques are used to achieve more uniform transistor operation and, with the transistors used, there is no detracting from operating speeds.

Extreme care should be exercised with external wiring for T-303. In particular, any leads to pins 2 and 3 should be as short as possible and placed away from any leads carrying signals. DC resetting may be done as described in the paragraph "Use of Reset Generators" in the "Family Information" section of this catalog.

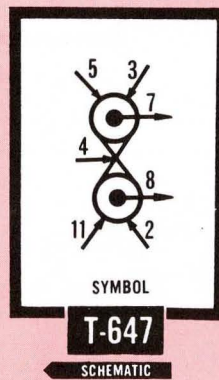
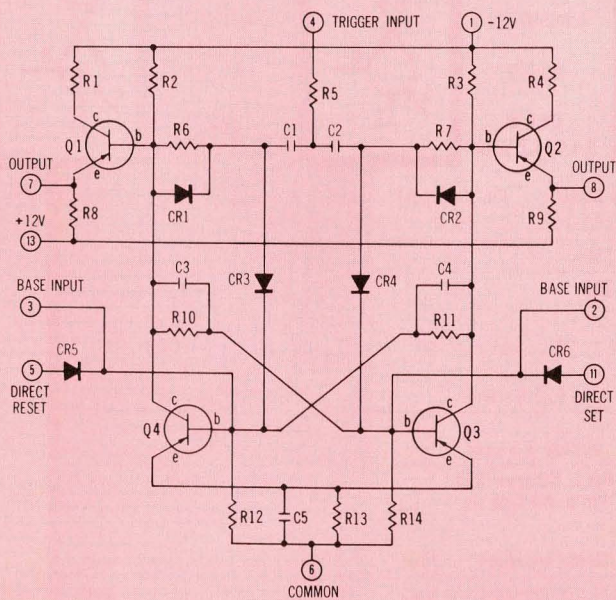
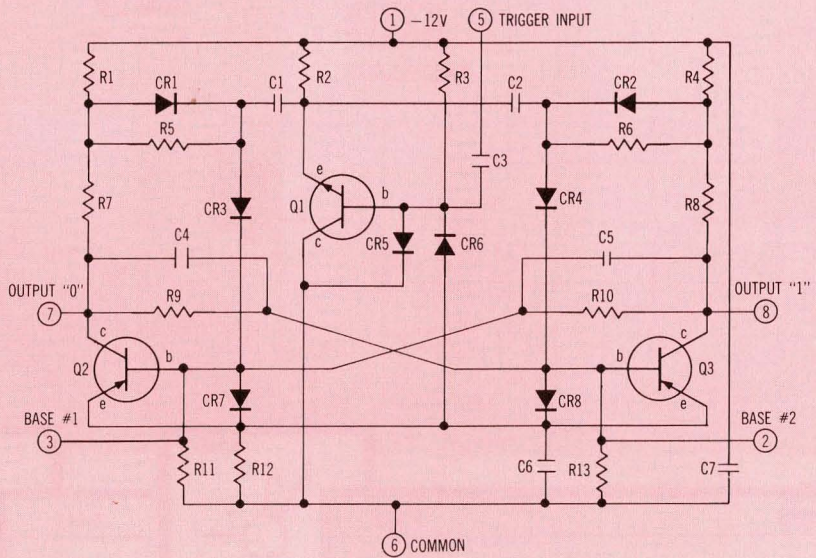
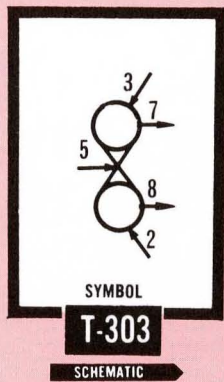
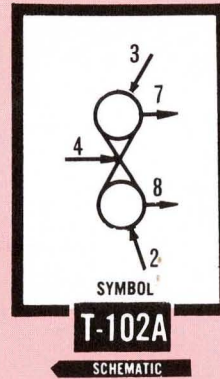
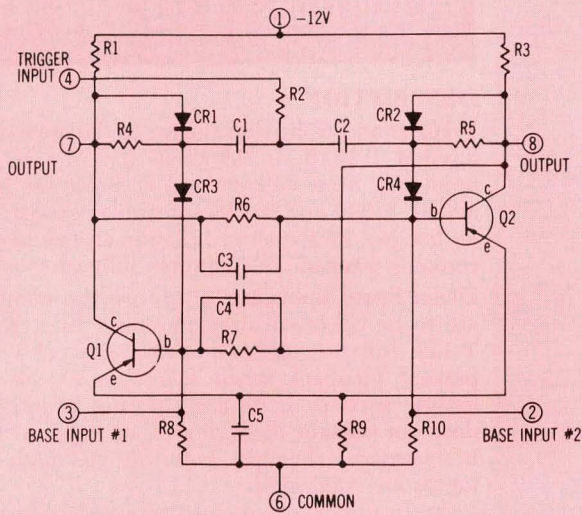
T-647 is a T flip-flop containing integral PNP emitter followers on both outputs to improve DC-load driving ability. Transistor base connections are available for set-reset operation and, additionally, DC set and reset inputs are provided at pins 11 and 5 respectively.

T FLIP-FLOPS	T-102A	T-303	T-647
INPUT			
Trigger Input			
SIGNAL FREQUENCY	0 to 250 Kc	0 to 5 Mc	0 to 250 Kc
AMPLITUDE			
Maximum	9V P-P	9V P-P	9V P-P
Minimum †	6V pos.-going pulse @ rise times up to 1.0 μsec	6V pos.-going pulse @ rise time up to 0.2 μsec from 0 to 2Mc*	6V pos.-going pulse @ rise time up to 1.0 μsec
RISE TIME	0.1 to 1.0 μsec	0.2 μsec max.*	0.1 to 1.0 μsec
INPUT LOAD CHARACTERISTICS:			
A, B	10, 100	0, 150	10, 100
C, D	16, 150	5, 25	16, 150
E, F	10, 100	0, 150	10, 100
Base Inputs			
MINIMUM AMPLITUDE (DC level shift from:)	-3.5 VDC to -1.0 VDC	0 VDC to -4 VDC	-3.5 VDC to -1.0 VDC
INPUT LOAD CHARACTERISTICS: (Refer to Description)			
A, B	10, 0	20, 0	10, 0
OUTPUT			
AMPLITUDE (nominal DC levels:)	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"
RISE TIME (depending on load, frequency, & input signal)	0.2 to 1.0 μsec	15 to 60 nsec	0.2 to 1.0 μsec
FALL TIME	approx. 2.0 μsec	0.1 to 0.5 μsec	approx. 2.0 μsec
LOAD DRIVE CHARACTERISTICS			
POWER REQUIRED	AB type I	two T-303 on each output or two T-303 on one output	CD type IV†
-12 VDC ± 10%	5.0 ma	18.5 ma	4.6 to 27 ma depending on load
+12 VDC ± 10%	none	none	3.9 to 11 ma depending on load
OPERATING TEMPERATURE RANGE			
	-45 to +65°C	-45 to +65°C	-45 to +65°C

*At 2 to 5 Mc, a rise time of 30% of input period or faster will trigger flip-flop with 6.0V pos.-going wave form. Sine-wave triggering may be extended by increasing input to 6.5V.

†When operating into capacitive loads, connect external 5.6 KΩ resistor from output to +12V supply.

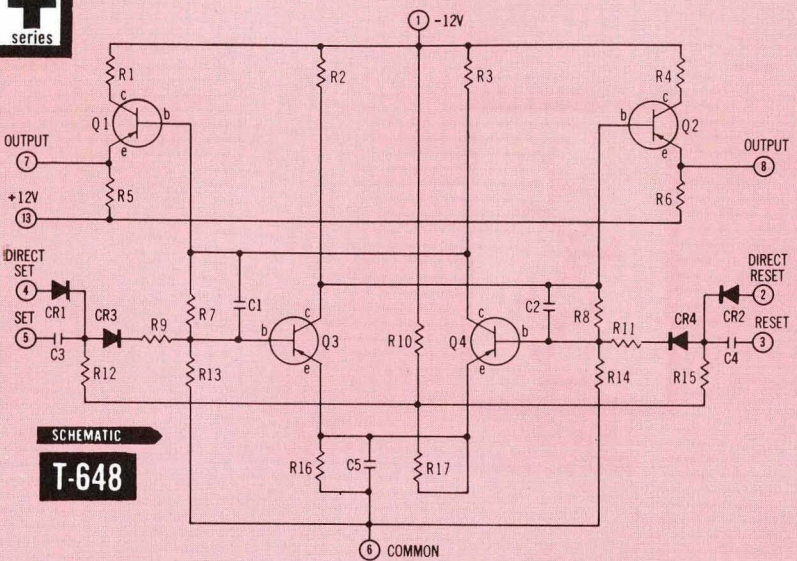
‡At faster rise times, less amplitude is required. However, these units will not trigger on inputs of 1.5V or less regardless of rise time.



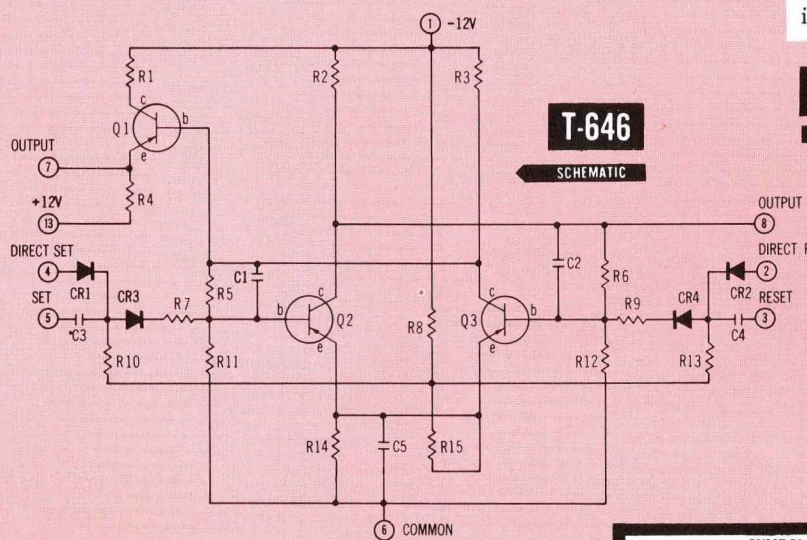
RS FLIP-FLOPS T-162, T-646, T-648

DESCRIPTION

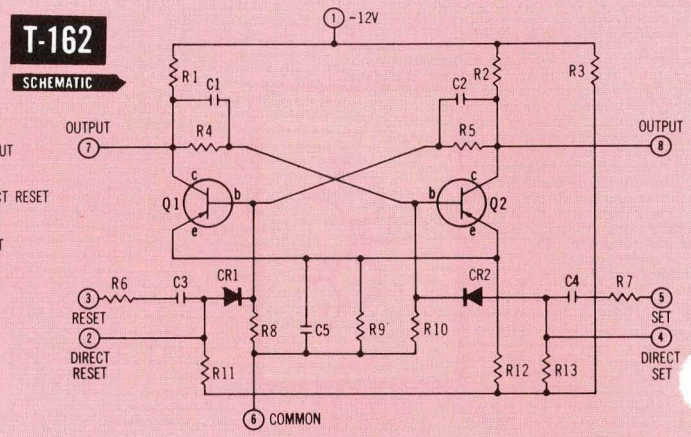
T-162 is an RS flip-flop similar to the general-purpose RST flip-flop T-101B. It differs in that the binary or trigger input has been deleted and a direct set input has been added. **T-646** and **T-648** are similar except T-646 contains an integral PNP emitter follower on one output and T-648 contains integral PNP emitter followers on both outputs. Direct Reset inputs are for use when a number of flip-flops are to be operated in synchronism by a Reset Generator T-109. Isolation diodes on these inputs of T-646 and T-648 prevent feedback when several units are connected together, such as in forming a ring counter. Since T-162 does not contain these diodes, an external isolating diode is necessary whenever both the AC and associated DC inputs are connected.



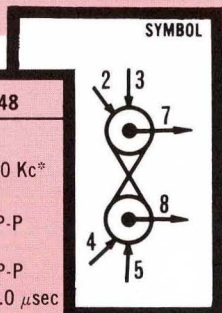
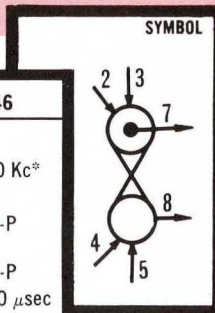
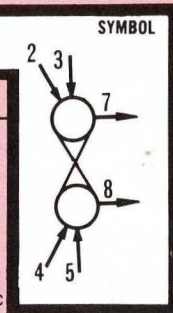
SCHEMATIC
T-648



SCHEMATIC
T-646



SCHEMATIC
T-162



RS FLIP FLOPS	T-162		T-646		T-648	
INPUT						
SIGNAL FREQUENCY RANGE	0 to 250 Kc*		0 to 300 Kc*		0 to 300 Kc*	
AMPLITUDE:						
Maximum	9V P-P		9V P-P		9V P-P	
Minimum (pos-going pulse @ rise times up to 1 μsec)†	6V P-P		6V P-P		6V P-P	
RISE TIME	0.1 to 1.0 μsec		0.1 to 1.0 μsec		0.1 to 1.0 μsec	
INPUT LOAD CHARACTERISTICS: (Refer to Description)						
A, B	Pins 3 & 5 (AC)	Pin 2 (direct)	Pins 3 & 5 (AC)	Pin 2 (direct)	Pins 3 & 5 (AC)	Pins 2 & 4 (direct)
C, D	20, 100	10, 0	15, 100	15, 0	15, 100	15, 0
E, F	40, 150	NA	40, 150	NA	40, 150	NA
OUTPUT						
AMPLITUDE (nominal DC levels)	-3V = "1", -11V = "0"		-3V = "1", -11V = "0"		-3V = "1", -11V = "0"	
RISE TIME (depending on load & input signal)	0.2 to 1.0 μsec		0.4 to 1.0 μsec		0.4 to 1.0 μsec	
FALL TIME (depending on load & input signal)	approx. 2.0 μsec		approx. 1.5 μsec		approx. 1.5 μsec	
LOAD DRIVE CHARACTERISTICS	AB type III		Pin 7: CD type IV†† Pin 8: AB type II‡		CD type IV††	
POWER REQUIRED						
-12 VDC ± 10%	5 ma		8.9 to 16 ma depending on load		8.9 to 27 ma depending on load	
+12 VDC ± 10%	none		3.9 to 11 ma depending on load		3.9 to 11 ma depending on load	
OPERATING TEMPERATURE RANGE	-45 to +65°C		-45 to +65°C		-45 to +65°C	

* With duty cycle of driving signal for frequencies above 150 Kc reduced to allow 5 μsec recovery time on each input.

† At faster rise times, less amplitude is required. However, these units will not trigger on inputs of 1.5V or less regardless of rise time.

‡ Capacitive loading on pin 8 may deteriorate rise time of pin 7 output. Output rise time can be restored by using emitter follower between flip-flop output and capacitive load.

†† When operating into capacitive loads, connect external 5.6 KΩ resistor from output to +12V supply.

DESCRIPTION

T-301A and **T-801A** are gated high-frequency flip-flops connected in Eccles-Jordan type bistable circuits. Anti-saturation techniques are employed to achieve high-frequency response. One of two input gates is enabled by a DC voltage level and the flip-flop is triggered by pulses supplied at a common input. A "DC Reset" is provided for use when a number of flip-flops are to be synchronously reset by a DC Reset Generator T-109. T-801A also has AC-coupled "Reset" and "Set" inputs along with a direct base input to provide maximum versatility.

T-604 and **T-629** are gated flip-flops for use where a flip-flop with gated set and reset inputs is required. These units also have provisions for parallel entry of binary "1" 's. The load characteristics for the parallel-data input lines and the "transfer data" inputs are identical to those called out for Data inputs and Shift Pulse inputs respectively in the specification table. T-629 has a Direct Reset input and T-604 has a direct base input connection which can be used to either set or reset the flip-flop. Both of

SHIFT REGISTER and GATED FLIP-FLOPS
T-301A, T-604, T-605, T-606, T-610, T-629, T-801A

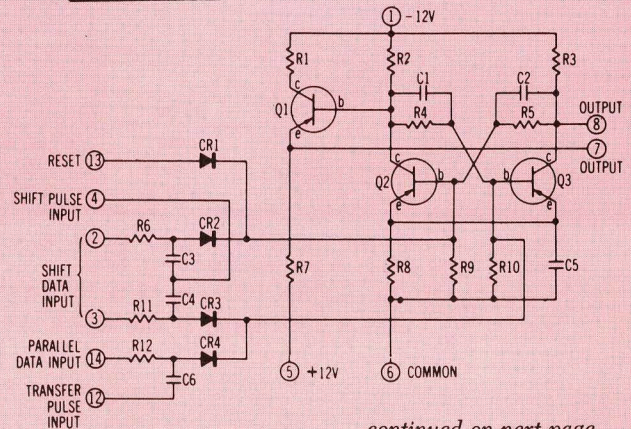
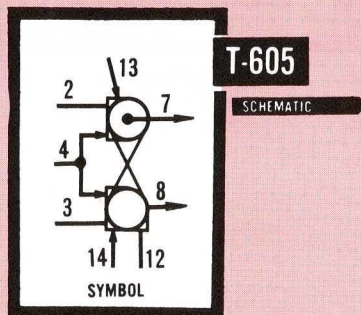
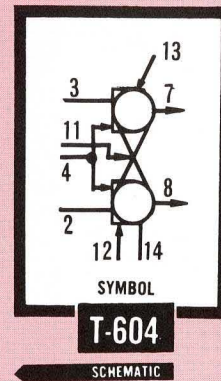
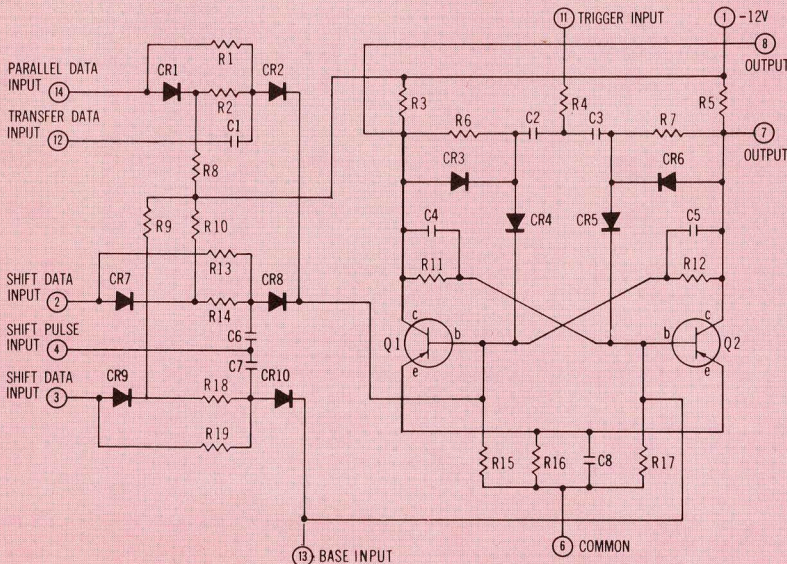
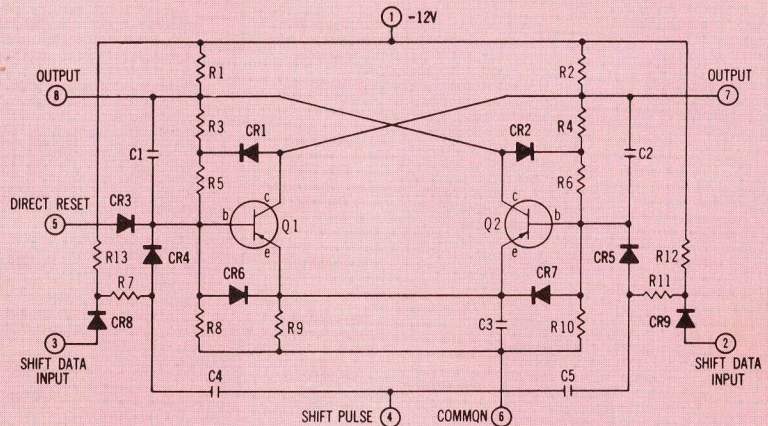
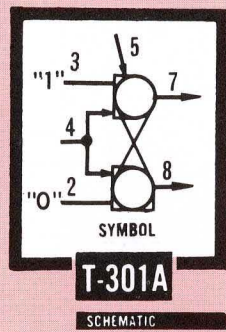
these units have an additional ungated trigger input for special operations.

T-605, T-606 and **T-610** are complete shift elements, containing the storage and gating circuits within a single package. One of the models, T-606, is a general-purpose element for flexible application. The T-605 and T-610 units each include an output emitter follower to facilitate parallel loading into DC logic.

The usual areas of application for these circuits are:

- T-605 — Parallel-in, parallel-out.
- T-606 — Serial-in, serial-out; or parallel-in- serial-out.
- T-610 — Serial-in, parallel-out.

The T-605 is a slow-speed element that will work at speeds up to 25Kc. The T-606 and T-610 are both medium-speed devices that will work at speeds up to 250Kc.



continued on next page

continued from preceding page

SHIFT REGISTER and GATED FLIP-FLOPS	T-301A Gated F/F (1 Mc)	T-604 Gated F/F (250 Kc)	T-605 Shift Reg. F/F (25 Kc)	T-606 Shift Reg. F/F (250 Kc)	T-610 Shift Reg. F/F (250 Kc)	T-629 Gated F/F (250 Kc)	T-801A Gated F/F (1 Mc)
INPUT							
Data Input							
SIGNAL FREQUENCY RANGE	0 to 500 Kc	0 to 125 Kc	0 to 12.5 Kc	0 to 125 Kc	0 to 125 Kc	0 to 125 Kc	0 to 500 Kc
SIGNAL LEVEL (nominal)							
Enable	-2.5 to -4.0 VDC	-3 VDC	-3 VDC	-3 VDC	-3 VDC	-3 VDC	-2.5 to -4.0 VDC
Disable	-10 to -12 VDC	-11 VDC	-11 VDC	-11 VDC	-11 VDC	-11 VDC	-10 to -12 VDC
RISE TIME (μ sec)	0.05 to 0.5	0.1 to 1.0	0.1 to 1.0	0.1 to 1.0	0.1 to 1.0	0.1 to 1.0	0.05 to 0.3
INPUT LOAD CHARACTERISTICS:							
A, B	5, 150	25, 150	25, 150	25, 150	25, 150	25, 150	5, 150
C, D	20, 200	20, 300	20, 200	20, 300	20, 300	20, 300	20, 200
E, F	5, 150	25, 150	25, 150	25, 150	25, 150	25, 150	5, 150
Shift Pulse							
SIGNAL FREQUENCY RANGE	0 to 1 Mc	0 to 250 Kc	0 to 25 Kc	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc	0 to 1 Mc
AMPLITUDE							
Maximum	9V P-P	9V P-P	9V P-P	9V P-P	9V P-P	9V P-P	9V P-P
Minimum	6V P-P	7.5V P-P	6V P-P	7.5V P-P	7.5V P-P	7.5V P-P	6V P-P
RISE TIME (μ sec)	0.05 to 0.2	0.4 (max.)	0.1 to 1.0	0.4 (max.)	0.4 (max.)	0.4 (max.)	0.05 to 0.2
INPUT LOAD CHARACTERISTICS:							
A, B	25, 150	50, 300	25, 150	50, 300	50, 300	50, 300	25, 150 •
C, D	20, 150	20, 150	20, 150	20, 150	20, 150	20, 150	20, 150 •
E, F	25, 150	50, 300	25, 150	50, 300	50, 300	50, 300	25, 150 •
Ungated Trigger							
SIGNAL FREQUENCY RANGE	— NA —	0 to 250 Kc	— NA —	— NA —	— NA —	0 to 250 Kc	— NA —
AMPLITUDE							
Maximum	— NA —	9V P-P	— NA —	— NA —	— NA —	9V P-P	— NA —
Minimum (pos.-going pulse @ rise times up to 1 μ sec)*	— NA —	6V P-P	— NA —	— NA —	— NA —	6V P-P	— NA —
RISE TIME (μ sec)	— NA —	0.1 to 1.0	— NA —	— NA —	— NA —	0.1 to 1.0	— NA —
INPUT LOAD CHARACTERISTICS:							
A, B	— NA —	10, 100	— NA —	— NA —	— NA —	10, 100	— NA —
C, D	— NA —	8, 75	— NA —	— NA —	— NA —	8, 75	— NA —
E, F	— NA —	10, 100	— NA —	— NA —	— NA —	10, 100	— NA —
Direct Reset							
REQUIRES SAME OUTPUT AS THAT GENERATED BY	T-109	T-109‡	T-109	T-109‡	T-109	T-109	T-109
INPUT LOAD CHARACTERISTICS: (Refer to Description)							
	20, 0	15, 0	10, 0	15, 0	10, 0	10, 0	20, 0
OUTPUT							
AMPLITUDE (Nominal DC levels)	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"	-3V = "1", -11V = "0"
RISE TIME (in μ sec & depending on load and input signal)	0.05 to 0.2	0.2 to 1.0	0.2 to 1.0	0.2 to 1.0	0.2 to 1.0	0.2 to 1.0	0.05 to 0.2
FALL TIME (in μ sec)	0.5 (max.)	2.0 (approx.)	2.0 (approx.)	2.0 (approx.)	2.0 (approx.)	2.0 (approx.)	0.5 (max.)
LOAD DRIVE CHARACTERISTICS:							
	AB type VI	Trigger Mode: AB type I SR Mode: AB type V	Pin 7: CD type IV Pin 8: AB type V	AB type V	Pin 7: CD type IV Pin 8: AB type V	Trigger Mode: AB type I SR Mode: AB type V	AB type VI
POWER REQUIRED							
-12 VDC \pm 10%	11 ma	7.3 ma	8.9 to 16 ma	6.6 ma max.	9.8 to 16.9 ma	7.3 ma max.	11 ma
+12 VDC \pm 10%	none	none	3.9 to 11 ma	none	3.9 to 11 ma	none	none
OPERATING TEMPERATURE RANGE							
	-45 to +65°C	-45 to +65°C	-45 to +65°C	-45 to +65°C	-45 to +65°C	-45 to +65°C	-45 to +65°C

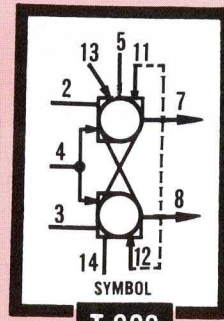
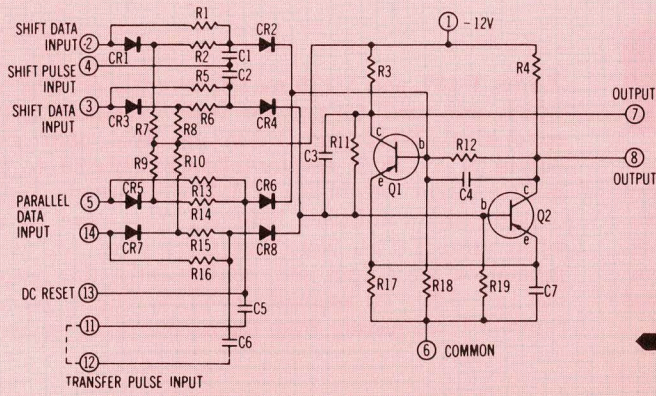
* At faster rise times, less amplitude is required. However, these units will not trigger on 1.5V or less regardless of rise time.

‡ Connect external resistor from Pin 13 to 12V common.

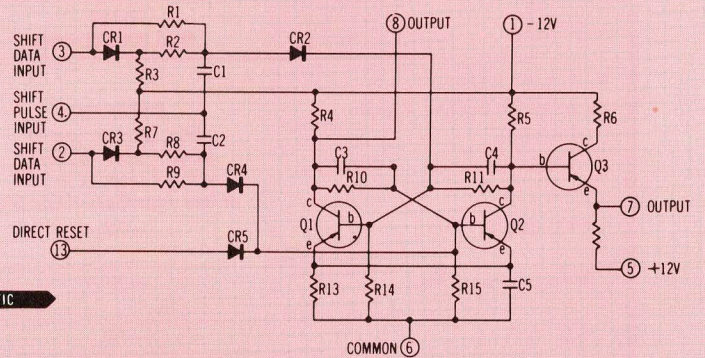
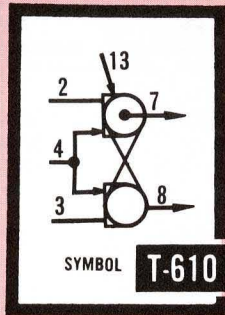
Value = $\frac{10,000}{N}$ where N is the number of Shift Register elements.

‡ Connect external diode to isolate transistor base circuit from T-109 output circuit.

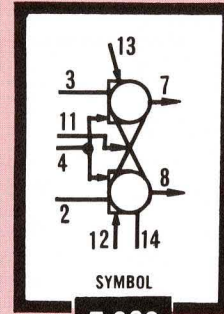
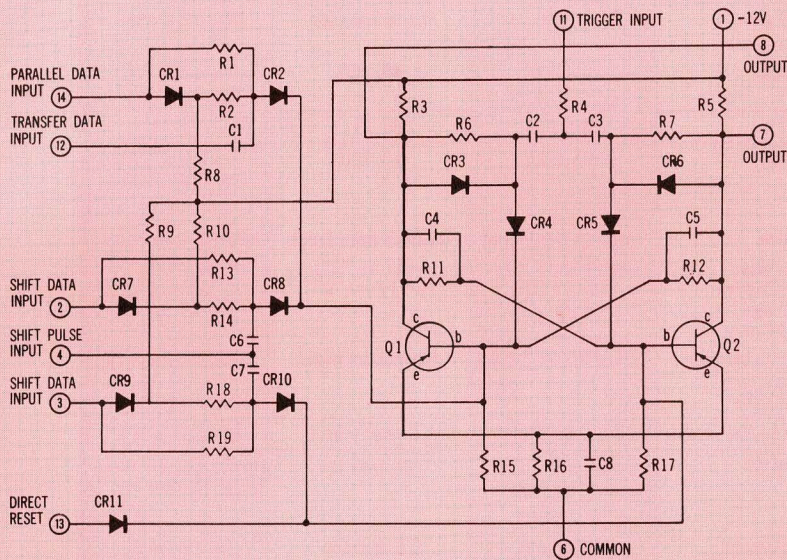
• Pins 4, 12 and 13.



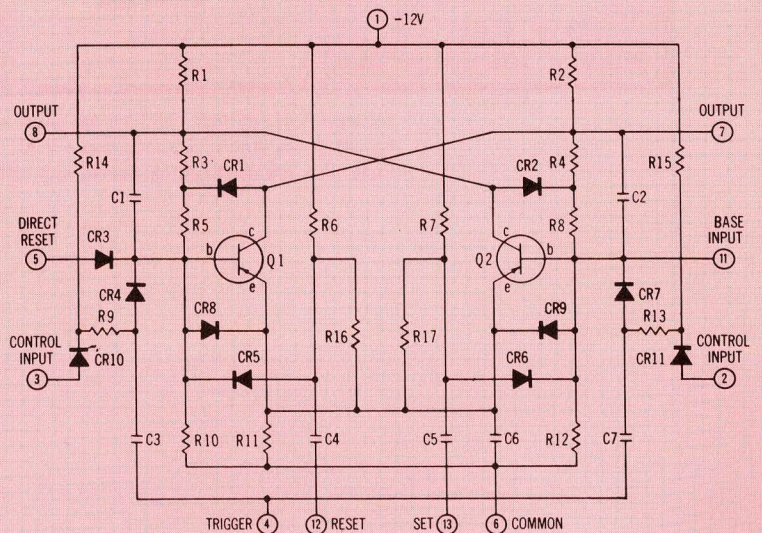
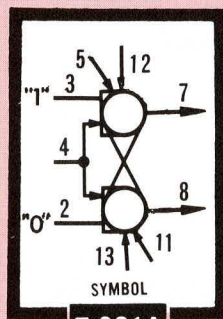
SCHEMATIC T-606



SCHEMATIC



SCHEMATIC T-629



SCHEMATIC T-801A

INVERTERS T-117, T-136, T-137, T-138

DESCRIPTION

T-117 contains two identical, independent Pulse Inverting Amplifiers. Each amplifier produces a standard positive-going pulse of 1 to 2 microseconds duration for each negative-going input pulse or voltage step. Inputs are shaped to produce outputs of improved rise time and standard amplitude.

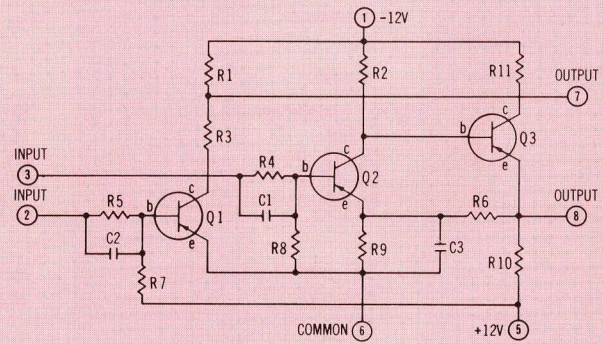
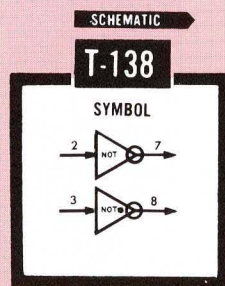
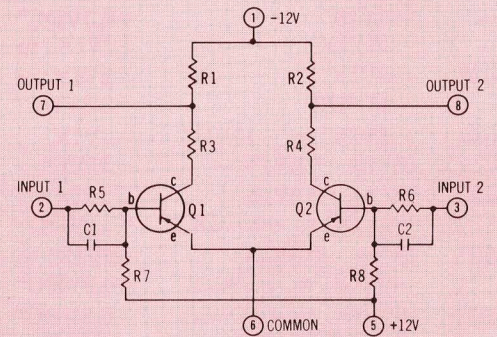
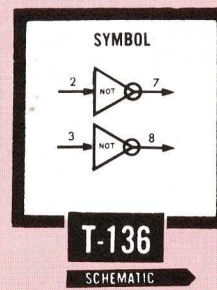
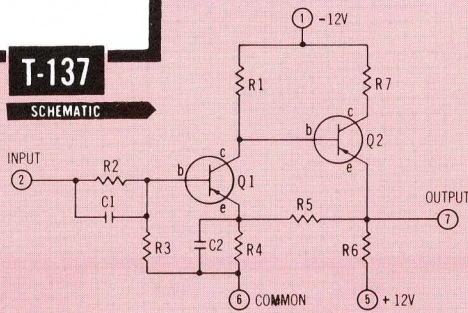
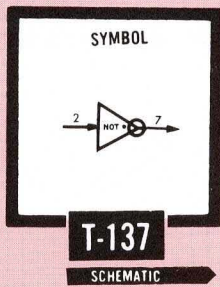
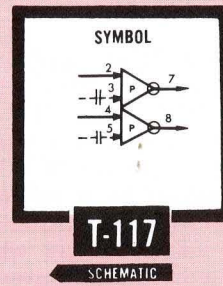
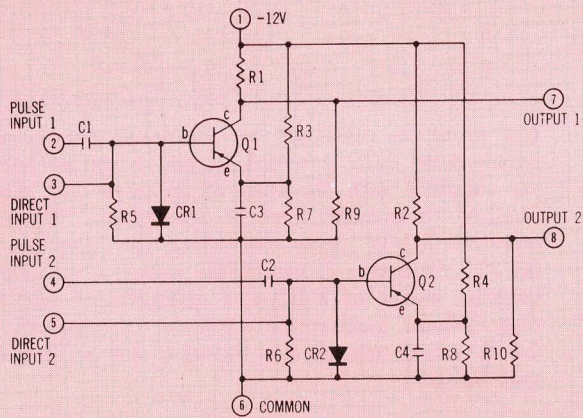
T-136, T-137, and T-138 are DC inverters or "Not" circuits which are used to provide logic inversion with level restoration. T-136 and T-138 are dual units and one output of T-138 is emitter-follower buffered to provide greater drive capability. T-137 is a single unit with built-in emitter-follower buffering. One note of caution when using T-136: Note that there is no DC return to ground on the output and, consequently, this output can rise to $-12V$. To establish a $-11V$ output, connect an external $11K\Omega$ resistor from the output pin to ground.

INVERTERS	T-117 Dual Pulse Inverter	T-136 Dual Inverter	T-137 Buffered Inverter	T-138 Dual Inverter
INPUT (each inverter)				
SIGNAL FREQUENCY RANGE	250 Kc max.	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc
AMPLITUDE	Min. pulse or step of 6V @ 1 μ sec rise time.* Will not respond to 1.5V or less, regardless of rise time	$-3V = "1"$, $-11V = "0"$	$-3V = "1"$, $-11V = "0"$	$-3V = "1"$, $-11V = "0"$
ON CURRENT (Max.)	—NA—	1.02 ma	0.36 ma	Pin 2: 1.02 ma Pin 3: 0.4 ma
OFF CURRENT (Max.)	—NA—	0.4 ma	0.1 ma	Pin 2: 0.4 ma Pin 3: 0.1 ma
RISE TIME	—NA—	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec
FALL TIME	0.1 to 1.0 μ sec*	0.1 to 2.0 μ sec	0.1 to 2.0 μ sec	0.1 to 2.0 μ sec
INPUT LOAD CHARACTERISTICS:				
A, B	15, 100	65, 200	40, 100	Pin 2: 65, 200 Pin 3: 40, 100
C, D	50, 75	40, 150	20, 75	pin 2: 40, 150 pin 4: 20, 75
E, F	15, 100	65, 200	40, 100	Pin 2: 65, 200 Pin 3: 40, 100
OUTPUT (each inverter)				
POLARITY	positive	inverted from input	inverted from input	inverted from input
AMPLITUDE	Leading edge: 9.5V max., 7V min. Trailing edge: 9V max., 7V min.	$-3V = "1"$, $-11V = "0"$	$-3V = "1"$, $-11V = "0"$	$-3V = "1"$, $-11V = "0"$
PULSE WIDTH (half amplitude points)	1.5 to 4.5 μ sec depending on input fall time and amplitude	depends on input	depends on input	depends on input
RISE AND FALL TIMES	0.15 to 0.5 μ sec	1.0 μ sec max.†	1.0 μ sec max.†	1.0 μ sec max.†
LOAD DRIVE CHARACTERISTICS	AB type VII	AB type XVIII	CD type IV	Pin 7: AB type XVIII Pin 8: CD type IV
POWER REQUIRED				
-12 VDC $\pm 10\%$	3.0 ma quiescent, 4.5 ma peak	10 ma max.	6.5 ma max.	16.3 ma max.
+12 VDC $\pm 10\%$	none	1 ma max.	4.0 ma max.	4.4 ma max.
OPERATING TEMPERATURE RANGE	-45 to $+65^\circ C$	-55 to $+71^\circ C$	-55 to $+71^\circ C$	-55 to $+71^\circ C$

* For signals of very poor rise time use direct input with external capacitor of suitable size.

For input rise time of 5.5 μ sec, use a 0.001 μ f capacitor.

† Faster rise and fall times obtainable with lighter loads.



LEVEL CONVERTERS

T-657, T-658, T-659, T-660, T-807, T-808

DESCRIPTION

These circuits are used for converting digital signals from one set of assigned voltage levels to some other set of voltage levels. That is, inputs of -6VDC (binary "1") and 0V (binary "0") could, for example, be converted to outputs of +6VDC (binary "1") and 0V (binary "0"). The specific output voltages are determined by a reference voltage. Actual input-to-output level conversion performed by each of the units (including voltage ranges where applicable) are listed below. There are two such converters in each container.

The units are packaged in cylindrical plug-in containers which mate with standard 14-pin miniature sockets that are supplied with the units at no extra cost. Pin #10 is blanked to provide keyway orientation. The containers measure 2-1/2" long (including the plug-in base) by 29/32" diameter. A removable cover is attached to the base by means of a bayonet arrangement and a locking ring. Where mechanical retention is required, standard 2-3/8" noval tube shields (either J-slot or Snap-on types) may be used.

TABLE I. Input and Output Voltage Levels

UNIT	INPUT	CORRESPONDING OUTPUT
T-657	-3VDC	+0.3VDC*
	-11VDC	+2VDC to +15VDC
T-658	-3VDC	-2VDC to -15VDC
	-11VDC	-0.3VDC*
T-659	-2VDC to -15VDC	-3VDC
	0V to -0.5VDC	-11VDC
T-660	0V to +0.5VDC	-3VDC
	+2VDC to +15VDC	-11VDC
T-807	0V to -0.5VDC	+2VDC to +15VDC
	-2VDC to -15VDC	+0.3VDC*
T-808	+2VDC to +15VDC	-0.3VDC*
	0V to +0.5VDC	-2VDC to -15VDC

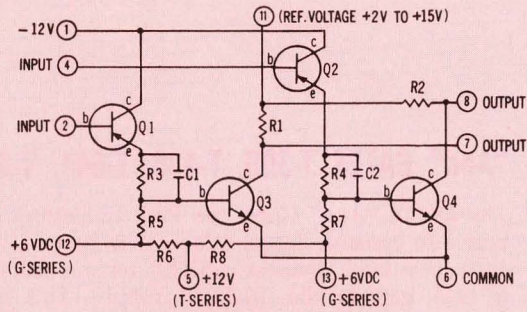
*Nominal saturation voltage of Ge transistor.

ELECTRICAL SPECIFICATIONS

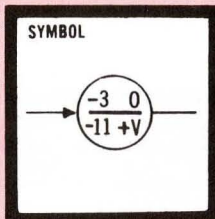
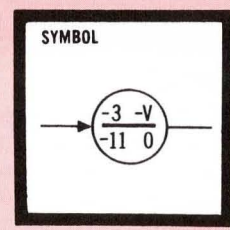
Since these units have been designed for level conversion, their power-supply requirements are quite flexible. However, they are not good driving sources and if capacitive loads are to be driven, then a buffer amplifier will generally be necessary between the level converter and the circuit to be driven.

LEVEL CONVERTERS	T-657	T-658	T-659	T-660	T-807	T-808
INPUT						
SIGNAL FREQUENCY RANGE	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc	0 to 1 Mc	0 to 1 Mc
SIGNAL LEVELS: see TABLE I						
RISE and FALL TIMES** max.	1 μsec	1 μsec	1 μsec	1 μsec	0.2 μsec	0.2 μsec
INPUT LOAD	50 KΩ impedance min. AB: 10, 0 CD: 30, 0 EF: 10, 0	50 KΩ impedance min. AB: 10, 0 CD: 30, 0 EF: 10, 0	0V input: 0.8 ma -15V input: 10 μamp max.	0V input: 0.2 ma +15V input: 0.06 ma	0V input: 0.8 ma -15V input: 40 μamp	0V input: 0.5 ma +4V input: 1 ma*
OUTPUT						
RISE TIME (no load) max.	0.5 μsec	0.3 μsec	0.5 μsec	0.5 μsec	0.065 μsec	0.04 μsec
FALL TIME (no load) max.	0.5 μsec	0.5 μsec	0.2 μsec	0.6 μsec	0.025 μsec	0.05 μsec
IMPEDANCE						
@ 0.3V level	50Ω	50Ω	NA	NA	50Ω	50Ω
@ -3V level	NA	NA	250Ω	350Ω	NA	NA
@ ref. level	1 KΩ	1 KΩ	NA	NA	1 KΩ	1 KΩ
@ -11V level	NA	NA	1 KΩ [AB type XIII]	1 KΩ [AB type XIII]	NA	NA
POWER REQUIRED (±10%***):						
-12VDC @:	10 ma	10 ma	25 ma	25 ma	9 ma	4 ma
+12VDC or +6VDC @:	10 ma	10 ma	NA	5 ma	14 ma	14 ma
REF:	+2V @ 4 ma to +15V @ 30 ma	-2V @ 4 ma to -15V @ 30 ma	NA NA	NA NA	+2V @ 4 ma to +15V @ 30 ma	-2V @ 4 ma to +15V @ 30 ma
OPERATING TEMPERATURE RANGE	-54°C to +71°C	-54°C to +71°C	-54°C to +71°C	-54°C to +71°C	-54°C to +71°C	-54°C to +71°C

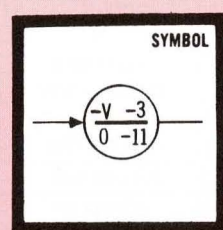
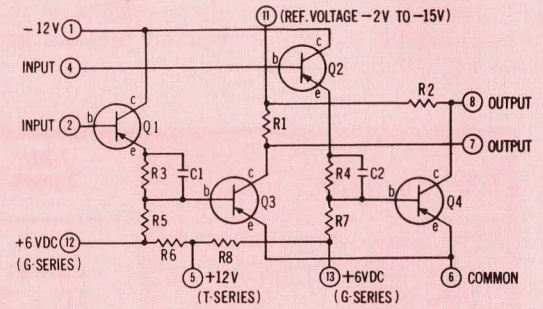
*For larger input signals, a resistor divider network may be used to reduce input current.
 **For maximum frequency input. At lower frequencies, a corresponding increase in time is permissible.
 ***With proportional changes in input/output characteristics.



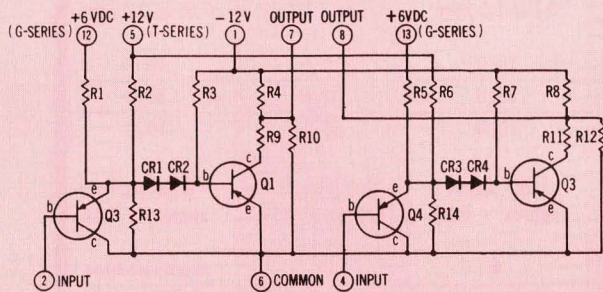
T-658



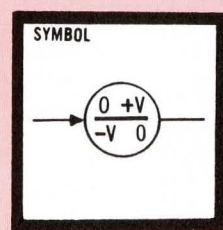
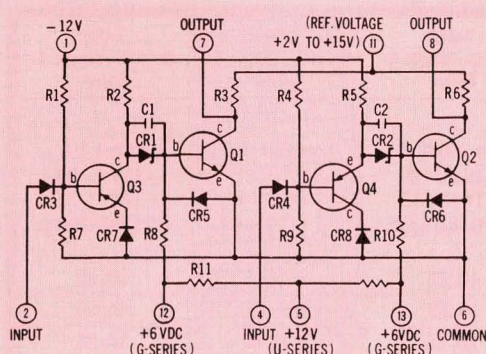
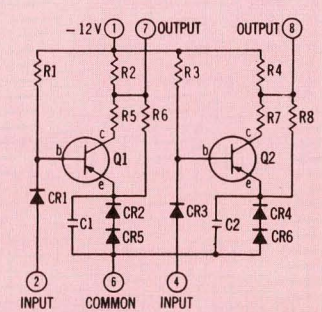
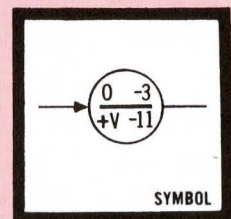
T-657



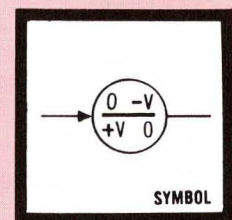
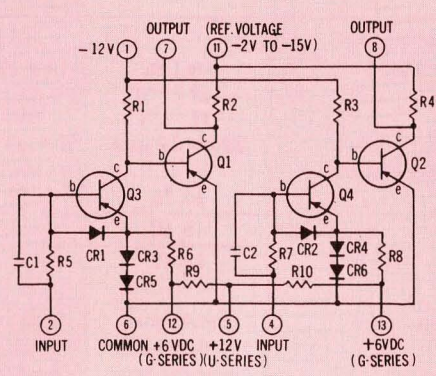
T-659



T-660



T-807



T-808

DCTL LOGIC

DESCRIPTION

DCTL Logic Gates use transistors connected as emitter followers at each input and all transistors share a common load resistor. The transistor base-emitter circuit functions as a diode and the emitter-follower configuration provides substantial current gain. The relatively high input impedance makes these units relatively light loads on the driving source. Another advantage of these circuits is that no interstage coupling element is required between gates or between gates and amplifiers.

"And" GATES T-309, T-439, T-641, T-650, T-802

The DCTL "And" Gates use PNP transistors and operate best into resistive loads. When it is necessary to drive a capacitive load, connect a 5.6KΩ resistor from the output of each gate to the +12-volt supply. This will increase driving ability for positive pulses as described in the "Use of Emitter Follower" paragraph in the "Family Information" section of this catalog.

DCTL "And" GATES	T-309 3-Input	T-439 3-Input	T-641 Dual 2-/single 4- Input	T-650 Dual 3-/single 6- Input	T-802 Dual 2-/single 4- Input
INPUT (Connect unused inputs to -3V)					
SIGNAL FREQUENCY RANGE	0 to 1 Mc	0 to 250 Kc*	0 to 250 Kc*	0 to 250 Kc*	0 to 1 Mc
AMPLITUDE	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"
RISE TIME	0.05 to 0.2 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.05 to 0.2 μsec
INPUT LOAD CHARACTERISTICS:					
A, B	10, 0	10, 0	10, 0	10, 0	10, 0
C, D	30, 0	30, 0	30, 0	30, 0	30, 0
E, F	10, 0	10, 0	10, 0	10, 0	10, 0
OUTPUT					
AMPLITUDE (equal to:)	input signal	input signal	input signal	input signal	input signal
LEVEL SHIFT	approx. +0.4V	approx. +0.3V	approx. +0.3V	approx. +0.3V	approx. +0.4V
RISE TIME:					
Unloaded (approx.)	input rise time	★	★	★	input rise time
Degradation Under Load	0.3 μsec max.	0.2 μsec max.	0.2 μsec max.	0.2 μsec max.	0.3 μsec max.
OUTPUT DRIVE CHARACTERISTICS	CD type IV	CD type IV	CD type IV	CD type IV	CD type IV
POWER REQUIRED (each gate)					
-12 VDC ± 10% (Depending on load)	3.9 to 11 ma	3.9 to 11 ma	3.9 to 11 ma	3.9 to 11 ma	3.9 to 11 ma
+12VDC ± 10% (Depending on load)	3.9 to 11 ma	3.9 to 11 ma	3.9 to 11 ma	3.9 to 11 ma	3.9 to 11 ma
OPERATING TEMPERATURE RANGE	-54 to +71°C	-54 to +71°C	-54 to +71°C	-54 to +71°C	-54 to +71°C

* Can be extended to 500 Kc with reduced load.

★ For inputs with rise times faster than 0.5 μsec., output rise time is 0.5 μsec. max. For slower input rise times, output rise time equals input rise time.

DCTL "Or" GATES	T-310 3-Input	T-440 3-Input	T-642 Dual 2-/single 4- Input	T-651 Dual 3-/single 6- Input	T-803 Dual 2-/single 4- Input
INPUT (Connect unused inputs to -12V)					
SIGNAL FREQUENCY RANGE	0 to 1 Mc	0 to 250 Kc*	0 to 250 Kc*	0 to 250 Kc*	0 to 1 Mc
AMPLITUDE	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"
RISE TIME	0.05 to 0.2 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.1 to 1.0 μsec	0.05 to 0.2 μsec
INPUT LOAD CHARACTERISTICS:					
A, B	10, 25	10, 25	10, 25	10, 25	10, 25
C, D	15, 50	15, 50	15, 50	15, 50	15, 50
E, F	10, 25	10, 25	10, 25	10, 25	10, 25
OUTPUT					
AMPLITUDE (equal to:)	input signal	input signal	input signal	input signal	input signal
LEVEL SHIFT	-0.5V max.	approx. -0.25V	approx. -0.25V	approx. -0.25V	-0.5V max.
RISE TIME (equal to:)	input rise time	input rise time	input rise time	input rise time	input rise time
OUTPUT DRIVE CHARACTERISTICS	EF type VIII	EF type VIII	EF type VIII	EF type VIII	EF type VIII
POWER REQUIRED (each gate)					
-12 VDC ± 10% (Depending on load)	1 to 21 ma	1 to 7 ma	1 to 7 ma	1 to 7 ma	1 to 21 ma
OPERATING TEMPERATURE RANGE	-54 to +71°C	-54 to +71°C	-54 to +71°C	-54 to +71°C	-54 to +71°C

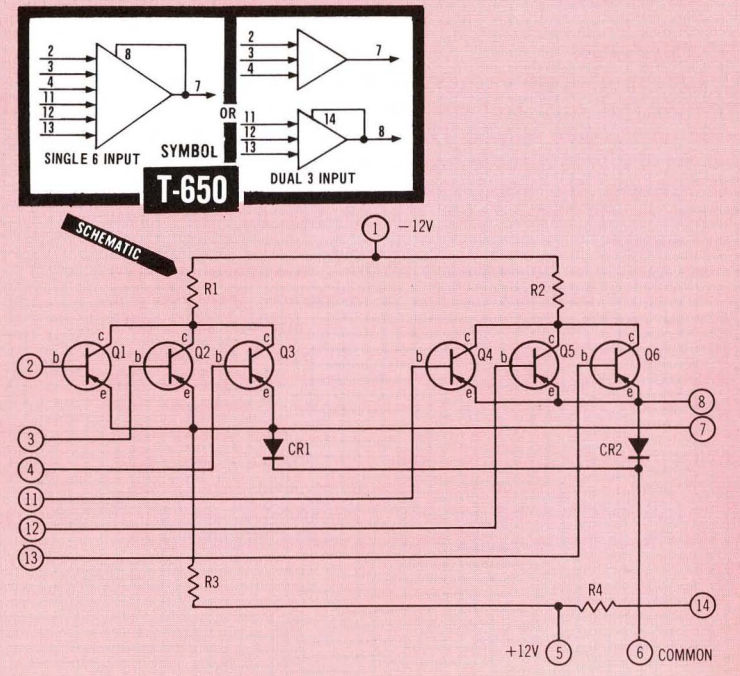
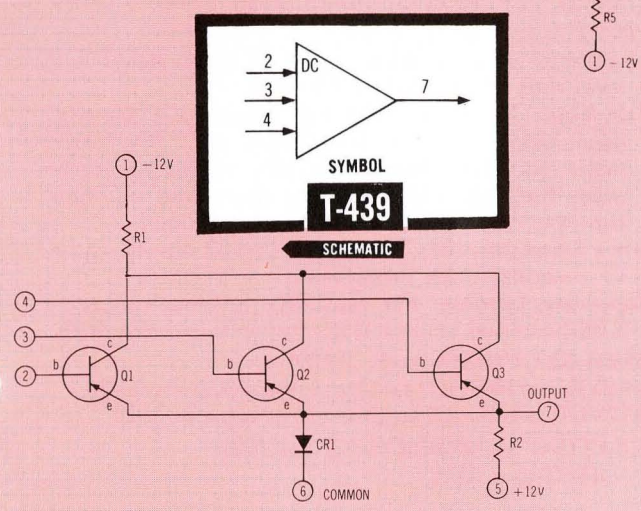
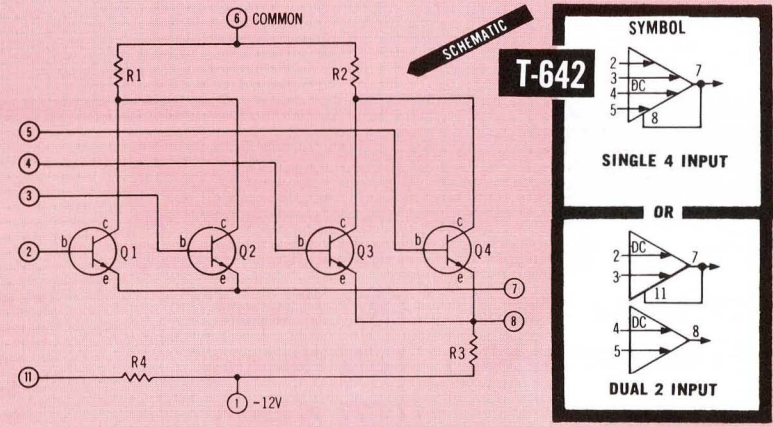
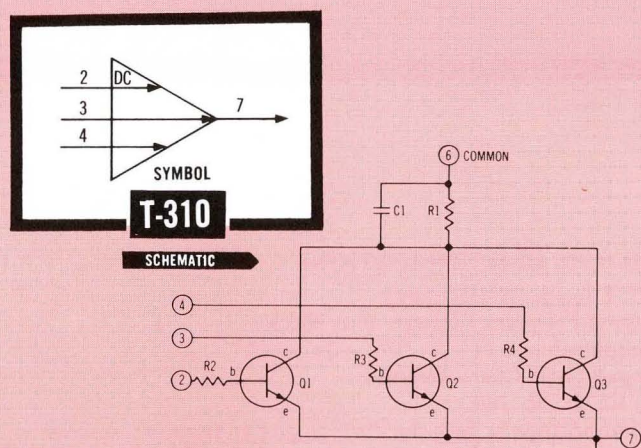
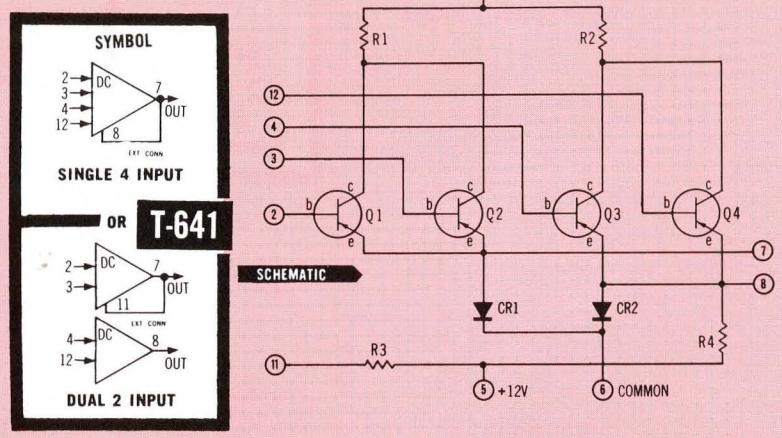
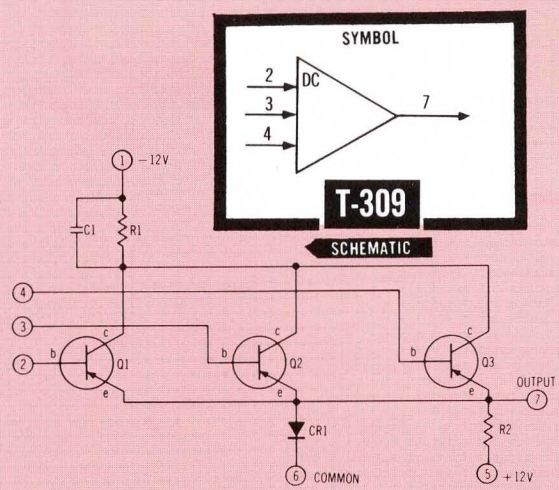
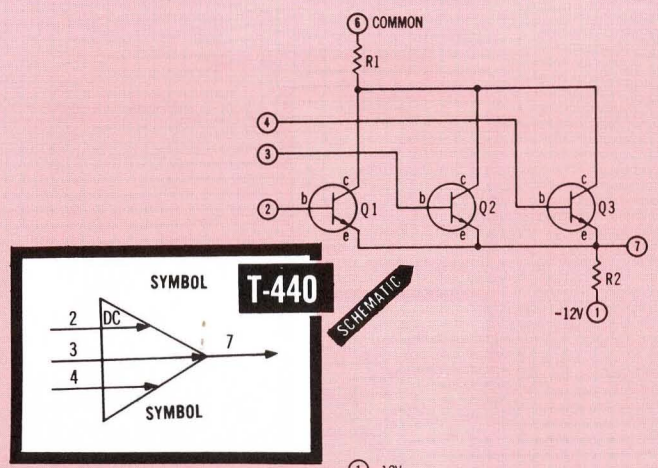
*Can be extended to 500 Kc with reduced load.

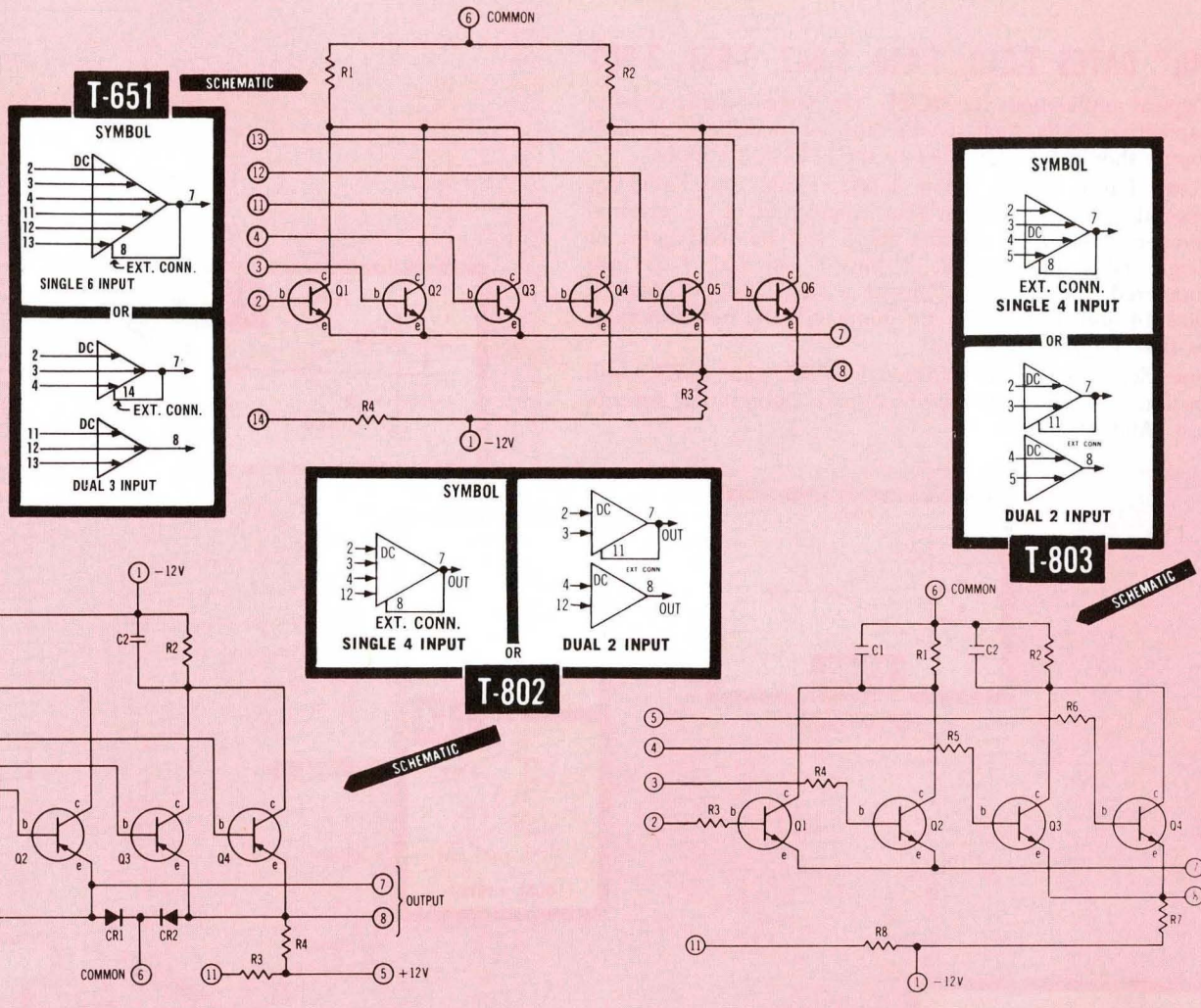
"Or" GATES T-310, T-440, T-642, T-651, T-803

Typical applications for DCTL "Or" Gates involve driving capacitive loads such as flip-flops or one-shots. Unused inputs should be connected to the -12-volt supply.

Gates T-641, T-642, T-650, T-651, T-802, and T-803 are exceptionally versatile in that connection of an external jumper determines whether these will be dual gates or single gates. For example, if pins 7 and 8 of T-651 are jumpered, the unit functions as a single 6-input gate; if pins 14 and 8 of T-651 are jumpered, the unit functions as two 3-input gates.

Specifications for one additional DCTL gate, T-653, will be found on the page which contains information describing "And/Or" gates.





DC "And" GATES

- | | |
|----------------------------------------------------------|------------------------------|
| T-404 (Dual, 2-input) | T-620 (Dual, 3-input) |
| T-432 (2-input "And"/
2-input "Exclusive-Or") | T-621 (7-input) |
| T-405 (4-input) | T-622 (10-input) |
| | T-627 (9-input) |

DESCRIPTION

This group of logic circuits has been developed on the principle that each unit contains an integral emitter follower on the gate output. This provides superior isolation and the ability to cascade logic in almost any combination. For example, the usual diode-gate limitation that "Or" circuits cannot drive "And" circuits does not exist with these circuits.

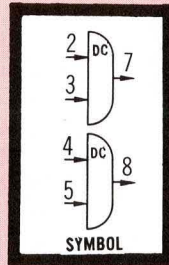
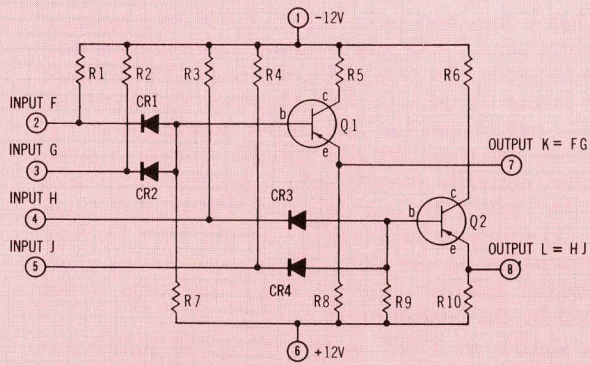
These gates can be cascaded up to a maximum of three gates before level restoration is necessary. However, if multiple-level-"anded" terms are to be applied to a gate with terms which have not been subjected to previous "and-ing," then resistors must be used to equalize the input levels and minimize pedestal noise. Resistance values are selected according to the rule that a 560-ohm resistor between source and gate input gives a level shift approximately equal to that caused by one gate circuit. Electrical specifications for the "Exclusive-Or" section of T-432 are on the data page which describes "Exclusive-Or" gates.

ELECTRICAL SPECIFICATIONS

- INPUT** (each "AND" gate)
 Signal Frequency Range: 0 to 250 Kc
 Amplitude: -11V = "0", -3V = "1"
 Input Load Characteristics:
 C, D: 30, 100
- Unused Inputs:** In order for the gate to function, unused inputs must be connected to either -3VDC or 0V.
- OUTPUT** (each "AND" gate)
 Amplitude: Approximately equal to input signal with level shift of +0.4 to +0.8V max.
 Rise Time: For inputs with rise times faster than 0.5 μ sec., output rise time is 0.5 μ sec. max. For slower input rise times, output rise time equals input rise time. Rise Time Degradation, depending on input rise time and load: 0.5 to 1.0 μ sec. maximum.
 Drive Characteristics: These are type CD drivers. Curve IV describes drive capabilities.
 Capacitive Loading: For capacitive loading, connect a 56K Ω external resistor from output to +12V supply.
- POWER REQUIRED** (each "AND" gate)
 -12VDC \pm 10%: 3.9 to 13 ma depending on load.
 +12VDC \pm 10%: 3.9 to 13 ma depending on load.
- OPERATING TEMPERATURE RANGE:**
 -45°C to +65°C

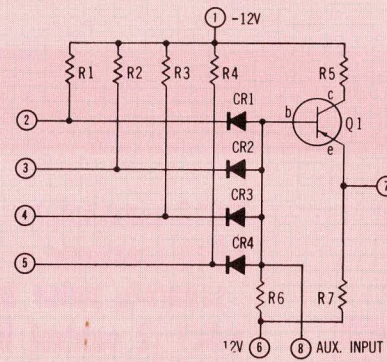
T-432

For symbol and schematic of T-432 see page 55.



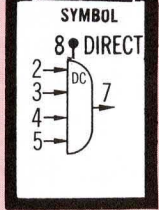
T-404

SCHEMATIC

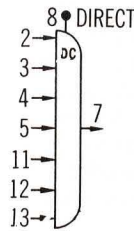


SCHEMATIC

T-405

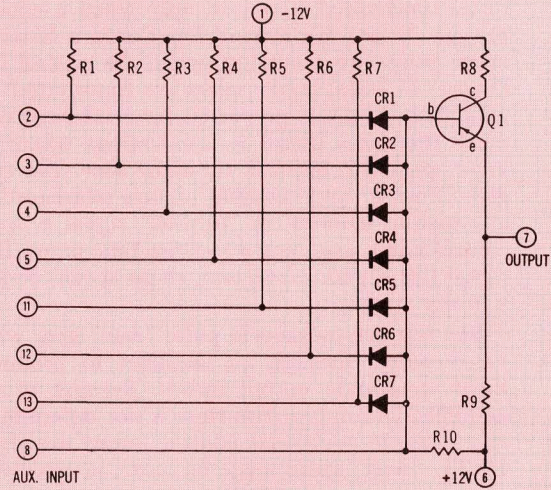
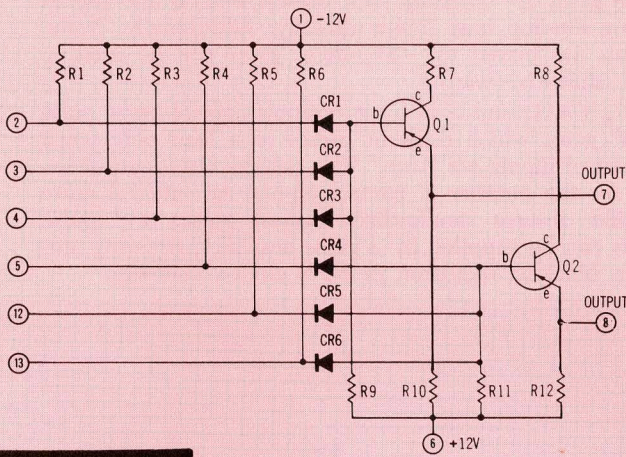


SYMBOL



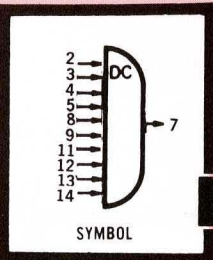
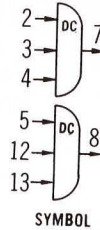
T-621

SCHEMATIC



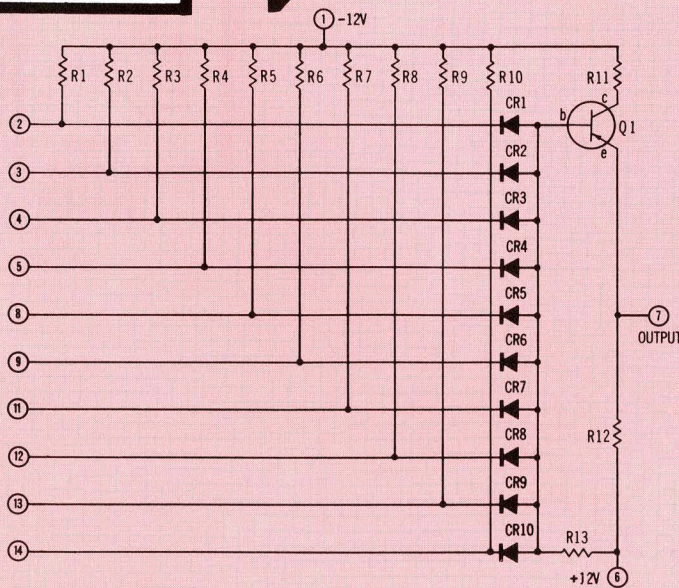
SCHEMATIC

T-620



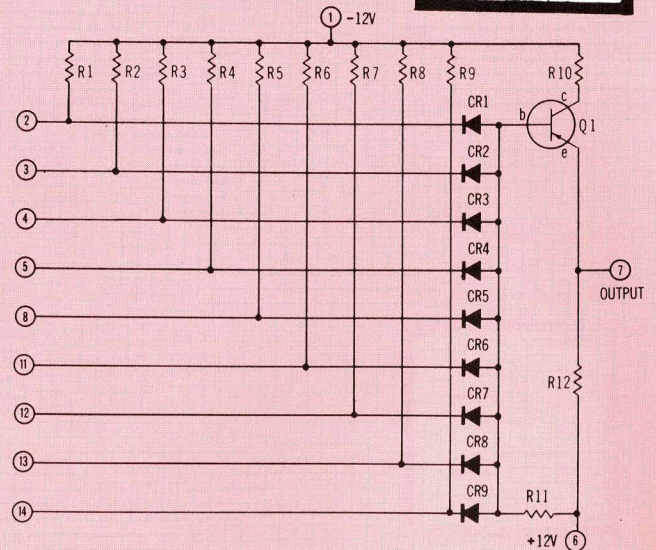
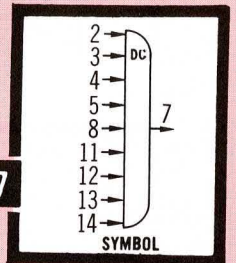
T-622

SCHEMATIC



SCHEMATIC

T-627



PULSE "And" GATES

- T-318**
- T-410A (dual)**
- T-637 (dual)**
- T-448 (dual)**
- T-413 (dual with Or'ed outputs)**
- T-630 (triple)**
- T-612 (sextuple)**
- T-613 (sextuple, separate pulse inputs)**
- T-447 (2 control inputs)**
- T-411 (4 control inputs)**
- T-601 (8 control inputs)**

DESCRIPTION

The purpose of a pulse gate is to permit an applied pulse to be transmitted to a load only when a control input is present. When this control input is in a binary "O" state, input pulses are grounded; when the control input is in a binary "1" state, input pulses are transmitted through the gate. These control properties have inherent delays which make the gates useful in applications where trigger and logic operations occur at the same time. The specifications give "Enable" and "Disable" delays referenced to the time at which a "turn-on" or "turn-off" signal is applied at the control input, assuming a fast-rise-time input. If the control signal has a poor waveform, these specifications on delay will not apply.

T-318 is a one-megacycle pulse "And" gate which couples gated pulses through an amplifier to produce standard 8-volt amplitude output pulses. Because of this built-in amplification, output rise time is not determined by input rise time. If additional control inputs are desired, 1-Mc DCTL "And" gates may be used to provide inputs to

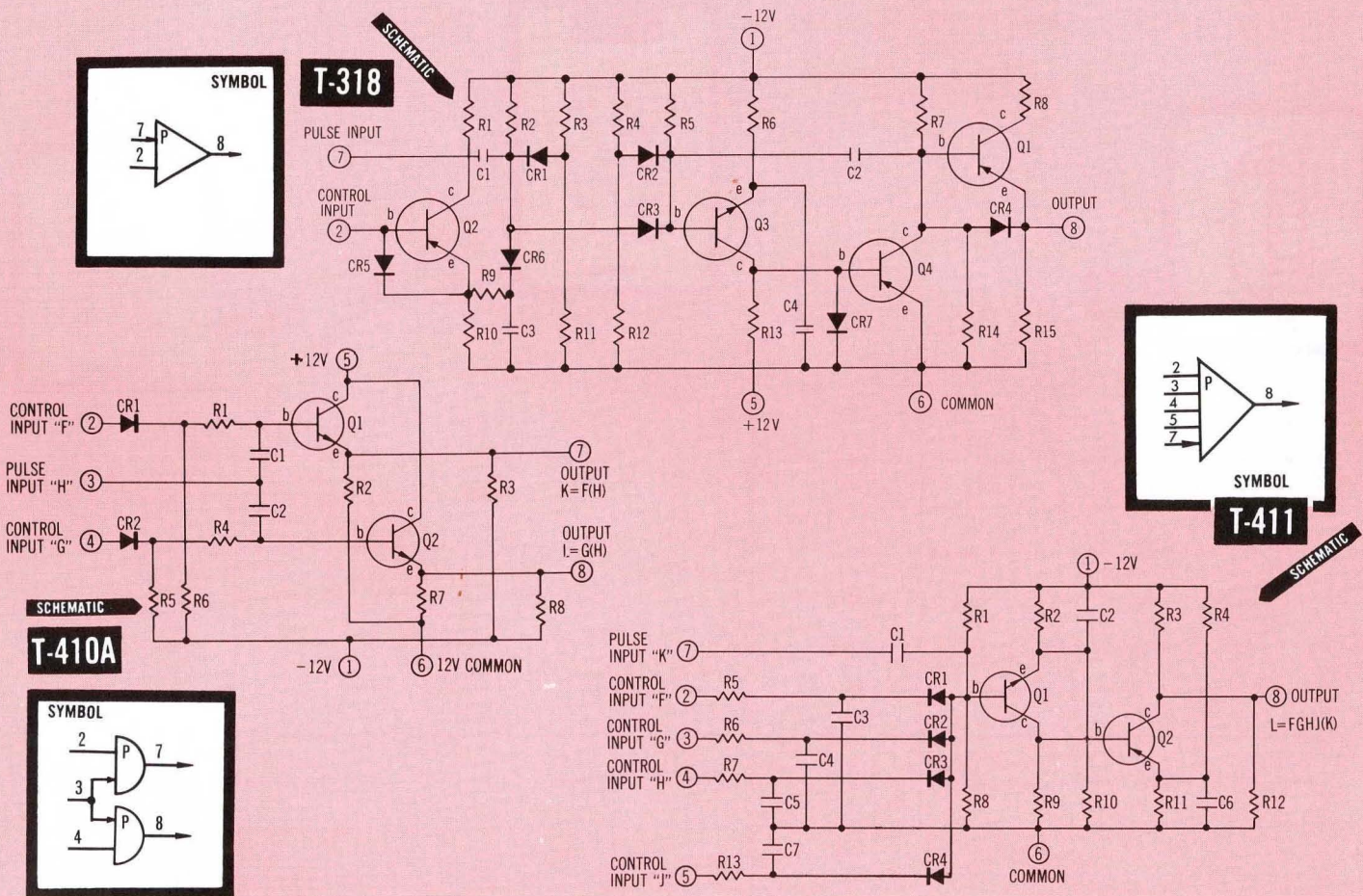
pin 2. **T-318** may operate with pulse logic (can be cascaded with other **T-318**'s) and can also trigger capacitive loads. Another typical application for this unit is to drive **N-109** and **N-110** decades.

T-410A, **T-637**, and **T-448** are dual pulse "And" gates; **T-410A** has a common pulse input, **T-637** has separate pulse inputs, and **T-448** has separate pulse inputs plus a built-in amplifier. Outputs of **T-410A** and **T-637** will not normally exceed 7V peak-to-peak. However, the sharp rise time of the output and the low output impedance of the NPN emitter followers provide reliable trigger signals. These gates normally operate into capacitive loads and may be "Or" mixed but not cascaded. Features of these gates are (1) ability to be controlled directly by a flip-flop, squaring amplifier, or one-shot without need for an intervening emitter follower, and (2) output rise time is not determined by the control input.

T-413 is similar to **T-637** except the gated pulses are "Or'ed" together internally. **T-630** is also similar to **T-637** except it contains three gates.

T-612 and **T-613** are economical low-frequency diode pulse gates each containing six gate circuits; **T-612** has a common pulse input and **T-613** has separate pulse inputs. These gates are basically poor drivers but do find use in driving flip-flop base inputs directly. Additionally, if the outputs are biased to -3V, these gates can be used to drive capacitive loads.

T-447, **T-411**, and **T-601** are multiple-control-input pulse "And" gates which transmit pulses to a load only when all control inputs are "true." The circuits are identical except for the number of control inputs. An integral pulse amplifier insures standardized output pulses and pulse inputs can be supplied by a pulse amplifier, squaring amplifier, blocking oscillator, or NPN emitter follower.



PULSE "And" GATES	T-318	T-410A	T-411	T-413	T-447	T-448
INPUT						
Control Input(s)						
AMPLITUDE (level shift from:)	-11 to -3V	-11 to -3V	-11 to -3V	-11 to -3V	-11 to -3V	-11 to -3V
RISE TIME	0.2 μ sec max.	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec
GATE ENABLE TIME (nominal)	1 μ sec	2 μ sec	3 μ sec	2 μ sec	3 μ sec	3 μ sec
GATE DISABLE TIME (nominal)	1 μ sec	4 μ sec	4 μ sec	4 μ sec	4 μ sec	4 μ sec
INPUT LOAD CHARACTERISTICS						
A, B	20, 200	10, 200	2, 200	10, 200	2, 200	2, 200
C, D	25, 100	†	†	†	†	†
E, F	20, 200	20, 200	2, 200	10, 200	2, 200	2, 200
Pulse Input(s)						
SIGNAL FREQUENCY RANGE	1 Mc max.	250 Kc max.	250 Kc max.	250 Kc max.	250 Kc max.	250 Kc max.
AMPLITUDE (P-P):	6.5V min. 9V max.	7.5V @ 0.25 μ sec*	6.5V min. 9V max.	7.5V @ 0.25 μ sec*	6.5V min. 9V max.	6.5V min. 9V max.
RISE TIME	.05 μ sec max.	0.25 μ sec max.	0.1 to 0.5 μ sec	0.25 μ sec max.	0.1 to 0.5 μ sec	0.1 to 0.5 μ sec
INPUT LOAD CHARACTERISTICS:						
A, B	10, 100	20, 200	5, 150	10, 100	5, 150	5, 150
C, D	45, 150	†	†	†	†	†
E, F	10, 100	20, 200	5, 150	10, 100	5, 150	5, 150
OUTPUT (each gate)						
AMPLITUDE (positive pulse, P-P)	8V	4.5V	8V	4.5V	8V	8V
RISE TIME	.02 μ sec max.	0.25 μ sec max.	0.4 μ sec max.	0.25 μ sec max.	0.4 μ sec max.	0.4 μ sec max.
PULSE DURATION (nominal)	0.3 μ sec @ 250 Kc	1.1 μ sec	0.5 to 3.0 μ sec	1.1 μ sec	0.5 to 3.0 μ sec	0.5 to 3.0 μ sec
LOAD DRIVE CHARACTERISTICS						
	**	†	†	†	†	†
POWER REQUIRED						
-12 VDC \pm 10% (peak)	30 ma	3.6 ma	6 ma	3.6 ma	9 ma	18 ma
+12 VDC \pm 10%	5 ma	0.8 ma	none	0.8 ma	none	none
OPERATING TEMPERATURE RANGE						
	-55 to +71°C	-45 to +65°C	-45 to +65°C	-45 to +65°C	-45 to +65°C	-45 to +65°C

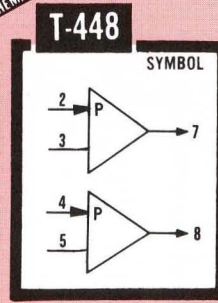
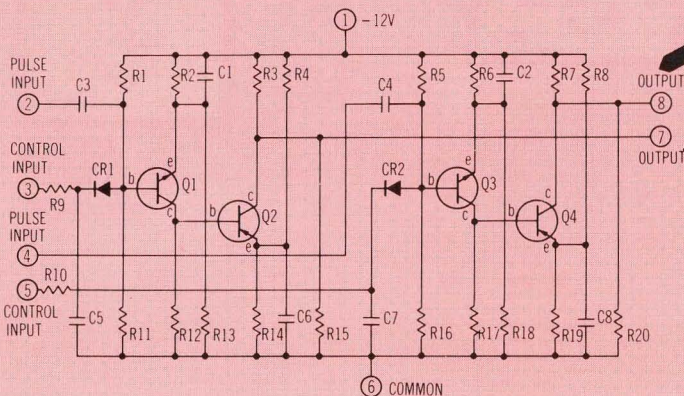
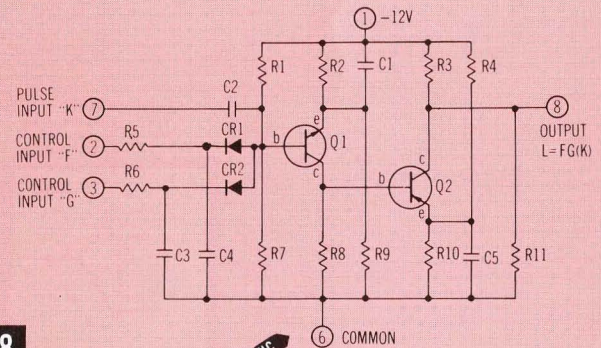
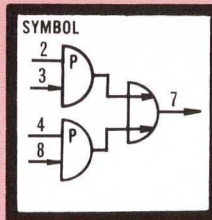
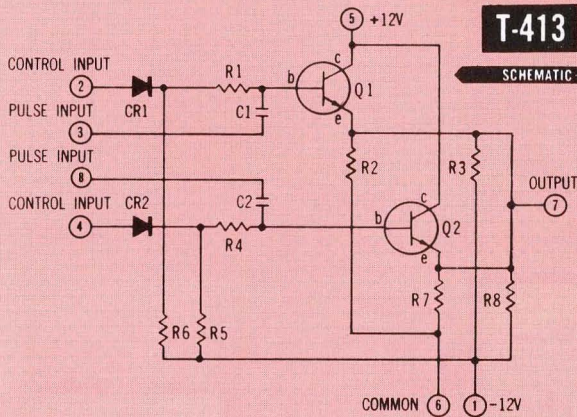
* Lower amplitudes require faster rise times.

† Pulse "And" gates are not recommended as loads for CD drivers due to rise-time deterioration (Exception: T-318).

**One N-109 or N-110 decade or two T-303 flip-flops.

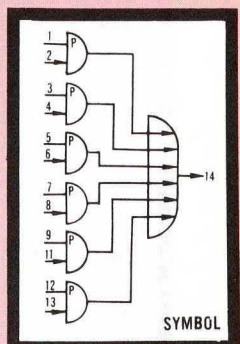
‡ These gates should be used only to drive capacitive loads such as flip-flops. Max. load = 5 "T" inputs, or 4 "RS" inputs.

table continued on next page

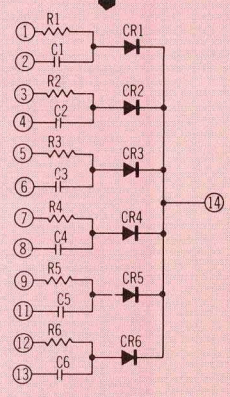


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PULSE "And" GATES	T-601	T-612	T-613	T-630	T-637
INPUT					
Control Input(s)					
AMPLITUDE (level shift from:)	-11 to -3V	-11 to -3V	-11V to -3V	-11 to -3V	-11 to -3V
RISE TIME	0.2 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec
GATE ENABLE TIME (nominal)	3 μ sec	10 μ sec	25 μ sec	2 μ sec	2 μ sec
GATE DISABLE TIME (nominal)	4 μ sec	10 μ sec	25 μ sec	4 μ sec	4 μ sec
INPUT LOAD CHARACTERISTICS					
A, B	2, 200	8, 150	8, 150	10, 200	10, 200
C, D	†	†	†	†	†
E, F	2, 200	8, 150	8, 150	10, 200	10, 200
Pulse Input(s)					
SIGNAL FREQUENCY RANGE	250 Kc max.	10 Kc max.	5 Kc max.	250 Kc max.	250 Kc max.
AMPLITUDE (P-P):	6.5V min. 9V max.	7.5V @ 0.25 μ sec*	7.5V @ 0.25 μ sec*	7.5V @ 0.25 μ sec*	7.5V @ 0.25 μ sec*
RISE TIME	0.1 to 0.5 μ sec	0.25 μ sec max.	0.25 μ sec max.	0.25 μ sec max.	0.25 μ sec max.
INPUT LOAD CHARACTERISTICS:					
A, B	5, 150	80, 800	80, 800	10, 100	10, 100
C, D	†	†	†	†	†
E, F	5, 150	80, 800	80, 800	10, 100	10, 100
OUTPUT (each gate)					
AMPLITUDE (positive pulse, P-P)	8V	4.5V	4.5V	4.5V	4.5V
RISE TIME	0.4 μ sec max	• input rise time	• input rise time	0.25 μ sec max.	0.25 μ sec max.
PULSE DURATION (nominal)	0.5 to 3.0 μ sec	1.1 μ sec	1.1 μ sec	1.1 μ sec	1.1 μ sec
LOAD DRIVE CHARACTERISTICS					
	†	†	†	†	†
POWER REQUIRED					
-12 VDC \pm 10% (peak)	6 ma	none	none	8.1 ma	3.6 ma
+12 VDC \pm 10%	none	none	none	1.8 ma	0.8 ma
OPERATING TEMPERATURE RANGE					
	-45 to +65°C	-54 to +71°C	-54 to +71°C	-45 to +65°C	-45 to +65°C

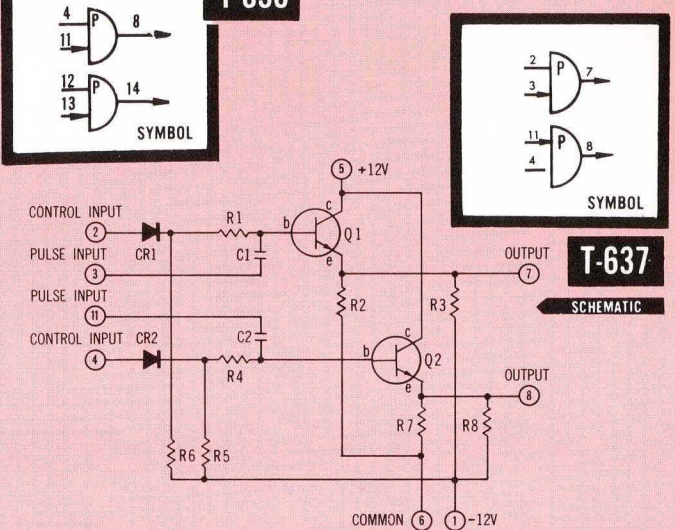
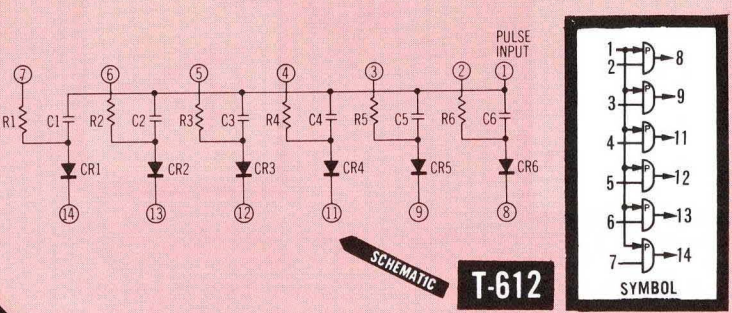
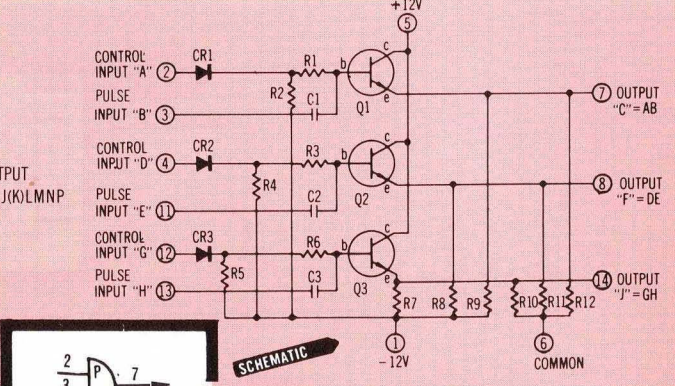
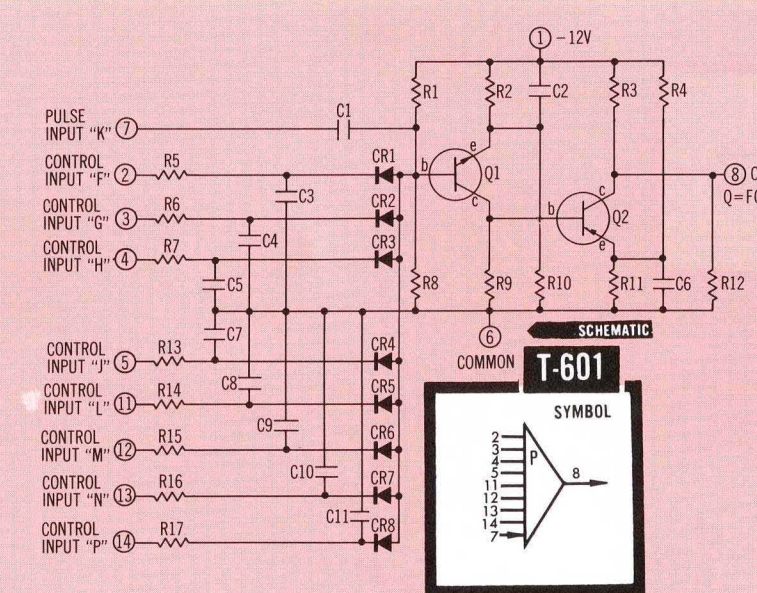


T-613



* Lower amplitudes require faster rise times.
† Pulse "And" gates are not recommended as loads for CD drivers due to rise-time deterioration (Exception: T-318).
‡ For narrow input pulse width.

‡ These gates should be used only to drive capacitive loads such as flip-flops. Max. load = 5 "T" inputs, or 4 "RS" inputs.



DESCRIPTION

Design considerations for these logic circuits were similar to those for the DC "And" gates in that an integral emitter follower is used to provide circuit isolation and the ability to cascade logic in almost any combination. Two typical loads for these units are: (1) 2 parallel "Or" gates with each gate operating into 2 more parallel "Or" gates for a total logic load of 6 "Or" gates, and (2) 3 parallel "And" gates with each gate operating into 3 more parallel "And" gates for a total logic load of 12 "And" gates.

T-442 is a 3-input "Or" gate with a 2-stage level restoring circuit and an emitter-follower output; basically a cascaded combination of one-half of a T-406, a T-106, and a T-111. This unit was designed to provide level restoration in the "Carry" line of parallel adders and subtractors. Normally, this level restoration is necessary after every third operation.

ELECTRICAL SPECIFICATIONS

INPUT (Each "Or" gate)

Signal Frequency Range: 0 to 250 Kc

Amplitude: -11V = "0", -3V = "1"

Input Load Characteristics (all units except T-442)

C, D: 50, 150

Input Load Characteristics of T-442

C, D: 25, 300

Unused Inputs: Connect unused inputs to pin 1 (-12VDC)

DC "Or" GATES

T-406 (Dual, 2-input)
T-407 (4-input)
T-442 (3-input)
T-614 (7-input)

T-623 (6-input)
T-634 (8-input)
T-635 (9-input)

OUTPUT (Each "Or" gate)

Amplitude: Approximately equal to input signal. T-442 causes negligible level shift; all other units produce a level shift of +0.1V.

Rise Time: For inputs with rise times faster than 0.5 μ sec., output rise time is 0.5 μ sec. max. For slower input rise time, output rise time equals input rise time. Rise Time Degradation, depending on input rise time and load: 0.5 to 1.0 μ sec. maximum.

Drive Characteristics: These are type CD drivers. Curve IV describes drive capabilities.

Capacitive Loading: For capacitive loading, connect a 5.6K Ω external resistor from output to +12V supply.

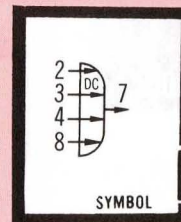
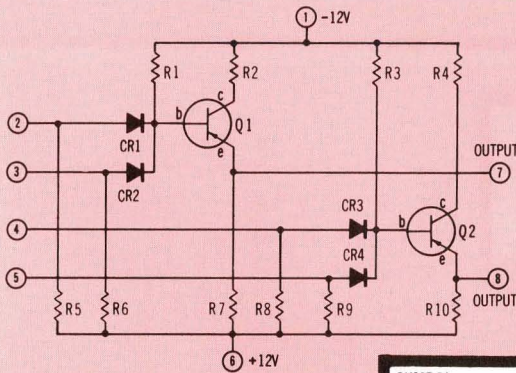
POWER REQUIRED (Each "Or" gate)

-12VDC \pm 10%: 3.9 to 11 ma depending on load. T-442 requires 12 to 20 ma.

+12VDC \pm 10%: 3.9 to 11 ma depending on load. T-442 requires a maximum of 12 ma.

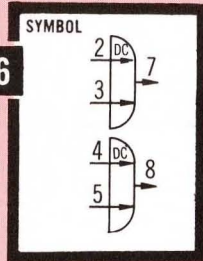
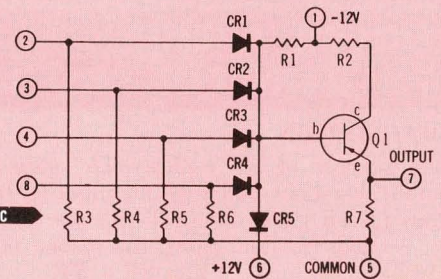
OPERATING TEMPERATURE RANGE:

-45°C to +65°C



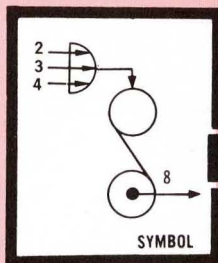
T-407

SYMBOL SCHEMATIC



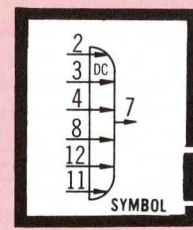
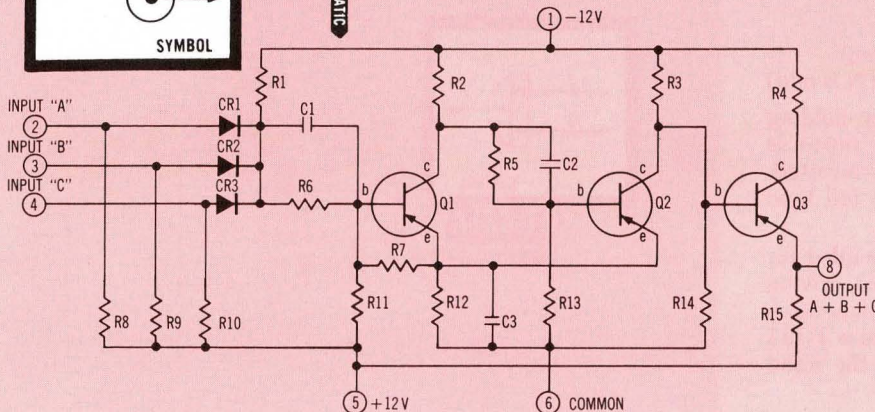
T-406

SYMBOL SCHEMATIC



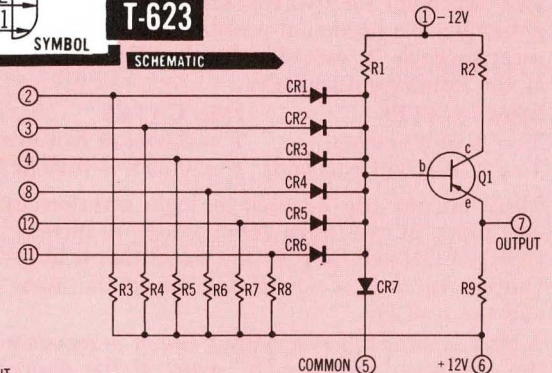
T-442

SYMBOL SCHEMATIC



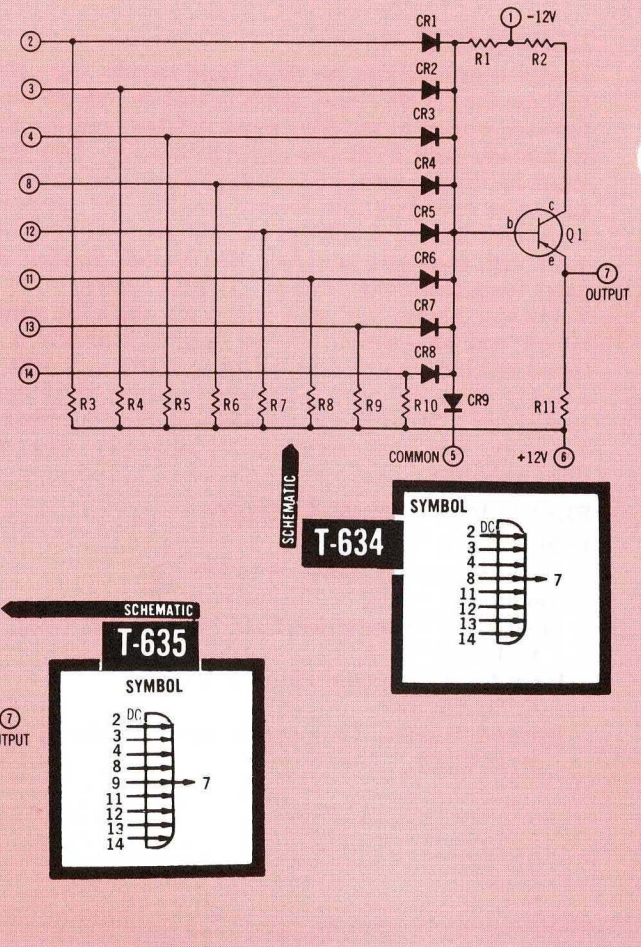
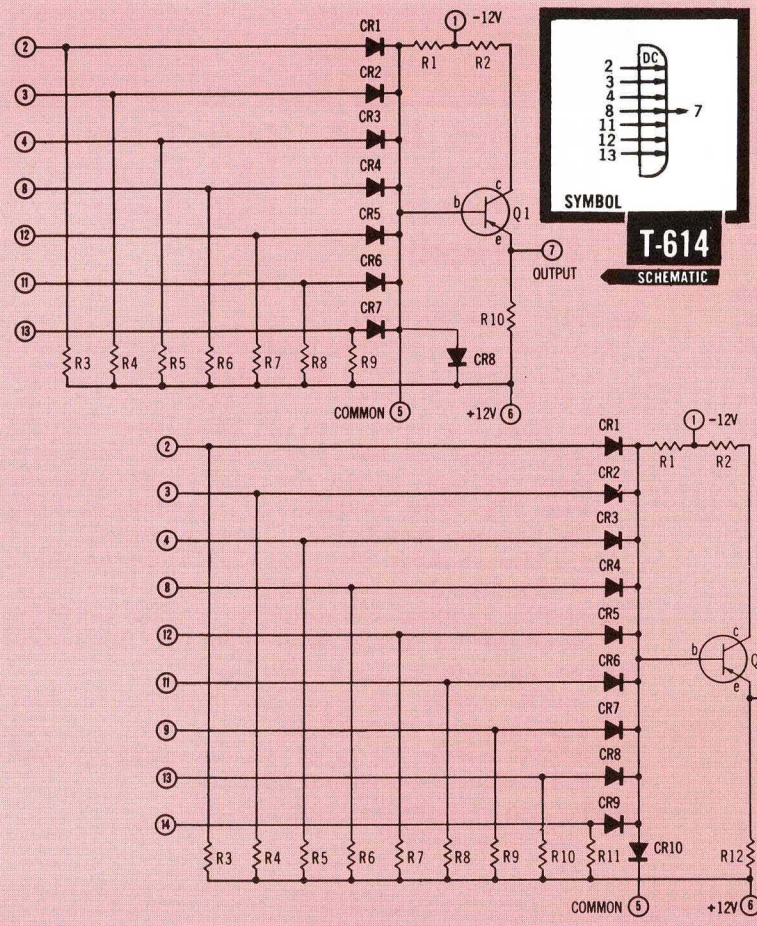
T-623

SYMBOL SCHEMATIC



schematics continued on next page

continued from preceding page



EXCLUSIVE-“Or” GATES T-315, T-421A, T-422, T-423A, T-432, T-805

DESCRIPTION

The purpose of an “exclusive-Or” gate is to provide an output when one and only one input is “true.” Logic equations for all gates except T-422 are: $X = A\bar{B} + \bar{A}B$ and, for dual gates, the second equation is: $Y = EF + \bar{E}\bar{F}$

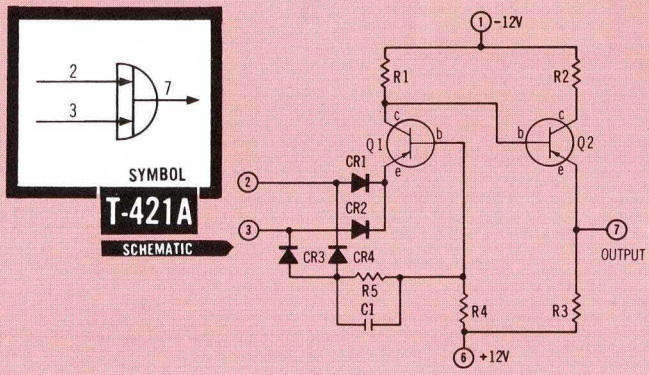
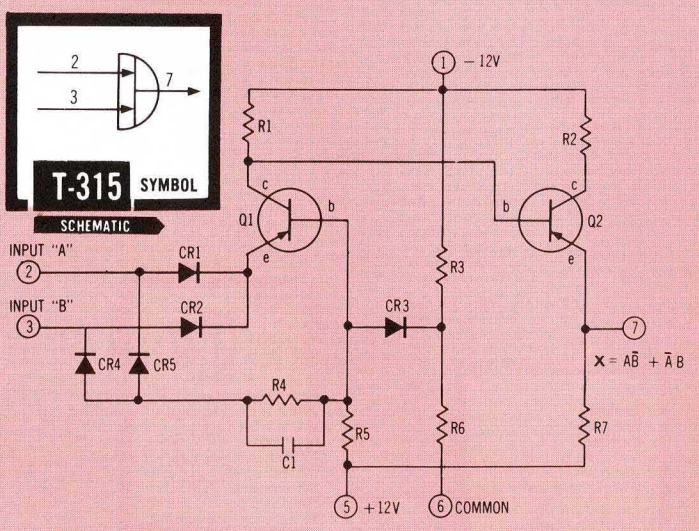
Since T-422 is a 3-input gate, the equation for T-422 is: $X = ABC + \bar{A}BC + A\bar{B}C$

The time delay between input and output signal excursions, measured between half-amplitude points, is 1.5 μsec maximum for one 250-Kc gate or 2.0 μsec maximum for two cascaded 250-Kc gates. Corresponding delays for the 1-Mc gates are 0.5 μsec maximum for one gate or 0.7 μsec maximum for two cascaded 1-Mc gates. In order to determine the maximum possible accumulated delay (T in μsec) through N cascaded “exclusive-Or” gates, use one of the following equations:

250Kc GATES	1Mc GATES
$T = N$ (if N is even)	$T = 0.35N$ (if N is even)
$T = N + 0.5$ (if N is odd)	$T = 0.35N + 0.15$ (if N is odd)

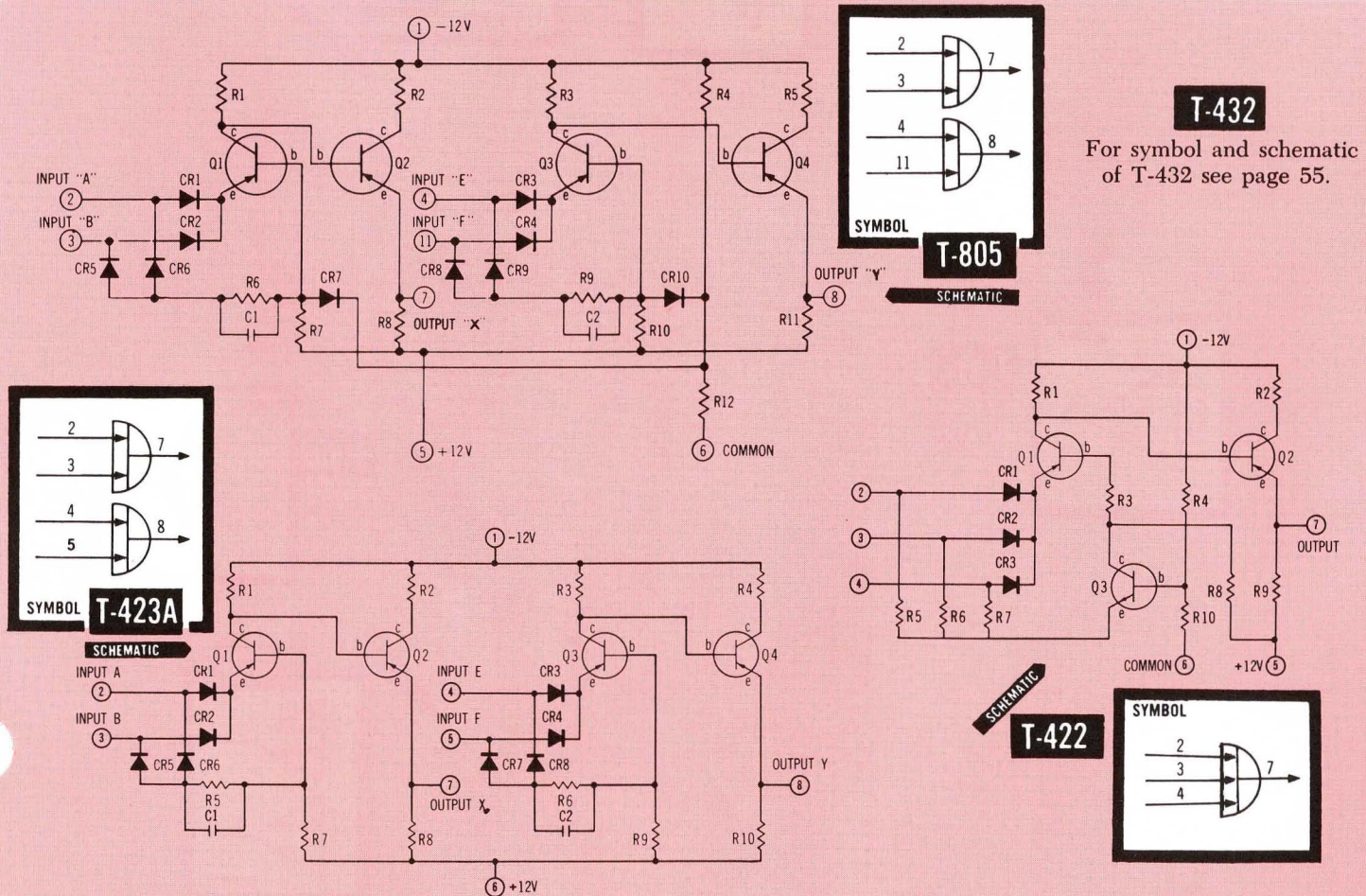
These circuits can be used as logic inverters by holding one input at -3 volts (ON) while a second input is switched ON and OFF by the signal that is to be inverted. Output rise time is now a function of the input fall time and the β of Q_1 .

A PNP-emitter-follower output circuit is recommended for driving these “exclusive-Or” gates. If the desired driving circuit does not have a PNP-emitter-follower configuration at its output, connect the driving circuit output to a T-111 (or equivalent) and the output of the T-111 to the input of the “exclusive-Or” gate.



EXCLUSIVE—"Or" GATES	T-315 2-Input	T-421A 2-Input	T-422 3-Input	T-423A Dual, 2-Input	T-432° 2-Input "And" / 2-Input Exclusive-"Or"	T-805 Dual, 2-Input
INPUT						
SIGNAL FREQUENCY RANGE	0 to 1 Mc	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc	0 to 1 Mc
AMPLITUDE (a level shift from:)	-11V (±1) to -3V (±0.6)	-11V (±1) to -3V (±1)	-11V (±1) to -3V (±0.6)	-11V (±1) to -3V (±0.6)	-11V (±1) to -3V (±0.6)	-11V (±1) to -3V (±0.6)
INPUT LOAD CHARACTERISTICS:						
C, D	50, 150	50, 150	50, 150	50, 150	50, 150	50, 150
OUTPUT						
RISE AND FALL TIME (max.)	2.0 μsec	2.5 μsec	2.0 μsec	2.5 μsec	2.5 μsec	2.0 μsec
AMPLITUDE	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"
LEVEL SHIFT:						
Typical	-0.15V	-0.15V	-0.2V	-0.15V	-0.15V	-0.15V
Maximum	-0.25V	-0.25V	-0.3V	-0.25V	-0.25V	-0.25V
RISE TIME	0.5 μsec max.	1.0 μsec max.	1.0 μsec max.	1.0 μsec max.	1.0 μsec max.	0.5 μsec max.
DELAY TIME, INPUT TO OUTPUT (See "Description")	0.5 μsec max.	1.5 μsec max.	2 μsec typ	1.5 μsec max.	1.5 μsec max.	0.5 μsec max.
DRIVE CHARACTERISTICS (Max.)	CD Type XX	CD Type IV	CD Type IV	CD Type IV	CD Type IV	CD Type XX
POWER REQUIRED						
-12VDC ± 10%	8 ma	6 ma	9 ma	12 ma	(Including "And" section:) 3.9 to 11 ma depending on load	16 ma
+12VDC ± 10%	6 ma	6 ma	8 ma	12 ma	3.9 to 11 ma depending on load	12 ma
OPERATING TEMPERATURE RANGE	-54 to +71 °C	-54 to +71 °C	-54 to +71 °C	-54 to +71 °C	-45 to +65 °C	-54 to +71 °C

*These specifications are for the "exclusive-Or" section of T-432. For the "And" section of T-432, see DC "And"



PULSE "Or" GATES/MIXER AMPLIFIERS

- T-430 (2-input)
- T-412 (5-input)
- T-431 (3-input)
- T-602 (9-input)
- T-663 (dual, 2-input)

DESCRIPTION

These are multiple-input pulse mixers or "Or" gates with an integral pulse amplifier to produce standardized output pulses. Inputs may be either voltage steps or pulses; a fast-rise-time output pulse is produced each time an input pulse or step is applied to any of the inputs.

External R-C networks and blocking diodes may be connected to the pin-5 input of T-431 to give additional mixing capability.

ELECTRICAL SPECIFICATIONS

INPUT

Amplitude: Minimum input is a 7.0-volt positive pulse or step at rise times as long as 0.8 μ sec. Circuits will

respond to lower-amplitude inputs at faster rise times but will not respond to 1.5V or less regardless of rise time.

Signal Frequency Range: 250Kc maximum.

Input Impedance: 270pf maximum.

Input Characteristics:

A	B	C	D	E	F
10	100	0	200	10	100

OUTPUT

Amplitude: 8.5V peak-to-peak positive pulse from -11VDC to -2.5VDC.

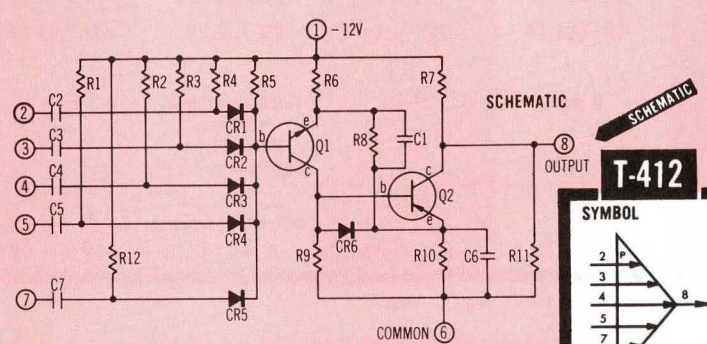
Rise Time: 0.4 μ sec maximum into a capacitive load.

Duration: 0.5 to 2.0 μ sec

Drive Characteristics: These are type AB drivers. Curve XIII describes drive capabilities.

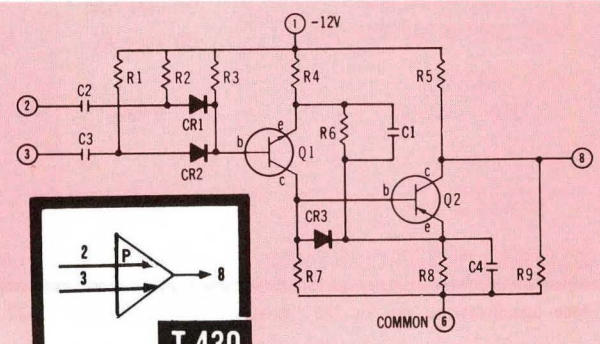
POWER REQUIRED: -12VDC, $\pm 10\%$; 2 ma quiescent, 10 ma peak (except T-663 which requires double this current).

OPERATING TEMP. RANGE: -45°C to +65°C



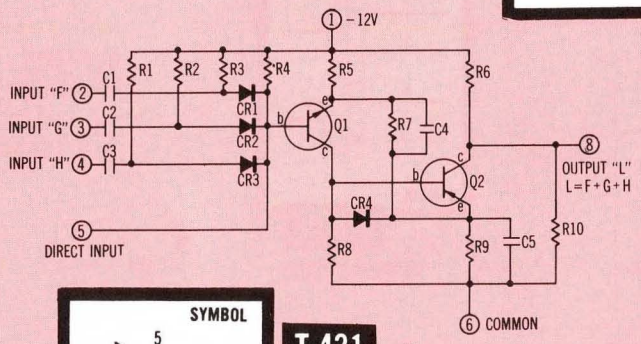
T-412

SYMBOL



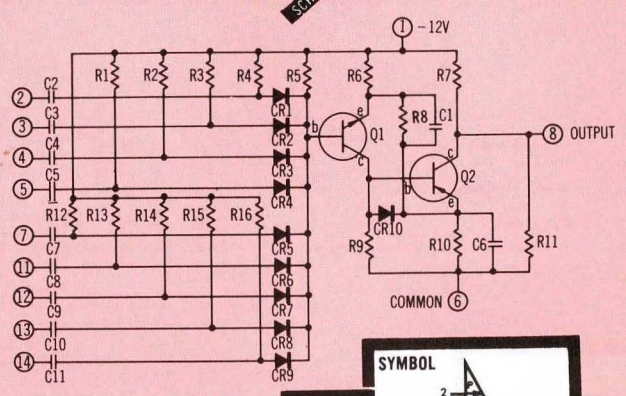
T-430

SYMBOL



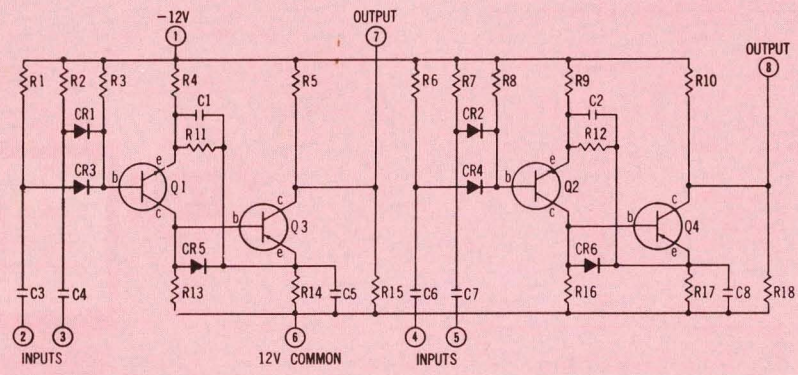
T-431

SYMBOL



T-602

SYMBOL



T-663

SYMBOL

DESCRIPTION

T-432 is a dual logic unit consisting of a 2-input DC "And" gate and a 2-input "Exclusive-OR" gate. Specifications for the "Exclusive-OR" section are contained on the "Exclusive-OR" data sheet elsewhere in this catalog.

T-433 is a dual logic unit that contains a 2-input DC "And" gate and a 2-input DC "Or" gate. This unit is basically one-half of a T-404 and one-half of a T-406.

T-434 is a dual 2-input DC "And" gate with "Or'ed" output. If the inputs are defined as A (pin 2), B (pin 3), C (pin 4), and D (pin 5), then the output is logically defined as $AB + CD$.

"And"/"Or" GATES
T-432, T-433, T-434, T-653

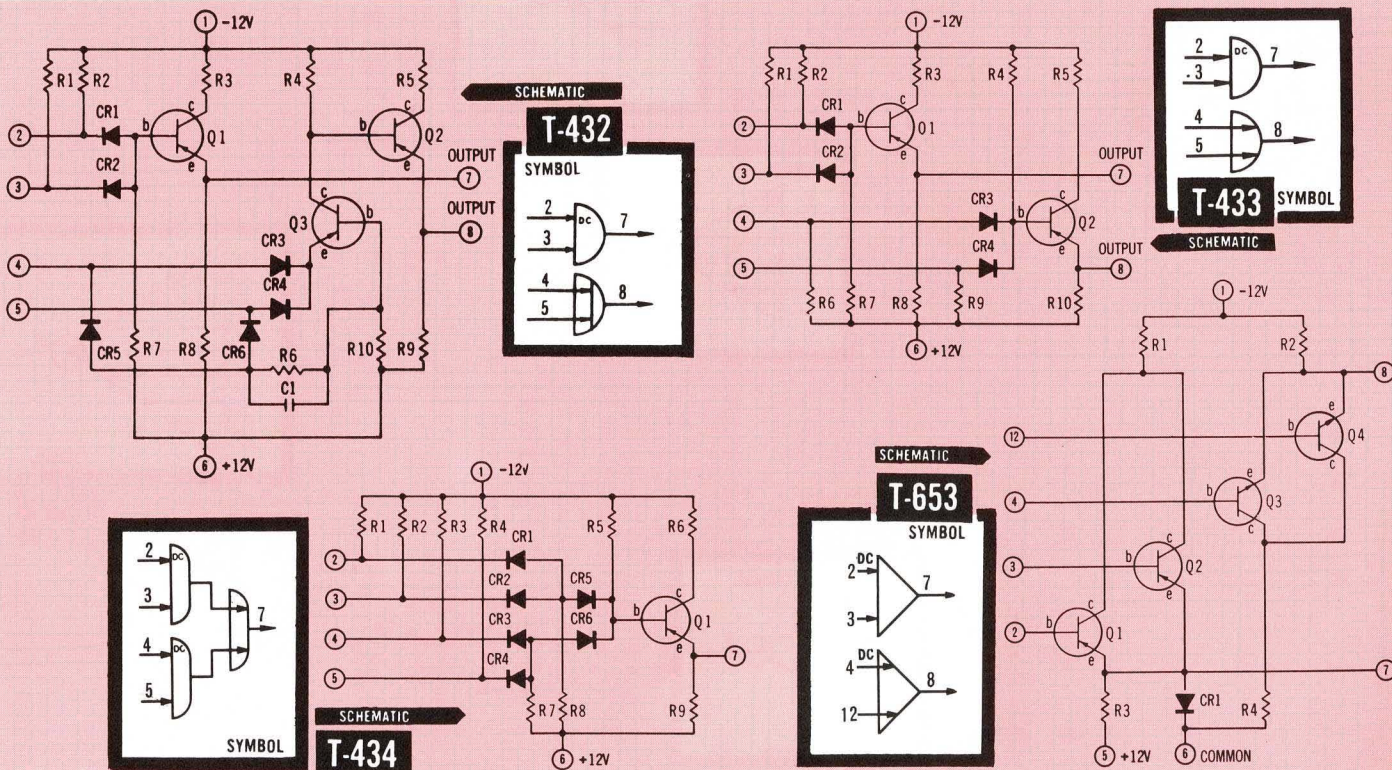
T-653 is a dual logic unit which consists of a 2-input DCTL "And" gate and a 2-input DCTL "Or" gate. The circuits are similar to those discussed on the data sheet describing other DCTL logic units. Essentially, this unit is one-half of a T-641 and one-half of a T-642.

"AND"/"OR" GATES	T-432 2-input "And"/2-input "Exclusive-Or"	T-433 2-input "And"/2 input "Or"	T-434 Dual 2-input "And" with "Or'ed" output	T-653 DCTL logic 2-input "And"/ 2-input "Or"
INPUT				
SIGNAL FREQUENCY RANGE	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc
AMPLITUDE	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"	-11V = "0", -3V = "1"
INPUT LOAD CHARACTERISTICS:				
A, B				And: 10, 0 Or: 10, 25
C, D	30, 100	30, 100	30, 100	And: 30, 0 Or: 15, 50
E, F				And: 10, 0 Or: 10, 25
OUTPUT				
AMPLITUDE (approx)	★	★	★	equal to input
LEVEL SHIFT	+0.4V	And: +0.4V Or: +0.1V	+0.3V	And: +0.3V Or: -0.25V
RISE TIME (depending on input rise time)	0.5 to 1.0 μsec	0.5 to 1.0 μsec	0.5 to 1.0 μsec	0.2 μsec max
DRIVE CHARACTERISTICS†	CD type IV	CD type IV	CD type IV	And: CD type IV Or: EF type VIII
POWER REQUIRED				
-12 VDC ± 10% (depending on load)	each gate 17 ma	each gate 3.9 to 11 ma	4.5 to 13 ma	4.9 to 18 ma
+12 VDC ± 10% (depending on load)	17 ma	3.9 to 11 ma	4.5 to 13 ma	3.9 to 11 ma
OPERATING TEMPERATURE RANGE	-45 to +65°C	-45 to +65°C	-45 to +65°C	-54 to +71°C

*Specifications for "Exclusive-Or" section are on table titled "Exclusive-Or" Gates

†When "And" gates are to drive capacitive loads, connect an external 5.6 KΩ resistor from output to 12V supply.

★ For inputs with rise time faster than 0.5 μsec., output rise time is 0.5 μsec. max. For slower input rise times, output rise time equals input rise time.



"Nor" and "Nand" GATES T-308, T-437, T-438, T-645

DESCRIPTION

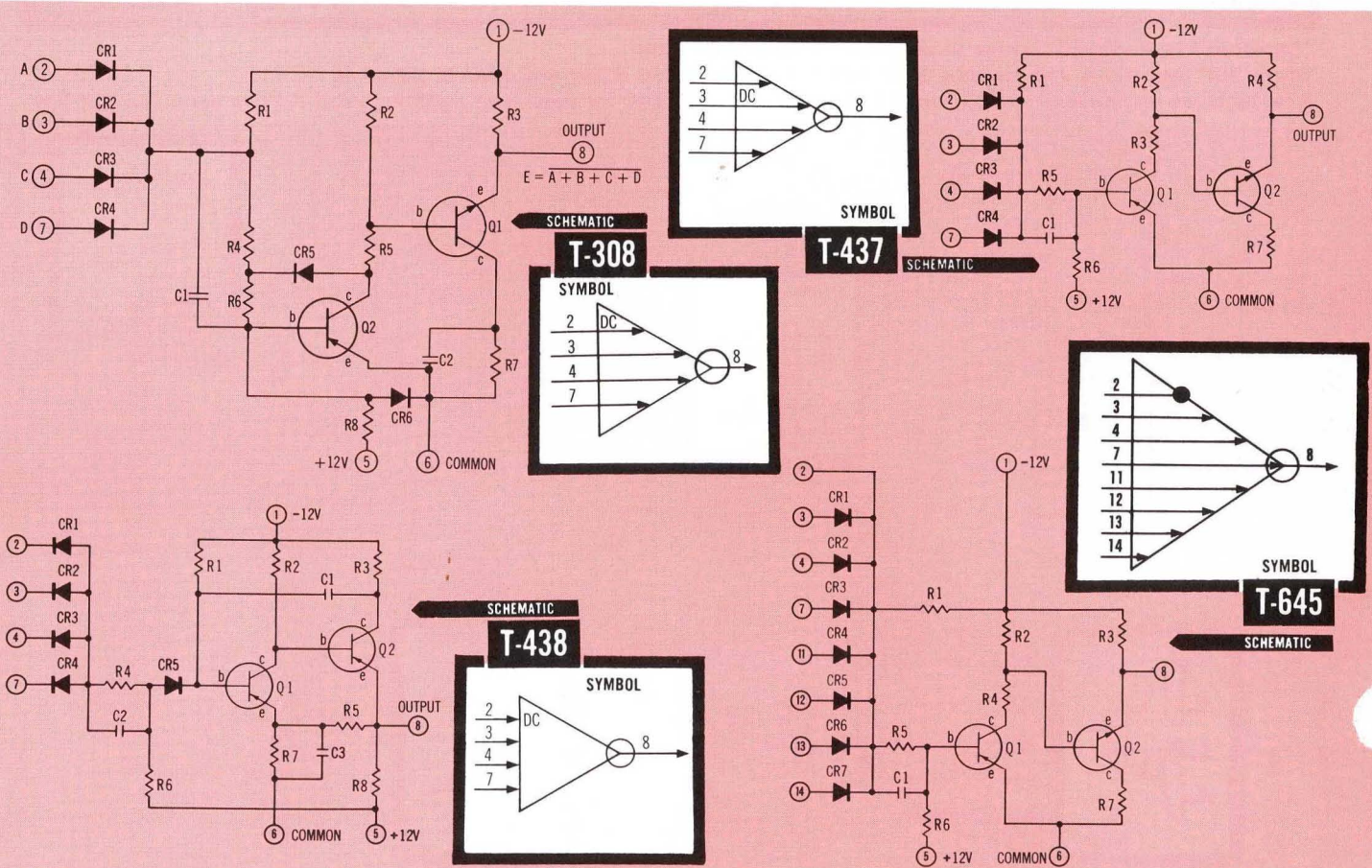
"Nor" and "Nand" Gates are versatile logic circuits which provide "not-Or" ("Nor") and "not-And" ("Nand") functions. For example, NOR Gate T-437 consists of a 4-input "Or" gate operating into an inverting amplifier. The inverter

provides both inversion and level restoration. Outputs are from an integral emitter follower and thus no inter-stage coupling element is necessary between gates or between gates and amplifiers.

DTL circuits used overcome a major short-coming of conventional R-C input circuits in the "Nor" gates. That is, when one input signal is at the "1" level and the remaining inputs are all switching simultaneously, the output will remain in the "0" state.

"NOR"/"NAND" GATES	T-308 (4-input "Nor")	T-437 (4-input "Nor")	T-438 (4-input "Nand")	T-645 (7-input "Nor")
INPUT				
SIGNAL FREQUENCY RANGE	0 to 1 Mc	0 to 250 Kc	0 to 250 Kc	0 to 250 Kc
AMPLITUDE ($\pm IV$)	-3V = "1" -11V = "0"	-3V = "1" -11V = "0"	-3V = "1" -11V = "0"	-3V = "1" -11V = "0"
RISE TIME	.05 to 0.2 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec	0.1 to 1.0 μ sec
INPUT LOAD CHARACTERISTICS				
C, D			25, 75	
E, F	15, 20	5, 20		5, 20
OUTPUT				
AMPLITUDE (unloaded, $\pm IV$)	-3V to -11V	-3V to -11V	-3V to -11V	-3V to -11V
MAXIMUM RISE TIME (under typical load, less loading will yield faster rise time)	0.2 μ sec	1.0 μ sec	1.0 μ sec	1.0 μ sec
DRIVE CHARACTERISTICS	EF type XV*	EF type XVII*	CD type IV†	EF type XVII*
POWER REQUIRED				
+12 VDC ($\pm 10\%$)	1.0 ma	0.5 ma	5.5 ma	0.5 ma
-12 VDC ($\pm 10\%$)	7.5 ma	6.0 ma	9 ma	6.0 ma
OPERATING TEMPERATURE RANGE	-55 to +71°C	-54 to +71°C	-54 to +71°C	-54 to +71°C

*When driving capacitive loads, connect a 5.6 K Ω external resistor from output to -12V supply.
 †When driving capacitive loads, connect a 5.6 K Ω external resistor from output to +12V supply.



MULTIVIBRATORS T-104, T-166, T-167, T-314

DESCRIPTION

T-104 and T-314 are general-purpose multivibrators used to generate square waves and time-base frequencies. The operating frequency is established by use of external timing capacitors. Equations which describe the approximate relationship between period of oscillation T (in μsec) and the value of two external capacitors C_x (in pf) are as follows:

$$C_x = 45(T-2.6) \quad \text{T-104}$$

$$C_x = 75(T-1) \quad \text{T-314}$$

T-104 can operate in either a free-running or a synchronized mode; T-314 has no provision for external synchronization. Additionally, to provide frequency multiplication, T-104 can be synchronized by an input frequency somewhat lower than the frequency of oscillation. Frequency multiplication by factors of 2, 3, 4, or 5 are possible at output rates as high as 150 Kc. This is accomplished by using the input pulse rate to synchronize the multivibrator at a frequency slightly higher than the free-running frequency of the multivibrator. If, for example, it is desired

to multiply an input 5Kpps pulse rate to a 25Kpps output pulse rate, charging capacitors C_x would be selected such that the circuit would free-run at approximately 24.7Kc. Input 5Kpps pulses then force the circuit to operate at 25Kc. The chart below defines the nominal harmonic relationship of the synchronizing (locking) signal to the MV output. Figures shown in the right-hand column are the percentage deviations (from the free-running frequency) over which reliable locking can be obtained.

SYNC/FREE-RUN FREQ.	LOCKING RANGE
F	0 to +20%
2f ⁺	0 to +12%
f/2	0 to +7%
f/3	0 to +4.5%
f/4	0 to +3.5%
f/5	0 to +2.5%

⁺When locked at 2F, output loading is restricted to pin 8 only.

MULTIVIBRATORS	T-104	T-166 (One-Shot)	T-167 (One-Shot)	T-314
INPUT				
SIGNAL FREQUENCY RANGE	0 to 325 Kc	0 to 250 Kc	0 to 250 Kc	— No Input — Natural frequency is 1 Mc (+0.3 Mc to -0.1 Mc)
AMPLITUDE:				
Will respond to positive pulse inputs of:	6.0V or more	6.0V or more	6.0V or more	—NA—
at rise times up to:	1.0 μsec max.	1.0 μsec max.	1.0 μsec max.	—NA—
Will not respond to inputs of:	1.5V or less	1.5V or less	1.5V or less	—NA—
regardless of rise time.				
Maximum amplitude	9V	9V	9V	—NA—
RISE TIME:	0.1 to 1.0 μsec [*]	0.1 to 1.0 μsec [*]	0.1 to 1.0 μsec [*]	—NA—
INPUT LOAD CHARACTERISTICS:				
A, B	10, 100	10, 100	10, 100	—NA—
C, D	16, 150	16, 150	16, 150	—NA—
E, F	10, 100	10, 100	10, 100	—NA—
OUTPUT				
AMPLITUDE (nominal level shift from:)	-11V to -3V	-11V to -3V	-11V to -3V	-11V to -3V
RISE TIME (nominal, under typical load)	0.4 μsec	0.5 μsec	0.2 μsec	0.3 μsec under max. load at 100 Kc
FALL TIME	Approx. 25% of period	pin 7: Nominal 20% of pulse duration Pin 8: Nominal 1.5 μsec	Pin 7: Nominal 1.5 μsec Pin 8: Nominal 20% pulse duration	0.2 μsec max.
PULSE DURATION	See Description	See Description	See Description	See Description
Minimum Period	2.6 μsec typical	Approx. 2.0 μsec	1.5 μsec	1 μsec ††
Maximum Period	60 sec‡	1 sec ‡	1 sec	10 μsec ††
DUTY CYCLE				
To 50 Kc	—NA—	70% max.	70% max.	—NA—
To 250 Kc	—NA—	50% max.	50% max.	—NA—
LOAD DRIVE CHARACTERISTICS	AB type XII	AB type XI	AB type XI	AB type XIX
POWER REQUIRED				
-12 VDC \pm 10%	5.5 ma	7 ma	5.5 ma	22 ma
OPERATING TEMPERATURE RANGE	-45 to +65°C	-45 to +65°C	-45 to +65°C	-54 to +71°C

* For inputs with rise times slower than 1.0 μsec , use an external capacitor of appropriate size and connect to direct input.

† Equation in DESCRIPTION valid only for periods up to 1 second.

‡ For duty cycles greater than 50%, pulse duration is shorter.

†† The period may be decreased by use of external resistors connected across pins 3 and 1 and pins 5 and 1. Minimum values for these resistors are 10 K Ω . The value of these resistors should be determined experimentally for the desired period between 1 and 10 μsec . Dynamic values of resistance may be used to frequency-modulate T-314.

continued on next page

T-166 and **T-167** are one-shot multivibrators. Primary functions of these units include pulse-width generation, time delay, and temporary digit storage. **T-166** contains a built-in noise rejection circuit which minimizes the inherent noise sensitivity of one-shot circuits. **T-167** has been specifically designed to provide a minimum of pulse width variation over the temperature range. **T-167 is superior to T-166** for pulse-width-stability over the temperature range but **T-166 is superior to T-167** for pulse-width-stability under power supply voltage changes.

Both circuits are triggered by a positive pulse or positive-going input step. Outputs are two rectangular pulses of opposite polarity. The time duration of output pulses is

determined by an externally connected capacitor. Pulse widths from 2 μsec to 1 second are obtainable at duty cycles up to 70%. The approximate relations between pulse duration and capacity are given by the following equations:

T-166*

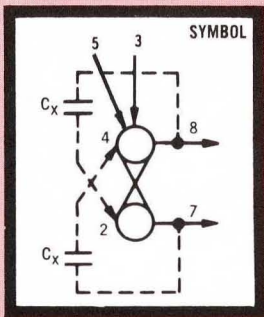
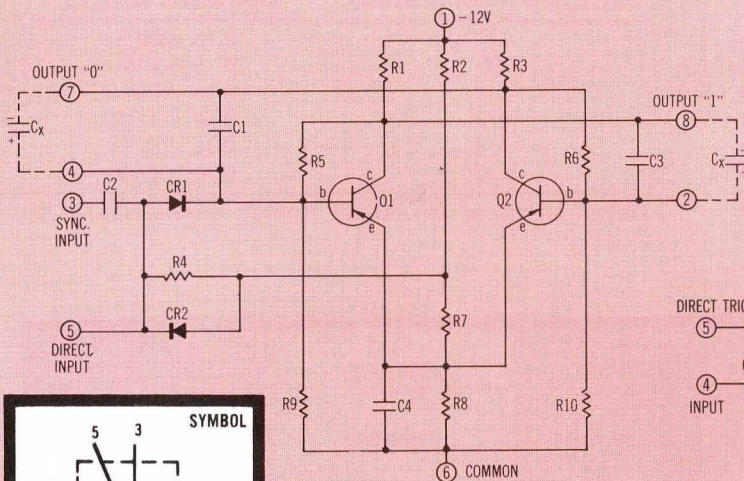
$$C_x = 60(T-2)$$

T-167

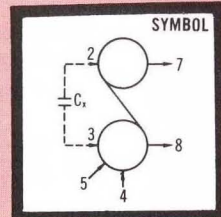
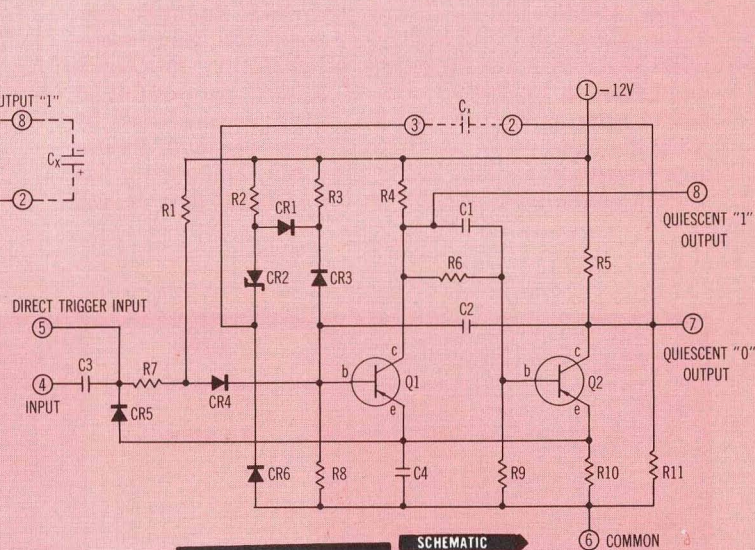
$$C_x = 100(T-2)$$

T in μsec
C_x in pf

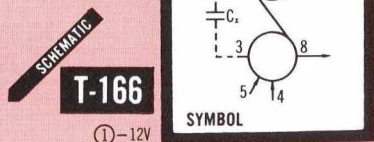
*For duty cycles greater than 50%, pulse width is slightly narrower than the equation indicates. When a polarized capacitor is used, the positive terminal should connect to Pin 3.



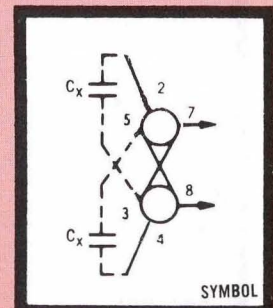
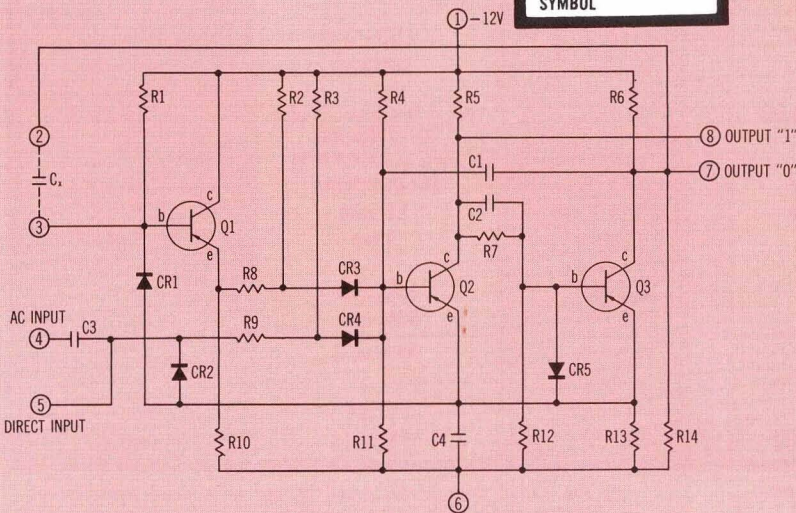
T-104
SCHEMATIC



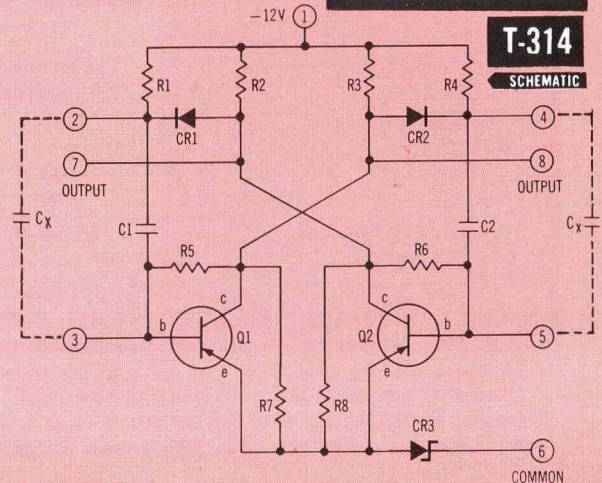
T-167
SCHEMATIC



T-166
SCHEMATIC



T-314
SCHEMATIC



BLOCKING OSCILLATOR T-110

DESCRIPTION

T-110 is a blocking oscillator using two transistors in a monostable circuit. When triggered, the T-110 generates a sharp positive pulse capable of driving a heavy capacitive load.

ELECTRICAL SPECIFICATIONS

INPUT:

Signal Frequency Range: 0 to 250Kc

Trigger Amplitude:

Minimum: Will always operate on positive-going pulse of 6V or more at rise times as long as one microsecond. Faster rise times will allow lower-amplitude trigger signals but the circuit will not trigger on any positive-going pulse of 1.5V or less regardless of rise time.

Maximum: 9V P-P

Rise Time: 0.1 to 1.0 μ sec

Input Load Characteristics:

A, B: 25, 100

C, D: 30, 130

E, F: 25, 100

OUTPUT:

Amplitude (unloaded): 8V P-P from -11VDC to -3VDC

Polarity: Positive

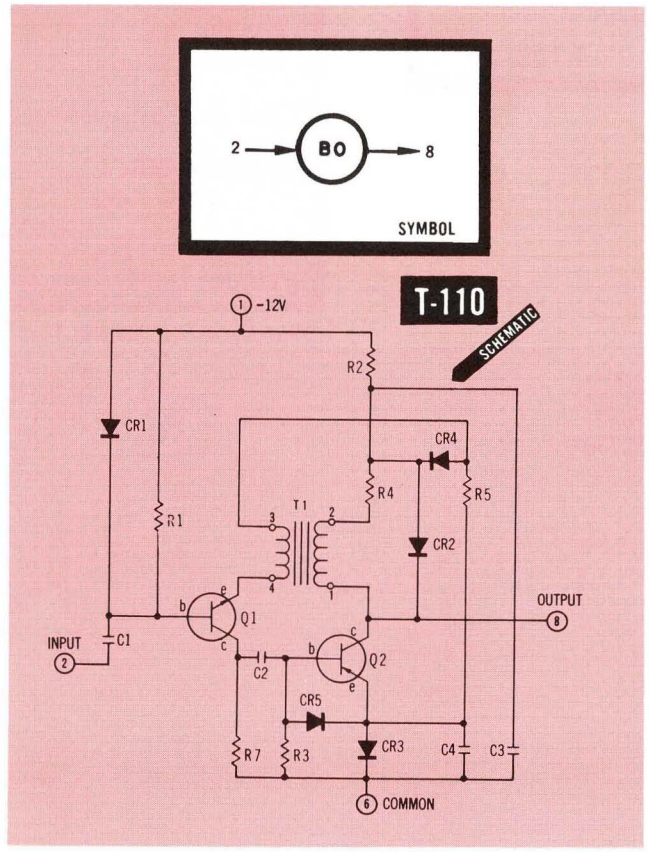
Rise Time: 0.1 μ sec to 0.8 μ sec depending on load

Duration: 0.5 to 2.0 μ sec depending on input amplitude. (Pulse duration is narrower with lower input amplitudes.)

Load Drive Characteristics: This is an AB type driver capable of driving up to 20 paralleled flip-flop inputs.

POWER REQUIRED: -12VDC \pm 10% at 12 ma quiescent and at 40 ma peak.

OPERATING TEMPERATURE RANGE: -45 to +65°C



RESET GENERATORS T-109, T-129

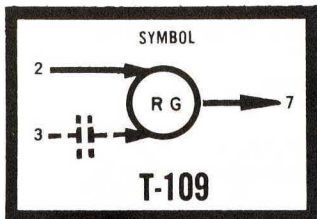
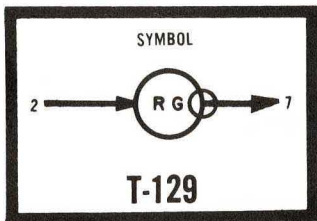
DESCRIPTION

Reset Generator T-109 is designed to reset (or set) T-Series type flip-flops and Reset Generator T-129 is designed to reset N-Series type decades.

In use, the T-109 output is applied to the direct reset (or set) input of the flip-flops concerned. When an ON signal (nominally -3VDC) is applied to the T-109, one of the transistors in each flip-flop is held in a cut-off condition

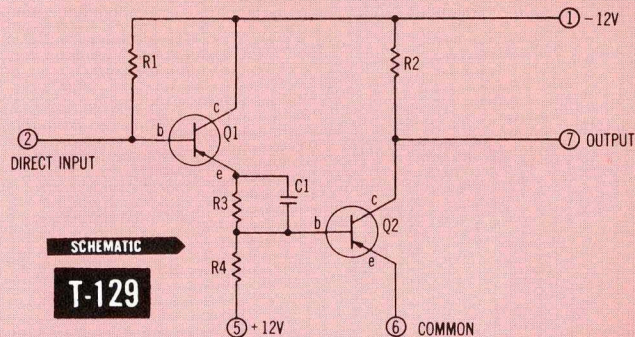
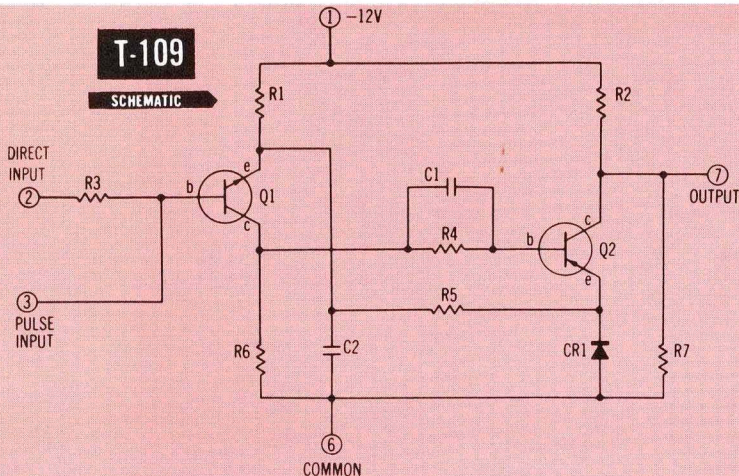
suspending normal flip-flop operation. When an OFF signal (nominally -11VDC) is applied to the T-109, the flip-flops will respond normally to input signals. The T-129 similarly suspends operation of decades but, in this case, does so by saturating one transistor in each N-Series flip-flop (Refer to "Use of Reset Generators" in the "Family Information" section of this catalog.)

The standard input for these units is an 8-volt DC level shift (-11 to -3VDC) such as would be obtained from a flip-flop, one-shot, or gate. Push-button switches can also be used if care is taken to avoid "contact bounce" problems. Pulse resetting may also be employed.



RESET GENERATORS	T-109 (for T-series)	T-129 (for N-series)
INPUT		
SIGNAL FREQUENCY RANGE	0 to 250 Kc	50 Kc max with N-Series
AMPLITUDE:		
Direct Input (Level Shift)	min: -9 to -4 VDC max: -12 to 0 VDC	min: -9.5 to -4 VDC max: -12 to 0 VDC
Pulse Input		
Minimum Pulse or Level Shift	7V P-P through external capacitor to pin 3	7V P-P through external capacitor (470 pf capacitor → 15 μsec output pulse)
Rise Time	0.1 to 0.6 μsec	1.0 μsec max
Add connections necessary:	(1) 33 KΩ external resistor between pins 3 and 6 (2) External jumper between pins 1 and 2	(1) None
INPUT LOAD CHARACTERISTICS:		
A, B	pin 2: 5, 50 pin 3: 30, 50	10, 25
C, D	pin 2: 10, 25 pin 3: 45, 150	5, 25
E, F	pin 2: 5, 50 pin 3: 10, 25	10, 25
OUTPUT		
AMPLITUDE (Level shift from:)		
Unloaded	-5 to -0.3 VDC	0 to -12 VDC
Max. Load	-4 to -0.3 VDC	0 to -4 VDC
DURATION	1 μsec min. to DC	15 μsec min. to DC
RISE TIME (Nominal)	0.5 μsec	0.5 μsec
FALL TIME (Nominal)	0.5 μsec	DC Input: 1 μsec AC Input: 1/4 input pulse width
LOAD DRIVE CHARACTERISTICS	AB Driver Max A = 150 Max B = 200	*AB Driver Max A = 300 Max B = 400
POWER REQUIRED		
-12VDC ± 10%	quiescent: 3 ma during reset: 7 ma	quiescent: 20 ma during reset: 13 ma
+12VDC ± 10%	None	1.5 ma
OPERATING TEMPERATURE RANGE	-45 to +65°C	-54 to +71°C

*When loaded with less than 3 decades, insert 1 KΩ resistor in series with output.



ELECTRICAL SPECIFICATIONS

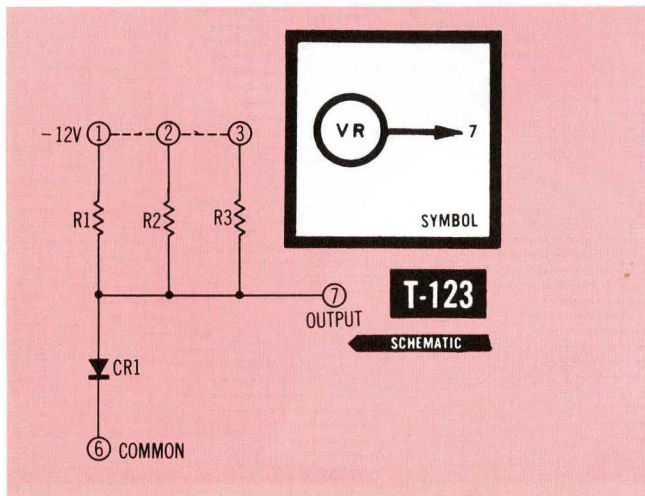
OUTPUT:

- Voltage Level:** -7.5VDC ($\pm 1.0V$)
- Regulated Output Current:**
 - No Jumper: 0 to 6 ma
 - Jumper between Pins 1 & 2: 12 ma
 - Jumper between Pins 1 & 2 & 3: 18 ma
- Impedance:** Approximately 10Ω

POWER REQUIRED: -12VDC $\pm 10\%$

- No Jumper: 22 ma
- Jumper between Pins 1 & 2: 44 ma
- Jumper between Pins 1 & 2 & 3: 66 ma

OPERATING TEMPERATURE RANGE: -45 to +65°C



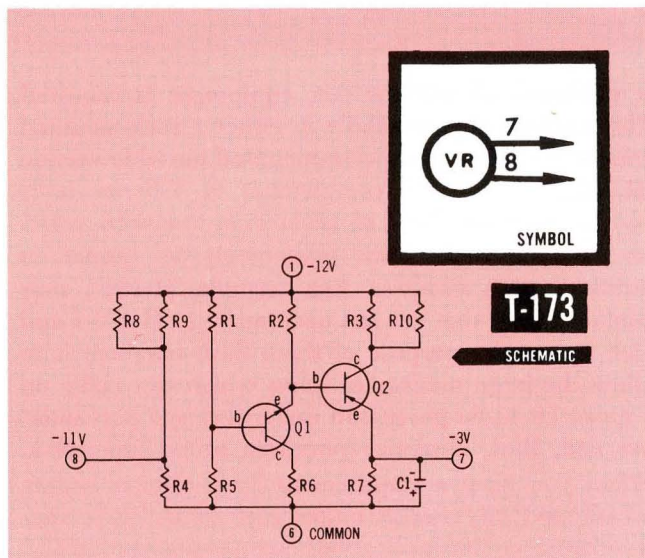
VOLTAGE REGULATOR T-123

DESCRIPTION

T-123 is a shunt-type, regulated, negative 7.5-volt supply. A medium-power zener diode is used yielding low output impedance and good regulation. Three ranges of regulated current are available by means of an external jumper. The usual application for T-123 is to supply bias for neon type Minisig® indicators when they are used with T-Series units. This bias shifts the Minisig operating characteristics to accommodate the output signal levels of T-Series circuits. Table 1 lists permissible neon Minisig loads for the three current ranges established by an external jumper.

Table 1

Load Units	No Jumper	Jumper Pins 1 & 2	Jumper Pins 1, 2, & 3
R-101 R-121	6	13	20
R-201 R-221	3	6	10



BIAS SUPPLY T-173

DESCRIPTION

This unit provides -3VDC and -11VDC bias voltages. The circuit has been designed to draw current to a positive source; if it is desired to draw current to a negative source, it will be necessary to balance the load by drawing on equal current to a positive source.

ELECTRICAL SPECIFICATIONS

OUTPUT:

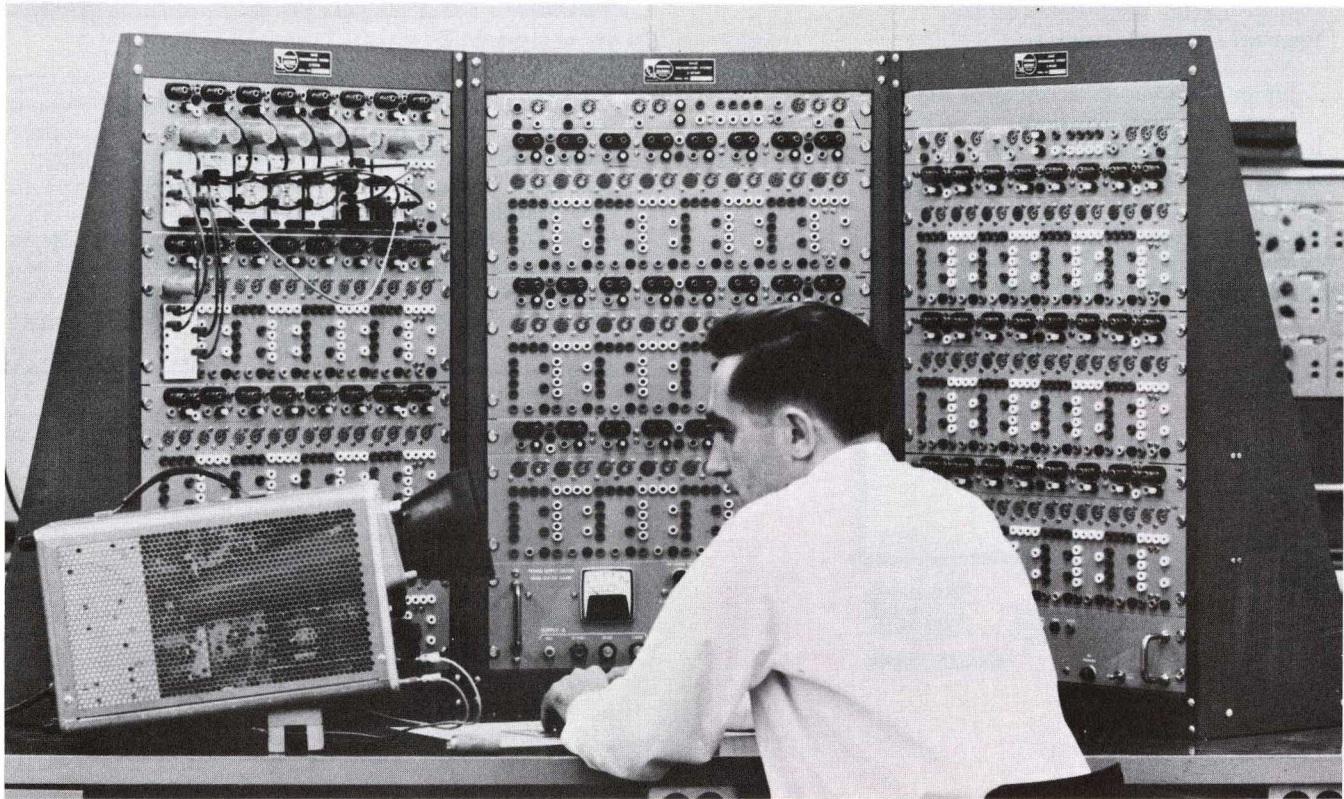
- Amplitude:** -3VDC ($\pm 0.3V$) at Pin 7 and -11VDC ($\pm 0.5V$) at Pin 8.
- Loading:** -3VDC output: 90 ma maximum
- 11VDC output: 20 ma maximum

POWER REQUIRED: -12VDC $\pm 10\%$ at 275 ma

OPERATING TEMPERATURE RANGE: -54 to +71°C

related equipment section

This section of the catalog presents information on related equipment which can be used with T and CT-Series circuit modules.

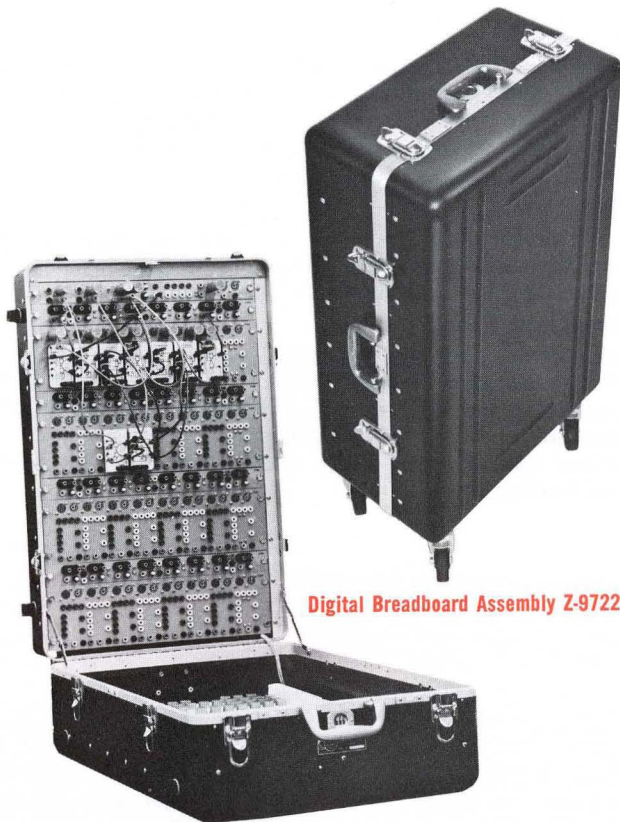


DIGITAL SYSTEM BREADBOARD AND TRAINING EQUIPMENT

This equipment provides a means of rapidly building and testing alternate ways of formulating digital electronic systems or portions of a system. T-Series units to be tried are plugged into sockets on panels. These sockets are permanently wired to groupings of banana jacks immediately underneath the sockets. Plastic circuit symbol cards for each unit type showing circuit symbols, input and output connections, etc., fit over the group of banana jacks exposing the proper pattern for the unit to be connected in the system. Signal connections are then made by patching card-to-card in the line-up being tried. No soldering is necessary (saving engineering time and breadboard materials) and the symbol cards provide means for rapidly visualizing the system or drawing a system diagram.

This equipment can be built up in stages to any desired degree of complexity and the system may be operated slowly to permit detailed observation of each mode of operation. Indicator panels provide light indications, where desired, to show circuit states and, thus,

a minimum of external test equipment is required. This equipment is available in either a rack-mounted version (H-180) or a suitcase-mounted portable version (H-181). **Because the complement of T-Series units and number and kind of accessories required varies for different users, these equipments are quoted in terms of dash numbers.** For example, H-180-1 may contain things that are not necessarily in H-180-2 and vice versa. The purpose of these dash numbers is to allow the large number of items which can make up a given kit to be purchased under just one part number and, thus, minimize purchase order paperwork. **When you have a requirement for a digital system breadboard kit, contact either your local EECo representative or the applications engineers at our factory. These people will work with you to establish your needs and then specify the complement you require and assign a dash number which defines your kit.** The following paragraphs identify components of the suitcase-mounted and rack-mounted equipments.



Digital Breadboard Assembly Z-97221

SUITCASE-MOUNTED EQUIPMENT (H-181)

Digital Breadboard Kit H-181 is composed of digital bread-board assembly Z-97221 plus selected T-, N-, U-, and M-Series circuits and circuit cards. Digital bread-board assembly Z-97221 is an integrated system of breadboarding panels for systems made up of digital circuit modules. The assembly is contained in a EECo case mounted on casters for ease of portability and includes patch panels, indicator panels, a signal generator panel, power supplies, and storage facilities for plug-in circuits, patch cords, and accessories. The assembly may be used in any location where 115VAC is available; and, since auxiliary test equipment is not ordinarily required, the H-181 is a self-sufficient portable design laboratory. The unit can be locked and stored when not in use.

ELECTRICAL SPECIFICATIONS

Input Power: 115VAC $\pm 10\%$, 60 cps; maximum of 30 watts. Line frequency may be 50-400 cps if -100VDC or $+100\text{VDC}$ power supplies are not operated. Line cord is approximately 15 feet long and has a standard 2-prong plug.

Capacity: The assembly includes 4 T-927 circuit breadboard panels, each of which can accommodate up to eight circuit modules. Thus, this assembly can be used to breadboard systems of up to 32 modules. (H-159 adaptors are necessary to use N-Series modules.)

Supply Voltages Available: Power supply panel Z-97432 provides regulated power for use with any standard T-Series, N-Series, M-Series, UB-Series, or R-Series unit. Voltages from this power panel are cabled into the circuit breadboard panels via assembly cabling and are also available for test purposes or external patching purposes at jacks on the power panel.

Voltages available are:

- +12VDC, 1 amp
- 12VDC, 1 amp
- +150VDC, 15 ma (optional)
- 100VDC, 15 ma (optional)
- 7.5VDC, 18 ma (optional)
- 3VDC, 90 ma max. to a positive source
- 11VDC, 90 ma max. to a positive source

PHYSICAL SPECIFICATIONS

Dimensions: Approximately 36" high x 23" wide x 12" thick.

Weight: Approximately 80 pounds including plug-in circuits and accessories.

Material and Finish: Dark blue Fiberglas with brushed aluminum and chrome plated fittings.

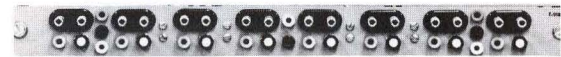
Casters: Four rubber-tired casters, permanently mounted.

EQUIPMENT INCLUDED IN Z-97221

T-918 and T-958 Indicator and Tie Point Panels (2 Each) 1 $\frac{3}{4}$ " x 19", with 8 Minisig indicators and 8 dual binding posts for external parts such as resistors, diodes, capacitors, etc. Indicators light when input signal is -3 volts. T-918 accommodates R-341 indicators; T-958 accommodates R-342 indicators. (R-341 draws power mainly from -12 volts and R-342 draws power mainly from $+12$ volts.)



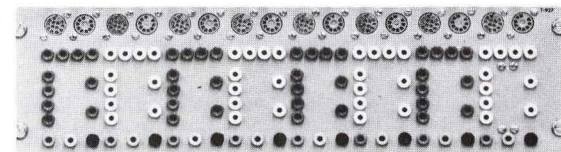
T-918 Indicator and Tie Point Panel



T-958 Indicator and Tie Point Panel

T-927 Systems Development Panel (4 Supplied)

5 $\frac{1}{4}$ " x 19", with eight 9-pin and eight 13-pin sockets. Each panel accepts up to 8 circuits at one time. H-159 socket adaptor is necessary for use with N-Series modules. Power connections are permanently wired to the sockets and other circuit connections are wired to the banana jack grouping immediately below the sockets.



T-927 Systems Development Panel

T-965A Signal Generator Panel (1 Supplied less plug-ins)

1 $\frac{3}{4}$ " x 19" with:

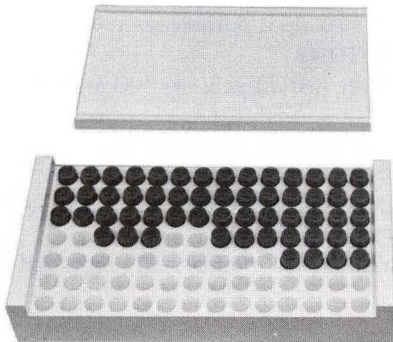
- a. 8 toggle switches for manual insertion of data bits.
- b. 8 Minisig indicators to show settings of these toggle switches.
- c. Socket for T-104 and 5-position rotary selector switch for generation of timing waveform.
- d. 2 Minisig indicators to show state of this timing waveform.
- e. Push-button switch for DC reset signal.
- f. Push-button switch and socket for T-5089 One-shot MV for generation of single clock pulses.



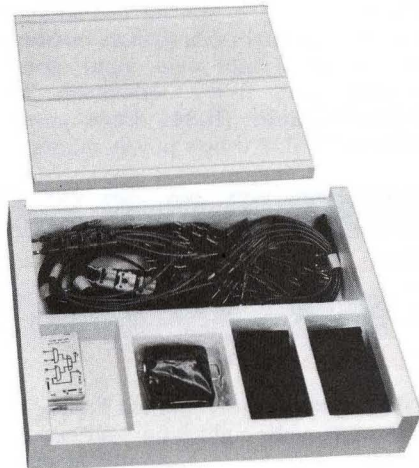
T-965A Signal Generator Panel

Storage Boxes

The T-946 circuit storage box provides shock resistant storage for up to 96 T-Series circuits. The T-947 accessory storage box is a partitioned container for storing circuit cards, patch cords, component plugs, etc.



T-946 Circuit Storage Box



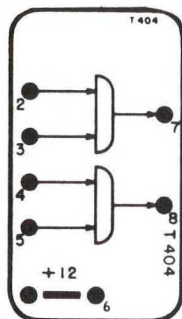
T-947
Accessory Storage Box

ACCESSORIES (Not included in Z-97221)

Plastic Circuit Symbol Cards

Plastic cards corresponding to specific T-Series circuit modules are imprinted with circuit symbols showing input and output connections, power connections, part numbers, etc.

Perforations in the circuit cards match with banana jacks on the T-927 circuit panels. These cards facilitate patching circuit interconnections, visualizing the system, drawing a system diagram, and determining the cost of a system. Circuit cards are available as T-919/xxx, where xxx is the appropriate circuit number. For example: T-919/101B is a circuit card for flip-flop T-101B.



Typical Plastic Circuit Symbol Card

Patch Cords

Patch cords H-106 through H-120 are available in 8", 12", and 18" lengths, and in black, red, green, blue, and yellow, to facilitate circuit interconnection identification. Black patch cords are also available in 4" lengths as H-101. (For specific part numbers see Price List.)

Power Plugs

T-920 power plugs are black dual banana plugs with a shorting bar between pins. These are used to make +12 volt and ground connections on T-927 panels.

Component Plugs

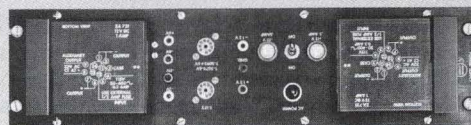
Component plugs are available in red (T-928), yellow (T-929), and blue (T-930). These are similar to the T-920 power plug but do not have a shorting bar. Component plugs are used with the T-918 and T-958 panels to hold a resistor, capacitor, or diode, and are mounted between dual binding posts.

SUITCASE MOUNTED EQUIPMENT (H-189)

Digital Breadboard Kit H-189 is a smaller version of Kit H-181. The case contains a T-965A Signal Generator Panel, 3 T-927 System Development Panels, 2 T-958 Indicator and Tie-Point Panels, and a Z-101663 Power Panel. Specific kits also contain selected T-, N-, and UB-Series circuit modules and accessories; dash numbers are assigned, as previously described, to define each specific kit.



Suitcase Mounted
Equipment H-189



Power Panel Z-101663

ELECTRICAL SPECIFICATIONS

Input Power: 115VAC $\pm 10\%$, 50 to 400 cps. Maximum power drain is 30 watts. Line cord is 15 feet long and has standard 2-prong plug.

Capability: The assembly includes 3 T-927 circuit breadboard panels, each of which can accommodate up to eight digital modules. Thus, systems of up to 24 modules can be handled.

Supply Voltages Available: Power Panel Z-101663 provides regulated power for use with any standard T-, N-, and UB-Series units. Voltages from this Power Panel are coupled to the circuit breadboard panels via assembly cabling and are also available for test purposes or for external patching purposes at jacks on the power panel.

Voltages Available Are:

+12VDC	-6VDC
-12VDC	-3VDC
+6VDC	-11VDC

PHYSICAL SPECIFICATIONS

Dimensions: Approximately 24" high x 20" wide x 9" thick.

Weight: Approximately 40 lbs. including plug-ins and accessories.

Material and Finish: Dark blue Fiberglas with brushed aluminum and chrome plated fittings.

Casters: Four rubber-tired casters, permanently mounted.

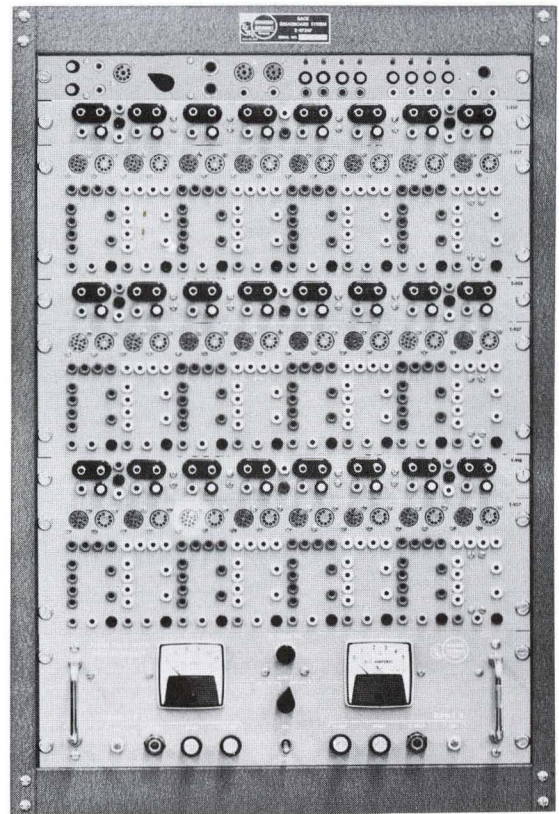
RACK-MOUNTED EQUIPMENT (H-180)

Rack-Mounted Digital Breadboard Kits H-180 are comprised of rack-mounted assemblies Z-97597A, Z-97598, and Z-97599A plus the accessories described for digital breadboard Kit H-181. The rack-mounted digital breadboard assemblies form an integrated system of breadboarding panels for circuits made up of EEC₀ digital modules. These assemblies are mounted in racks for laboratory or classroom use and include: Power supplies, breadboarding panels, indicator panels, signal generator panel, and system cabling.

Each assembly is intended primarily for experimental breadboarding of portions of larger digital systems. Combinations of assemblies may be used to breadboard complete digital systems and such combinations are designated a Digital Breadboard Kit H-180. Dash numbers can then be appended to the part number (H-180-1, H-180-2, etc.) in order to define each specific kit.

Z-97597A includes a dual 5-amp power supply ZA-720 and a signal generator panel T-965A. In applications where more than 24 plug-ins are required, Z-97597A can be used to provide power and signals to one or more Z-97598 assemblies which contain only breadboarding and indicator panels. If 24 or less plug-ins are required, a Z-97599A assembly can be used. Accessory equipment for these assemblies is the same as described for the suitcase mounted Kit H-181. Circuit and accessory storage boxes may be purchased separately.

The following paragraphs briefly describe these three rack-mounted digital assemblies.

**Z-97597A**

This rack forms a nucleus of several breadboard assemblies made up of the Z-97597A and one or more Z-97598 auxiliary assemblies. Inter-rack cabling feeds power from Z-97597A to the companion Z-97598 assemblies. In addition to the power supply, Z-97597A contains a T-965A signal generator panel, one T-918 and two T-958 indicator and tie point panels, and three T-927 system development panels.

PHYSICAL SPECIFICATIONS

Dimensions: Approximately 32" high x 21" wide x 17" deep.

Finish: Rack is gray wrinkle; panels are gray baked enamel.

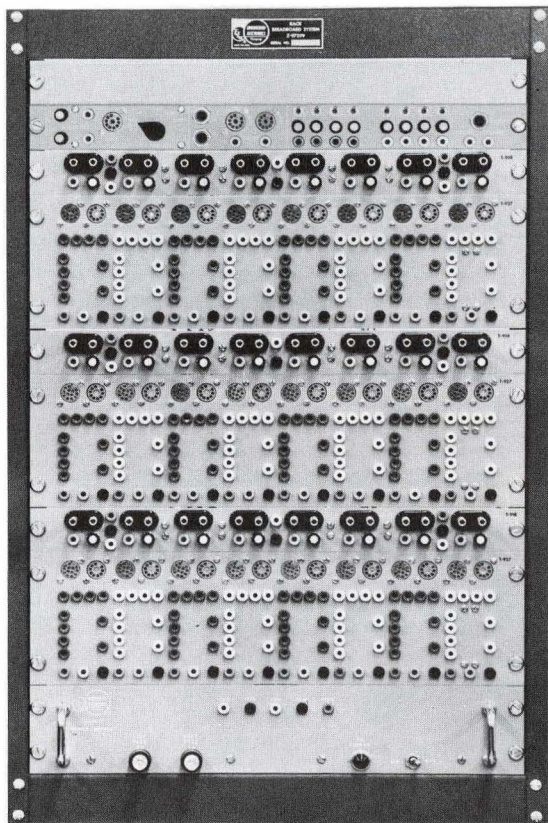
ELECTRICAL SPECIFICATIONS

Input Power: 115VAC, 50-400 cps, 120 watts maximum. Power cord is 8 feet long and has a standard two-prong plug.

Circuit Breadboarding Capability: Assembly includes three T-927 system development panels, each of which can accommodate up to eight modules at one time.

Output Power Capability: Power supply provides two channels of regulated 12-volt power. Each channel is rated at 5 amperes. Power is terminated at a terminal board on the rack and inter-rack cabling must be used to carry power to other racks in the system.

continued on next page



Z-97599A

This assembly is intended primarily for experimental breadboarding of portions of larger digital systems. The assembly contains a T-965A signal generator panel, a T-918 and two T-958 indicator and tie point panels, a Z-97617 panel/chassis power supply, and three T-927 system development panels.

PHYSICAL SPECIFICATIONS

Dimensions: Approximately 32" high x 21" wide x 15" deep.

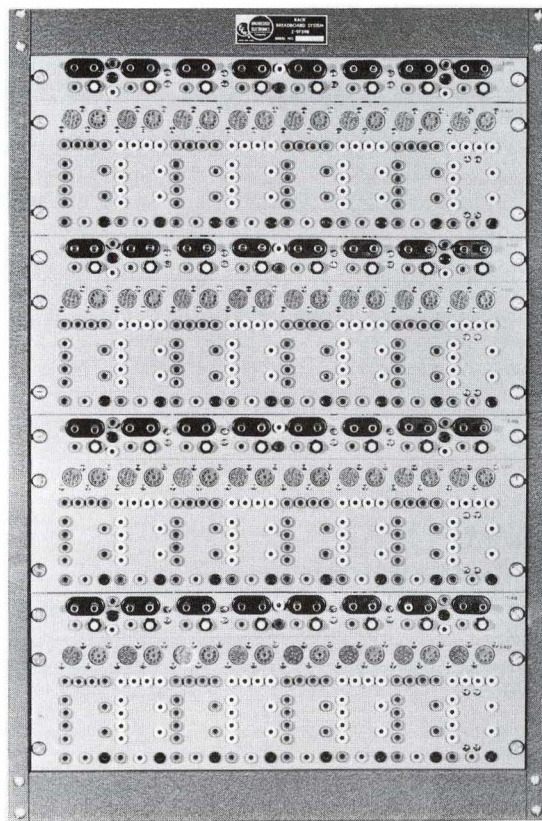
Finish: Rack is gray wrinkle; panels are gray baked enamel.

ELECTRICAL SPECIFICATIONS

Input Power: 115VAC $\pm 10\%$, 50-400 cps. Maximum power drain is 25 watts. AC line cord is 8 feet long and has standard 2-prong plug.

Circuit Breadboarding Capability: Assembly includes three T-927 system development panels. Each panel accommodates up to eight modules; a total capacity of 24 modules at one time.

Power Supply Voltages: Z-97617 panel/chassis power supply provides -12VDC, +12VDC, -11VDC, and -3VDC. Power supply voltages are cabled to system development panels by a rack cabling. Power supply voltages are also available at test jacks on the Z-97617 panel.



Z-97598

This is a companion unit for Z-97597A and is used in layout of extensive breadboarding facilities for digital modules. This assembly contains T-927 development panels and T-918 and T-958 indicator panels only. Power must be supplied from either the Z-97597A or from external power supplies.

PHYSICAL SPECIFICATIONS

Dimensions: Approximately 32" high x 21" wide x 15" deep.

Finish: Rack is gray wrinkle; panels are gray baked enamel.

ELECTRICAL SPECIFICATIONS

Input Power: +12VDC and -12VDC. Input power is supplied to the terminal board on the rack.

Circuit Breadboarding Capability: The system includes four T-927 system development panels. Each panel can accommodate up to eight modules at one time.

Approximate Weight: 34 lbs.

POWER SUPPLIES

recommended for use with T-Series units.

EECO Power Supplies shown here are designed for

integration into complex systems and equipment OR laboratory use. They are solid-state, convection-cooled, 12-volt supplies featuring excellent regulation and military-quality parts.

Information on other EECO Power Supplies is available through your local EECO Representative.



ZA-720

Model ZA-720 is a solid-state, convection-cooled, dual 12-volt DC, 5-amp regulated power supply featuring military-quality parts and excellent regulation. Ripple voltage is held to less than 0.001 volt rms under the worst combination of input voltage and load current.

The supply provides two completely independent 12-volt DC sources, rated at 5-amps each, isolated from ground and from the chassis. Either polarity may be grounded or the two source outputs may be placed in series. Operating temperature range is -20°C to $+65^{\circ}\text{C}$ (-4°F to $+149^{\circ}\text{F}$).

Two meters on the front panel permit measurement of output voltage and current for each supply independently. A switch is provided for selection of source to be measured.

ELECTRICAL SPECIFICATIONS

Input Power: 115V ($\pm 10\%$) AC, 2 amps, 50-400 cps.

Output Power: Supply A: 12VDC at 0-5 amps.

Supply B: 12VDC at 0-5 amps.

(Either polarity may be grounded, or both may be placed in series.)

Both supplies are independently adjustable over the range of 11 to 13V.

Regulation:

Voltage Regulation: 0.1% at DC to 1% at 25Kc for any load change between 0 and 5 amps, and/or any input voltage specified.

Ripple Voltage: Less than 0.001 volt rms under the worst combination of input voltage and load current.

Output Impedance: Figure 1 shows a typical variation of output impedance over the frequency range of 10 cps to 1Mc. Below 10 cps the impedance is still lower and falls to a typical value of 0.001Ω at DC.

Duty: Continuous.

PHYSICAL SPECIFICATIONS

Mounting: Standard rack-panel mounting with amateur notching. Chassis sliders optional.

Weight: 35 pounds.

Dimensions: $5\frac{1}{4}$ " panel height, 19" width, 14" depth behind panel.

Finish: Panel is finished in gray enamel; chassis is cadmium-plated steel, clear iridite.

Front Panel Controls:

Meters: The output voltage and current are measured by two meters on the front panel. The supply to be measured is selected by a switch located between the two meters.

Output Voltage Control: Output voltage of either supply may be varied $\pm 1\text{VDC}$ by adjusting its individual potentiometer mounted on the front panel.

Fuzes: One 2.0-amp fuze and one spare for each supply.

Front Panel Indicators:

Power on (red).

DC power on (amber).

Blown-fuze indicators.

Cooling: Convection.

Operating Temperature Range: -20°C to $+65^{\circ}\text{C}$ (-4°F to $+149^{\circ}\text{F}$). May be operated at $+71^{\circ}\text{C}$ if maximum load current is reduced to 4 amps.

Pin Connections:

Terminal 1 (TB1 and TB2): 115VAC input.

Terminals 3 and 4: (TB1 and TB2): negative output terminal.

Terminal 5: (TB1 and TB2): chassis ground.

Terminals 6 and 7: (TB1 and TB2): positive output terminal.

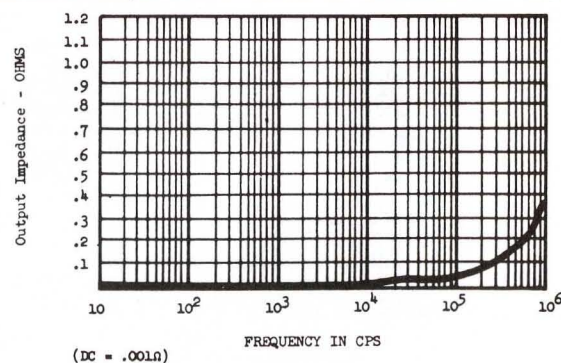


Fig. 1 Output Impedance vs Frequency
ZA-720



ZA-735

Model ZA-735 is a transistorized 12VDC, 1-ampere regulated power supply which is isolated from the chassis and can be used as either a positive or negative source with reference to ground. The supply is contained in a cast aluminum case which functions as a heat radiator for the supply. Features are:

Overload Protection: Output current is limited above the rated load of one ampere. However, ZA-735 will sustain a continuous short circuit and will return to normal operation when the overload or short circuit is removed.

Battery Back-up: Provision has been made for a battery input so that this power supply can be used in systems designed for fail-safe operation. When AC power fails or is removed from the supply, battery power is automatically transferred through the regulator to the load without discontinuity. The regulator corrects any voltage variations in the battery output thus assuring a constant 12-volt output.

ELECTRICAL SPECIFICATIONS

Input Power: 117 ($\pm 10\%$) volts AC, 0.3 amps, 50-400 cps.

Output Power: 12VDC at 0 to 1 amp. The unit may be used as either a positive or a negative supply. The output is adjustable ± 1 volt by means of an adjustment located at the rear of the supply. The unit also provides 34VAC (center-tapped) for operating a bias power supply ZA-727.

Regulation: Line: 0.05% Load: 0.1%

Ripple: Less than 1 millivolt rms under the worst combination of input voltage and load current.

Output Impedance: Figure 1 shows a typical variation of output impedance over the frequency range of 10 cps to 1 Mc. Below 10 cps the impedance falls to a typical value of 0.006 ohms at dc.

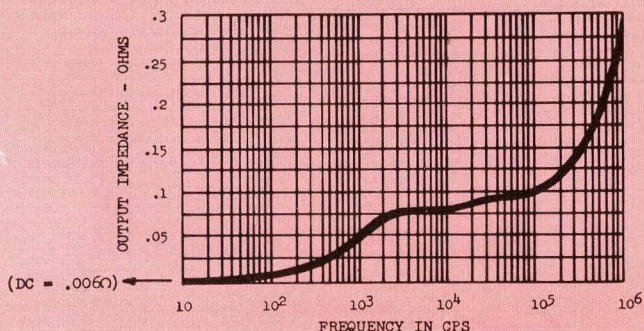


Figure 1. Output Impedance vs. Frequency.

Battery Back-up: A battery back-up for fail-safe operation may be incorporated by adding an isolating diode and a 14-to-18-volt battery. This will allow an uninterrupted output if the a-c line voltage fails. Figure 2 shows the connection.

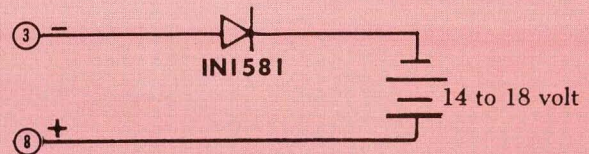


Figure 2. External Circuit Needed for Battery Back-up.

Overload Protection: Unit is current-limited above rated load of one ampere. Short circuit current is approximately 20% of rated current. The supply will sustain a continuous short circuit and will return to normal operation when the overload or short circuit is removed.

Fuses: No fusing of a-c input power is required due to the overload protection feature. However, if additional protection is desired, a $\frac{1}{2}$ -amp fuse may be placed in series with the a-c line.

Pin Connections:

- Pins 1 and 10: a-c line voltage.
- Pins 2 and 9: 34VAC (CT @ pins 5 and 8).
- Pins 3 and 8: Battery back-up.
- Pins 4 and 5: Positive output terminal.
- Pins 6 and 7: Negative output terminal.

PHYSICAL SPECIFICATIONS

Dimensions: See Figure 3 for outline drawing with mounting dimensions.

- Height: 4 inches
- Width: $2\frac{3}{4}$ inches
- Length: $4\text{-}7/16$ inches

Weight: 2 lb., 12 oz.

Finish: Flat black baked resin #539-B

Cooling: Convection

Operating Temperature Range: -20°C to $+65^{\circ}\text{C}$ (-4°F to $+149^{\circ}\text{F}$). Air circulation is required above 50°C .

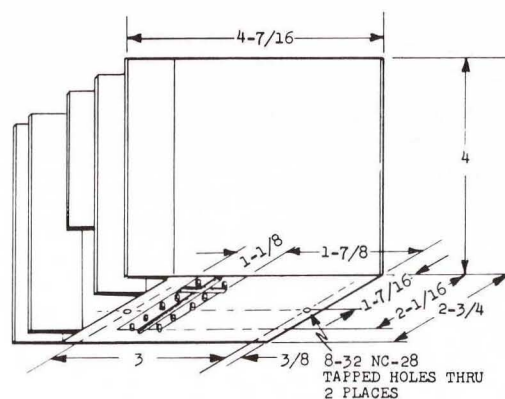
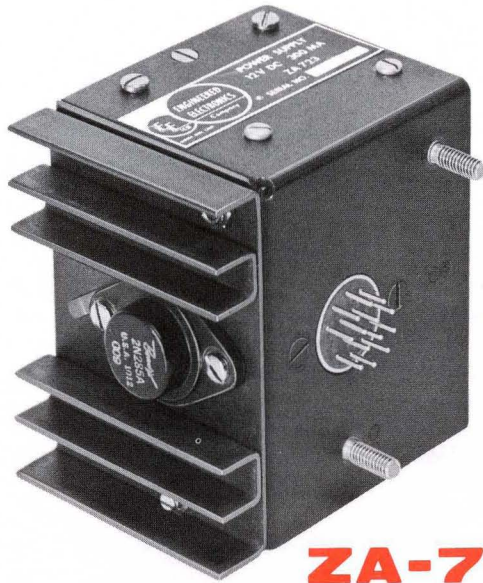


Figure 3. Outline Drawing of ZA-735



ZA-723

Model ZA-723 is a plug-in, solid-state, convection-cooled, 12 volt DC, 300 ma regulated power supply featuring military-quality parts and excellent regulation. Ripple voltage is held to less than 0.001 volt rms under the worst combination of input voltage and load current. The supply is isolated from the chassis and can be used as either a positive or negative voltage source with reference to ground. Operating temperature range is -20°C to $+65^{\circ}\text{C}$ (-4°F to $+149^{\circ}\text{F}$).

Attractively finished in black anodize, the unit weighs only 1 $\frac{3}{8}$ pounds and can be mounted on a chassis along with other circuitry. Two #8-32 x $\frac{1}{2}$ " studs secure the supply to the mounting surface.

ELECTRICAL SPECIFICATIONS

Input Power: 115 ($\pm 10\%$) volts AC, 0.1 ampere; 50-400 cps.

Output Power: 12VDC, 0-0.3 amp (+ or -), adjustable over the range of 11 to 13V (33VAC with center tap at positive terminal available for auxiliary positive bias unit).

Regulation:

Voltage: 0.1% at DC to 1% at 25Kc for any load change between 0 and 0.3 amp and/or for any input voltage specified. This includes an output connector loss of 0.05%.

Ripple: Less than 0.001 volt rms under the worst combination of input voltage and load current.

Output Impedance: See Figure 1 which shows a typical variation of output impedance over the frequency range of 10 cps to 1Mc. Below 10 cps, the impedance is still lower and falls to a typical value of 0.04Ω at DC.

Duty: Continuous.

PHYSICAL SPECIFICATIONS

Mounting: Model ZA-723 power supply can be mounted on a chassis along with other circuitry. It plugs into a modified 14-pin miniature socket which is furnished with the unit. Two #8-32 x $\frac{1}{2}$ " studs secure this supply to a mounting surface.

Weight: 1- $\frac{3}{8}$ pounds.

Dimensions: 2- $\frac{7}{8}$ " x 2- $\frac{7}{8}$ " x 2- $\frac{3}{16}$ " seated height.

Finish: Black anodize.

Output Voltage Control: Output voltage may be varied over the range of 11 to 13VDC by adjusting a potentiometer through opening in the heat-sink side of the power supply.

Fuzes: A 1/4-amp fuze should be used external to this unit in series with the AC input power line. 3/8-amp slo-blo fuze internal to supply to prevent damage in the event of faulty external fuzing.

Cooling: Convection.

Operating Temperature Range: -20°C to $+65^{\circ}\text{C}$ (-4°F to $+149^{\circ}\text{F}$).

Pin Connections: Pin hole No. 10 is blocked in the socket and Pin No. 10 is deleted from the header to provide pins 6 and 7.

index keying. Pin connections are as follows:

Pins 4 and 12: Input 115VAC power at 0.1 ampere.

Pins 1 and 2: Output negative terminal.

Pins 6 and 7: Output positive terminal.

Pins 8 and 9: Output 33 volt AC, center-tapped at pins 6 and 7.

Pins 3, 5, 11, 13, and 14: Case Common (connect chassis ground).

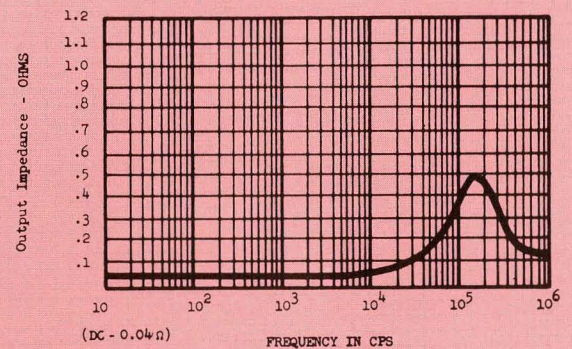


Figure 1. Output Impedance vs. Frequency.

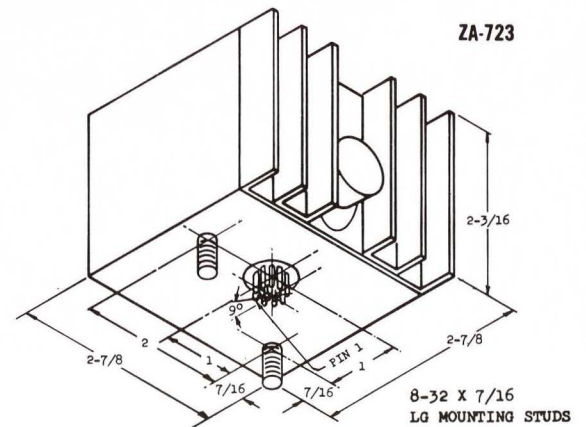
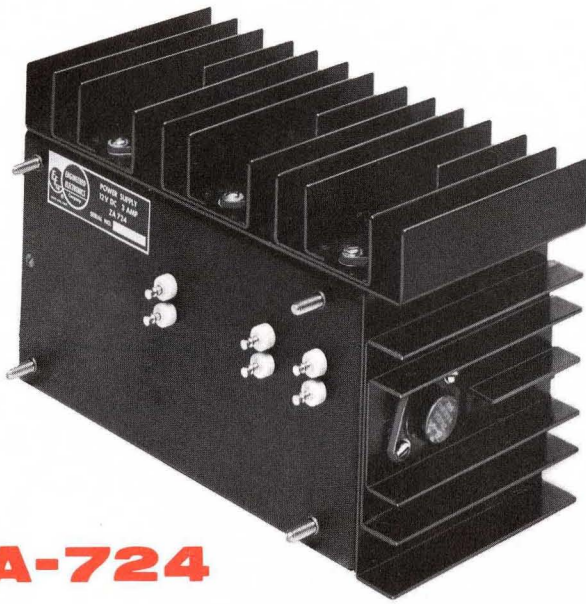


Figure 2. Outline Drawing
(measurements in inches)

ZA-724



Power Supply ZA-724 is a general-purpose, transistorized, regulated power supply that will provide 12 volts DC to a 3-amp load in continuous-duty operation. AC and DC circuits are isolated from the case, and either output terminal may be grounded to provide a positive or negative output with respect to circuit ground. The unit may be secured to a chassis by means of four #8-32 x 1/2" studs that are integral with the case. Electrical connections are made to feed-through terminals on the bottom of the case. Attractively finished in black anodize, the unit weighs only 6 pounds and can be mounted on a chassis along with other circuitry. The seated height is 3 3/4".

ELECTRICAL SPECIFICATIONS

Input Power: 115 (±10%) volts AC, 1 ampere, 50-400 cps.

Output Power: 12 volts DC, 0-3 amp (+ or -), adjustable over the range of 11 to 13 volts. (33 volts AC with center tap at positive terminal available for auxiliary positive bias unit).

Regulation:

Voltage Regulation: 0.1% at DC to 1% at 25Kc for any load change between 0 and 3 amp and/or for any input voltage specified.

Ripple: Less than 0.001 volt rms under the worst combination of input voltage and load current.

Output Impedance: See Figure 1 which shows a typical variation of output impedance over the frequency range of 10 cps to 1Mc. Below 10 cps the impedance is still lower and falls to a typical value of 0.004Ω at DC.

PHYSICAL SPECIFICATIONS

Mounting: The power supply can be mounted on a chassis along with other circuitry. Feed-through type input and output terminals are on the bottom of the supply; these terminals fit through 3 holes, 3/4" diameter in the chassis. Both input and output power connections are soldered connections.

Weight: 6 pounds.

Dimensions: 7 7/8" x 4 3/4" x 3 3/4" seated height.

Finish: Black anodize.

Output Voltage Control: Output voltage may be varied over the range of 11 to 13 volts DC by adjusting a potentiometer through an opening in the back of the power supply.

Fuze: A 1 1/2-ampere fuze is internal to the supply and is accessible from a screw-driver-operated fuze extractor in the top of the power supply.

Cooling: Convection.

Operating Temperature Range: -20°C to +65°C (-4°F to +149°F).

Pin Connections:

Pins 1 and 2: Input 115 volts AC power at 1 ampere.

Pin 5: Negative output terminal.

Pin 6: Positive output terminal.

Pins 3 and 4: 33 volt AC output, center tapped at Pin 6.

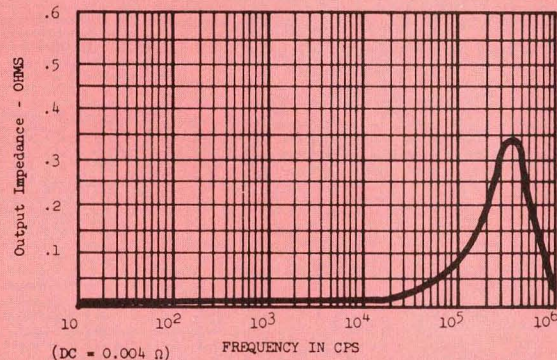
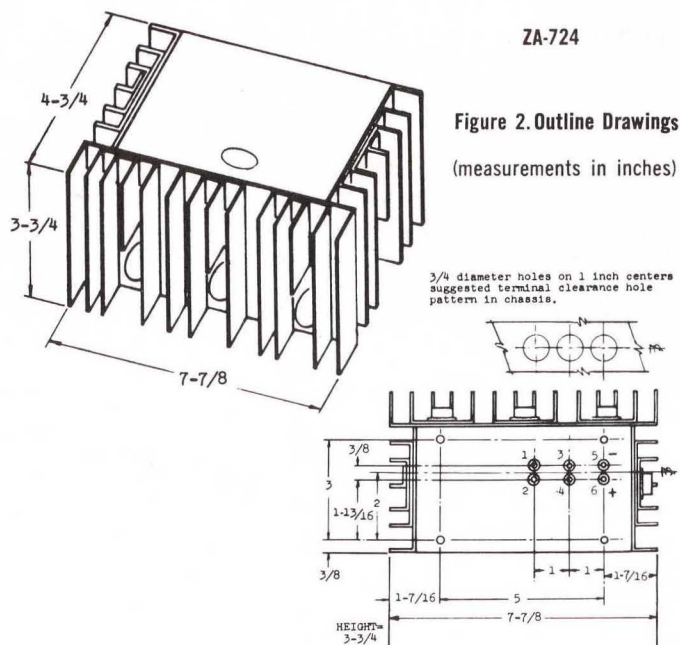


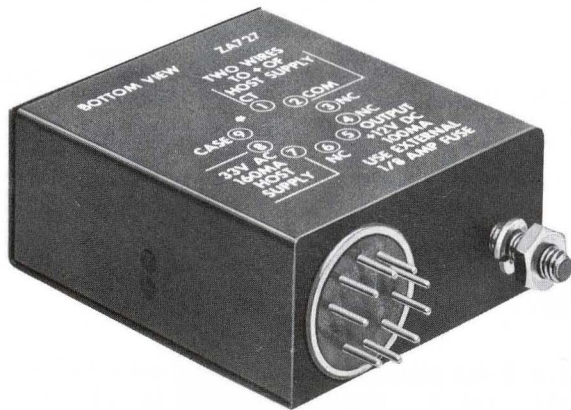
Figure 1. Output Impedance vs. Frequency.



ZA-724

Figure 2. Outline Drawings (measurements in inches)

3/4 diameter holes on 1 inch centers suggested terminal clearance hole pattern in chassis.



ZA-727

Bias Supply ZA-727 is an auxiliary regulated power supply that will furnish +12 volts DC or +24 volts DC to a 100-milliampere load in continuous-duty operation. Input power is provided by another (host) power supply. The unit features military-quality parts and excellent regulation. Ripple voltage is held to less than 0.001 volt rms under the worst combination of the input voltage and load current. Host supplies can be ZA-721, ZA-725, ZA-723⁺, or ZA-724.

⁺When Model ZA-727 is used to furnish full 100-ma bias current, derate Model ZA-723 to 250 ma.

Attractively finished in black anodize, the unit weighs only 2 ounces and can be mounted on a chassis along with other circuitry. One #8-32 x 1/2" stud secures the supply to a mounting surface.

ELECTRICAL SPECIFICATIONS

Input Power: 33 volts AC, 160 ma, 50-400 cps from center-tapped transformer secondary of ZA-721, ZA-723, ZA-724, or ZA-725 power supplies.

Output Power: +12 volts DC, 0-100 ma with respect to positive terminal of host supply. The positive terminal of the host power supply is used as a common DC return point.

Regulation:

Voltage Regulation: Less than 0.1% at DC from no load to full load of 100 ma and/or for input variations as specified for operation of host supply.

Ripple: Less than 0.001 volt rms under the worst combination of input voltage and load current.

Output Impedance: See Figure 1 which shows a typical variation of output impedance over the frequency range of 10 cps to 1Mc. Below 10 cps, the impedance is still lower and falls to a typical value of 0.02Ω at DC.

PHYSICAL SPECIFICATIONS

Mounting: The bias supply can be mounted on a chassis along with other circuitry. It plugs into a 9-pin miniature tube socket, which is furnished with the unit. One #8-32 x 1/2" stud secures the supply to a mounting surface.

Weight: 2 ounces.

Dimensions: 1" x 1-13/16" x 2-3/16" seated height.

Finish: Black anodize.

Fuze: Internal 3/10 amp.

Cooling: Convection.

Operating Temperature Range: -20°C to +65°C (-4°F to +149°F).

Pin Connections:

Pins 7 and 8: Input 33 volt AC power at 100 ma from transformer secondary of host supply.

Pin 1: Return to center tap of transformer of host supply.

Pin 5: +12 volt DC output at 100 ma.

Pin 2: Common return to positive terminal of host supply (must be separate wire from that called out on Pin 1 above).

Pin 9: Case ground.

Pins 3, 4, and 6: Not used.

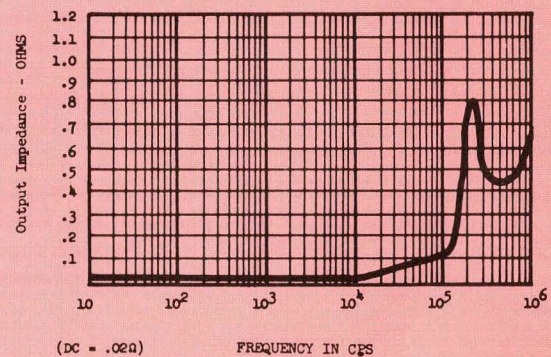


Figure 1. Output Impedance vs. Frequency.

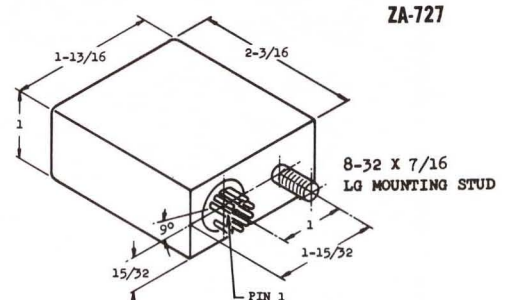


Figure 2. Outline Drawing
(measurements in inches)



TIMING SOURCES (CRYSTAL-CONTROLLED) H-221, H-222, H-223

DESCRIPTION

These transistorized, crystal-controlled, oscillator circuits generate rectangular waves for precision timing applications. H-221 is for frequency range 1 Kc to 100 Kc, H-222 is used over the frequency range 100 Kc to 250 Kc, and H-223 operates in the frequency range 250 Kc to 1 Mc. The circuits are housed in rectangular plug-in oven assemblies which mate with standard octal sockets. Models are available for heater voltages of 28 volts AC/DC or 115 volts AC/DC.

The basic part numbers (H-221, H-222, and H-223) define complete families of timing sources which operate in their respective frequency ranges. **Specific** timing generators are defined by addition of a "dash" number and letter. The "dash" number defines a particular set of individual parameters (set frequency, stability, and power drain). The "dash" letter defines oven heater voltage requirements. For example, H-221-1A is a 1.0 Kc ($\pm 0.001\%$) frequency source with a stability of $\pm 0.0005\%$ over the temperature range and a 12-ma maximum current demand on the 12-volt power source. The "dash" letter "A" signifies 115 volt AC/DC heater requirement ("B" signifies 28 volt AC/DC heater).

Four basic timing sources are offered as listed in Table I. These are available on a 1-to-3-week delivery basis. Special frequencies within the range of those stated for each timing source may be ordered with delivery of approximately 8 to 12 weeks.

TABLE 1 STANDARD TIMING SOURCES

Part No.	Frequency	Initial Setting Accuracy	Frequency Stability over Temp. Range	-12 volt Power Required	Heater Voltage
H-221-1A	1.0 Kc	$\pm 0.001\%$	$\pm 0.0005\%$	12 ma max	115 V AC
H-221-1B	1.0 Kc	$\pm 0.001\%$	$\pm 0.0005\%$	12 ma max	28 V DC
H-221-2A	10 Kc	$\pm 0.001\%$	$\pm 0.0005\%$	12 ma max	115 V AC/DC
H-221-2B	10 Kc	$\pm 0.001\%$	$\pm 0.0005\%$	12 ma max	28 V AC/DC
H-222-1A	100 Kc	$\pm 0.0005\%$	$\pm 0.0005\%$	12 ma max	115 V AC/DC
H-222-1B	100 Kc	$\pm 0.0005\%$	$\pm 0.0005\%$	12 ma max	28 V AC/DC
H-223-1A	1 Mc	$\pm 0.0005\%$	$\pm 0.0003\%$	12 ma max	115 V AC/DC
H-223-1B	1 Mc	$\pm 0.0005\%$	$\pm 0.0003\%$	12 ma max	28 V AC/DC

Table 2 lists pin connections for these units. Note that pin connections are essentially identical for all three units **except** for pins 5 & 6 of H-221 units. Trimming of H-221 timing sources must be done with external capacitors as follows:

- No trimming desired: jumper pin 5 to pin 6.
- To lower frequency: jumper pin 5 to pin 6 and connect a shunt capacitor to pin 2. (For H-221-1, a 470 pf capacitor lowers the frequency approximately 0.001%.)
- To raise frequency: insert a series capacitor between pins 5 and 6. (For H-221-1, a 2500 pf capacitor raises the frequency approximately 0.001%)

H-222 and H-223 sources have internal trim capacitors which permit frequency adjustment to compensate for crystal aging. It is necessary to remove the outside cover to make this adjustment.

TABLE 2 PIN CONNECTIONS

Pin No.	H-221	H-222	H-223
1	-12V Power	-12V Power	-12V Power
2	12V Common	12V Common	12V Common
3 & 8	Heater voltage	Heater voltage	Heater voltage
4	Case ground	Case ground	Case ground
5 & 6	Trim	External jumper	External jumper
7	Output	Output	Output
9	Unused	Unused	Unused

TIMING SOURCES	H-221	H-222	H-223
OUTPUT			
AMPLITUDE*	8V P-P	8V P-P	8V P-P
RISE TIME (max.)	1 μ sec	1 μ sec	0.05 μ sec
IMPEDANCE	1500 Ω max.	1500 Ω max.	250 Ω AC coupled
MAX. RESISTIVE LOAD	3.9K Ω to -12V 47K Ω to +12V	2.7K Ω to -12V	3.9 Ω to -12V
FREQ. SET TOLERANCE	$\pm 0.001\%$ @ 25°C ambient	$\pm 0.0005\%$ @ 25°C ambient	$\pm 0.0005\%$ @ 25°C ambient
FREQ. STABILITY	$\pm 0.0005\%$	$\pm 0.0005\%$	$\pm 0.0003\%$
Over Ambient Temp. Range			
FREQ. SHIFT vs. LOAD	Negligible	Negligible	Negligible
(Freq. Shift from no load to full load)			
FREQ. TRIMMING RANGE	$\pm 0.001\%$ or more	0.003% or more	0.002% or more
WARM-UP TIME	15 minutes	30 minutes	30 minutes
POWER REQUIRED			
CIRCUIT: -12VDC @	12 ma max	12 ma max	12 ma max
HEATER (115V AC/DC** or 28V AC/DC)	40 watts	40 watts	40 watts
AMBIENT TEMPERATURE RANGE	-54°C to +65°C	-54°C to +65°C	-54°C to +65°C

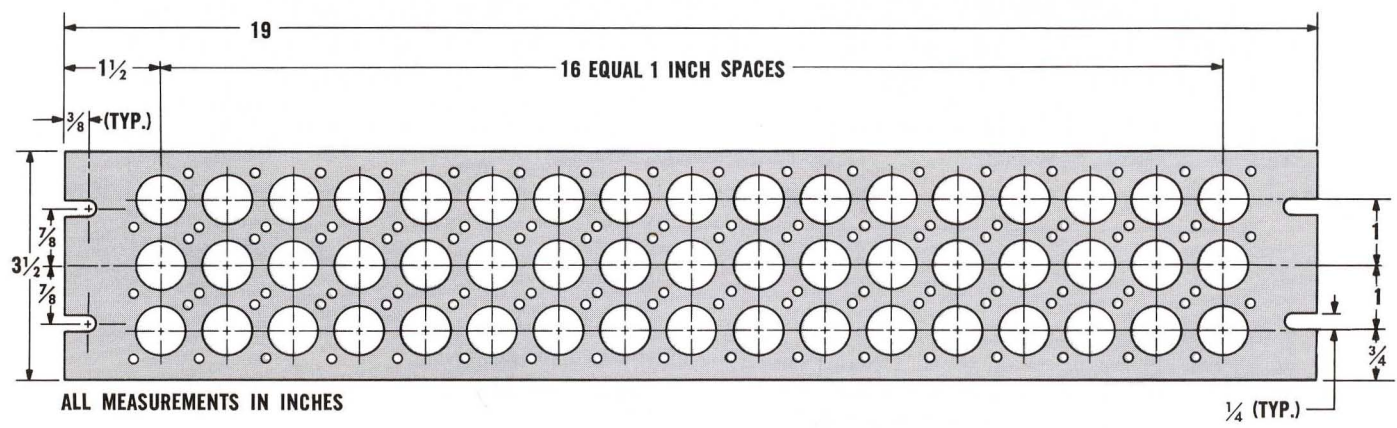
*Nominal levels are -3VDC and -11VDC

**See DESCRIPTION

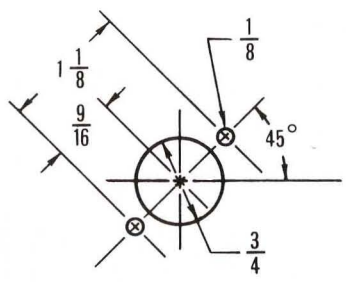


Typical T-Series Installation
Using T-901, T-902, or T-903

PANELS AND CHASSIS



Layout of Panels T-901, T-902, T-903



T-932-1 has the same outline dimensions as T-901 but has only 38 socket holes. These holes are spaced on 1.3-inch centers across the 19-inch dimension and on 1.1-inch centers across the 3 1/2-inch dimension in order to allow room for IERC hold down hardware.

T-932-2 is the same basic panel as T-932-1 with sockets and hold down hardware furnished unassembled. See price list for specific parts.

T-933-1 has the same outline dimensions as T-901 but has only 45 socket holes spaced on 1 1/8-inch centers to accommodate EBY, Cinch-Jones, and Elco hold down hardware.

T-933-2 consists of panel T-933-1 and 45 each sockets, bases, and shields furnished unassembled. See price list for specific part numbers.

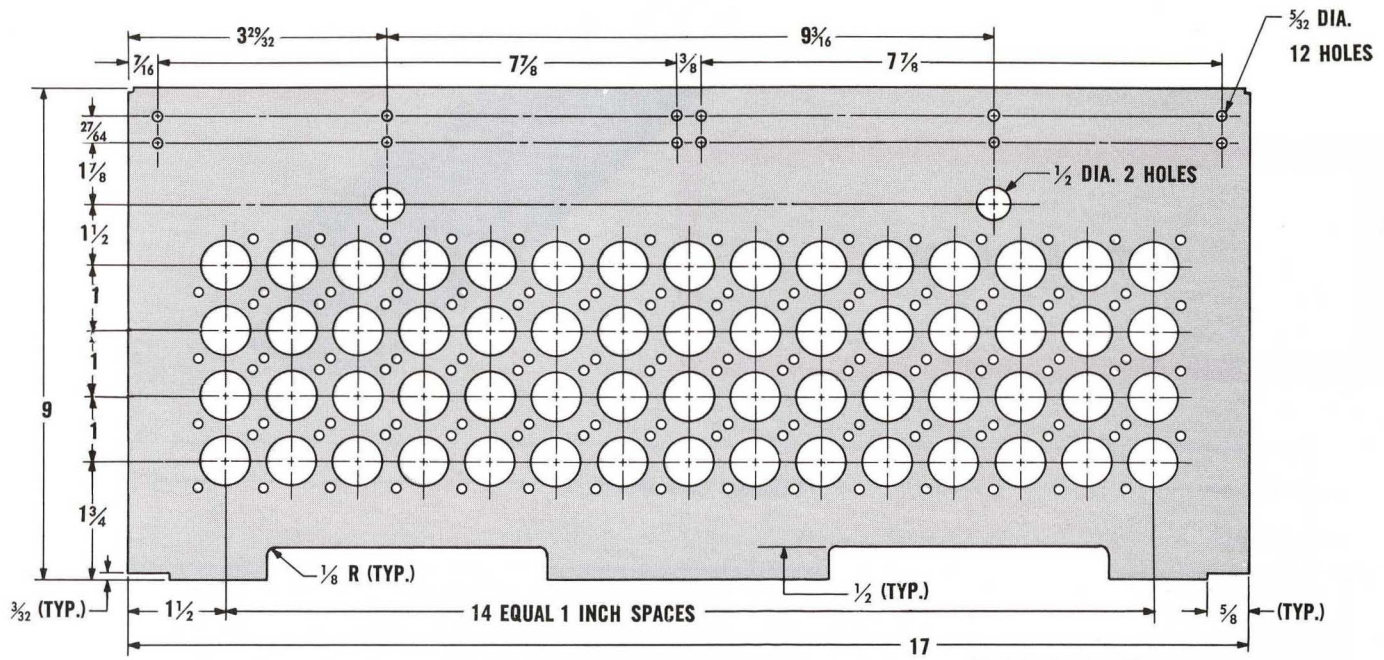
T-901, T-902, and T-903 are all 3 1/2" x 19" panels which can accommodate up to 51 T-Series circuits. These panels all have a gray finish and standard Amateur notch and holes for sockets are drilled on 1-inch centers. T-901 is supplied without sockets, T-902 is identical but with 9-pin sockets installed, and T-903 is identical to T-902 but with the sockets buss-wired for power.

T-961 is identical to T-902 except 13 pin sockets are installed.

T-962 is identical to T-903 except 13-pin sockets are installed.

HOLD DOWN HARDWARE





Layout of Chassis H-164

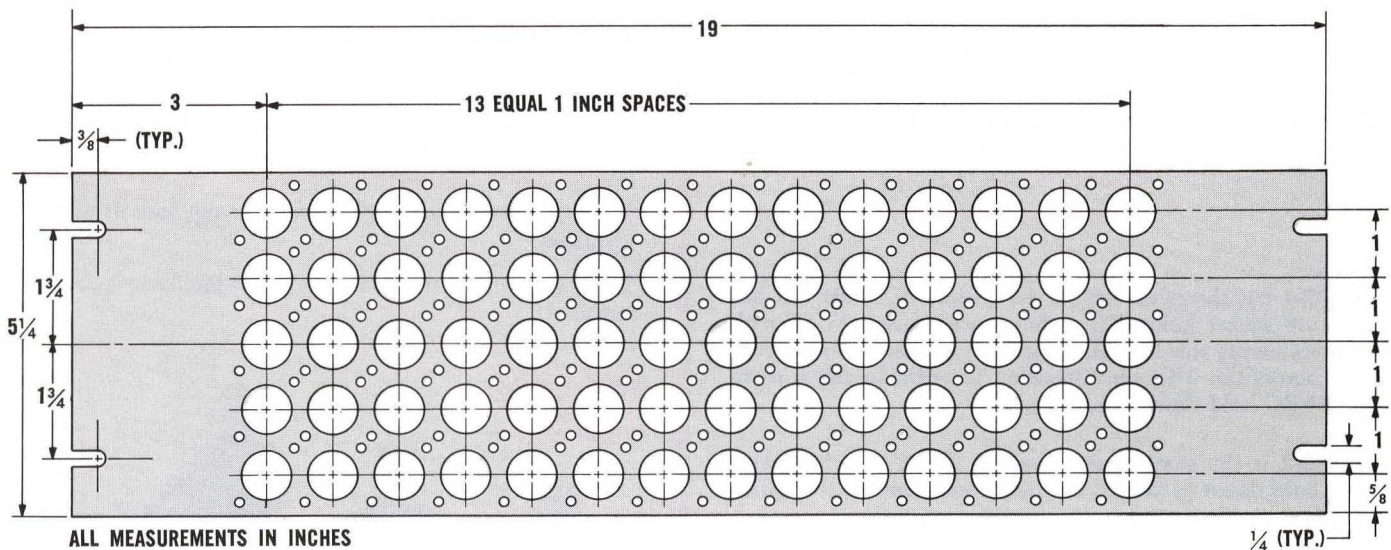
T-934, T-935, and T-936 are all 5 1/4" x 19" panels which can accommodate up to 70 T-Series circuits. These panels all have a gray finish and standard Amateur notch and holes for sockets are drilled on 1-inch centers. T-934 is supplied without sockets, T-935 is identical but with 9-pin sockets installed,

and T-936 is identical to T-935 but with the sockets buss-wired for power.

T-963 is identical to T-935 except 13-pin sockets are installed.

T-964 is identical to T-936 except 13-pin sockets are installed.

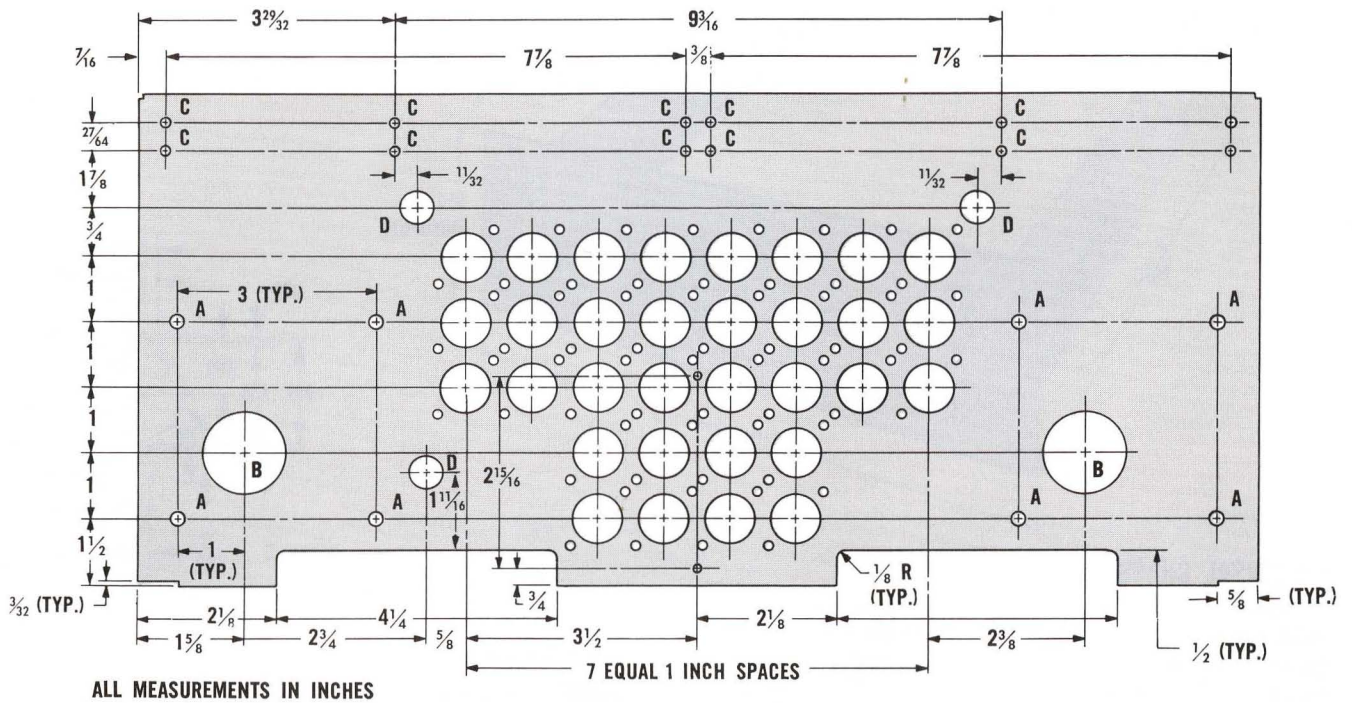
Panel layout is shown below



Layout of Panels T-934, T-935, T-936

Universal Chassis H-164 contains a chassis with 60-socket holes and a 20-terminal Jones strip. Two front panel heights are available; 3 1/2" (H-164-1) and 5 1/4" (H-164-2). These front panels have a gray finish and standard Amateur notch.

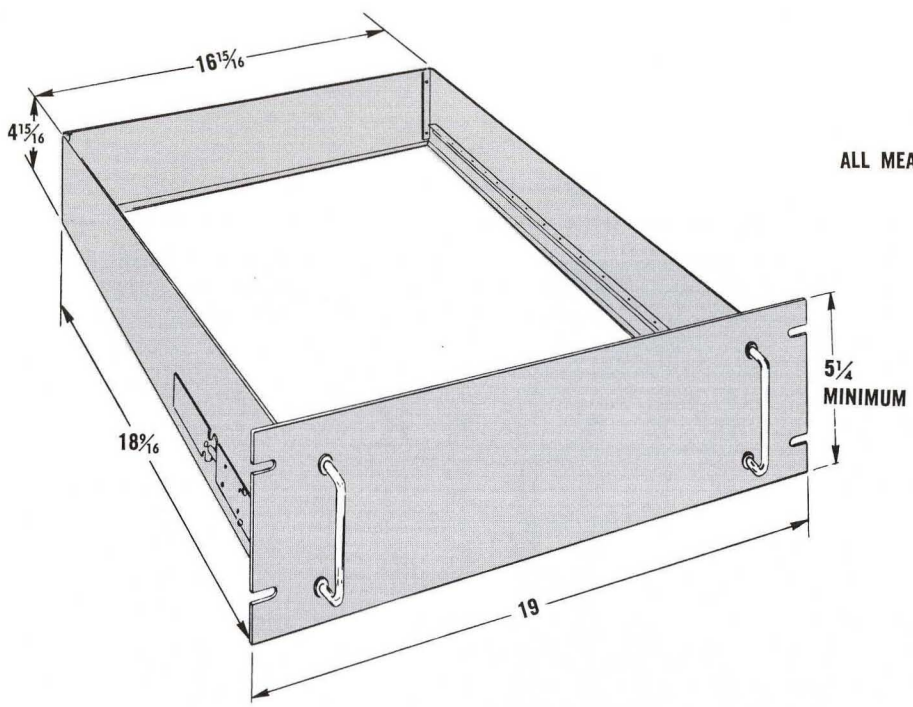
Layout of Chassis H-164 is shown at top of page



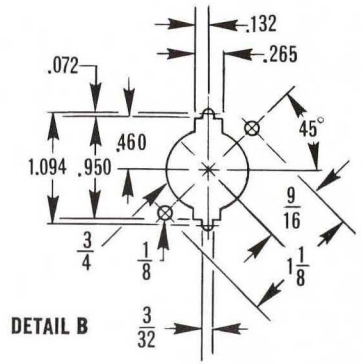
Layout of Chassis H-165

Universal Chassis H-165 contains a chassis with 32 socket holes, a 20-terminal Jones strip, and mounting holes for two ZA-721 power supplies. Two front panel heights are available; 3 1/2" (H-165-1) and 5 1/4" (H-165-2).

HOLE SCHEDULE		
LETTER	SIZE	QUANTITY
A	7/32	8
B	1 1/4	2
C	5/32	12
D	1/2	3



ALL MEASUREMENTS IN INCHES



UNIVERSAL CHASSIS

Universal Chassis H-264 is a standard size drawer that holds optional combinations of four chassis types. The front panel is finished in grey enamel, has amateur notching, and is available in four heights: 5 1/4", 7", 8 3/4", and 10 1/2". H-264 can be supplied with tilt, rigid or no slides. The mounting chassis are cold-rolled steel finished with cadmium plate and clear iridite. Depth of each drawer permits the following chassis combinations per drawer:

H-266 or H-268	H-265 or H-267	Depth Used (Max. = 17.5")
5	0	17.5"
0	3	15.75"
2	2	17.50"
3	1	15.75"

Chassis types:

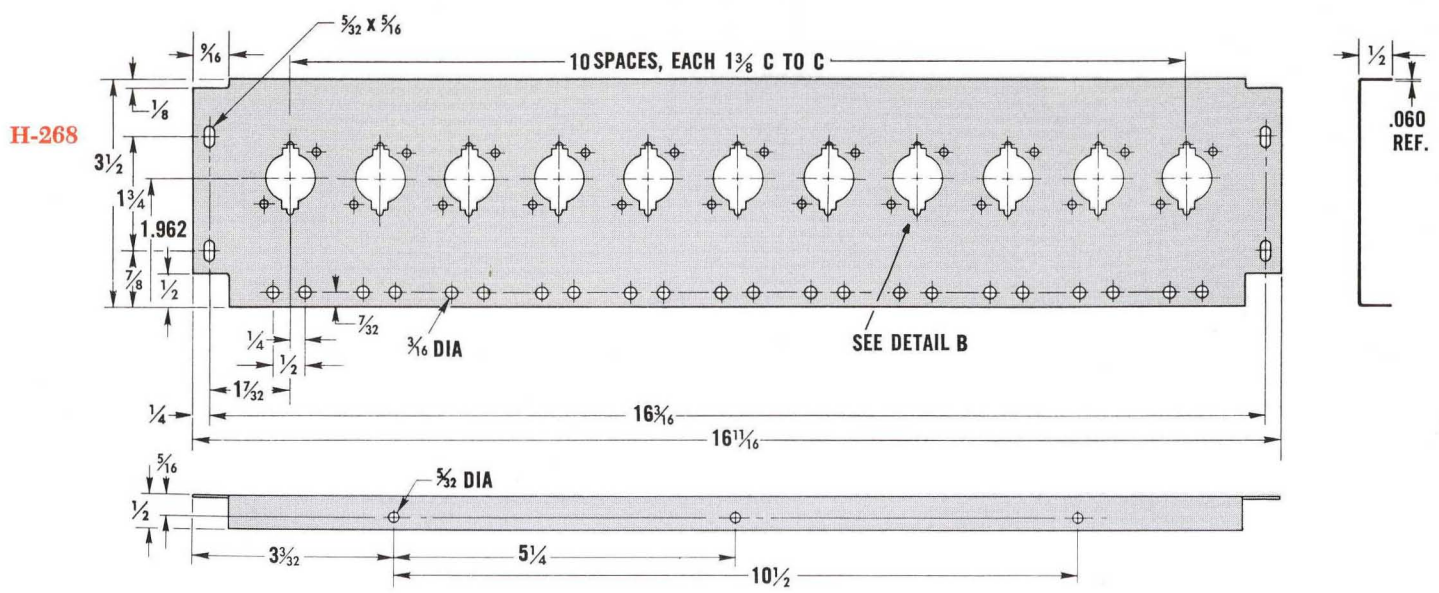
H-265, 5 1/4" deep, for 48 T-Series Modules with hold-down hardware.

H-266, 3 1/2" deep, for 45 T-Series Modules without hold-down hardware.
(H-265 and H-266 can hold either the 9 or 13 pin standard miniature sockets used for T-Series Modules.)

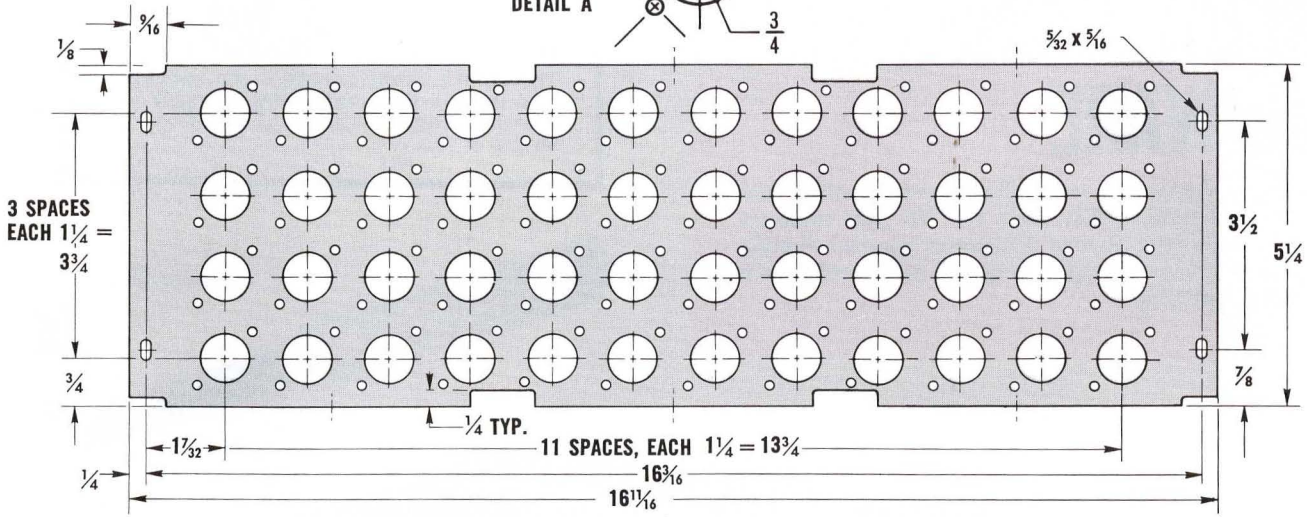
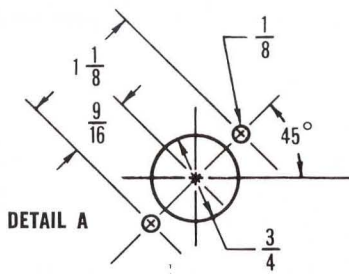
H-268, 3 1/2" deep, for 11 N-100 Series Decades.
(H-268 can hold either the 14 or 29 pin sockets used for N-Series Decades.)

H-267, 5 1/2" deep, holds combinations of EECO Power Supplies such as two ZA-727 or ZA-723 or one each ZA-724 and ZA-727, etc.

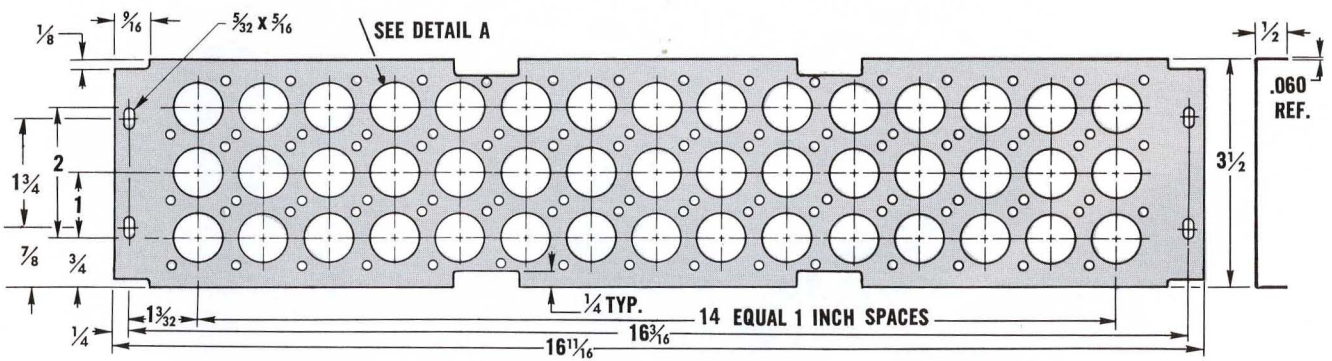
When ordering H-264, specify chassis types and quantities, panel height and type of slide.



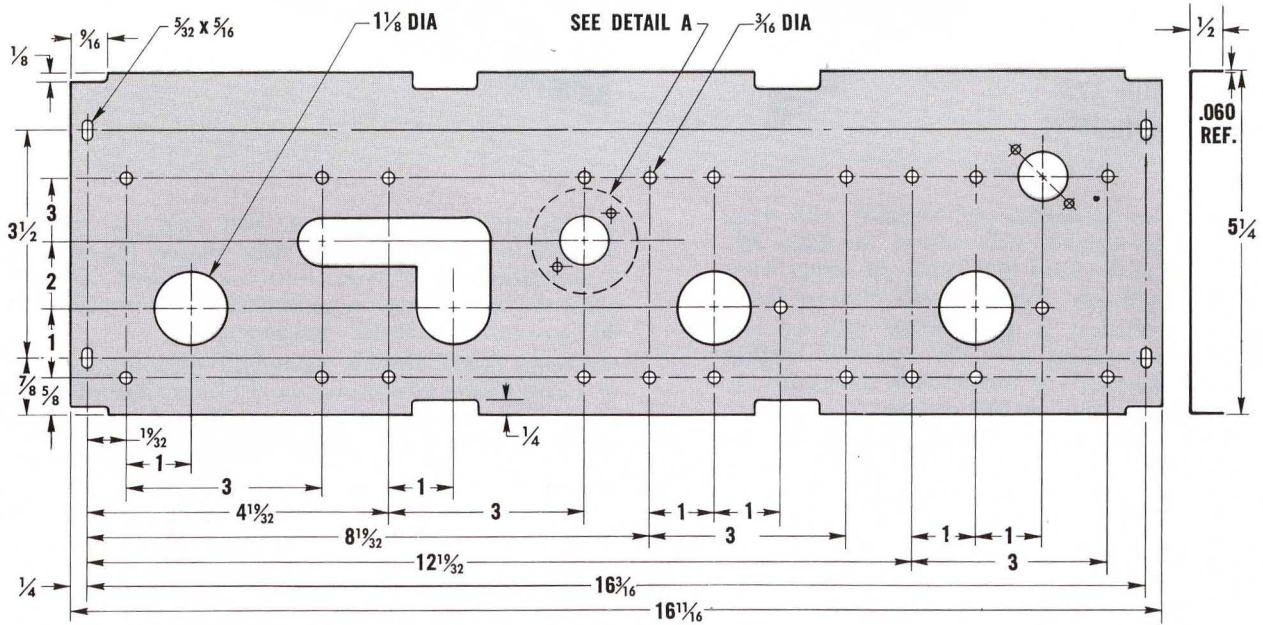
ALL MEASUREMENTS IN INCHES



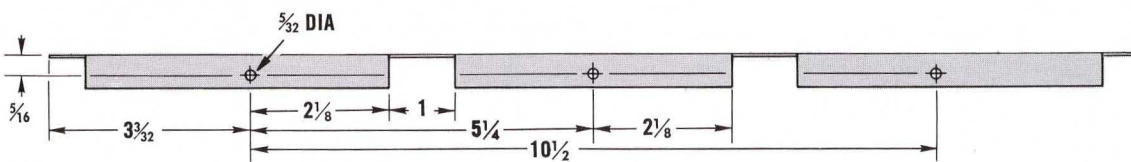
H-265



H-266



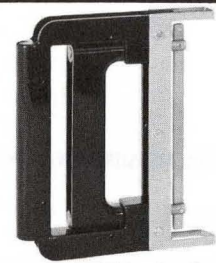
H-267



CIRCUIT CARD HARDWARE

The hardware shown here is specifically recommended and can be ordered from EECo, using the "H" part numbers shown. For the convenience of companies supplied directly by the manufacturer, the manufacturers' part numbers are shown (in parenthesis).

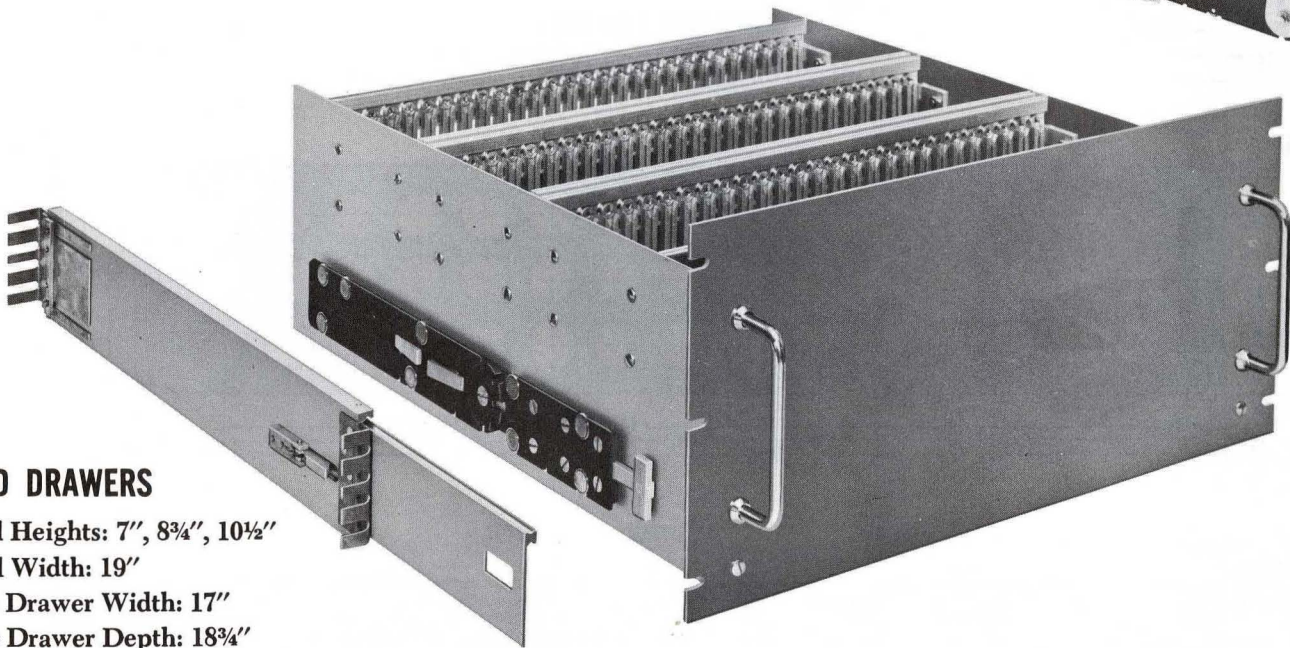
CARD EXTRACTOR



H-410

This durable extractor engages the circuit card through the corner holes to enable a smooth, easy withdrawal of card from bucket or file.

tilt-type slide



CARD DRAWERS

Panel Heights: 7", 8 $\frac{3}{4}$ ", 10 $\frac{1}{2}$ "

Panel Width: 19"

Basic Drawer Width: 17"

Basic Drawer Depth: 18 $\frac{3}{4}$ "

EECo Card Drawer Assemblies are available with three optional front panel heights, with any of the Card File Assemblies shown in the Card File Table and either without slides, with rigid-type slides, or with tilt-type slides.

Front Panels are finished in grey enamel with amateur notching. They are available in 7", 8 $\frac{3}{4}$ " and 10 $\frac{1}{2}$ " heights. Heights must be specified. If Varicon-type connectors are used, the panel height must be 8 $\frac{3}{4}$ " or 10 $\frac{1}{2}$ ".

Connectors: Any of the connector assemblies can be used (see Card File and Connector Tables). The first number after the dash in the Drawer Assembly number indicates the type of card file — connector assemblies used. This number is identical to the last number of the Card File Number. For example:

H-417-3 indicates Card File H-401-3 is used in the card drawer assembly.

The **Slides** offered are sturdy, ball-bearing slides capable of handling over three times the weight of a fully loaded Drawer. If no slides are included, the last number of the Drawer Assembly number remains the same as shown in the preceding paragraph. Adding a "1" to the dash num-

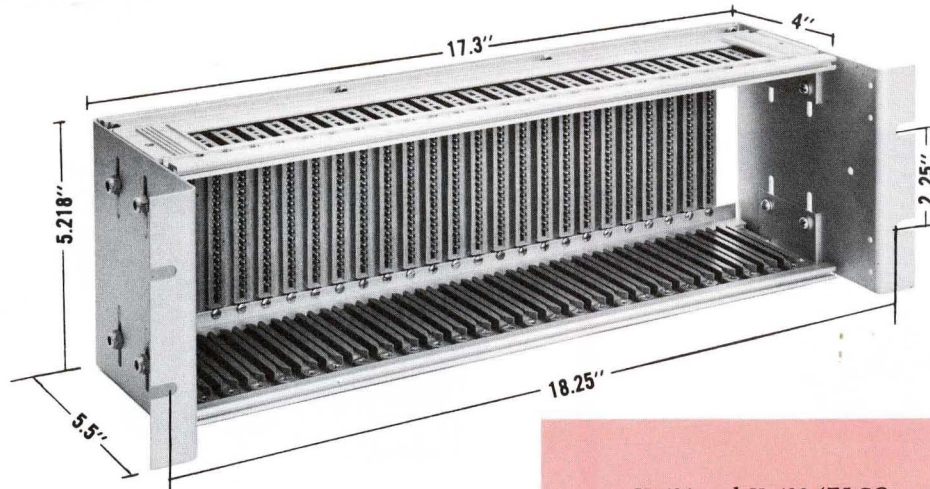
ber (31 instead of 3) indicates that rigid-type slides are installed; adding a "2" to the dash number (32 instead of 3) indicates that tilt-type slides are installed. Tilt slides allow the open drawer to be positioned horizontally, tilted 90° upward or tilted 90° downward.

Capacity: H-417 Drawer Assemblies hold the equivalent of 3 card files (a total maximum of 81 circuit cards). H-419 Drawer Assemblies hold the equivalent of 2 card files (a maximum of 54 circuit cards).

NUMBERING SYSTEM:

H-417	= 3 file capacity
H-419	= 2 file capacity
-1 thru -9	= without slides
-11, 21, 31, 41, 51, 61, 71, 81, & 91	= with rigid-type slides
-12, 22, 32, 42, 52, 62, 72, 82, & 92	= with tilt-type slides.

EXAMPLE: Card Drawer Assembly number H-419-72 holds 2 files (54 cards) and is mounted with wire-wrap Varicon connectors, tilt-type slides.

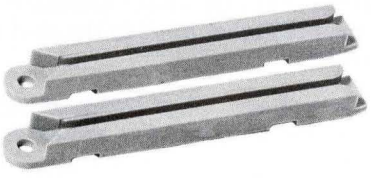


CARD FILES

H-401 and H-402 (ELCO modified VARIPAK II 9016-2-S or equivalent)

These sturdy, all-aluminum cases hold up to 27 circuit cards each. They are available from EECO with 82 holes on each mounting panel to permit combinations of equal or variable spacing of the card guides and connectors. We also supply these universal card files with connectors and card guides already mounted as shown in the chart below.

GUIDE SETS



H-403, two guides and snap-in pins per set (ELCO 9016.1201 or equivalent)

Made of polycarbonate with excellent di-electric properties and high mechanical strength. Each guide is held firmly in place by one snap-in pin that permits the guide to be removed and relocated without damage to either guide or plate.

POLARIZING KEYS

EECo No.	Manufacturer's Number	Material	Type
H-407	ELCO 6002.3124	Polyethylene	Between-Contact
H-408	ELCO 6007.3414	Polyethylene	On-Contact
H-409	.....	Stainless Steel	On-Contact
H-415	ELCO 5006.3414	Polyethylene	Between-Contact
H-436	Viking 091-0024-000	Polyethylene	Between-Contact

(or equivalents)

Card File #	Type Connectors	Connectors Installed	Guides Sets Installed
H-401-1	H-404, H-405 or H-406	None	27
H-401-2	Solder-Lug H-404	27	27
H-401-3	Taper-Tab H-405	27	27
H-401-4	Taper-Pin H-406	27	27
H-401-5	H-411, H-412 or H-413	None	27
H-401-6	Solder-Lug H-411	27	27
H-401-7	Wire-Wrap H-412	27	27
H-401-8	Wire-Wrap H-413	27	27
H-401-9	Taper-Pin H-414	27	27
H-402-1	H-404, H-405 or H-406	None	None
H-402-2	H-411, H-412 or H-413	None	None

CONNECTORS

Part #	Connector Type	Connections	For Board Type	Depth Extending From File Mount	Connector Width	On-Contact Type Tabs	Between-Contact Type Tabs	Manufacturer's Number
H-404	Single Solder-Lug	22	Ribbon-Type	0.4687"	0.343"	H-408	H-407	CANNON PBA22-2AE2G (or equivalent)
H-405	Single Taper-Tab	22	Ribbon-Type	0.4687"	0.343"	H-408	H-407	H. H. Buggie 5211 (or equivalent)
H-406	Double Taper-Pin	22	Ribbon-Type	0.45"	0.437"	H-409	H-407	Kennedy KI-1500-22 (or equivalent)
H-411	Solder/Taper Tab	35	Varicon	0.73"	0.5312"	.....	H-415	ELCO 7008-35-5-2-1 NPGF (or equivalent)
H-412	Wire-Wrap (2 wires)	35	Varicon	1.2"	0.5312"	.....	H-415	ELCO 7008-35-5-2-5 NPGF (or equivalent)
H-413	Solder-Lug (3 wires)	35	Varicon	0.87"	0.5312"	.....	H-415	ELCO 7008-35-5-2-12 NPGF (or equivalent)
H-414	Taper-Pin	34	Varicon	0.8"	0.5312"	.....	H-415	ELCO 7009-34-5-2-22 NPGF (or equivalent)
H-416	Solder-Lug	44	Ribbon-Type	0.4687"	0.343"	H-408	H-407	ELCO 6007-44-5-M-8 NPGF (or equivalent)
H-435	Taper-Pin	44	Ribbon-Type	0.5"	0.57"	.....	H-436	Viking 2VH22/15AW5 (or equivalent)

*Separately supplied connectors are furnished with brass screws and nuts.

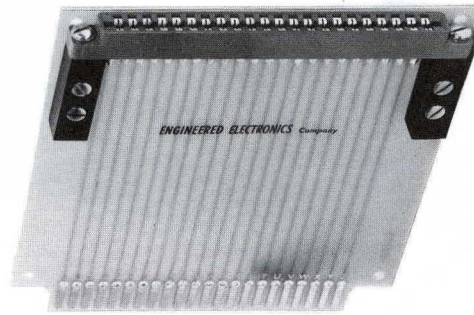
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ADAPTER CARD ASSEMBLY H-270

H-270 holds two standard T-Series units and plugs into a standard 22 pin connector. This enables efficient employment of a T-Series unit in a file or drawer of CT, G, U or N-Series circuit cards.

H-270 is a standard 4½" x 5½" circuit card that plugs into the 22-pin ribbon-type connectors shown on the previous page. They can be mounted on 1.4 inch centers which permits a maximum of 11 of these adapters in a H-401-1 card file.



CARD EXTENDER ASSEMBLY H-227

A circuit card is plugged into H-227 which in turn is inserted into the card's scheduled connector. This extends the card beyond the other cards in the card file or drawer to permit testing.

H-227 is a standard 4½" x 5½" circuit card that plugs into the 22-pin ribbon-type connectors shown on the previous page.

NOTES:

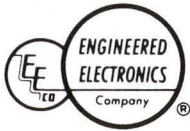
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Special Issue Data Sheets

Special data sheets will cover new information available before this catalog is republished. Those received can be quickly inserted in, or at the end of, the correct section.

To receive these data sheets, be *sure* to mail the post card enclosed in this catalog.



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WARRANTY

Engineered Electronics Company hereby warrants standard circuit modules of our manufacture to be free from defects. If **at any time** a module fails in normal service due to defective parts, workmanship or packaging, Engineered Electronics Company will repair or replace the module without charge, providing required parts are still available.*

In addition, repairable modules damaged by misuse, accident, neglect, or improper installation, will be repaired at cost.

*Except indicators and power supplies.

