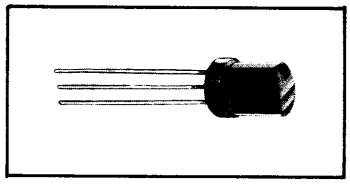
45.66 7/66
(Supersedes 45.66 12/65)

ELECTRONIC INNOVATIONS IN ACTION
SEMICONDUCTORS

# Silicon Switching TRANSISTORS

## PLANAR EPITAXIAL PASSIVATED

NPN
2N3973
2N3974
2N3975
2N3976



The General Electric 2N3973-2N3976 planar epitaxial passivated NPN silicon transistors are designed primarily for medium speed industrial switching and large signal R.F. amplifiers. They feature excellent $h_{FE}$ holdup at collector currents between 0.1 mA and 500 mA, adequate switching times for 2 MHz saturated logic circuits, and 350 MHz typical gain bandwidth product.

## absolute maximum ratings: (25° C) (unless otherwise specified)

### VOLTAGES

| | | |
|---|---|---|
| Collector to Emitter | $V_{CEO}$ | 30 Volts |
| Collector to Emitter | $V_{CES}$ | 40 Volts |
| Emitter to Base | $V_{EBO}$ | 5 Volts |
| Collector to Base | $V_{CBO}$ | 60 Volts |

### CURRENT

| | | |
|---|---|---|
| Collector (Steady State)* | $I_C$ | 400 mA |

### DISSIPATION

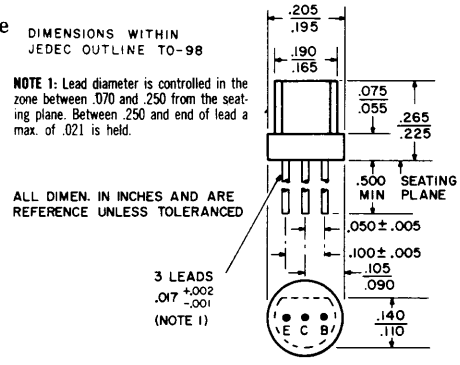
| | | |
|---|---|---|
| Total Power (Free Air @ 25°C)* | $P_T$ | 360 mW |
| Total Power (Free Air @ 65°C)** | $P_T$ | 250 mW |

### TEMPERATURE

| | | |
|---|---|---|
| Storage | $T_{stg}$ | −55 to 150°C |
| Operating | $T_J$ | 150°C |
| Lead, 1/16" ± 1/32" from case for 10 seconds maximum | $T_L$ | 260°C |

### FEATURES

Low Cost
Low Saturation Voltage
High Current



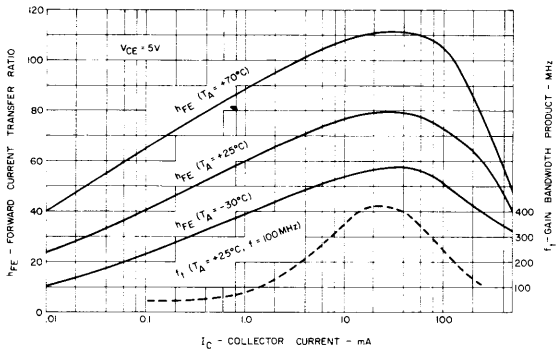

*Determined from power limitations due to saturation voltage at this current.
**Derate 2.88 mW/°C increase in ambient temperature between 25 and 150°C.

## electrical characteristics: (25° C) (unless otherwise specified)

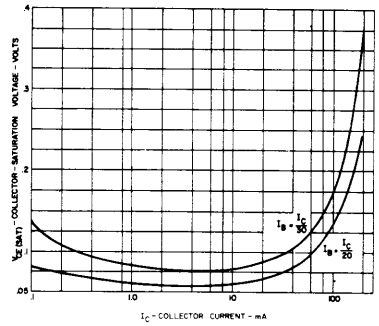
| | | | Min. | Typ. | Max. | |
|---|---|---|---|---|---|---|
| **STATIC CHARACTERISTICS** | | | | | | |
| **Collector Cutoff Current** | | | | | | |
| $V_{CB} = 40V, I_E = 0$ | | $I_{CBO}$ | | .0006 | .5 | μA |
| **Emitter Cutoff Current** | | | | | | |
| $V_{EB} = 5V, I_C = 0$ | | $I_{EBO}$ | | .004 | .5 | μA |
| **Collector Cutoff Current** | | | | | | |
| $V_{CE} = 40V, V_{BE} = 0$ | | $I_{CES}$ | | .001 | .5 | μA |
| **Static Forward Current Transfer Ratio** | | | | | | |
| $V_{CE} = 1V, I_C = 10$ mA | 2N3973 & 75 | $h_{FE}$ | 35 | | 100 | |
| | 2N3974 & 76 | $h_{FE}$ | 55 | | 200 | |
| $V_{CE} = 1V, I_C = 150$ mA | 2N3973 & 75 | $h_{FE}$ | 30 | | | |
| | 2N3974 & 76 | $h_{FE}$ | 50 | | | |
| **Collector-Emitter Saturation Voltage** | | | | | | |
| $I_C = 150$ mA, $I_B = 15$ mA | | $V_{CE\ (SAT)}$ | | .14 | .3 | Volts |
| **Base-Emitter Saturation Voltage** | | | | | | |
| $I_C = 150$ mA, $I_B = 15$mA | | $V_{BE\ (SAT)}$ | | .9 | 1.3 | Volts |
| **Collector-Emitter Breakdown Voltage** | | | | | | |
| $I_C = 10$ mA, $I_B = 0$ | | $BV_{CES}$ | 40 | | | Volts |
| **Collector-Base Breakdown Voltage** | | | | | | |
| $I_C = 10$ μA, $I_E = 0$ | | $BV_{CBO}$ | 60 | | | Volts |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| **Collector Capacitance** | | | | | | |
| $V_{CB} = 10V, I_E = 0$, f = 1 MHz‡ | | $C_{ob}$ | | 5.2 | 7 | pF |
| **Transition Capacitance** | | | | | | |
| $V_{BE} = 0.5V, I_C = 0$, f = 1 MHz | | $C_{ib}$ | | 20 | | pF |
| **Gain Bandwidth Product** | | | | | | |
| $V_{CE} = 5V, I_C = 20$ mA, f meas. = 100 MHz | | $f_t$ | 200 | 350 | | MHz |
| **Switching Times** | | | | | | |
| $I_{B1} \approx I_{B2} \approx 10$ mA, $I_C \approx 100$ mA | | | | See Figure 1 for exact values. | | |
| **Turn-on Time** | | $t_{on}$ | | | 60 | nsec. |
| **Turn-off Time** | 2N3973 & 74 | $t_{off}$ | | | 110 | nsec. |
| | 2N3975 | $t_{off}$ | | | 200 | nsec. |
| | 2N3976 | $t_{off}$ | | | 250 | nsec. |

‡Hz is equivalent to cycles per second.

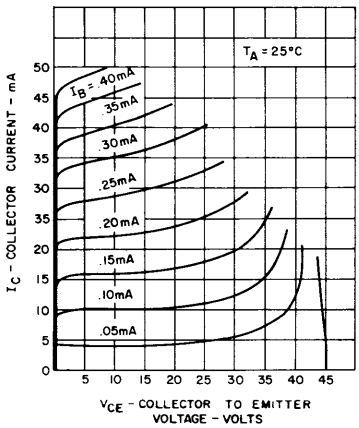
# TYPICAL CHARACTERISTICS
# ($T_A = 25°C$ unless otherwise specified)



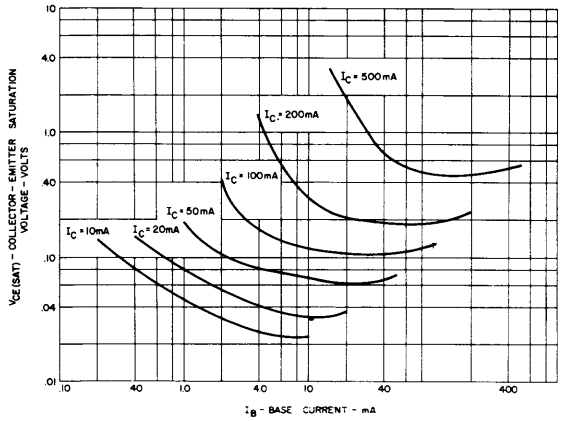

**Forward Current Transfer Ratio and Gain Bandwidth Product vs. Collector Current**



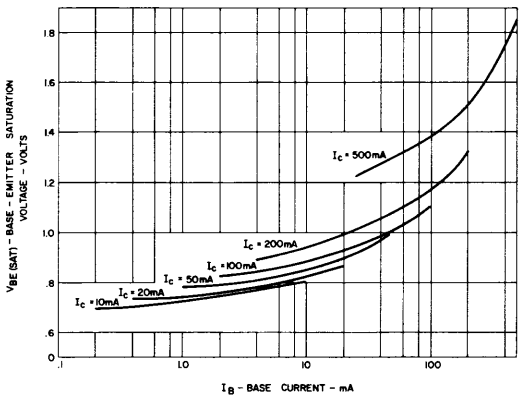

**Collector Saturation Voltage vs. Collector Current at Beta = 20 and 30**



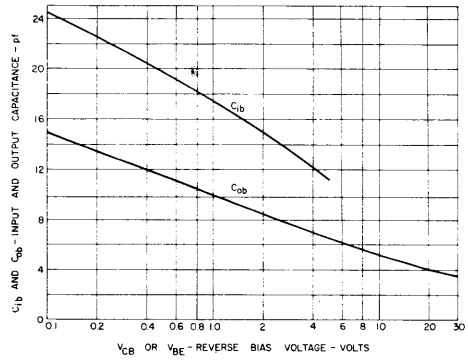

**Collector Characteristics**



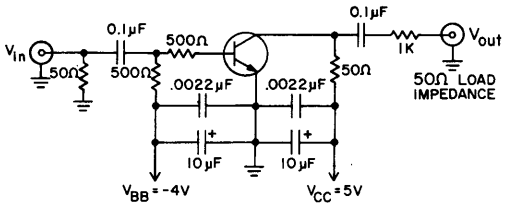

**Collector Saturation Voltage vs. Base Current**




**Base Saturation Voltage vs. Base Current**




**Output Capacitance and Input Capacitance vs. Voltage**



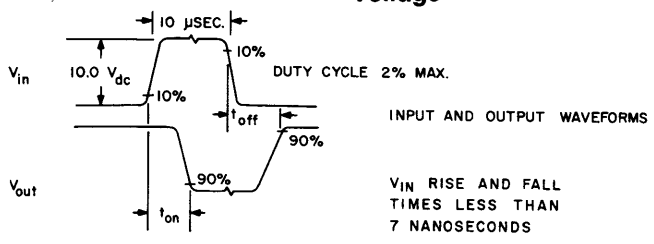




**FIGURE 1**

Printed in U.S.A.

ELECTRONIC INNOVATIONS IN ACTION

SEMICONDUCTORS

45.46 5/66

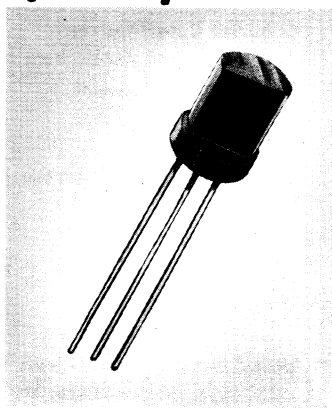
# Silicon Transistor

## PLANAR EPITAXIAL PASSIVATED

NPN 2N4256

13/07/02

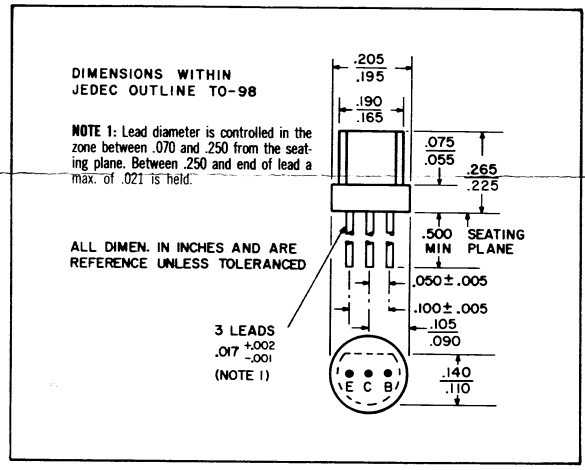
The General Electric 2N4256 is a planar epitaxial, passivated NPN transistor characterized for low level medium speed switching applications in industrial circuits. This transistor features a high current transfer ratio over a wide range of collector current, a low collector saturation voltage, and a guaranteed stored base charge.



- Low Cost
- High Beta
- Low $V_{CE(SAT)}$
- Rugged Encapsulation

## absolute maximum ratings: (25°C Unless Otherwise Specified)

| | | |
|---|---|---|
| **Voltages** | | |
| Collector to Emitter | $V_{CES}$ | 30 Volts |
| Emitter to Base | $V_{EBO}$ | 5 Volts |
| Collector to Base | $V_{CBO}$ | 30 Volts |
| **Current** | | |
| Collector (Steady State)* | $I_C$ | 100 mA |
| **Dissipation** | | |
| Total Power (Free air at 25°C)† | $P_T$ | 200 mW |
| Total Power (Free air at 55°C)† | $P_T$ | 120 mW |
| **Temperature** | | |
| Storage | $T_{STG}$ | −55 to 125°C |
| Operating | $T_J$ | 100°C |
| Lead Soldering, 1/16" ± 1/32" from case for 10 sec. max. | $T_L$ | 260°C |




*Determined from power limitations due to saturation voltage at this current.

†Derate 2.67 mW/°C increase in ambient temperature above 25°C.

## electrical characteristics (25°C Unless Otherwise Specified)

### STATIC CHARACTERISTICS

| | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| **Collector to Base Breakdown Voltage** ($I_C = 100\mu A$) | $V_{CBO}$ | 30 | | | V |
| **Collector to Emitter Breakdown Voltage** ($V_{EB} = 0, I_C = 1mA$) | $V_{CES}$ | 30 | | | V |
| **Emitter to Base Breakdown Voltage** ($I_E = 100\mu A$) | $V_{EBO}$ | 5 | | | V |
| **Forward Current Transfer Ratio** ($I_C = 2mA, V_{CE} = 4.5V$) | $h_{FE}$ | 100 | 220 | 500 | |
| **Forward Current Transfer Ratio** ($I_C = 10mA, V_{CE} = 0.2V$) | $h_{FE}$ | 60 | 120 | | |
| **Forward Current Transfer Ratio** ($I_C = 50mA, V_{CE} = 0.2V$) | $h_{FE}$ | 20 | | | |

## STATIC CHARACTERISTICS

| | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| **Collector-Emitter Saturation Voltage** ($I_C$ = 0.1 to 10mA, $I_B = I_C/50$) | $V_{CE(SAT)}$ | | 0.16 | 0.20 | V |
| **Collector-Emitter Saturation Voltage** ($I_C$ = 50mA, $I_B$ = 2.5mA) | $V_{CE(SAT)}$ | | 0.14 | 0.20 | V |
| **Base-Emitter Saturation Voltage** ($I_C$ = 50mA, $I_B$ = 2.5mA) | $V_{BE(SAT)}$ | | 0.82 | 0.92 | V |
| **Collector Cutoff Current** ($V_{CB}$ = 30V) | $I_{CBO}$ | | 0.1 | 500 | nA |
| **Collector Cutoff Current** ($V_{CB}$ = 18V, $T_A$ = 100°C) | $I_{CBO}$ | | | 15 | μA |
| **Collector Cutoff Current** ($V_{CE}$ = 30V, $V_{EB}$ = 0) | $I_{CES}$ | | 0.1 | 500 | nA |
| **Emitter Cutoff Current** ($V_{EB}$ = 5V) | $I_{EBO}$ | | 0.1 | 500 | nA |

## DYNAMIC CHARACTERISTICS

| | | | | | |
|---|---|---|---|---|---|
| **Collector Capacitance** ($V_{CB}$ = 10V, $I_E$ = 0, f = 1 MHz) | $C_{ob}$ | | 2.7 | 4.0 | pF |
| **Transition Capacitance** ($V_{EB}$ = 0.5V, $I_C$ = 0, f = 1 MHz) | $C_{ib}$ | | 10 | | pF |
| **Stored Base Charge (Circuit 1)** ($I_B$ = 0.32mA, $I_C$ = 10mA) | $Q_{SB}$ | | 250 | 600 | pC |
| **Gain Bandwidth product** ($V_{CE}$ = 1V, $I_C$ = 10mA) | $f_T$ | | 200 | | MHz |
| **Turn-on Time (Figure 1)** ($I_C$ = 10mA) | $t_{on}$ | | 4.0 | | nS |
| **Turn-off Time (Figure 1)** ($I_C$ = 10mA) | $t_{off}$ | | 40 | 100 | nS |
| **Turn-on Time (Figure 2)** ($I_C$ = 10mA, $I_{B1}$ = 0.32mA, $I_{B2}$ = 54μA) | $t_{on}$ | | | 180 | nS |
| **Turn-off Time (Figure 2)** ($I_C$ = 10mA, $I_{BI}$ = 0.32mA, $I_{B2}$ = 54μA) | $t_{off}$ | | 2.5 | 3.5 | μS |

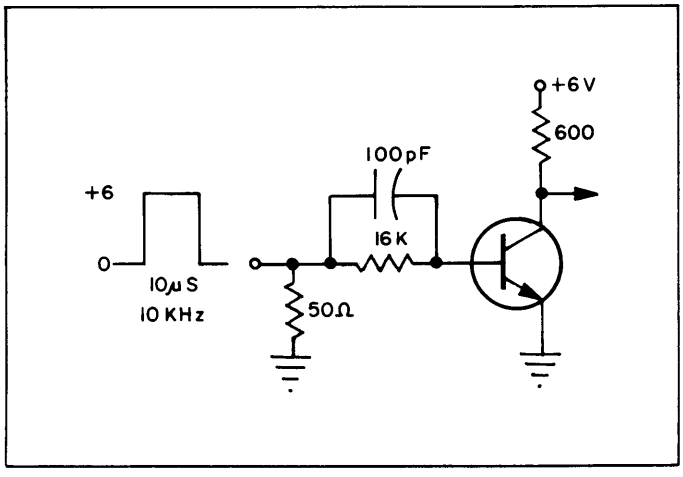



Figure 1

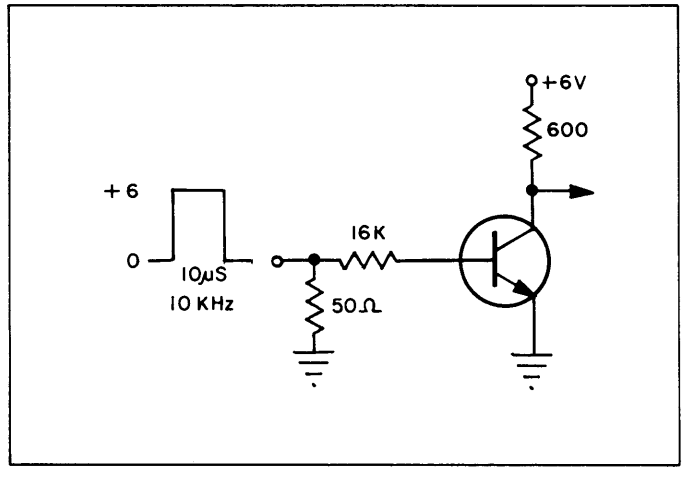



Figure 2

$Q_{SB}$ measured in circuit of Figure 1, the capacitor is adjusted to give a turn off time of 100nS, and $Q_{SB}$ is calculated from the equation $Q_{SB} = 6C$.

ELECTRONIC INNOVATIONS IN ACTION
SEMICONDUCTORS

# Silicon Consumer — Industrial Transistors

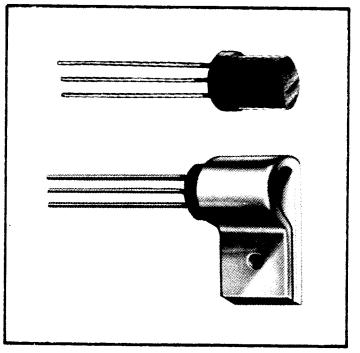
## PLANAR EPITAXIAL PASSIVATED

**NPN**

**2N4424**

**2N4425**

The General Electric 2N4424 and 2N4425 types are NPN, silicon, planar, passivated, epitaxial transistors intended for general purpose industrial circuits. These transistors are especially suited for high level linear amplifiers or medium speed switching circuits in industrial control applications.



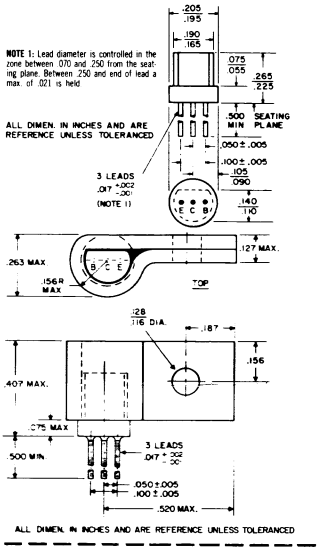
**FEATURES:**

- **Low Saturation Voltage**
- **High Beta**
- **900 mW @ 25°C Case** ..... **2N4425**
- **360 mW @ 25°C Free Air** ..... **2N4424**

## absolute maximum ratings: (25°C) (unless otherwise specified)

| | | 2N4424 | 2N4425 | |
|---|---|---|---|---|
| **Voltages** | | | | |
| Collector to Emitter | $V_{CEO}$ | 40 | 40 | V |
| Emitter to Base | $V_{EBO}$ | 5 | 5 | V |
| Collector to Base | $V_{CBO}$ | 60 | 60 | V |
| **Current** | | | | |
| Collector (Steady State)* | $I_C$ | 500 | 500 | mA |
| **Dissipation** | | | | |
| Total Power (Free Air at 25°C)** | $P_T$ | 360 | 560 | mW |
| Total Power (Free Air at 65°C)** | $P_T$ | 250 | 380 | mW |
| Total Power (Heatsink at 25°C)*** | $P_T$ | — | 900 | mW |
| **Temperature** | | | | |
| Storage | $T_{stg}$ | −55 to +150 | | °C |
| Operating | $T_j$ | +150 | | °C |
| Lead soldering, 1/16" ± 1/32" from case for 10 sec. max. | $T_L$ | +260 | | °C |

*Determined from power limitations due to saturation voltage at this current.
**Derate 2.88mW/°C increase in ambient temperature above 25°C.
***Derate 7.2 mW/°C for rise in heatsink temperature above 25°C.




## electrical characteristics: (25°C) (unless otherwise specified)

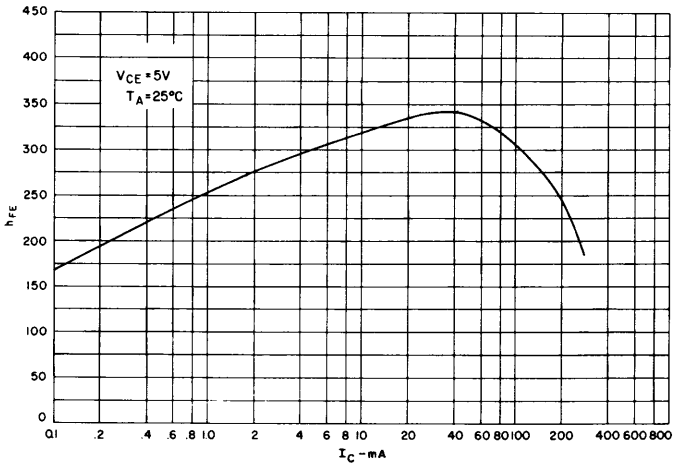
### DC CHARACTERISTICS

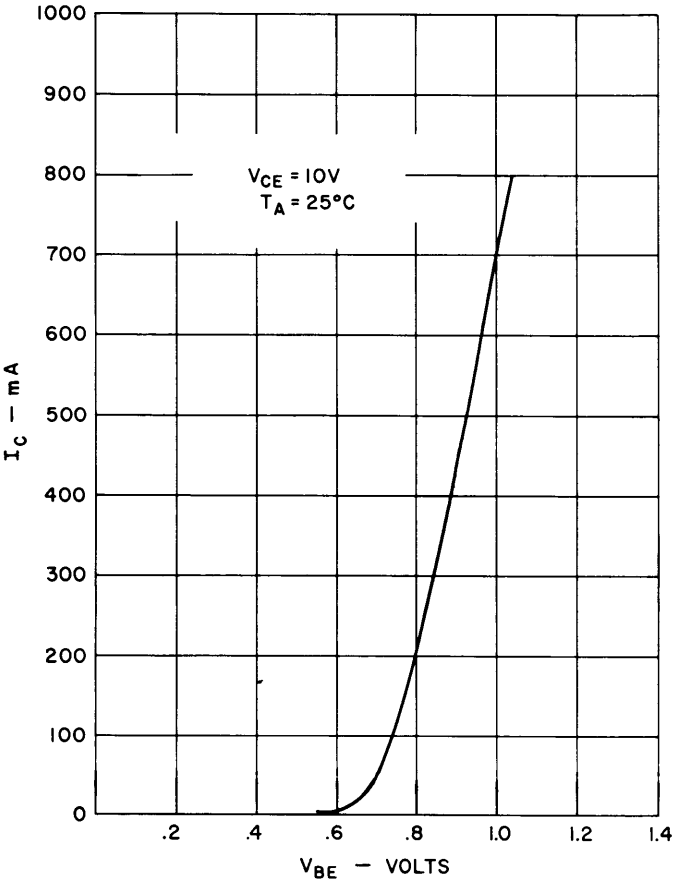
| | | Min. | Max. | |
|---|---|---|---|---|
| **Collector Cutoff Current** ($V_{CB}$ = 40V) | $I_{CBO}$ | | 30 | nA |
| ($V_{CB}$ = 40V, $T_A$ = 100°C) | $I_{CBO}$ | | 10 | μA |
| ($V_{CB}$ = 40V) | $I_{CES}$ | | 30 | nA |
| **Emitter Cutoff Current** ($V_{EB}$ = 5V) | $I_{EBO}$ | | 100 | nA |
| **Forward Current Transfer Ratio** ($V_{CE}$ = 4.5V, $I_C$ = 2 mA) | $h_{FE}$ | 180 | 540 | |
| **Collector Emitter Breakdown Voltage** ($I_C$ = 10 mA) | $V_{(BR)CEO}$ | 40 | | V |
| **Collector Base Breakdown Voltage** ($I_C$ = 10 μA) | $V_{(BR)CBO}$ | 60 | | V |
| **Emitter Base Breakdown Voltage** ($I_E$ = 0.1 μA) | $V_{(BR)EBO}$ | 5 | | V |
| **Collector Saturation Voltage** ($I_B$ = 3 mA, $I_C$ = 50 mA) | $V_{CE(sat)}$ | | .30 | V |
| **Base Saturation Voltage** ($I_B$ = 3 mA, $I_C$ = 50 mA) | $V_{BE(sat)}$ | | .85 | V |

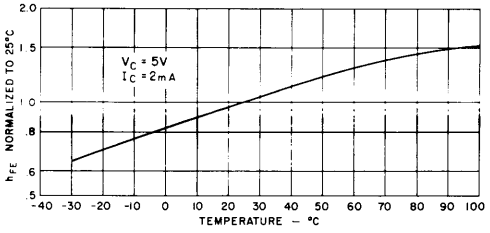
### SMALL SIGNAL CHARACTERISTICS

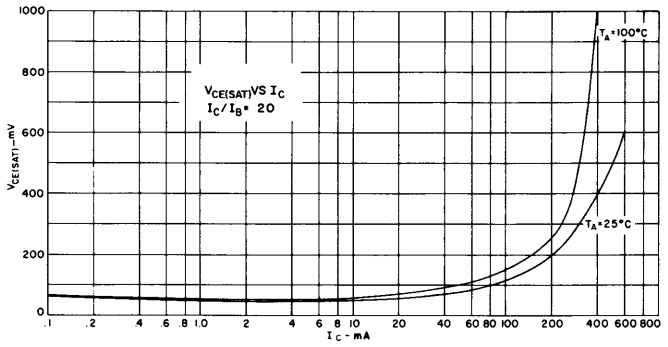
| | | | | |
|---|---|---|---|---|
| **Forward Current Transfer Ratio Collector Voltage** ($V_C$ = 4.5V, $I_C$ = 2 mA, f = 1 kHz) | $h_{fe}$ | 180 | | |
| | | | **Typical** | |
| **Forward Current Transfer Ratio** ($V_{CE}$ = 10V, $I_C$ = 1 mA, f = 1 kHz, $T_A$ = 25°C) | $h_{fe}$ | | 180 | |
| **Input Impedance** | $h_{ie}$ | | 5100 | ohms |
| **Output Admittance** | $h_{oe}$ | | 14 | μmhos |
| **Voltage Feedback Ratio** | $h_{re}$ | | .27 | $\times 10^{-3}$ |

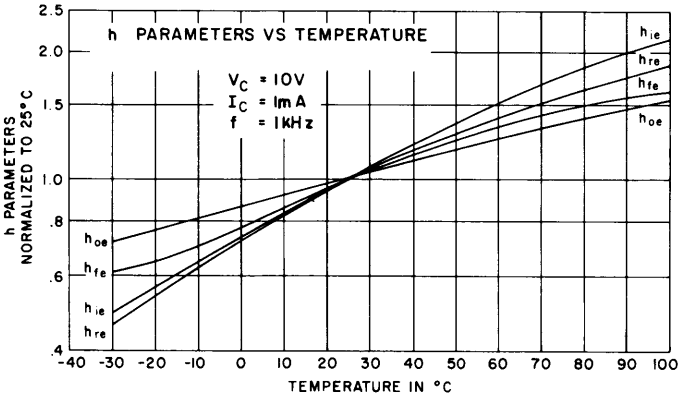
GENERAL ELECTRIC

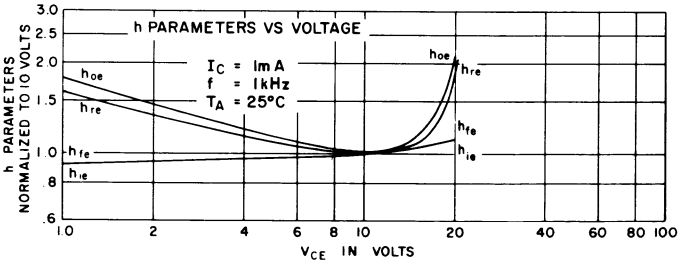

$V_{CE}$ = 5V
$T_A$ = 25°C
$h_{FE}$
$I_C$ - mA

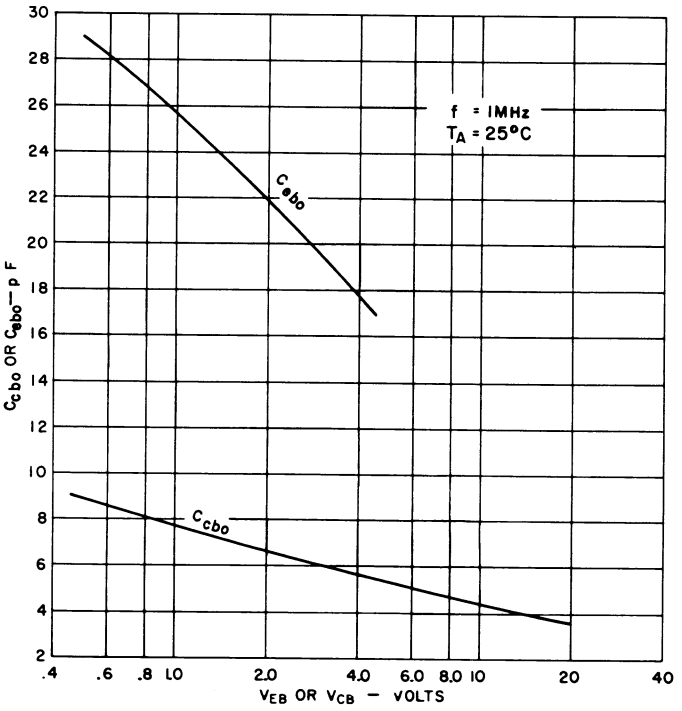

$V_{CE}$ = 10V
$T_A$ = 25°C
$I_C$ - mA
$V_{BE}$ - VOLTS

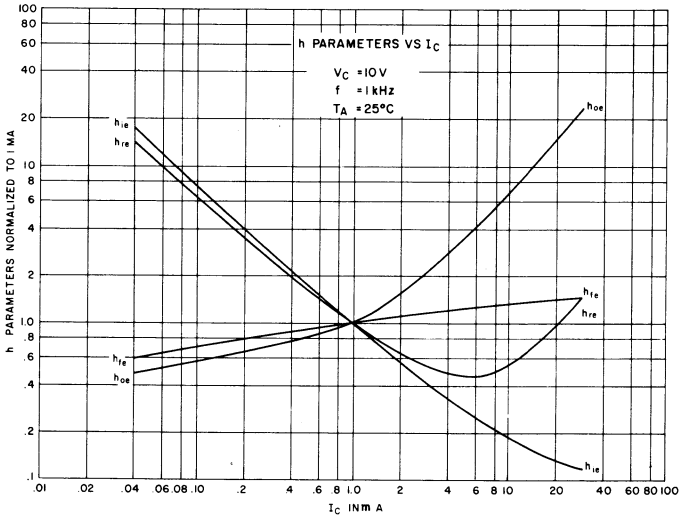

$V_C$ = 5V
$I_C$ = 2mA
$h_{FE}$ NORMALIZED TO 25°C
TEMPERATURE - °C

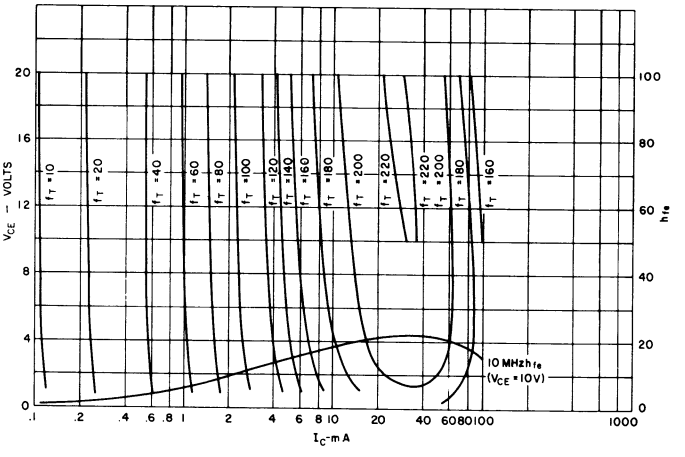

$V_{CE(SAT)}$ VS $I_C$
$I_C/I_B$ = 20
$T_A$ = 100°C
$T_A$ = 25°C
$V_{CE(SAT)}$ - mV
$I_C$ - mA

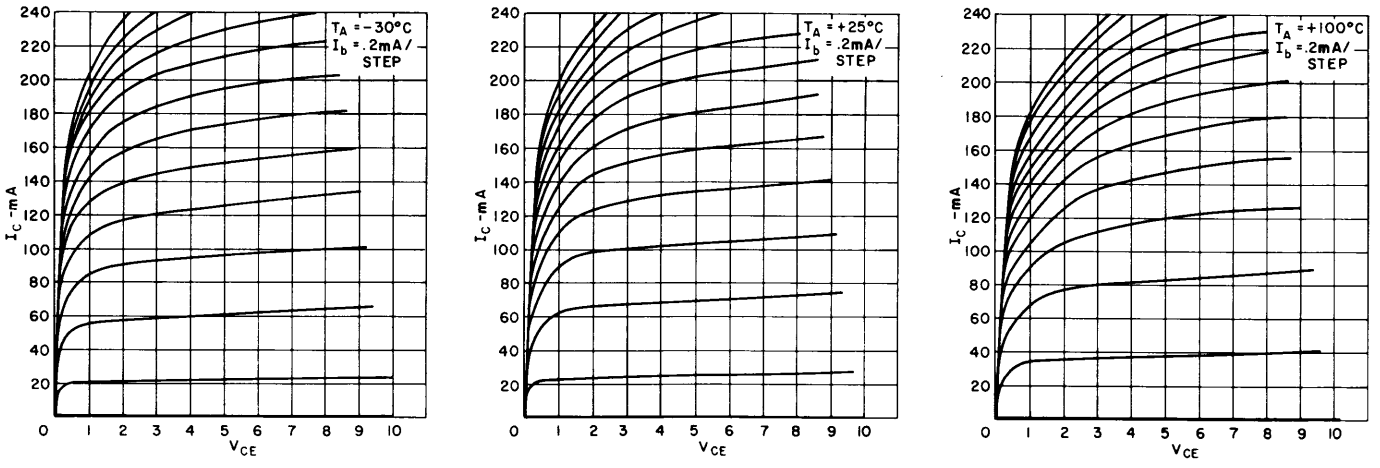

h PARAMETERS VS TEMPERATURE
$V_C$ = 10V
$I_C$ = 1mA
f = 1kHz
$h_{ie}$
$h_{re}$
$h_{fe}$
$h_{oe}$
h PARAMETERS NORMALIZED TO 25°C
TEMPERATURE IN °C


h PARAMETERS VS VOLTAGE
$I_C$ = 1mA
f = 1kHz
$T_A$ = 25°C
h PARAMETERS NORMALIZED TO 10 VOLTS
$V_{CE}$ IN VOLTS
$h_{oe}$
$h_{re}$
$h_{fe}$
$h_{ie}$

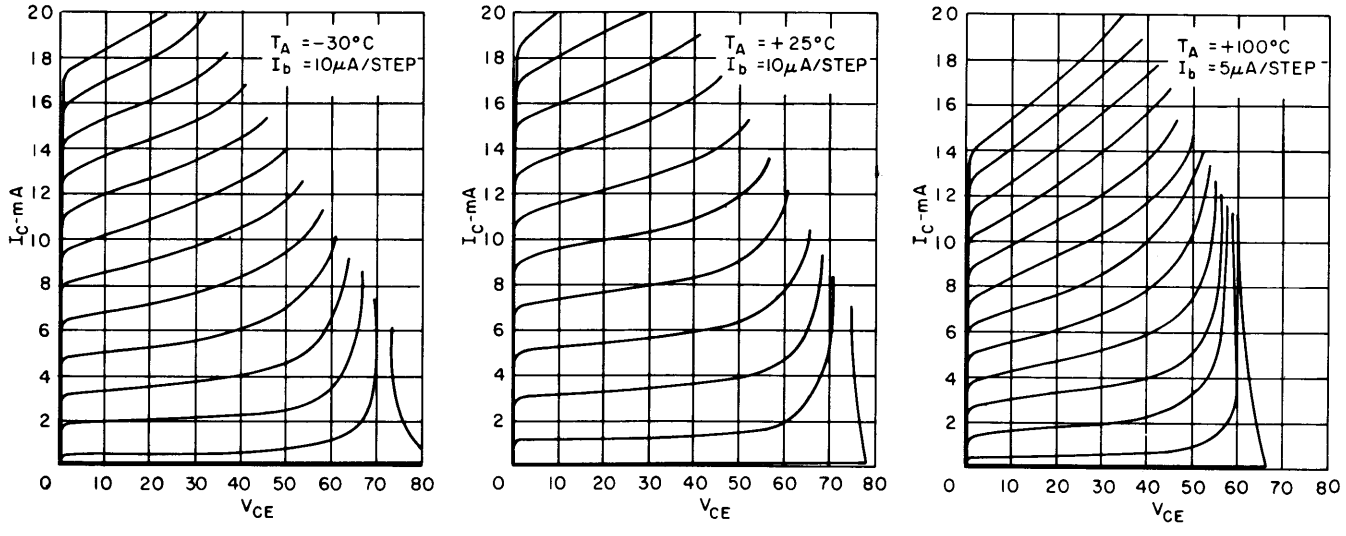

f = 1MHz
$T_A$ = 25°C
$C_{obo}$
$C_{cbo}$
$C_{cbo}$ OR $C_{obo}$ — p F
$V_{EB}$ OR $V_{CB}$ — VOLTS


h PARAMETERS VS $I_C$
$V_C$ = 10V
f = 1kHz
$T_A$ = 25°C
h PARAMETERS NORMALIZED TO 1 MA
$I_C$ IN m A
$h_{ie}$
$h_{re}$
$h_{oe}$
$h_{fe}$


$V_{CE}$ — VOLTS
$I_C$-m A
h fe
10 MHz $h_{fe}$
($V_{CE}$ = 10V)
$f_T$ = 10
$f_T$ = 20
$f_T$ = 40
$f_T$ = 60
$f_T$ = 80
$f_T$ = 100
$f_T$ = 120
$f_T$ = 140
$f_T$ = 160
$f_T$ = 180
$f_T$ = 200
$f_T$ = 220
$f_T$ = 200
$f_T$ = 180
$f_T$ = 160




**Typical Common Emitter Current Characteristic Curves**




**Typical Common Emitter Characteristic Curves**

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SEMICONDUCTOR PRODUCTS DEPARTMENT
ELECTRONICS PARK, SYRACUSE, N. Y. 13201

GENERAL ELECTRIC

(In Canada, Canadian General Electric Company, Ltd., Toronto, Ont. Outside the U.S.A., and Canada, by: Electronic Component Sales, I.G.E. Export Division, 159 Madison Avenue, New York, N. Y. 10016

ELECTRONIC INNOVATIONS IN ACTION

SEMICONDUCTORS

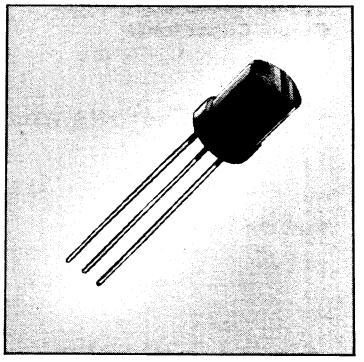
# Silicon TRANSISTORS

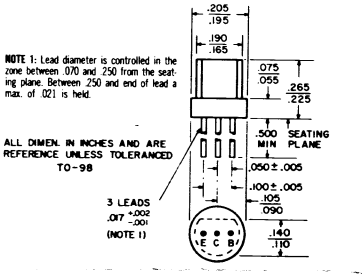
## PLANAR EPITAXIAL PASSIVATED

NPN

**2N4951**
**2N4952**
**2N4953**
**2N4954**

The General Electric 2N4951-2N4954 are silicon NPN planar passivated epitaxial devices intended for high speed switching, amplifier, and core driver applications. The devices feature excellent switching speeds and low collector saturation voltages up to the maximum current rating. These epoxy encapsulated units are electrically equivalent to the 2N2220-22 series.






## absolute maximum ratings: (25°) (unless otherwise specified)

| | | 2N4951-3 | 2N4954 | |
|---|---|---|---|---|
| **Voltages** | | | | |
| Collector to Base | $V_{CBO}$ | 60 | 40 | Volts |
| Collector to Emitter* | $V_{CEO}$ | 30 | 30 | Volts |
| Emitter to Base | $V_{EBO}$ | 5 | 5 | Volts |
| **Current** | | | | |
| Collector | $I_C$ | 500 | 500 | mA |
| **Dissipation** | | | | |
| Total Power† | $P_T$ | 360 | 360 | mW |
| **Temperature** | | | | |
| Storage | $T_{stg}$ | −55 to +150°C | | |
| Operating Junction | $T_j$ | +150°C | | |
| Lead (1/16" from case for 10 seconds) | | +260°C | | |

*This value applies when the Base-Emitter diode is open-circuited.
†Derate linearly to 150°C free-air temperature at the rate of 2.87 mW/°C.

## electrical characteristics: (25°) (unless otherwise specified)

| | | 2N4951 | | 2N4952 | | 2N4953 | | 2N4954 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | |
| **Collector to Base Breakdown Voltage** | | | | | | | | | | |
| ($I_C = 10\ \mu A, I_E = 0$) | $V_{(BR)CBO}$ | 60 | | 60 | | 60 | | 40 | | Volts |
| **Collector to Emitter Breakdown Voltage** | | | | | | | | | | |
| ($I_C = 10$ mA, $I_B = 0$)‡ | $V_{(BR)CEO}$ | 30 | | 30 | | 30 | | 30 | | Volts |
| **Emitter to Base Breakdown Voltage** | | | | | | | | | | |
| ($I_E = 10\ \mu A, I_C = 0$) | $V_{(BR)EBO}$ | 5 | | 5 | | 5 | | 5 | | Volts |
| **Collector Cutoff Current** | | | | | | | | | | |
| ($V_{CB} = 40$V, $I_E = 0$) | $I_{CBO}$ | | 50 | | 50 | | 50 | | | nA |
| ($V_{CB} = 30$V, $I_E = 0$) | $I_{CBO}$ | | | | | | | | 50 | nA |
| **Emitter Cutoff Current** | | | | | | | | | | |
| ($V_{EB} = 3$V, $I_C = 0$) | $I_{EBO}$ | | 50 | | 50 | | 50 | | 500 | nA |
| **Static Forward Current Transfer Ratio** | | | | | | | | | | |
| ($I_C = 1$ mA, $V_{CE} = 10$V) | $h_{FE}$ | 20 | | 50 | | 75 | | 20 | | |
| ($I_C = 10$ mA, $V_{CE} = 10$V)‡ | $h_{FE}$ | 40 | | 75 | | 150 | | 40 | | |
| ($I_C = 150$ mA, $V_{CE} = 10$V)‡ | $h_{FE}$ | 60 | 200 | 100 | 300 | 200 | 600 | 60 | 600 | |

‡Pulse test: Pulse width = 300 μsec, duty cycle ≤ 2%.

GENERAL ELECTRIC

| | | | 2N4951, 2, 3, 4 Min. | Max. | |
|---|---|---|---|---|---|
| **Base to Emitter Voltage** | | | | | |
| ($I_C = 150$ mA, $V_{CE} = 10$V)‡ | | $V_{BE}$ | | 1.2 | Volts |
| **Base to Emitter Saturation Voltage** | | | | | |
| ($I_C = 150$ mA, $I_B = 15$ mA)‡ | | $V_{BE(sat)}$ | | 1.3 | Volts |
| **Collector to Emitter Saturation Voltage** | | | | | |
| ($I_C = 150$ mA, $I_B = 15$ mA)‡ | | $V_{CE(sat)}$ | | 0.3 | Volts |
| **Small-Signal Common-Emitter Forward Current Transfer Ratio** | | | | | |
| ($I_C = 20$ mA, $V_{CE} = 10$V, f = 100 MHz) | | $\|h_{fe}\|$ | 2.5 | | |
| **Common-Base Open-Circuit Output Capacitance** | | | | | |
| ($I_E = 0$, $V_{CB} = 10$V, f = 1 MHz) | | $C_{cb}$ | | 8 | pF |

## Switching Characteristics

| | | | | | |
|---|---|---|---|---|---|
| **Turn-On Time** | | | | | |
| ($I_C = 150$ mA, $V_{CC} = 30$V, $I_{B1} = 15$ mA, Figure 1) | | $t_{on}$ | | 40 | nsec |
| **Turn-Off Time** | | | | | |
| ($I_C = 150$ mA, $V_{CC} = 30$V, $I_{B1} =$ | 2N4951, 2 | $t_{off}$ | | 350 | nsec |
| $-I_{B2} = 15$ mA, Figure 2) | 2N4953, 4 | $t_{off}$ | | 400 | nsec |

‡Pulse test: Pulse Width = 300 μsec, duty cycle ≤ 2%.

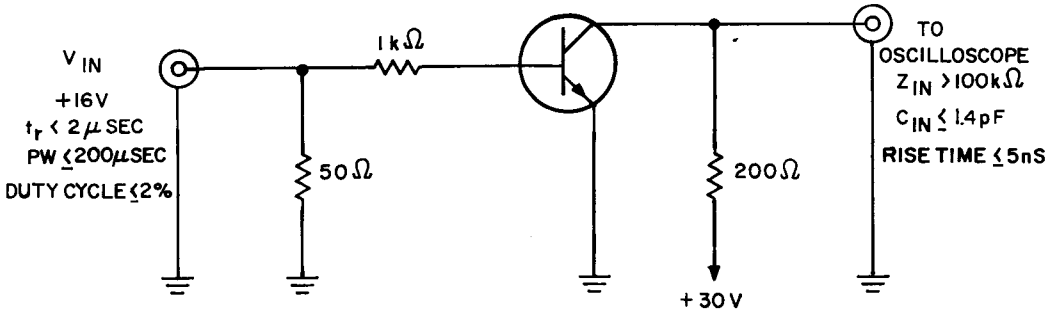



**FIGURE 1. TEST CIRCUIT FOR DETERMINING TURN-ON TIME**

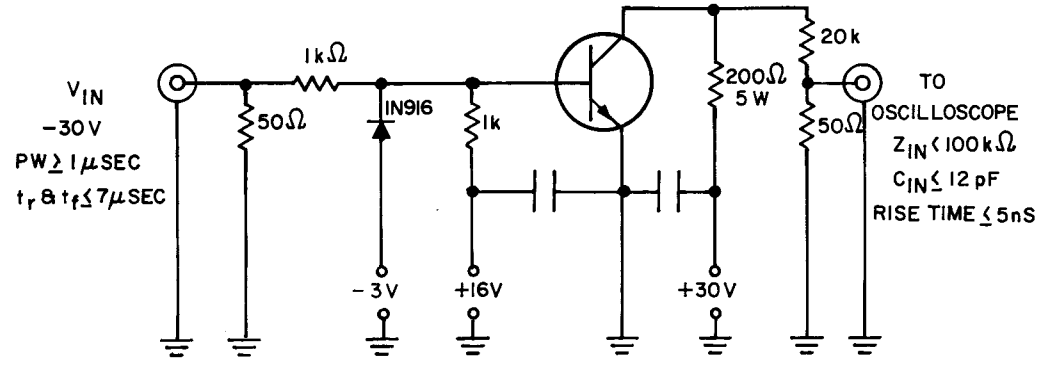



**FIGURE 2. TEST CIRCUIT FOR DETERMINING TURN-OFF TIME**

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