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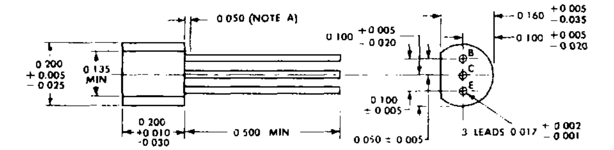
# A COMPLETE FAMILY OF LOW-NOISE, LOW- TO MEDIUM-CURRENT SILECT† TRANSISTORS‡ FOR USE IN HI-FI AUDIO AMPLIFIERS AND GENERAL PURPOSE LOW-FREQUENCY APPLICATIONS

- High $V_{(BR)CEO}$ . . . 65 V Min (TIS96 and TIS99)
- Excellent $h_{FE}$ Linearity to 100 mA

## mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

TIS94, TIS95, TIS96

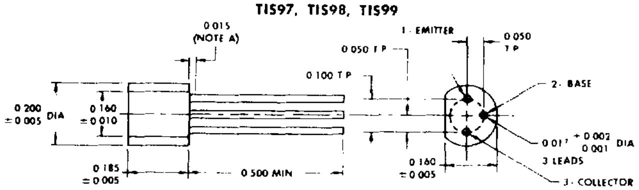



ECB

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES A. Lead diameter is not controlled in this area
B. All dimensions are in inches

TIS97, TIS98, TIS99




NOTES A. Lead diameter is not controlled in this area
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package
C. All dimensions are in inches

## absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

| | TIS94 TIS97 | TIS95 TIS98 | TIS96 TIS99 |
|---|---|---|---|
| Collector-Base Voltage | 60 V | 80 V | 80 V |
| Collector-Emitter Voltage (See Note 1) | 40 V | 60 V | 65 V |
| Emitter-Base Voltage | 6 V | 6 V | 6 V |
| Continuous Collector Current | ← | 200 mA | → |
| Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2) | ← | 625 mW | → |
| Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3) | ← | 1.25 W | → |
| Storage Temperature Range | ← | −65°C to 150°C | → |
| Lead Temperature 1/16 Inch from Case for 10 Seconds | ← | 260°C | → |

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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## electrical characteristics at 25°C free-air temperature

| PARAMETER | | TEST CONDITIONS | | TIS94 TIS97 MIN | TIS94 TIS97 TYP | TIS94 TIS97 MAX | TIS95 TIS98 MIN | TIS95 TIS98 TYP | TIS95 TIS98 MAX | TIS96 TIS99 MIN | TIS96 TIS99 TYP | TIS96 TIS99 MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage | $I_C = 10$ mA, $I_B = 0$, | See Note 4 | 40 | | | 60 | | | 65 | | | V |
| $I_{CBO}$ | Collector Cutoff Current | $V_{CB} = 40$ V, $I_E = 0$ | | | | 10 | | | 10 | | | 10 | nA |
| | | $V_{CB} = 60$ V, $I_E = 0$ | | | | 10 | | | | | | | µA |
| | | $V_{CB} = 80$ V, $I_E = 0$ | | | | | | | 10 | | | 10 | µA |
| $I_{EBO}$ | Emitter Cutoff Current | $V_{EB} = 6$ V, $I_C = 0$ | | | | 20 | | | 20 | | | 20 | nA |
| $h_{FE}$ | Static Forward Current Transfer Ratio§ | $V_{CE} = 5$ V, $I_C = 100$ µA | | 250 | 340 | 700 | | | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | 100 | 200 | 300 | | | | |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA, | See Note 4 | | | | | | | 60 | 125 | | |
| | | $V_{CE} = 5$ V, $I_C = 100$ mA, | See Note 4 | | | | | | | 55 | 110 | 300 | |
| $V_{BE}$ | Base-Emitter Voltage | $V_{CE} = 5$ V, $I_C = 100$ µA | | 0.45 | | 0.65 | | | | | | | V |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | 0.5 | | 0.7 | | | | V |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA, | See Note 4 | | | | | | | 0.6 | | 0.8 | V |
| $V_{CE}$ | Collector-Emitter Voltage | $I_B = 0.1$ mA, $I_C = 10$ mA, | See Note 4 | | | | | | 1 | | | | V |
| | | $I_B = 2$ mA, $I_C = 100$ mA, | See Note 4 | | | | | | | | | 2 | V |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $I_B = 5$ mA, $I_C = 100$ mA, | See Note 4 | | | | | | 0.5 | | | 0.5 | V |
| $h_{ie}$ | Small-Signal Common-Emitter Input Impedance | $V_{CE} = 5$ V, $I_C = 100$ µA | f = 1 kHz | | 115 | | | | | | | | kΩ |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | | 6.4 | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA | | | | | | | | | 0.5 | | |
| $h_{fe}$ | Small-Signal Common-Emitter Forward Current Transfer Ratio | $V_{CE} = 5$ V, $I_C = 100$ µA | f = 1 kHz | 250 | 440 | 800 | | | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | 100 | 240 | 400 | | | | |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA | | | | | | | | 60 | 130 | 500 | |
| $h_{re}$ | Small-Signal Common-Emitter Reverse Voltage Transfer Ratio | $V_{CE} = 5$ V, $I_C = 100$ µA | f = 1 kHz | | $30 \times 10^{-4}$ | | | | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | | $1.5 \times 10^{-4}$ | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA | | | | | | | | | $0.9 \times 10^{-4}$ | | |
| $h_{oe}$ | Small-Signal Common-Emitter Output Admittance | $V_{CE} = 5$ V, $I_C = 100$ µA | f = 1 kHz | | 11 | | | | | | | | µmho |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | | 6 | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA | | | | | | | | | 50 | | |
| $y_{fe}$ | Small-Signal Common-Emitter Forward Transfer Admittance | $V_{CE} = 5$ V, $I_C = 100$ µA | f = 1 kHz | | 3.8 | | | | | | | | mmho |
| | | $V_{CE} = 5$ V, $I_C = 1$ mA | | | | | 30 | 38 | | | | | |
| | | $V_{CE} = 5$ V, $I_C = 10$ mA | | | | | | | | | 260 | | |
| $\lvert h_{fe} \rvert$ | Small-Signal Common-Emitter Forward Current Transfer Ratio | $V_{CE} = 5$ V, $I_C = 10$ mA, | f = 100 MHz | 2 | | | 2 | | | 2 | | | |
| $C_{cb}$ | Collector-Base Capacitance | $V_{CB} = 5$ V, $I_E = 0$, | f = 1 MHz, See Note 5 | 1 | | 4 | 1 | | 4 | 1 | | 4 | pF |
| $C_{eb}$ | Emitter-Base Capacitance | $V_{EB} = 0.5$ V, $I_C = 0$, | f = 1 MHz, See Note 5 | | | 16 | | | 16 | | | 16 | pF |

## operating characteristics at 25°C free-air temperature

| PARAMETER | | TEST CONDITIONS | TIS94, TIS97 MAX | UNIT |
|---|---|---|---|---|
| F | Spot Noise Figure | $V_{CE} = 5$ V, $I_C = 30$ µA, $R_G = 10$ kΩ, f = 1 kHz, Noise Bandwidth = 100 Hz | 2 | dB |
| $\bar{F}$ | Average Noise Figure | $V_{CE} = 5$ V, $I_C = 100$ µA, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 6 | 3 | dB |

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.

5. $C_{cb}$ and $C_{eb}$ are measured using three-terminal measurement techniques with the third electrode (emitter or collector, respectively) guarded.

6. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

§The TIS96 and TIS99 are color-coded on $h_{FE}$ measured at $V_{CE} = 5$ V, $I_C = 100$ mA. Each $h_{FE}$ bracket has a 2-to-1 spread as follows: red, 55-110; orange, 90-180; yellow, 150-300. No particular $h_{FE}$ distribution is implied by this coding system.



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