TYPES A5T2222, TIS109, TIS110, TIS111
N-P-N SILICON TRANSISTORS

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SILECT† TRANSISTORS‡
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

featuring

- High f_T . . . . 350 MHz typ at 10 V, 20 mA
- Low $V_{CE(sat)}$ . . . . 0.13 V typ at 150 mA
- High Maximum I_C . . . . 800 mA
- A5T2222 Electrically Similar to 2N2222, 2N3116, and 2N4952
- TIS109 Processing Includes Operational Aging at 300 mW for 24 Hours
- TIS110 Electrically Similar to 2N4400
- TIS111 Electrically Similar to 2N4401

mechanical data

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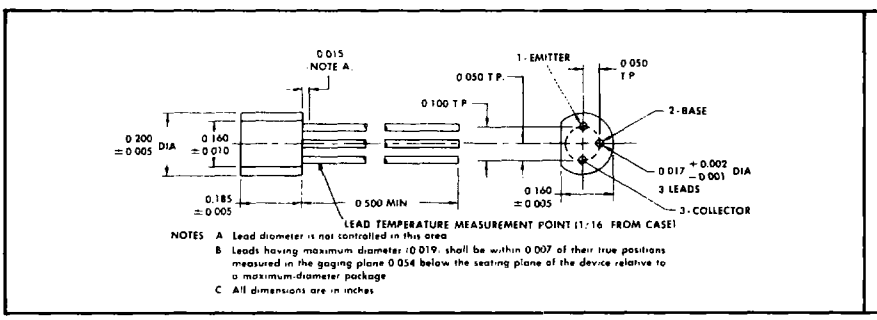
These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions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



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

	A5T2222 TIS109	TIS110 TIS111
Collector-Base Voltage	60 V	60 V
Collector-Emitter Voltage (See Note 1)	30 V	40 V
Emitter-Base Voltage	5 V	6 V
Continuous Collector Current	800 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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A5T2222, TIS109

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		A5T2222 MIN	A5T2222 MAX	TIS109 MIN	TIS109 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 μA, I_E = 0		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0,	See Note 4	30		30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 μA, I_C = 0		5		5		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 20 V, I_E = 0					100	nA
		V_{CB} = 50 V, I_E = 0			10			nA
		V_{CB} = 50 V, I_E = 0,	T_A = 100°C		3		3	μA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 3 V, I_C = 0			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 100 μA		35		20		
		V_{CE} = 10 V, I_C = 1 mA		50		30		
		V_{CE} = 10 V, I_C = 10 mA	See Note 4	75		40		
		V_{CE} = 10 V, I_C = 150 mA		100	300	100	400	
		V_{CE} = 10 V, I_C = 500 mA		30		20		
		V_{CE} = 1 V, I_C = 150 mA		50		35		
V_{BE}	Base-Emitter Voltage	I_B = 15 mA, I_C = 150 mA	See Note 4		1.3		1.3	V
		I_B = 50 mA, I_C = 500 mA			2.6		2.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 15 mA, I_C = 150 mA	See Note 4		0.4		0.4	V
		I_B = 50 mA, I_C = 500 mA			1.6		1.6	V
$\|h_{fe}\|$	*Small-Signal Common-Emitter* Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 20 mA,	f = 100 MHz	2.5		2.5		
f_T	Transition Frequency	V_{CE} = 10 V, I_C = 20 mA,	See Note 5	250		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0,	f = 1 MHz		8		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	V_{EB} = 0.5 V, I_C = 0,	f = 1 MHz		25		25	pF
$Re(h_{ie})$	*Real Part of Small-Signal* Common-Emitter Input Impedance	V_{CE} = 10 V, I_C = 20 mA,	f = 300 MHz		60		60	Ω

NOTES: 4. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}|$ = 1.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_d	Delay Time	V_{CC} = 30 V,	I_C = 150 mA,	$I_{B(1)}$ = 15 mA,	5	ns
t_r	*Rise Time*	$V_{BE(off)}$ = −0.5 V,		See Figure 1	15	*ns*
t_s	Storage Time	V_{CC} = 30 V,	I_C = 150 mA,	$I_{B(1)}$ = 15 mA,	190	ns
t_f	Fall Time	$I_{B(2)}$ = −15 mA,		See Figure 2	23	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

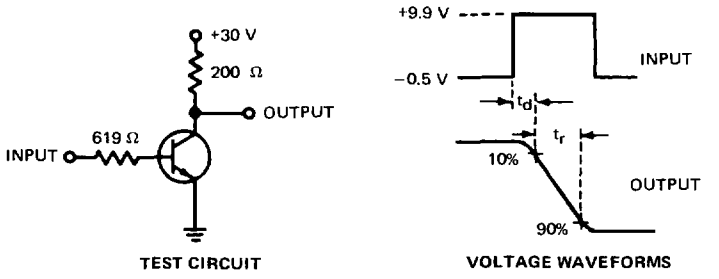


FIGURE 1–DELAY AND RISE TIMES

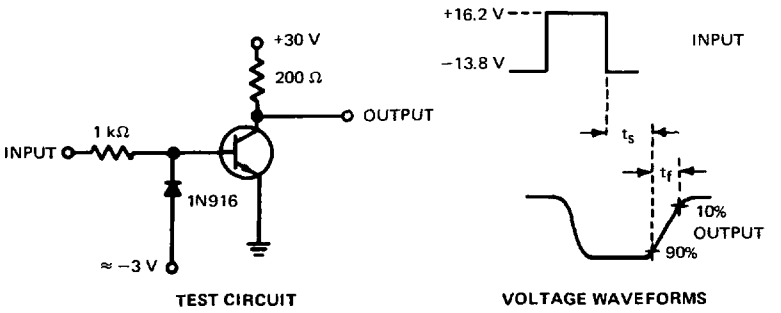


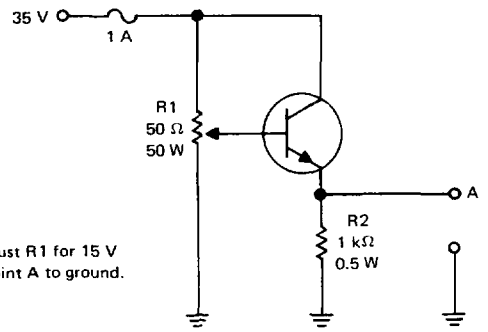
FIGURE 2–STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: for figure 1, $t_r \leq 2$ ns, $t_w \leq 200$ ns, duty cycle $\leq 2\%$; for figure 2, $t_f \leq 5$ ns, $t_w \approx 100\ \mu s$, duty cycle $\leq 17\%$.
b. All waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pF.

TIS109 OPERATIONAL AGING

All TIS109 transistors are aged for a minimum of 24 hours in the circuit shown at the right. Total device dissipation is approximately 300 mW. All static characteristics are tested prior to and after aging. Dynamic characteristics are tested as necessary to guarantee the specified limits after aging.

NOMINAL CONDITIONS
$V_{CE} = 20$ V
$I_E = -15$ mA
$T_A = 25°C$



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TIS110, TIS111

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		TIS110 MIN	TIS110 MAX	TIS111 MIN	TIS111 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA, I_E = 0		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0		40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 μA, I_C = 0		6		6		V
I_{CEV}	Collector Cutoff Current	V_{CE} = 35 V, V_{BE} = −0.4 V			100		100	nA
I_{BEV}	Base Cutoff Current	V_{CE} = 35 V, V_{BE} = −0.4 V			−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 1 V, I_C = 100 μA				20		
		V_{CE} = 1 V, I_C = 1 mA		20		40		
		V_{CE} = 1 V, I_C = 10 mA	See Note 4	40		80		
		V_{CE} = 1 V, I_C = 150 mA		50	150	100	300	
		V_{CE} = 2 V, I_C = 500 mA		20		40		
V_{BE}	Base-Emitter Voltage	I_B = 15 mA, I_C = 150 mA	See Note 4	0.75	0.95	0.75	0.95	V
		I_B = 50 mA, I_C = 500 mA			1.2		1.2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 15 mA, I_C = 150 mA	See Note 4		0.4		0.4	V
		I_B = 50 mA, I_C = 500 mA			0.75		0.75	
h_{ie}	Small-Signal Common-Emitter Input Impedance	V_{CE} = 10 V, I_C = 1 mA, f = 1 kHz		0.5	7.5	1	15	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio			20	250	40	500	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio				8 X 10^{-4}		8 X 10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			1	30	1	30	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 20 mA,	f = 100 MHz	2		2.5		
f_T	Transition Frequency	V_{CE} = 10 V, I_C = 20 mA,	See Note 5	200		250		MHz
C_{cb}	Collector-Base Capacitance	V_{CB} = 5 V, I_E = 0, See Note 6	f = 1 MHz,		6.5		6.5	pF
C_{eb}	Emitter-Base Capacitance	V_{EB} = 0.5 V, I_C = 0, See Note 6	f = 1 MHz,		30		30	pF

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

5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}|$ = 1.

6. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

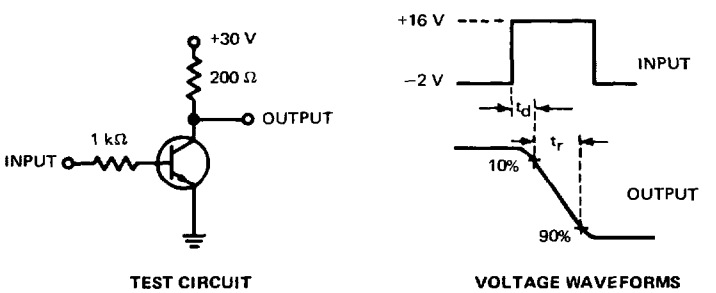
TIS110, TIS111

switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS†	MAX	UNIT
t_d Delay Time	V_{CC} = 30 V, I_C = 150 mA, $I_{B(1)}$ = 15 mA,	15	ns
t_r Rise Time	$V_{BE(off)}$ = −2 V, See Figure 3	20	ns
t_s Storage Time	V_{CC} = 30 V, I_C = 150 mA, $I_{B(1)}$ = 15 mA,	230	ns
t_f Fall Time	$I_{B(2)}$ = −15 mA, See Figure 4	60	ns

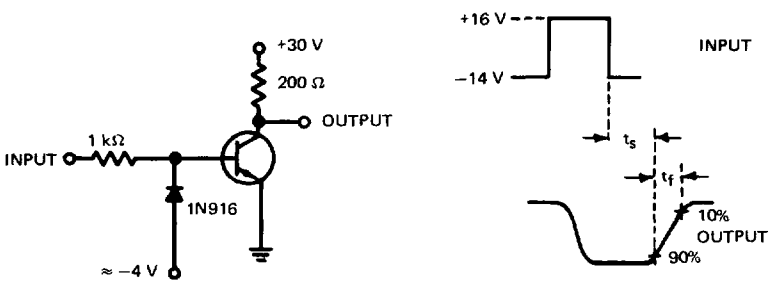
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 3–DELAY AND RISE TIMES



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 4–STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: for figure 3, $t_r \leq 2$ ns, $t_w \leq 10$ μs, duty cycle ≤ 2%; for figure 4, $t_f \leq 5$ ns, $t_w \approx 10$ μs, duty cycle ≤ 2%.
b. All waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pF.

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