2N5038, 2N5039, 2N6496

File Number **698**

High-Current, High-Power High-Speed Silicon N-P-N Planar Transistors

Devices for Switching and Amplifier Circuits in Industrial and Commercial Applications

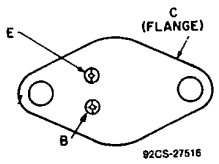
Features:

- *Maximum operating area curves for dc and pulse operation*
- *$I_{s/b}$-limit line beginning at 28 V*
- *High collector current rating*
- *High-dissipation capability*

RCA-2N5038, 2N5039 and 2N6496 are epitaxial silicon n-p-n planar transistors. They differ in breakdown-voltage ratings, leakage-current, and dc-beta values.

The high current-handling capability of these transistors in conjunction with fast switching speeds make these devices especially suited for switching-control amplifiers, power gates, switching regulators, converters, and inverters. Other recommended applications include dc-rf amplifiers and power oscillators. These transistors are supplied in the JEDEC TO-204AA package.

TERMINAL DESIGNATIONS



JEDEC TO-204AA

MAXIMUM RATINGS, *Absolute-Maximum Values:*

		2N5038	2N5039	2N6496	
*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	150	120	150	V
COLLECTOR-TO-EMITTER SUSTAINING VOLTAGE:					
With −1.5 volts (V_{BE}) of reverse bias and external base-to-emitter resistance (R_{BE}) = 100 Ω	$V_{CEX(sus)}$	150	120	–	V
With $R_{BE} \leq 50\ \Omega$	$V_{CER(sus)}$	110	95	130	V
With base open	$V_{CEO(sus)}$	90	75	110	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	7	7	7	V
*CONTINUOUS COLLECTOR CURRENT	I_C	20	20	15	A
*PEAK COLLECTOR CURRENT		30	30	–	A
*CONTINUOUS BASE CURRENT	I_B	5	5	5	A
*TRANSISTOR DISSIPATION:	P_T				
At case temperatures up to 25°C and V_{CE} up to 28 V		140	140	140	W
At case temperature of 100°C and V_{CB} of 20 V		80	80	80	W
At case temperatures up to 25°C and V_{CE} above 28 V		← See Fig. 1. →			
At case temperatures above 25°C and V_{CE} above 28 V		← See Figs. 1 & 2. →			
*TEMPERATURE RANGE:					
Storage & Operating (Junction)		← −65 to 200 →			°C
PIN TEMPERATURE (During Soldering)					
At distances ≥ 1/32 in. (0.8 mm) from seating plane for 10 s max.		← 230 →			°C

*In accordance with JEDEC registration data format (JS-6, RDF-1)

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ELECTRICAL CHARACTERISTICS, *At Case Temperature (T_C) = 25°C Unless Otherwise Specified*

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS: VOLTAGE V dc V_{CB}	V_{CE}	V_{EB}	V_{BE}	CURRENT A dc I_C	I_E	I_B	LIMITS: 2N5038 Min.	2N5038 Max.	2N5039 Min.	2N5039 Max.	2N6496 Min.	2N6496 Max.	UNITS
	Collector Cutoff Current: With base open	I_{CEO}		55					0	–	–	–	20	–	–	mA
				70					0	–	20	–	–	–	–	
*	With base-emitter junction reverse-biased	I_{CEV}		110		−1.5				–	–	–	50	–	–	
				140		−1.5				–	50	–	–	–	–	
				130		0				–	–	–	–	–	20	
*	At T_C = 150°C			85		−1.5				–	–	–	10	–	–	
				100		−1.5				–	10	–	–	–	–	
				130		0				–	–	–	–	–	25	
*	Emitter Cutoff Current	I_{EBO}			5		0			–	5	–	15	–	–	mA
					7		0			–	50	–	50	–	50	
	DC Forward-Current Transfer Ratio	h_{FE}		5			2[a]			50	200	30	150	–	–	
*				5			10[a]			–	–	20	100	–	–	
*				5			12[a]			20	100	–	–	–	–	
*				2			8[a]			–	–	–	–	12	100	
*	Magnitude of Small-Signal Forward-Current Transfer Ratio (At f = 5 MHz)	$\|h_{fe}\|$		10			2			12	–	12	–	12	–	
	Collector-to-Emitter Sustaining Voltage: With base open	$V_{CEO(sus)}$[b]														
*							0.2		0	90	–	75	–	110	–	V
	With base-emitter junction reverse biased and external base-to-emitter resistance (R_{BE}) = 100 Ω	$V_{CEX(sus)}$[b]				−1.5	0.2		0	150	–	120	–	–	–	
	With $R_{BE} \leq 50$ Ω	$V_{CER(sus)}$[b]					0.2		0	110	–	95	–	130	–	
	Emitter-to-Base Voltage	V_{EBO}					0	0.05		7	–	7	–	7	–	V
	Base-to-Emitter Voltage	V_{BE}		5			10[a]			–	–	–	1.8	–	–	
				5			12[a]			–	1.8	–	–	–	–	V
				2			8[a]			–	–	–	–	–	1.6	
	Collector-to-Emitter Saturation Voltage	$V_{CE(sat)}$					10[a]		1.0	–	–	–	1.0	–	–	
							12[a]		1.2	–	1.0	–	–	–	–	V
*							20[a]		5	–	2.5	–	2.5	–	–	
*							8[a]		0.8	–	–	–	–	–	1.0	
*	Base-to-Emitter Saturation Voltage	$V_{BE(sat)}$					20[a]		5	–	3.3	–	3.3	–	–	V
							8[a]		0.8	–	–	–	–	–	2.0	
	Output Capacitance	C_{ob}	10					0		–	400	–	400	–	400	pF
	Second-Breakdown Collector Current[e] (With base forward biased)	$I_{S/b}$[d]		28						5.0	–	5.0	–	5.0	–	A
				45						0.9	–	0.9	–	0.9	–	
	Second-Breakdown Energy (With base reverse biased, R_B = 20 Ω, L = 180 μH)	$E_{S/b}$[f]				−4	12			13	–	13	–	–	–	mJ
						−4	8			–	–	–	–	5.7	–	
*	Sat. Switching Rise Time	t_r	V_{CC} = 30 V				10		1.0[c]	–	–	–	0.5	–	–	μs
							12		1.2[c]	–	0.5	–	–	–	–	
							8		0.8[c]	–	–	–	–	–	0.5	
*	Sat. Switching Storage Time	t_s	V_{CC} = 30 V				10		1.0[c]	–	–	–	1.5	–	–	
							12		1.2[c]	–	1.5	–	–	–	–	
							8		0.8[c]	–	–	–	–	–	1.5	
*	Sat. Switching Fall Time	t_f	V_{CC} = 30 V				10		1.0[c]	–	–	–	0.5	–	–	
							12		1.2[c]	–	0.5	–	–	–	–	
							8		0.8[c]	–	–	–	–	–	0.5	
	Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$		10			10			–	1.25	–	1.25	–	1.25	°C/W

[a] Pulsed; pulse duration ≤350 μs, duty factor = 2%.

[b] CAUTION: The sustaining voltages $V_{CEO(sus)}$, $V_{CER(sus)}$, and $V_{CEX(sus)}$ MUST NOT be measured on a curve tracer.

[c] $I_{B1} = I_{B2}$ = value shown.

*In accordance with JEDEC registration data format (JS-6, RDF-1)

[d] $I_{S/b}$ is defined as the current at which second breakdown occurs at a specified collector voltage with the emitter-base junction forward-biased for transistor operation in the active region.

[e] Pulsed; 1-s non-repetitive pulse.

[f] $E_{S/b}$ is defined as the energy at which second breakdown occurs under specified reverse-bias conditions. $E_{S/b} = \frac{1}{2}LI^2$ where L is a series load or leakage inductance and I is the peak collector current.

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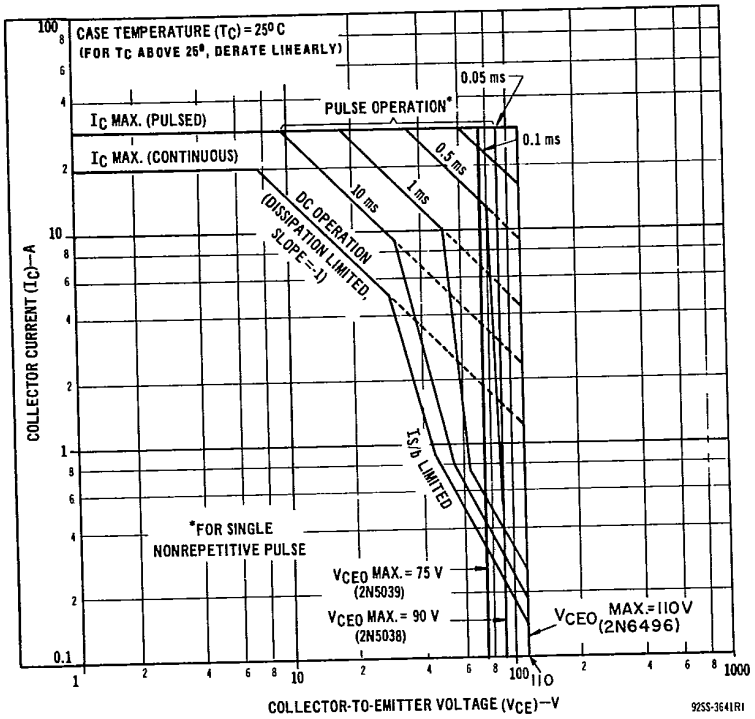

Fig. 1 — Maximum operating areas for all types.

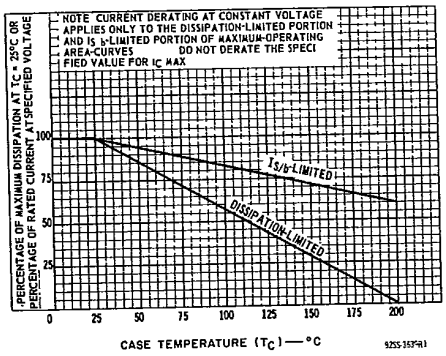

Fig. 2 — Dissipation derating curves for all types.

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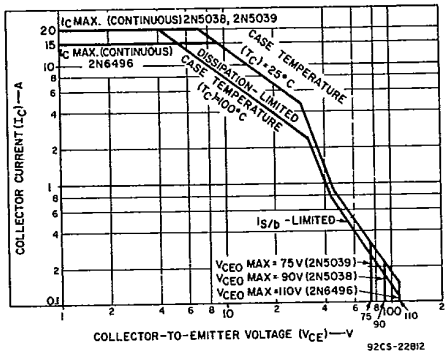

Fig. 3 - Maximum operating areas for all types.

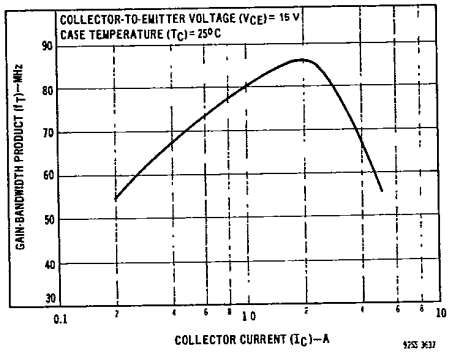

Fig. 4 - Typical gain-bandwidth product for all types.

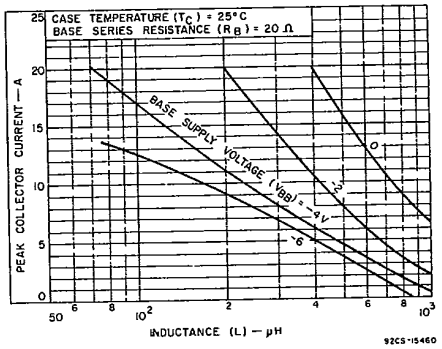

Fig. 5 - Maximum reverse-bias, second-breakdown characteristics for 2N5038 and 2N5039.

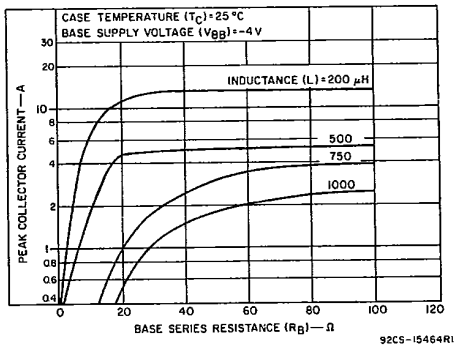

Fig. 6 - Maximum reverse-bias, second-breakdown characteristics for 2N5038 and 2N5039.

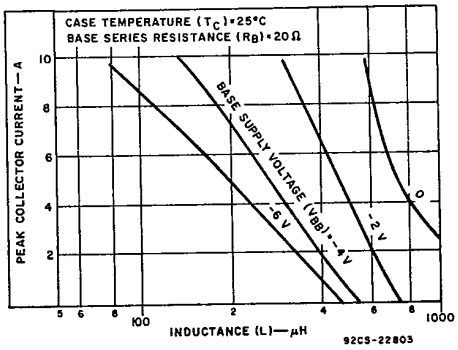

Fig. 7 - Maximum reverse-bias, second-breakdown characteristics for 2N6496.

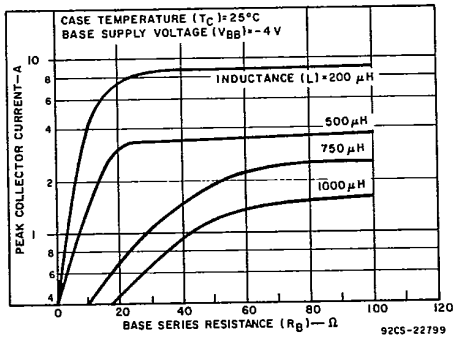

Fig. 8 - Maximum reverse-bias, second-breakdown characteristics for 2N6496.

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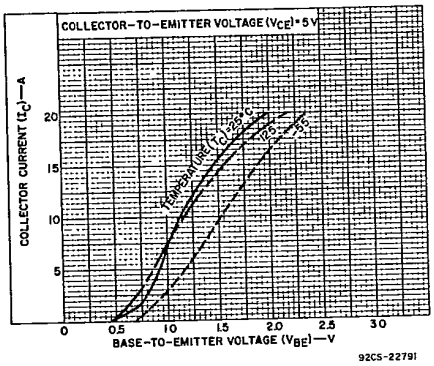

Fig. 9 – Typical transfer characteristics for 2N5038.

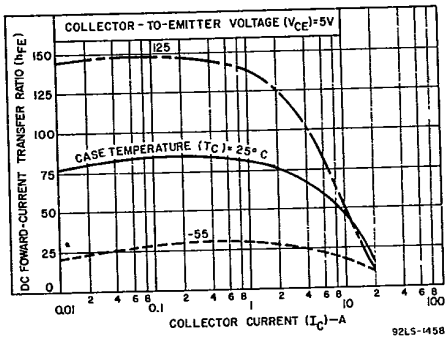

Fig. 10 – Typical dc beta characteristics for 2N5038.

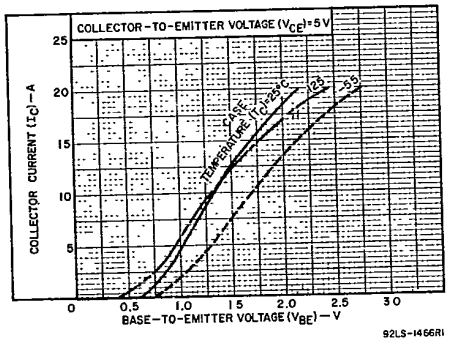

Fig. 11 – Typical transfer characteristics for 2N5039.

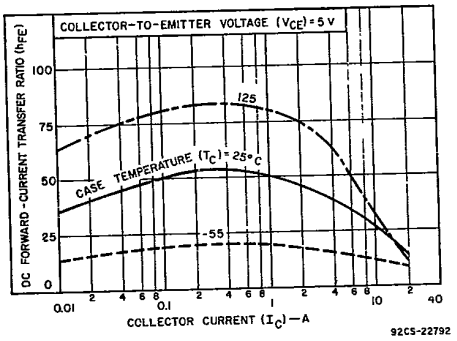

Fig. 12 –Typical dc beta characteristics for 2N5039.

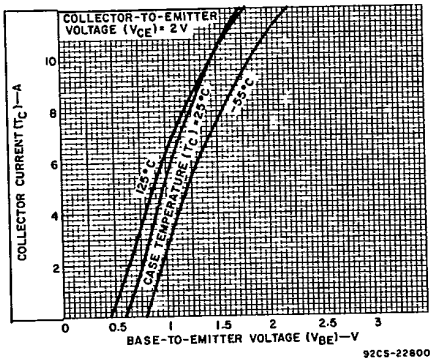

Fig. 13 – Typical transfer characteristics for 2N6496.

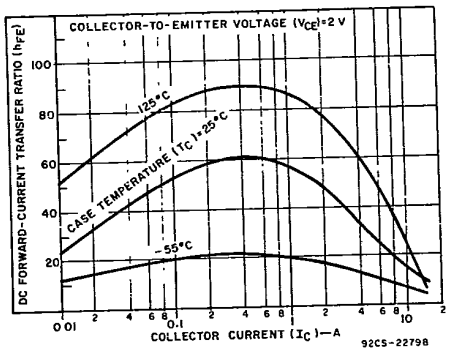

Fig. 14 – Typical dc beta characteristics for 2N6496.

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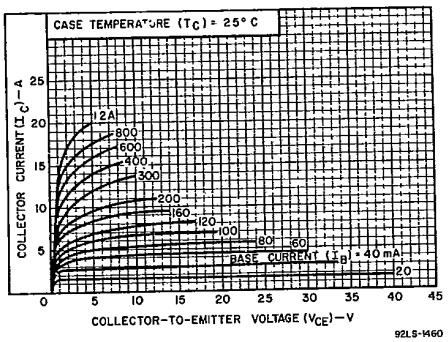

Fig. 15 – Typical output characteristics for 2N5038.

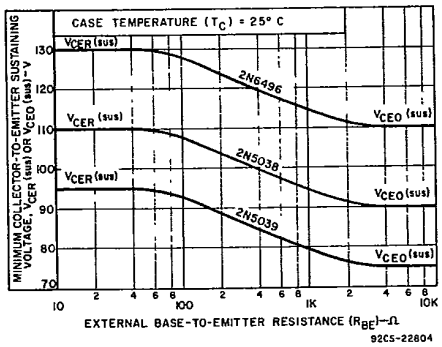

Fig. 16 – Collector-to-emitter sustaining voltage characteristic for all types.

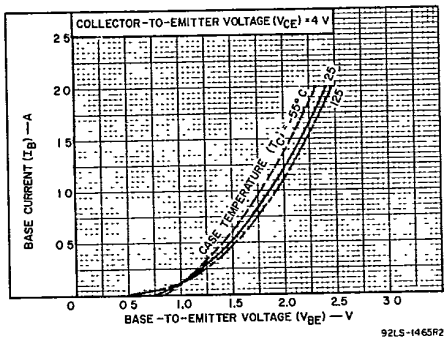

Fig. 17 – Typical output characteristics for 2N5039.

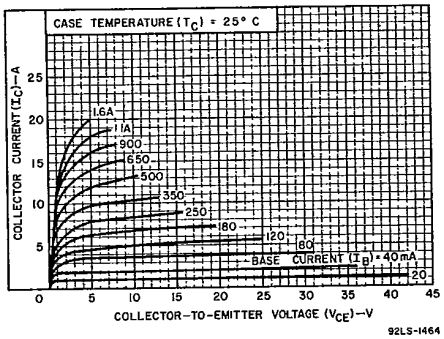

Fig. 18 – Typical input characteristics for 2N5038 and 2N5039.

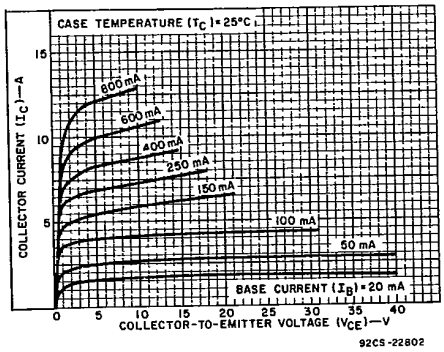

Fig. 19 – Typical output characteristics for 2N6496.

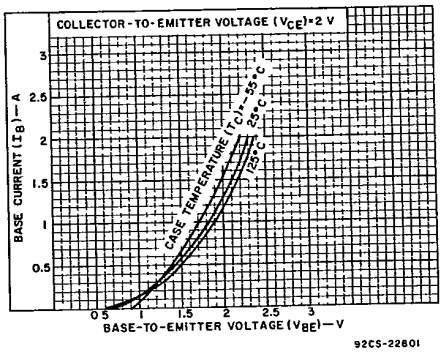

Fig. 20 – Typical input characteristics for 2N6496.

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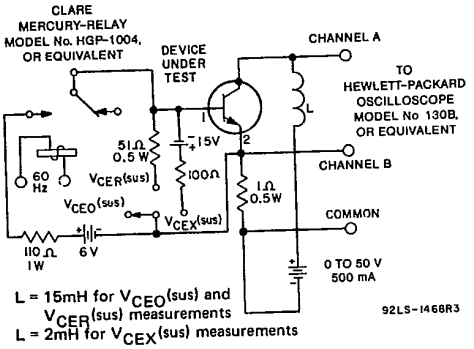
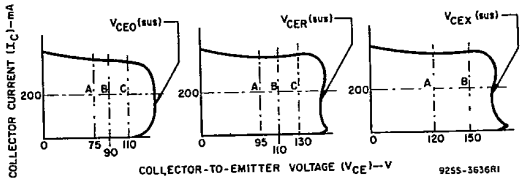


Fig. 21 – Circuit used to measure sustaining voltages $V_{CEO}(sus)$, $V_{CER}(sus)$, and $V_{CEX}(sus)$.



The sustaining voltages ($V_{CEO}(sus)$, $V_{CER}(sus)$, and $V_{CEX}(sus)$ are acceptable when the traces fall to the right of point "A" for type 2N5039, point "B" for type 2N5038 and point "C" for type 2N6496. (NOTE: 2N6496 is not tested for $V_{CEX}(sus)$.)

Fig. 22 – Oscilloscope display for measurement of sustaining voltages (Test circuit shown in Fig. 22).

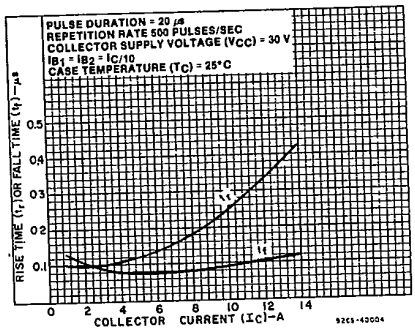


Fig. 23 – Typical rise-time and fall-time characteristics for all types.

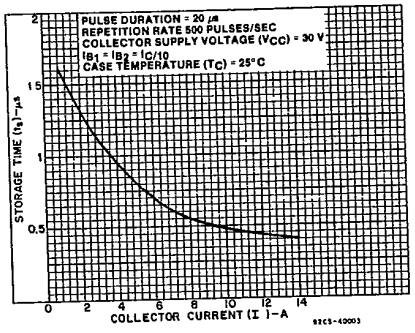


Fig. 24 – Typical storage time characteristic for all types.

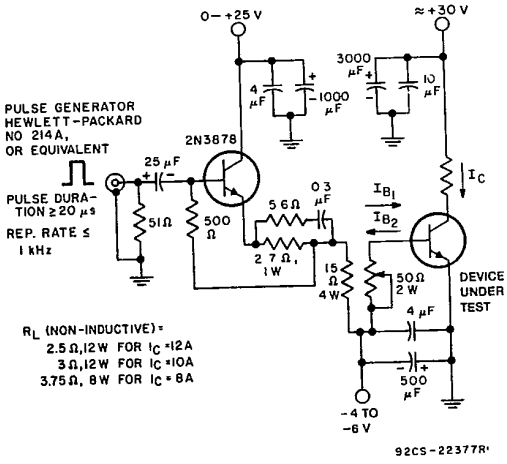


Fig. 25 – Circuit used to measure switching times for all types.

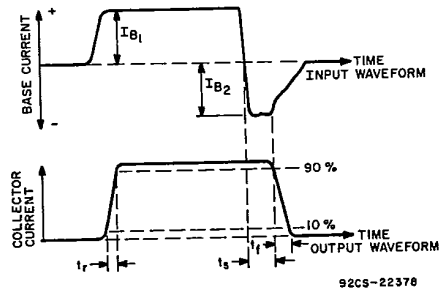


Fig. 26 – Phase relationship between input and output currents showing reference points for specification of switching times. (Test circuit shown in Fig. 26).