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

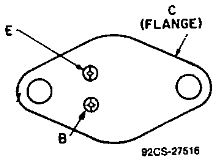
Features:

- *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 $R_{BE} \leqslant 50\ \Omega$	$V_{CER}(sus)$	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

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*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)	$\lvert h_{fe} \rvert$		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 $R_{BE} \leqslant 50\ \Omega$	$V_{CER}(sus)^b$					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	–	–	V
			5			12^a			–	1 8	–	–	–		
			2			8^a			–	–	–	–	–	1.6	
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					10^a		1.0	–	–	–	1.0	–	–	V
						12^a		1.2	–	1.0	–	–	–	–	
*						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] $I_{B_1} = I_{B_2}$ = value shown.

[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.

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

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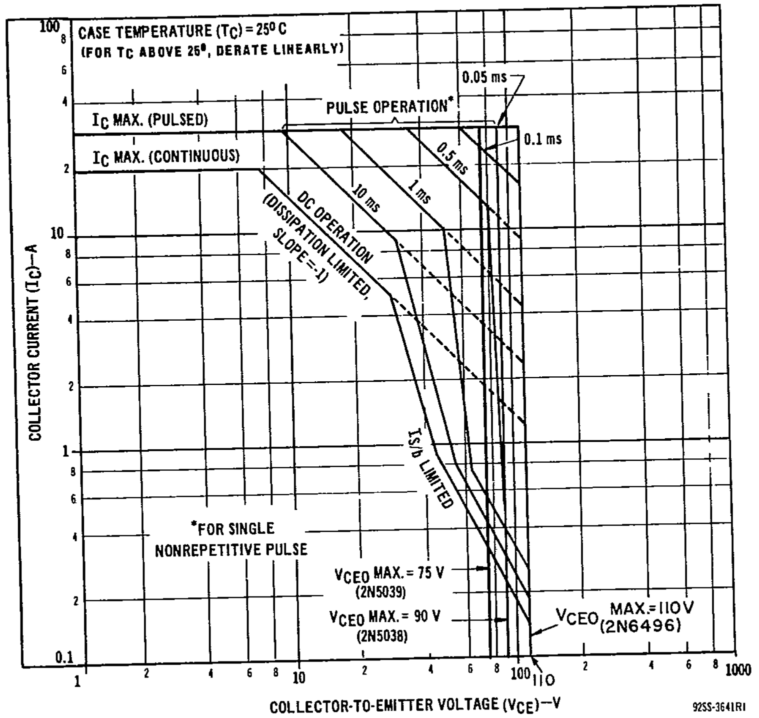

Fig. 1 — Maximum operating areas for all types.

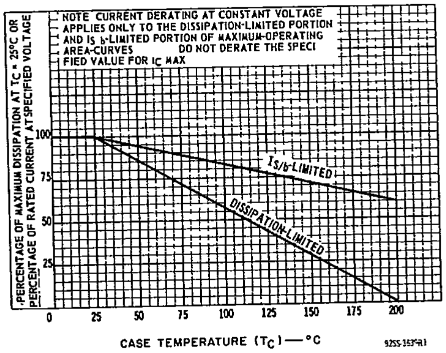

Fig. 2 — Dissipation derating curves for all types.

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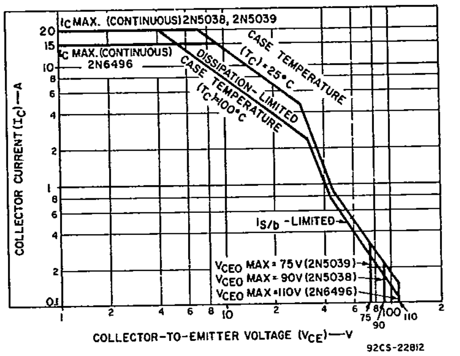

Fig. 3 - Maximum operating areas for all types.

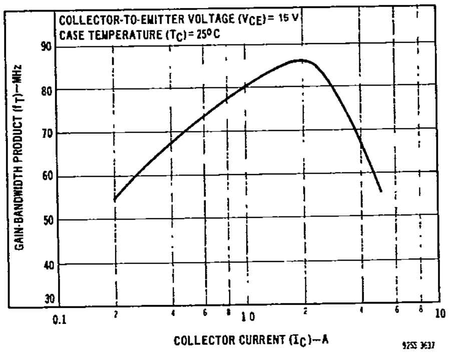

Fig. 4 - Typical gain-bandwidth product for all types.

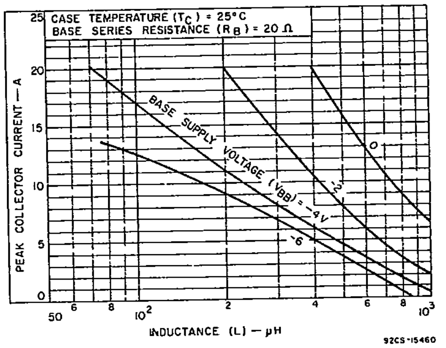

Fig. 5 - Maximum reverse-bias, second-breakdown characteristics for 2N5038 and 2N5039.

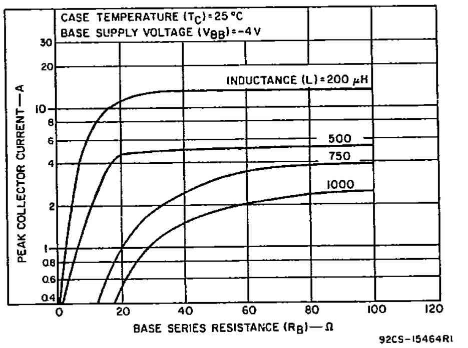

Fig. 6 - Maximum reverse-bias, second-breakdown characteristics for 2N5038 and 2N5039.

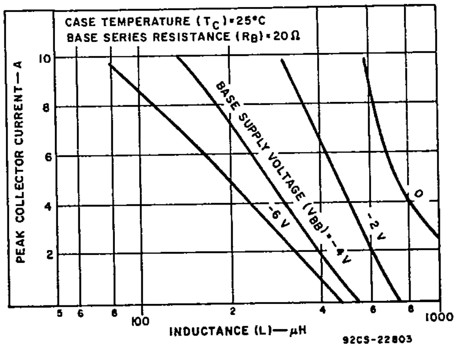

Fig. 7 - Maximum reverse-bias, second-breakdown characteristics for 2N6496.

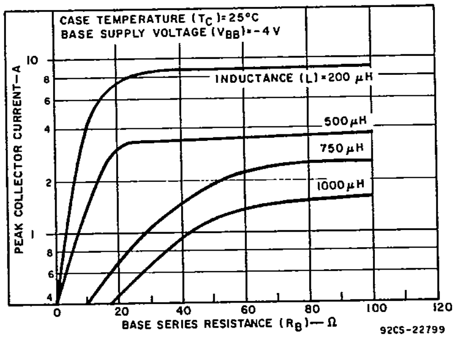

Fig. 8 - Maximum reverse-bias, second-breakdown characteristics for 2N6496.

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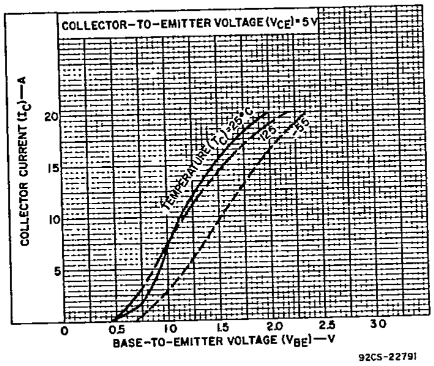

Fig. 9 - Typical transfer characteristics for 2N5038.

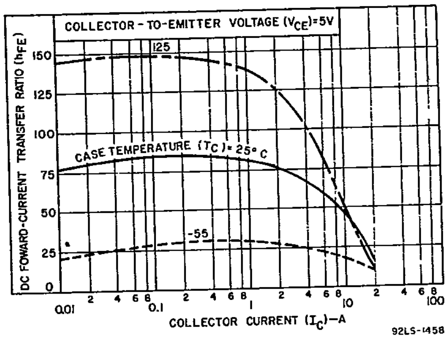

Fig. 10 - Typical dc beta characteristics for 2N5038.

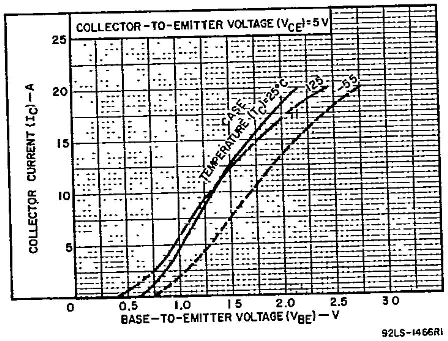

Fig. 11 - Typical transfer characteristics for 2N5039.

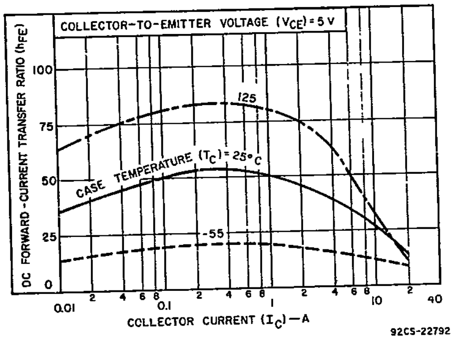

Fig. 12 -Typical dc beta characteristics for 2N5039.

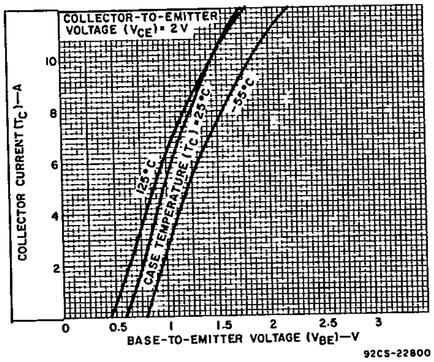

Fig. 13 - Typical transfer characteristics for 2N6496.

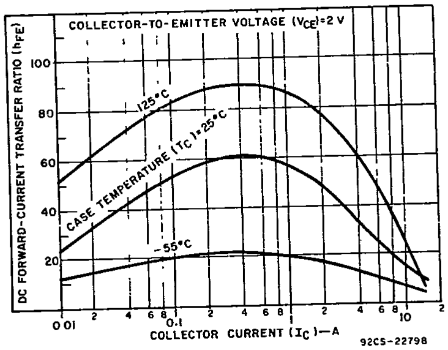

Fig. 14 - Typical dc beta characteristics for 2N6496.

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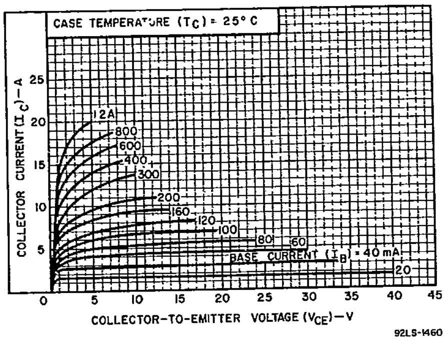

Fig. 15 - Typical output characteristics for 2N5038.

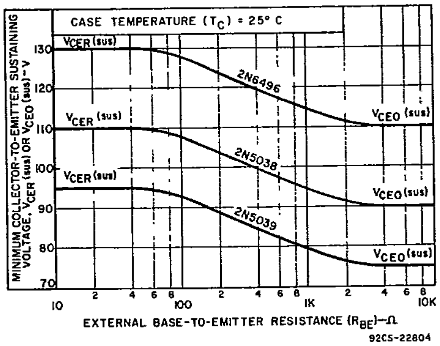

Fig. 16 - Collector-to-emitter sustaining voltage characteristic for all types.

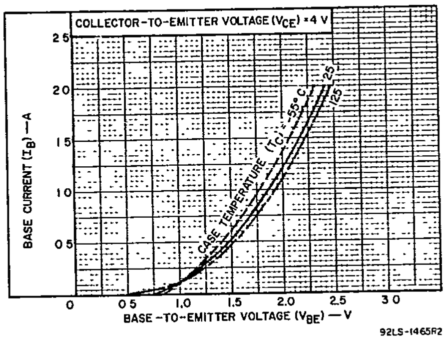

Fig. 17 - Typical output characteristics for 2N5039.

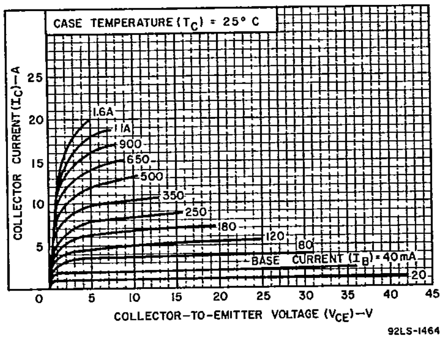

Fig. 18 - Typical input characteristics for 2N5038 and 2N5039.

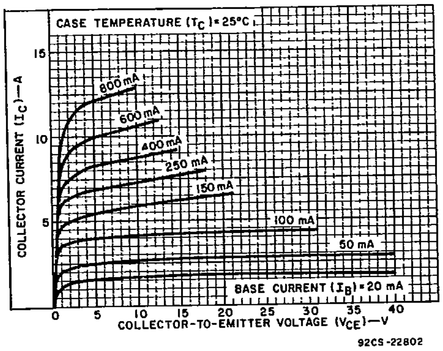

Fig. 19 - Typical output characteristics for 2N6496.

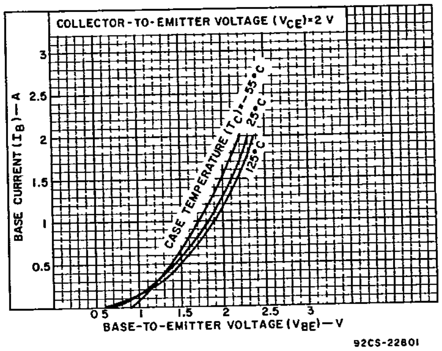

Fig. 20 - Typical input characteristics for 2N6496.

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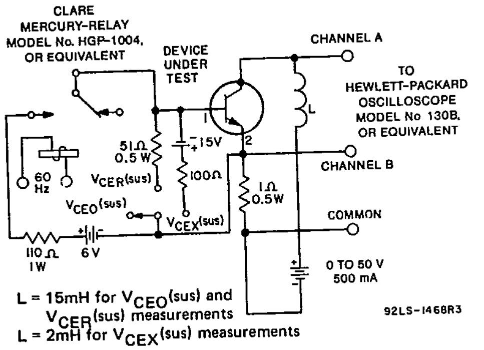
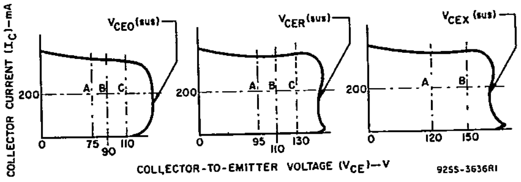


Fig. 21 - Circuit used to measure sustaining voltages V_{CEO}(sus), V_{CER}(sus), and V_{CEX}(sus).



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).

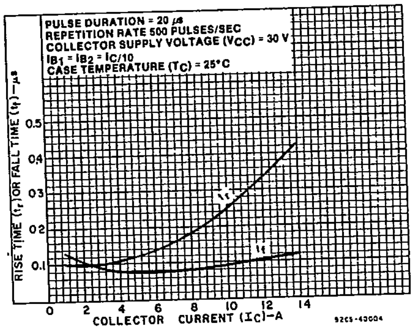


Fig. 23 - Typical rise-time and fall-time characteristics for all types.

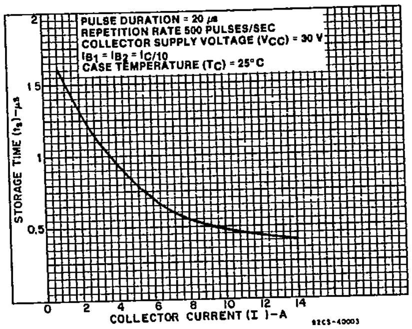


Fig. 24 - Typical storage time characteristic for all types.

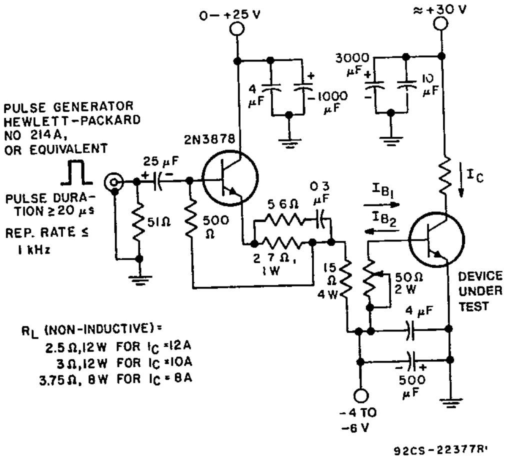


Fig. 25 - Circuit used to measure switching times for all types.

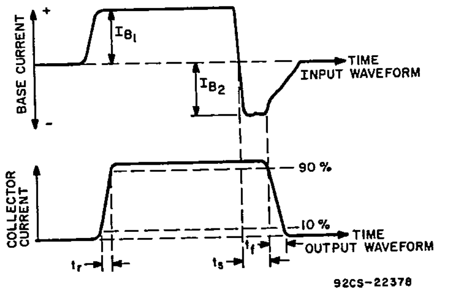


Fig. 26 — Phase relationship between input and output currents showing reference points for specification of switching times. (Test circuit shown in Fig. 26).