RCA
Solid State
Division

Power Transistors
2N5038
2N5039
2N6496

JEDEC TO-3 H-1570

High-Current, High-Power, High-Speed Silicon N-P-N Power 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 ratings**
- **High-dissipation capability**
- **Switching Time:** **Measured at:**
  t_r = 0.5 μs max. } **12 A (2N5038)**
  t_s = 1.5 μs max. } **10 A (2N5039)**
  t_f = 0.5 μs max. } **8 A (2N6496)**

RCA-2N5038, 2N5039, and 2N6496 are epitaxial silicon n-p-n power 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-3 package.

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)

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

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS VOLTAGE V dc V_{CE}	TEST CONDITIONS VOLTAGE V dc V_{BE}	TEST CONDITIONS CURRENT A dc I_C	TEST CONDITIONS CURRENT A dc I_B	LIMITS 2N5038 Min.	LIMITS 2N5038 Max.	LIMITS 2N5039 Min.	LIMITS 2N5039 Max.	LIMITS 2N6496 Min.	LIMITS 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	250	30	250	–	–	
*			5		10[a]		–	–	20	100	–	–	
*			5		12[a]		20	100	–	–	–	–	
*			2		8[a]		–	–	–	–	12	100	
*	Magnitude of Small-Signal Forward-Current Transfer Ratio: f = 5 MHz	$\|h_{fe}\|$	10		2		12	–	12	–	12	–	
	Collector-to-Emitter Sustaining Voltage: With base open	$V_{CEO(sus)}$			0.2	0	90[b]	–	75[b]	–	100[b]	–	V
	With base-emitter junction reverse biased and external base-to-emitter resistance (R_{BE}) = 100 Ω	$V_{CEX(sus)}$		−1.5	0.2	0	150[b]	–	120[b]	–			
	With $R_{BE} \leq 50\ \Omega$	$V_{CER(sus)}$			0.2	0	110[b]	–	95[b]	–	130[b]	–	
	Emitter-to-Base Voltage: I_E = 0.05 A	V_{EBO}			0		7	–	7	–	7	–	V
	Base-to-Emitter	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: V_{CB} = 10 V	C_{ob}					–	400	–	400	–	400	pF
	Forward-Bias Second-Breakdown Collector Current: t = 1s, nonrepetitive	$I_{S/b}$	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	$E_{S/b}$		−4	12		13	–	13	–	–	–	mJ
				−4	8		–	–	–	–	5.7	–	
†	Saturated Switching Time (V_{CC} = 30 V, $I_{B_1} = I_{B_2}$):	t_r			10	1.0	–	–	–	0.5	–	–	μs
	Rise Time (See Figs.24, 26, and 27)				12	1.2	–	0.5	–	–	–	–	
					8	0.8	–	–	–	–	–	0.5	
†	Storage Time (See Figs.25, 26, and 27)	t_s			10	1.0	–		–	1.5	–	–	
					12	1.2	–	1.5	–	–	–	–	
					8	0.8	–	–	–	–	–	1.5	
*	Fall Time (See Figs. 24, 26, and 27)	t_f			10	1.0	–	–	–	0.5	–	–	
					12	1.2	–	0.5	–	–	–	–	
					8	0.8	–	–	–	–	–	0.5	
	Thermal Resistance: Junction-to-Case	$R_{\theta JC}$	10		10		–	1.25	–	1.25	–	1.25	°C/W

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

[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. These sustaining voltages should be measured by means of the test circuit shown in Fig. 22.

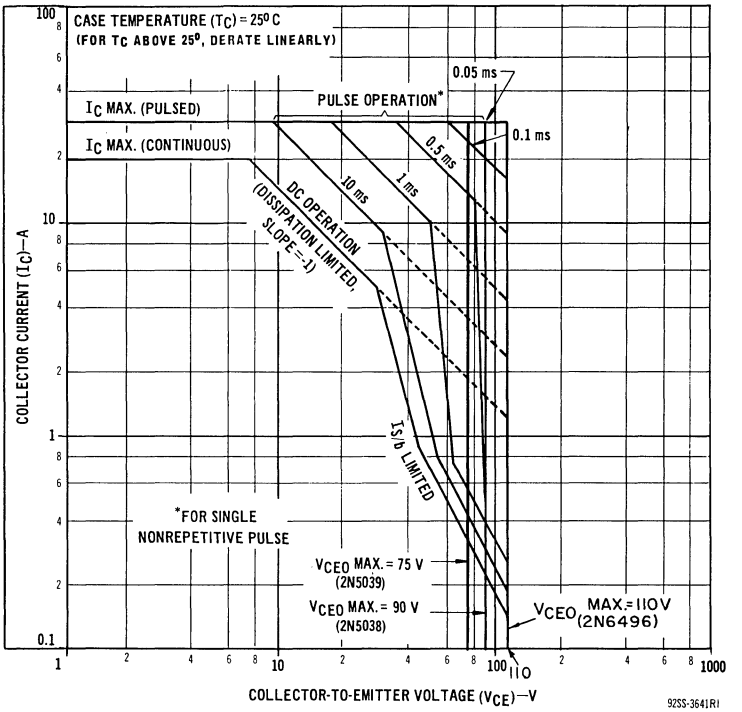


Fig. 1 — Maximum operating areas for all types.

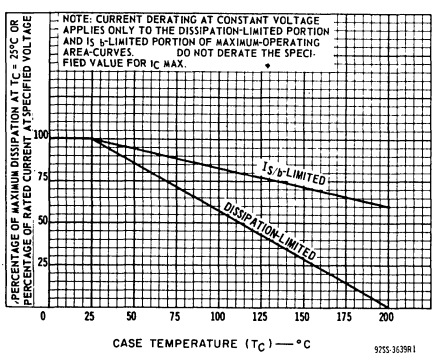


Fig. 2 — Dissipation derating curves for all types.

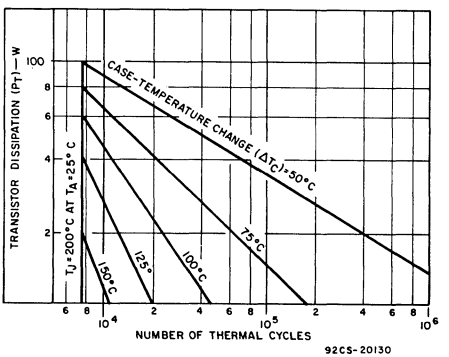


Fig. 3 — Thermal-cycling rating chart for all types.

TERMINAL CONNECTIONS

Pin 1 — Base
Pin 2 — Emitter
Case — Collector
Mounting Flange — Collector

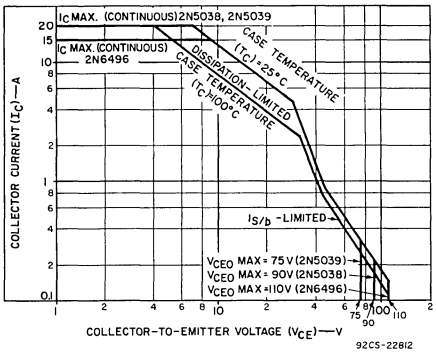


Fig. 4 — Maximum operating areas for all types.

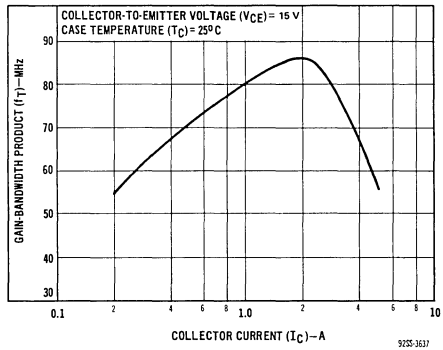


Fig. 5 — Typical gain-bandwidth product for all types.

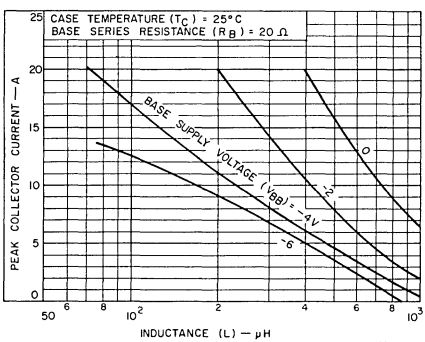


Fig. 6 — Maximum reverse-bias, second-breakdown characteristics for 2N5038 and 2N5039.

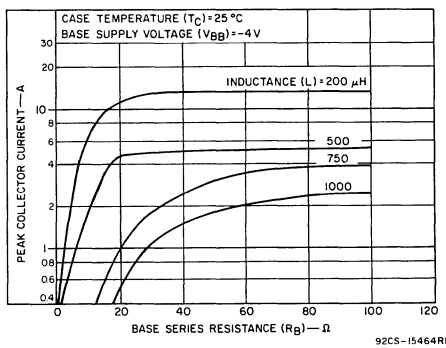


Fig. 7 — Maximum reverse-bias, second-breakdown characteristics for 2N5038 and 2N5039.

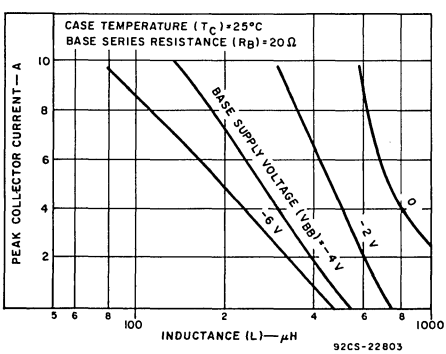


Fig. 8 — Maximum reverse-bias, second-breakdown characteristics for 2N6496.

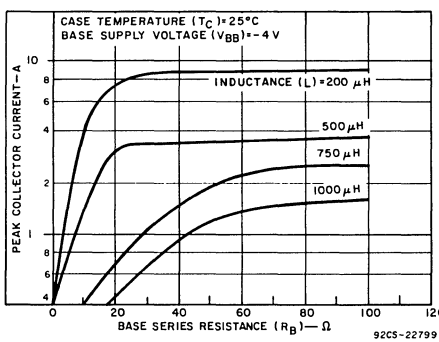


Fig. 9 — Maximum reverse-bias, second-breakdown characteristics for 2N6496.

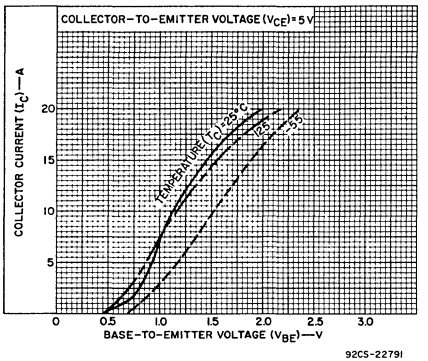


Fig. 10 – Typical transfer characteristics for 2N5038.

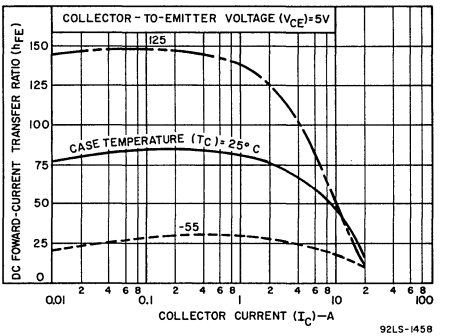


Fig. 11 – Typical dc beta characteristics for 2N5038.

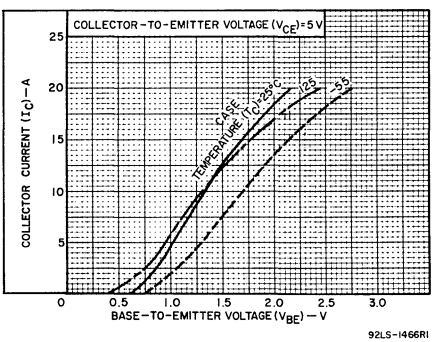


Fig. 12 – Typical transfer characteristics for 2N5039.

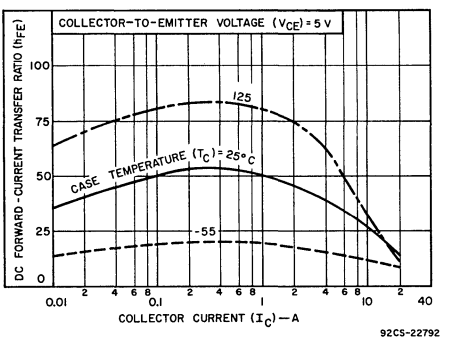


Fig. 13 – Typical dc beta characteristics for 2N5039.

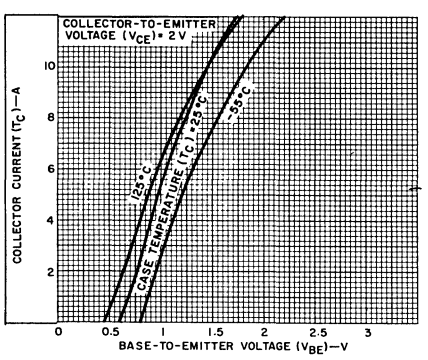


Fig. 14 – Typical transfer characteristics for 2N6496.

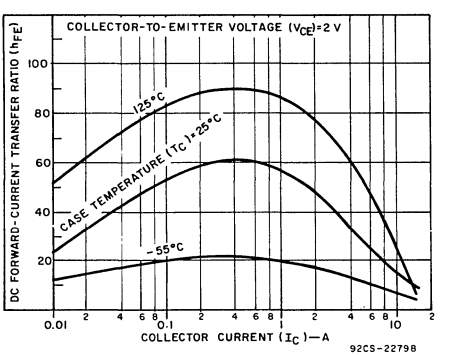


Fig. 15 – Typical dc beta characteristics for 2N6496.

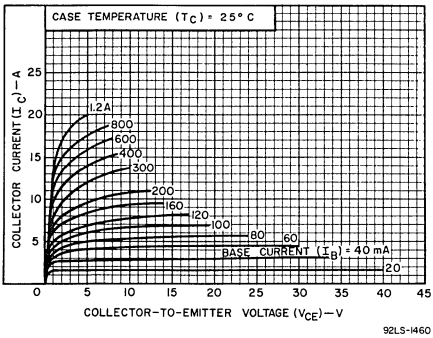


Fig. 16 — Typical output characteristics for 2N5038.

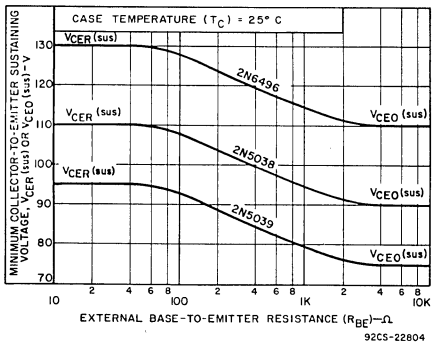


Fig. 17 — Collector-to-emitter sustaining voltage characteristic for all types.

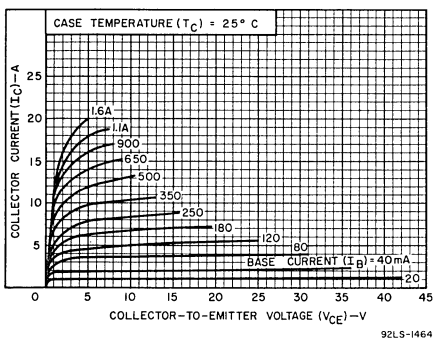


Fig. 18 — Typical output characteristics for 2N5039.

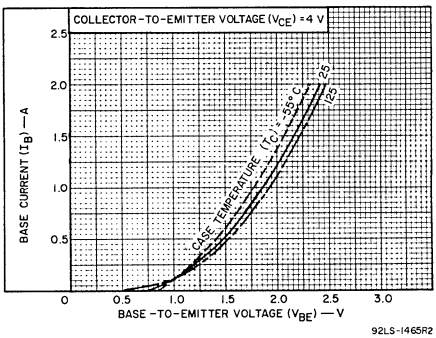


Fig. 19 — Typical input characteristics for 2N5038 and 2N5039.

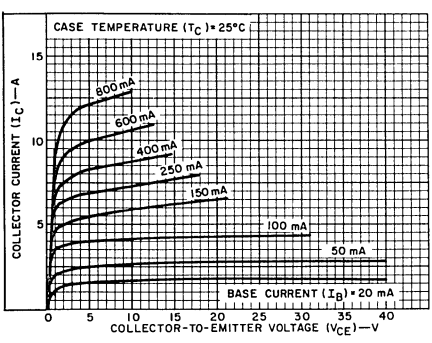


Fig. 20 — Typical output characteristics for 2N6496.

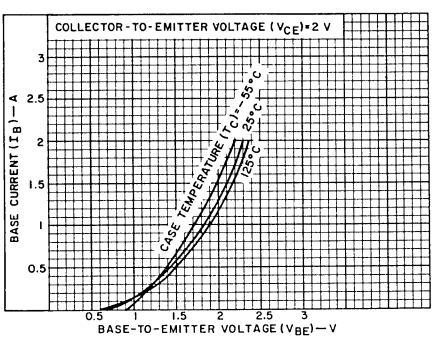
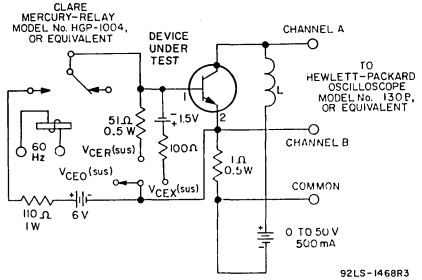
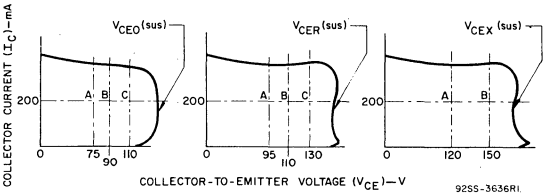


Fig. 21 — Typical input characteristics for 2N6496.



L = 15mH for V_{CEO}(sus) and V_{CER}(sus) measurements
L = 2mH for V_{CEX}(sus) measurements

Fig. 22 – 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. 23 – Oscilloscope display for measurement of sustaining voltages (Test circuit shown in Fig. 22).

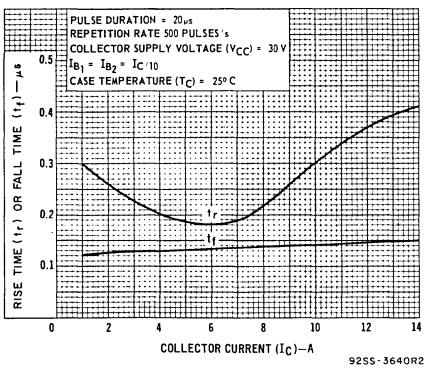


Fig. 24 – Typical rise-time and fall-time characteristics for all types.

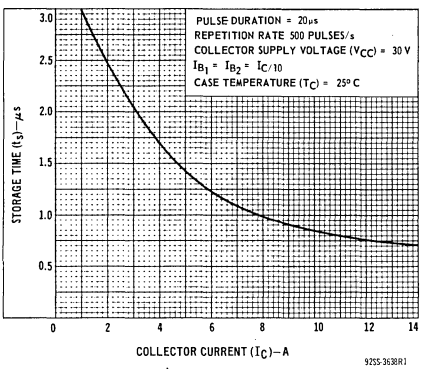


Fig. 25 – Typical storage time characteristic for all types.

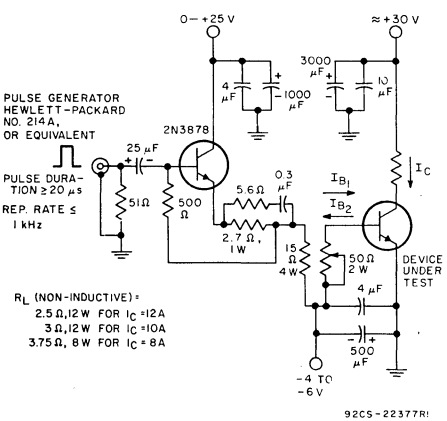


Fig. 26 – Circuit used to measure switching times for all types.

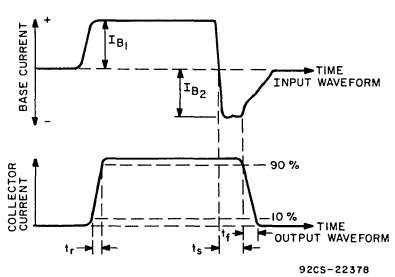


Fig. 27 – Phase relationship between input and output currents showing reference points for specification of switching times. (Test circuit shown in Fig. 26).