

# TYPES 2N2659, 2N2660, 2N2661, 2N2662, 2N2663, 2N2664 2N2665, 2N2666, 2N2667, 2N2668, 2N2669, 2N2670 P-N-P ALLOY-JUNCTION GERMANIUM MEDIUM-POWER TRANSISTORS

TYPES 2N2659 THRU 2N2670  
 BULLETIN NO. DL-5 664128, AUGUST 1968  
 REVISED FEBRUARY 1968

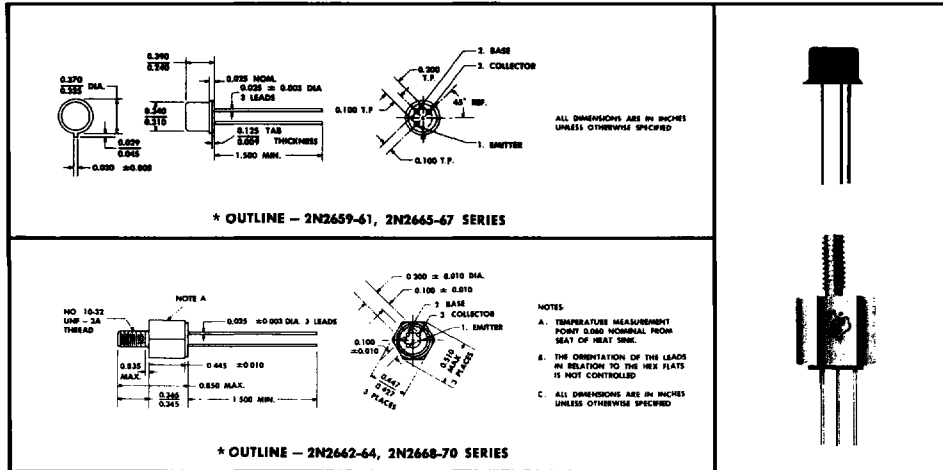
**50-, 70-, or 90-VOLT UNITS**  
**15 WATTS at 25°C CASE TEMPERATURE**  
 Choice of TO-5 or Stud Package  
 Guaranteed Beta at 1 amp and 500 ma  $I_c$

Guaranteed  $I_{CEX}$  at 85°C  
 LOW  $r_{CS}$  • LOW  $I_{CBO}$  • LOW  $V_{BE}$   
 for  
**RELAY DRIVERS • PULSE AMPLIFIERS**  
**SERVO AMPLIFIERS • AUDIO AMPLIFIERS**

## mechanical data

The transistors are in hermetically sealed, resistance-welded cases with glass-to-metal seals between case and leads. The 2N2659-2N2661 and 2N2665-2N2667 are in a round TO-5 package weighing approximately 2.4 grams. The 2N2662-2N2664 and 2N2668-2N2670 are in a stud package weighing approximately 5.4 grams.

\*THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



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## \*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N2659	2N2660	2N2661
Collector-Base Voltage	50 v	70 v	90 v
Collector-Emitter Voltage (See Note 1)	50 v	70 v	90 v
Emitter-Base Voltage	← 20 v →		
Collector Current	← 3 a →		
Base Current	← 1 a →		
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	← 15 w →		
Operating Case Temperature Range	-55°C to 100°C		
Storage Temperature Range	-55°C to 100°C		

NOTES: 1. This value applies when base-emitter voltage  $V_{BE} = +0.2$  v.  
 2. Derate linearly to 100°C case temperature at the rate of 200 mw/°C.

\*Indicates JEDEC registered data.

**TYPES 2N2659, 2N2660, 2N2661, 2N2662, 2N2663, 2N2664  
2N2665, 2N2666, 2N2667, 2N2668, 2N2669, 2N2670  
P-N-P ALLOY-JUNCTION GERMANIUM MEDIUM-POWER TRANSISTORS**

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TO-5 CASE	2N2659	2N2660	2N2661	UNIT	
		STUD CASE	2N2662	2N2663	2N2664		
		MIN	MAX	MIN	MAX	MIN	MAX
$BV_{CBO}$ Collector-Base Breakdown Voltage	$I_C = -600 \mu a, I_E = 0$		-50	-70	-90		v
* $BV_{CEO}$ Collector-Emitter Breakdown Voltage	$I_C = -100 ma, I_B = 0$ , (See Note 3)		-30	-40	-50		v
* $BV_{CES}$ Collector-Emitter Breakdown Voltage	$I_C = -50 ma, V_{BE} = 0$ , (See Note 3)		-50	-70	-90		v
$I_{CBO}$ Collector Cutoff Current	$V_{CB} = -25 v, I_E = 0$ $V_{CB} = -35 v, I_E = 0$ $V_{CB} = -45 v, I_E = 0$		-125	-125	-125		$\mu a$
* $I_{CEO}$ Collector Cutoff Current	$V_{CE} = -15 v, I_B = 0$ $V_{CE} = -20 v, I_B = 0$ $V_{CE} = -25 v, I_B = 0$		-20	-20	-20		ma
* $I_{CEX}$ Collector Cutoff Current	$V_{CE} = -50 v, V_{BE} = +0.2 v$ $V_{CE} = -70 v, V_{BE} = +0.2 v$ $V_{CE} = -90 v, V_{BE} = +0.2 v$		-600	-600	-600		$\mu a$
* $I_{CEX}$ Collector Cutoff Current	$V_{CE} = -25 v, V_{BE} = +0.2 v$ $V_{CE} = -35 v, V_{BE} = +0.2 v$ $V_{CE} = -45 v, V_{BE} = +0.2 v$		-125	-125	-125		$\mu a$
* $I_{CEX}$ Collector Cutoff Current	$V_{CE} = -25 v, V_{BE} = +0.2 v, T_C = 85^\circ C$ $V_{CE} = -35 v, V_{BE} = +0.2 v, T_C = 85^\circ C$ $V_{CE} = -45 v, V_{BE} = +0.2 v, T_C = 85^\circ C$		-5	-5	-5		ma
* $I_{EBO}$ Emitter Cutoff Current	$V_{EB} = -20 v, I_C = 0$		-100	-100	-100		$\mu a$
* $h_{FE}$ Static Forward Current Transfer Ratio	$V_{CE} = -0.5 v, I_C = -1 a$ , (See Note 4) $V_{CE} = -0.5 v, I_C = -500 ma$ , (See Note 4) $V_{CE} = -0.5 v, I_C = -250 ma$ , (See Note 4)	15	30 90 125	15 30 90 125	15 30 90 125		
$h_{FE}$ Static Forward Current Transfer Ratio	$V_{CE} = -0.5 v, I_C = -500 ma, T_C = -55^\circ C$ , (See Note 4) $V_{CE} = -0.5 v, I_C = -500 ma, T_C = +85^\circ C$ , (See Note 4)	20 30	90 110	20 30	90 110	20 30	90 110
* $V_{BE}$ Base-Emitter Voltage	$V_{CE} = -0.5 v, I_C = -500 ma$ , (See Note 4)		-0.6	-0.6	-0.6		v
* $V_{CE(sat)}$ Collector-Emitter Saturation Voltage	$I_B = -50 ma, I_C = -500 ma$ , (See Note 4) $I_B = -50 ma, I_C = -500 ma$ , (See Note 4) $T_C = +85^\circ C$ , (See Note 4)		-0.2 -0.25	-0.2 -0.25	-0.2 -0.25		v
* $h_{fe}$ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -3 v, I_C = -100 ma, f = 1 kc$	30	120	30 120	30 120		
* $ h_{fe} $ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -3 v, I_C = -100 ma, f = 140 kc$	2.0		2.0	2.0		
$C_{ob}$ Common-Base Open-Circuit Output Capacitance	$V_{CB} = -3 v, I_E = 0, f = 135 kc$	100 (typical)		100 (typical)	100 (typical)		pf

NOTES: 3. These characteristics are measured by a 1/2 sine wave sweep method.

4. These measurements are made with voltage sensing contacts located 0.25 inches from header of transistor. Voltage sensing contacts are separate from current carrying contacts.

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electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TO-5 CASE	2N2665	2N2666	2N2667	UNIT
		STUD CASE	2N2668	2N2669	2N2670	
			MIN MAX	MIN MAX	MIN MAX	
$BV_{CBO}$ Collector-Base Breakdown Voltage	$I_C = -600 \mu a, I_E = 0$		-50	-70	-90	v
$BV_{CEO}$ Collector-Emitter Breakdown Voltage	$I_C = -100 ma, I_B = 0$ , (See Note 3)		-30	-40	-50	v
$BV_{CES}$ Collector-Emitter Breakdown Voltage	$I_C = -50 ma, V_{BE} = 0$ , (See Note 3)		-50	-70	-90	v
$I_{CBO}$ Collector Cutoff Current	$V_{CB} = -25 v, I_E = 0$ $V_{CB} = -35 v, I_E = 0$ $V_{CB} = -45 v, I_E = 0$		-125	-125	-125	$\mu a$
$I_{CEO}$ Collector Cutoff Current	$V_{CE} = -15 v, I_B = 0$ $V_{CE} = -20 v, I_B = 0$ $V_{CE} = -25 v, I_B = 0$		-20	-20	-20	ma
$I_{CEX}$ Collector Cutoff Current	$V_{CE} = -50 v, V_{BE} = +0.2 v$ $V_{CE} = -70 v, V_{BE} = +0.2 v$ $V_{CE} = -90 v, V_{BE} = +0.2 v$		-600	-600	-600	$\mu a$
$I_{CEX}$ Collector Cutoff Current	$V_{CE} = -25 v, V_{BE} = +0.2 v$ $V_{CE} = -35 v, V_{BE} = +0.2 v$ $V_{CE} = -45 v, V_{BE} = +0.2 v$		-125	-125	-125	$\mu a$
$I_{CEX}$ Collector Cutoff Current	$V_{CE} = -25 v, V_{BE} = +0.2 v, T_C = 85^\circ C$ $V_{CE} = -35 v, V_{BE} = +0.2 v, T_C = 85^\circ C$ $V_{CE} = -45 v, V_{BE} = +0.2 v, T_C = 85^\circ C$		-5	-5	-5	ma
$I_{EBO}$ Emitter Cutoff Current	$V_{EB} = -20 v, I_C = 0$		-100	-100	-100	$\mu a$
$h_{FE}$ Static Forward Current Transfer Ratio	$V_{CE} = -0.5 v, I_C = -1 a$ , (See Note 4) $V_{CE} = -0.5 v, I_C = -500 ma$ , (See Note 4) $V_{CE} = -0.5 v, I_C = -250 ma$ , (See Note 4)		25 50 150 200	25 50 150 200	25 50 150 200	
$h_{FE}$ Static Forward Current Transfer Ratio	$V_{CE} = -0.5 v, I_C = -500 ma$ , (See Note 4) $T_C = -55^\circ C$ , $V_{CE} = -0.5 v, I_C = -500 ma$ , (See Note 4) $T_C = +85^\circ C$ ,		30 150 50 170	30 150 50 170	30 150 50 170	
$V_{BE}$ Base-Emitter Voltage	$V_{CE} = -0.5 v, I_C = -500 ma$ , (See Note 4)		-0.6	-0.6	-0.6	v
$V_{CE(sat)}$ Collector-Emitter Saturation Voltage	$I_B = -25 ma, I_C = -500 ma$ , (See Note 4) $I_B = -25 ma, I_C = -500 ma$ , (See Note 4) $T_C = +85^\circ C$ ,		-0.2 -0.25	-0.2 -0.25	-0.2 -0.25	v
$h_{fe}$ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -3 v, I_C = -100 ma, f = 1 kc$		50 200	50 200	50 200	
$ h_{fe} $ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -3 v, I_C = -100 ma, f = 150 kc$		2.0	2.0	2.0	
$C_{ob}$ Common-Base Open-Circuit Output Capacitance	$V_{CB} = -3 v, I_E = 0, f = 135 kc$		100 (typical)	100 (typical)	100 (typical)	pf

NOTES: 3. These characteristics are measured by a 1/2 sine wave sweep method.

4. These measurements are made with voltage sensing contacts located 0.25 inches from header of transistor. Voltage sensing contacts are separate from current carrying contacts.

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switching characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS †	TYPICAL	UNIT
$t_d$ Delay Time	$I_C = -500 \text{ ma}$	0.10	$\mu\text{sec}$
$t_r$ Rise Time	$V_{BE}(\text{OFF}) = 7.4 \text{ v}$	0.22	$\mu\text{sec}$
$t_s$ Storage Time	$R_L = 60 \Omega$	0.30	$\mu\text{sec}$
$t_f$ Fall Time	(See Figure 1)	1.25	$\mu\text{sec}$
$t_T$ Total Switching Time		1.9	$\mu\text{sec}$

† Voltage and current values are nominal, except values vary slightly with device parameters.

## PARAMETER MEASUREMENT INFORMATION

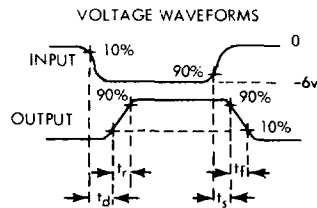
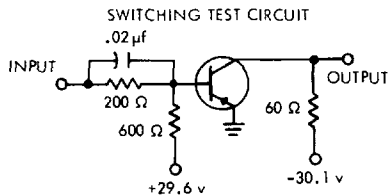
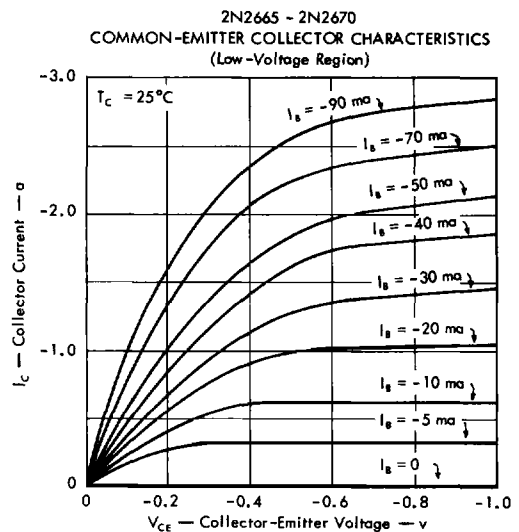
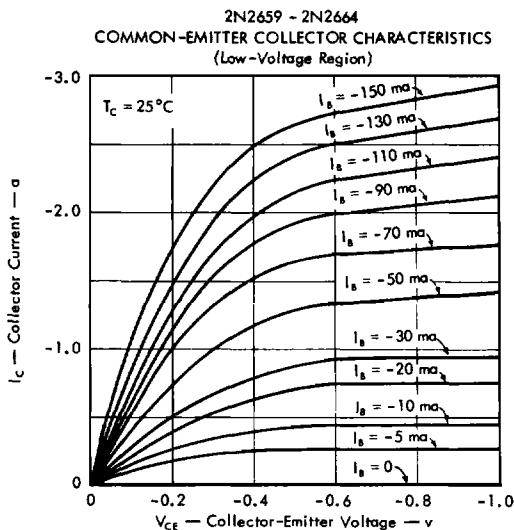


FIGURE 1

**NOTES:**

- (a) The input waveform has the following characteristics:  
 $t_r \leq 10 \mu\text{sec}$ ,  $t_f \leq 10 \mu\text{sec}$ ,  $PW = 1.6 \text{ msec}$ , Duty Cycle = 10%
- (b) Waveforms are monitored on an oscilloscope with the following characteristics:  
 $t_r \leq 14 \mu\text{sec}$ ,  $R_{in} \geq 10 \text{ M}\Omega$ ,  $C_{in} \leq 11.5 \text{ pf}$ .
- (c) Resistors must be non-inductive types.

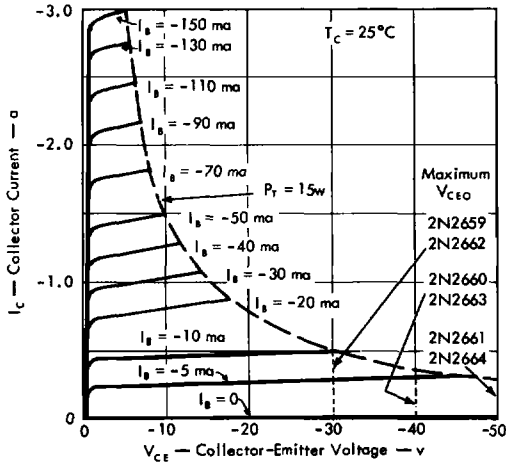
## TYPICAL CHARACTERISTICS



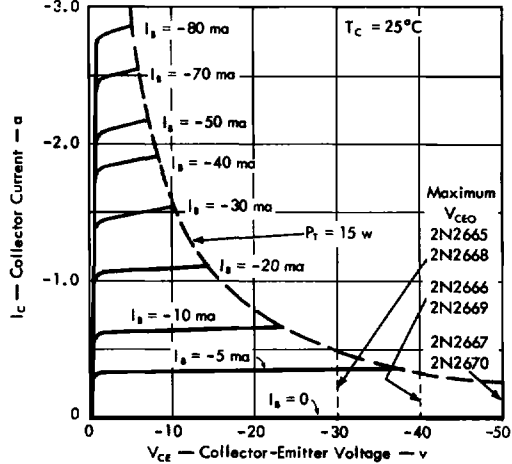
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## TYPICAL CHARACTERISTICS

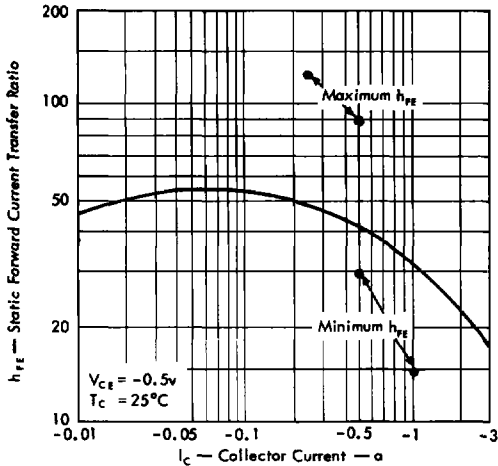
2N2659 - 2N2664  
COMMON-EMITTER COLLECTOR CHARACTERISTICS  
(High-Voltage Region)



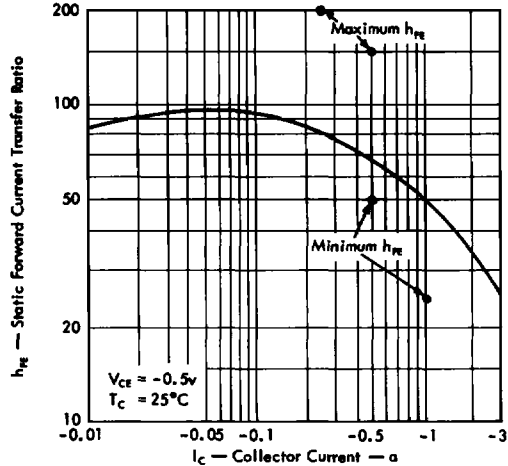
2N2665 - 2N2670  
COMMON-EMITTER COLLECTOR CHARACTERISTICS  
(High-Voltage Region)



2N2659 - 2N2664  
STATIC FORWARD CURRENT TRANSFER RATIO  
vs  
COLLECTOR CURRENT

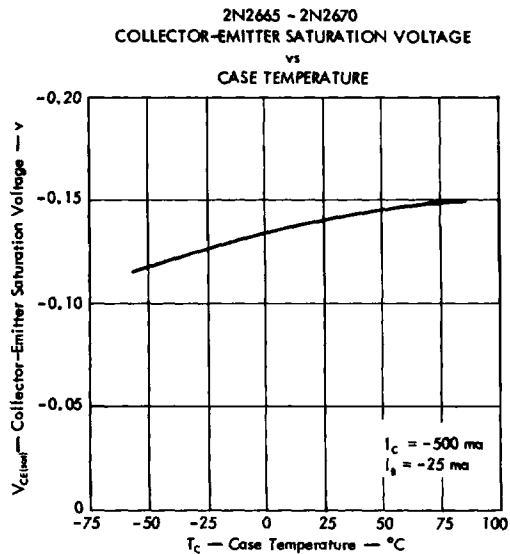
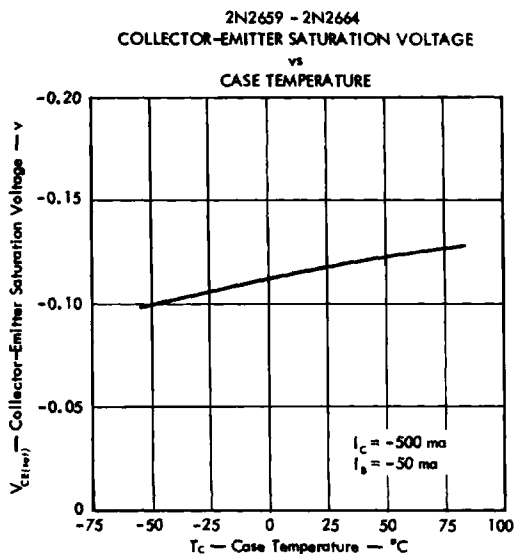
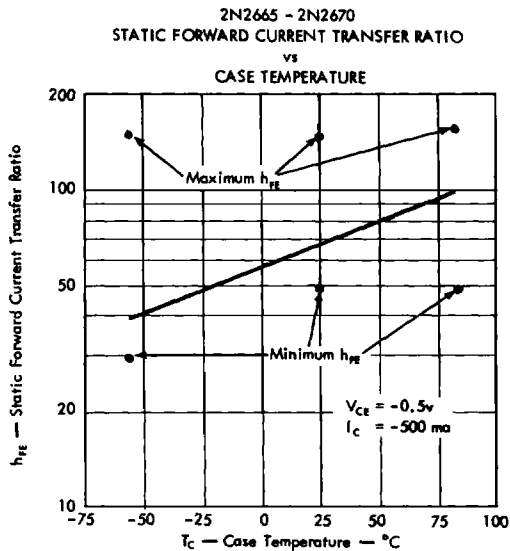
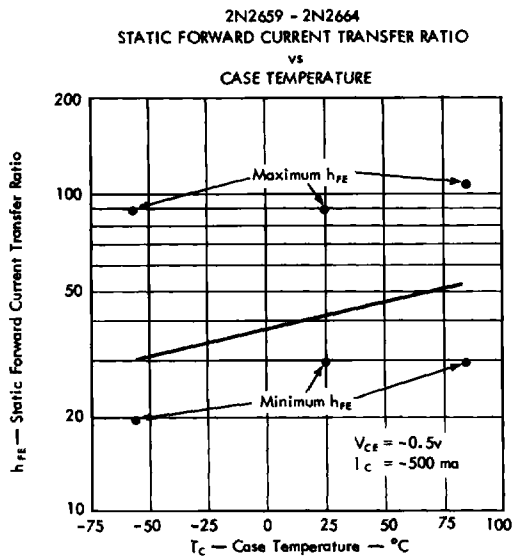


2N2665 - 2N2670  
STATIC FORWARD CURRENT TRANSFER RATIO  
vs  
COLLECTOR CURRENT



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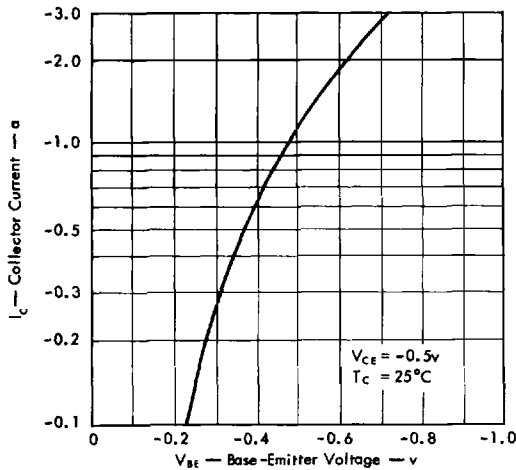
## TYPICAL CHARACTERISTICS



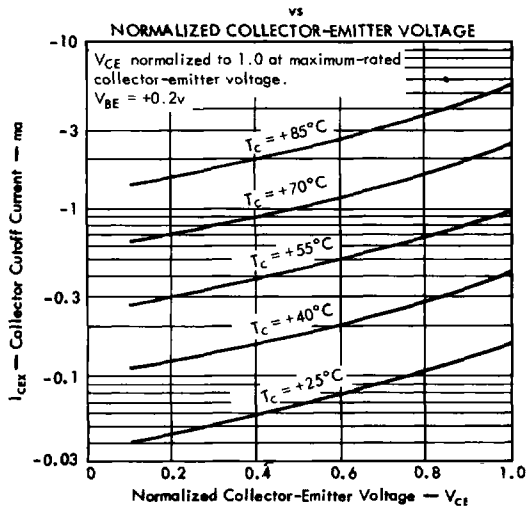
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## TYPICAL CHARACTERISTICS

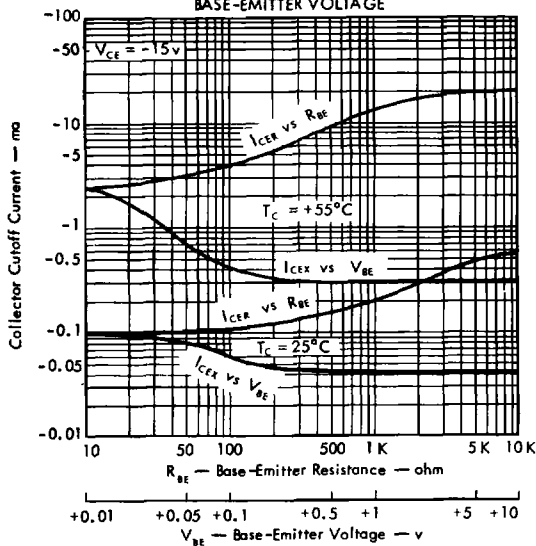
COMMON-EMITTER TRANSFER CHARACTERISTICS



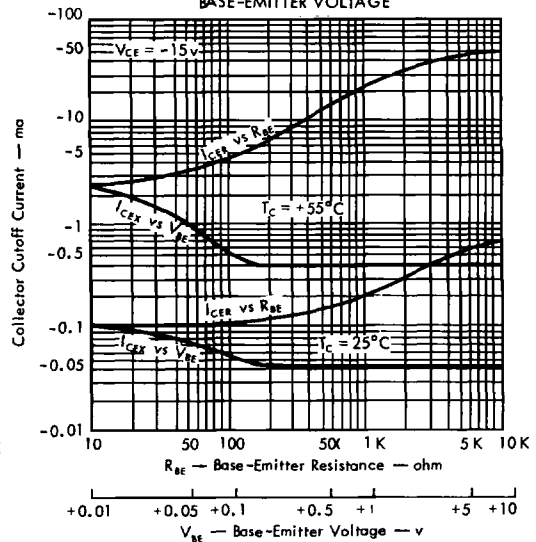
COLLECTOR CUTOFF CURRENT



2N2659 - 2N2664  
COLLECTOR CUTOFF CURRENT  
vs  
BASE-EMITTER RESISTANCE  
and  
BASE-EMITTER VOLTAGE

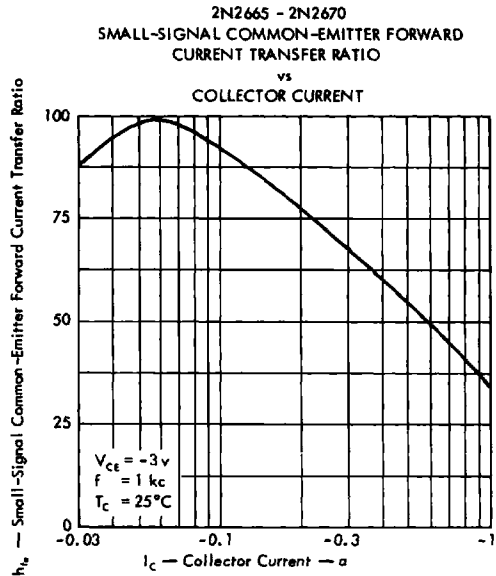
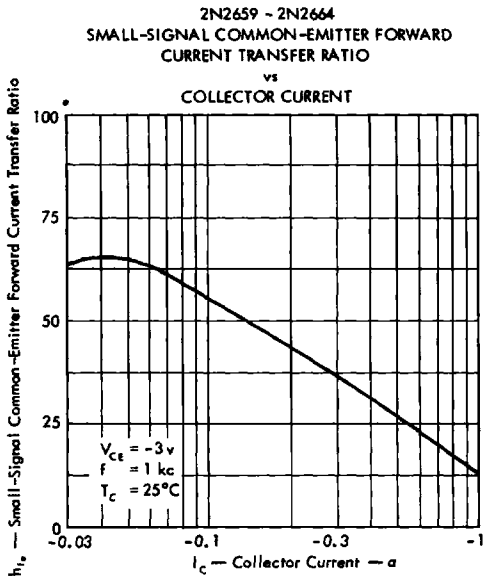


2N2665 - 2N2670  
COLLECTOR CUTOFF CURRENT  
vs  
BASE-EMITTER RESISTANCE  
and  
BASE-EMITTER VOLTAGE

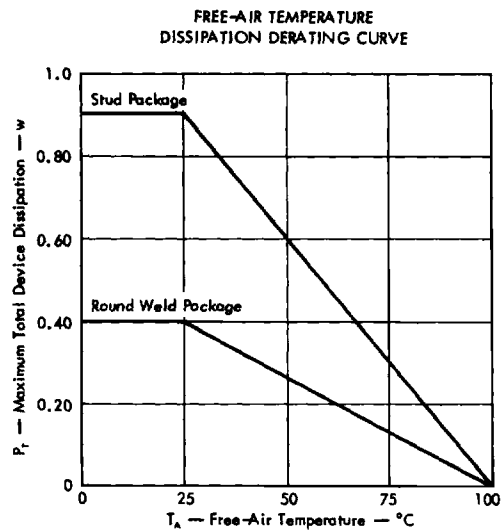
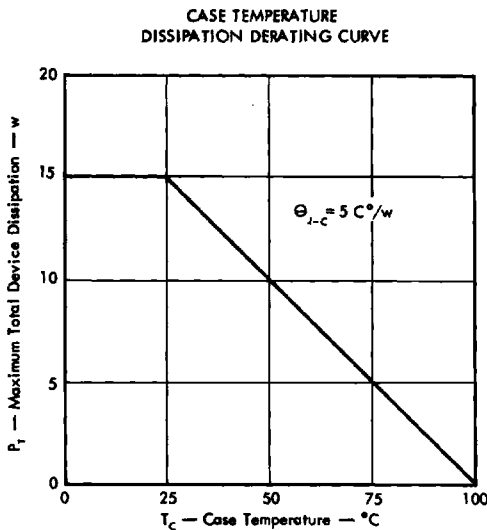


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2N2665, 2N2666, 2N2667, 2N2668, 2N2669, 2N2670  
P-N-P ALLOY-JUNCTION GERMANIUM MEDIUM-POWER TRANSISTORS**

**TYPICAL CHARACTERISTICS**



**THERMAL CHARACTERISTICS**



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