TYPES 2N456B, 2N457B, 2N458B, 2N1021A AND 2N1022A
P-N-P ALLOY-JUNCTION GERMANIUM POWER TRANSISTORS

TYPES 2N456B, 2N457B, 2N458B, 2N1021A, AND 2N1022A
BULLETIN NO. DL-S 633454, FEBRUARY 1963

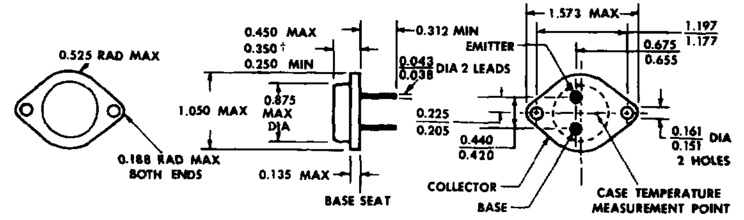
High-Power Transistors
for
Military and Industrial Applications

mechanical data

The use of silver alloy to assemble the mounting base and the use of resistance welding to seal the can, provide a hermetically sealed enclosure. During the assembly process the absence of flux, combined with extreme cleanliness, prevents sealed-in contamination.

The mounting base provides an excellent heat path from the collector junction to a heat sink which must be in intimate contact to permit operation at maximum rated dissipation.

*The transistors are in a JEDEC TO-3 case.



*THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

†The TI guaranteed maximum value.

DIMENSIONS ARE IN INCHES

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

	2N456B	2N457B	2N458B	2N1021A	2N1022A
Collector-Base Voltage	40 v	60 v	80 v	100 v	120 v
Collector-Emitter Voltage (see Note 1)	30 v	40 v	45 v	50 v	55 v
Emitter-Base Voltage	←		30 v		→
Collector Current	←		7 a		→
Base Current	←		3 a		→
Total Device Dissipation at (or below) 25°C Case Temperature (see Note 2)	←		150 w		→
Collector Junction Temperature	←		100°C		→
Storage Temperature Range	←		− 55°C to + 100°C		→

*Indicates JEDEC registered data

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to + 100°C case temperature at the rate of 2w/C°.

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

PARAMETER		TEST CONDITIONS	TYPE	MIN	TYP	MAX	UNIT
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = -2$ ma, $I_E = 0$	2N456B	−40			v
			2N457B	−60			
			2N458B	−80			
			2N1021A	−100			
			2N1022A	−120			
BV_{CEO}	Collector-Emitter Breakdown Voltage	$I_C = -500$ ma, $I_B = 0$ (see Note 3)	2N456B	−30*			v
			2N457B	−40*			
			2N458B	−45*			
			2N1021A	−50*			
			2N1022A	−55*			
BV_{CES}	Collector-Emitter Breakdown Voltage	$I_C = -200$ ma, $V_{BE} = 0$ (see Note 3)	2N456B	−50*			v
			2N457B	−60*			
			2N458B	−65*			
			2N1021A	−70*			
			2N1022A	−75*			
BV_{CEX}	Collector-Emitter Breakdown Voltage	$I_C = -2$ ma, $V_{BE} = +0.2$ v	2N456B	−40*			v
			2N457B	−60*			
			2N458B	−80*			
			2N1021A	−100*			
			2N1022A	−120*			
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = -2$ ma, $I_C = 0$	All	−30			v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20$ v, $I_E = 0$	2N456B			−0.5*	ma
		$V_{CB} = -40$ v, $I_E = 0$				−2.0*	
		$V_{CB} = -40$ v, $I_E = 0$, $T_C = 70°C$				−7.0*	
		$V_{CB} = -30$ v, $I_E = 0$	2N457B			−0.5*	ma
		$V_{CB} = -60$ v, $I_E = 0$				−2.0*	
		$V_{CB} = -60$ v, $I_E = 0$, $T_C = 70°C$				−7.0*	
		$V_{CB} = -40$ v, $I_E = 0$	2N458B			−0.5*	ma
		$V_{CB} = -80$ v, $I_E = 0$				−2.0*	
		$V_{CB} = -80$ v, $I_E = 0$, $T_C = 70°C$				−7.0*	
		$V_{CB} = -50$ v, $I_E = 0$	2N1021A			−0.5*	ma
		$V_{CB} = -100$ v, $I_E = 0$				−2.0*	
		$V_{CB} = -100$ v, $I_E = 0$, $T_C = 70°C$				−7.0*	
		$V_{CB} = -60$ v, $I_E = 0$	2N1022A			−0.5*	ma
		$V_{CB} = -120$ v, $I_E = 0$				−2.0*	
		$V_{CB} = -120$ v, $I_E = 0$, $T_C = 70°C$				−7.0*	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -30$ v, $I_C = 0$	All			−2.0*	ma
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1.5$ v, $I_C = -7$ a	All	22*	45	90*	—
		$V_{CE} = -1.5$ v, $I_C = -5$ a		30*	55		
		$V_{CE} = -1.5$ v, $I_C = -3$ a		35*	60		
		$V_{CE} = -1.5$ v, $I_C = -1$ a		40*	100		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -1.5$ v, $I_C = -7$ a	All		−1.2	−1.5*	v
		$V_{CE} = -1.5$ v, $I_C = -5$ a			−0.9		
		$V_{CE} = -1.5$ v, $I_C = -3$ a			−0.7		
		$V_{CE} = -1.5$ v, $I_C = -1$ a			−0.4		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -700$ ma, $I_C = -7$ a	All		−0.3	−0.5*	v
		$I_B = -500$ ma, $I_C = -5$ a			−0.2		
		$I_B = -300$ ma, $I_C = -3$ a			−0.1		
		$I_B = -100$ ma, $I_C = -1$ a			−.05		
f_T	Transition Frequency	$V_{CE} = -2$ v, $I_C = -1$ a (see Note 4)	All	200*			kc

*Indicates JEDEC registered data.

NOTES: 3. If the transistor is tested without a heat sink, perform this test with a 100 msec current pulse and a duty cycle less than 2%.

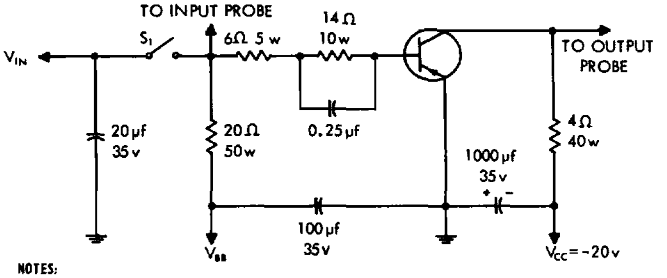
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 db/octave from f = 100 kc to the frequency at which $|h_{fe}| = 1$.

switching characteristics at 25°C case temperature

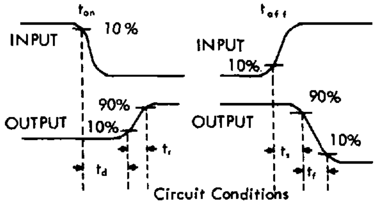
PARAMETER		TEST CONDITIONS†	2N456B, 2N457B, 2N458B, 2N1021A, 2N1022A			UNIT
			MIN	TYP	MAX	
t_d	Delay Time	$I_C = -5$ a, $I_{B(1)} = -0.5$ a, $V_{BE(off)} = 9$ v $R_L = 4\Omega$ (See Figure Below)		0.7		μsec
t_r	Rise Time			5		μsec
t_s	Storage Time			2		μsec
t_f	Fall Time			15		μsec
t_T	Total Switching Time			22.7		μsec

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

PARAMETER MEASUREMENT INFORMATION



VOLTAGE WAVEFORMS



Circuit Conditions

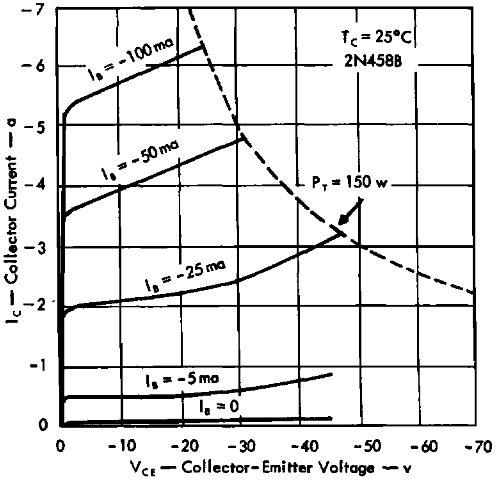
Test	V_{BB}	V_{IN}
Turn-On (t_d, t_r)	+9v	-11v
Turn-Off (t_s, t_f)	-21v	+9v

NOTES:

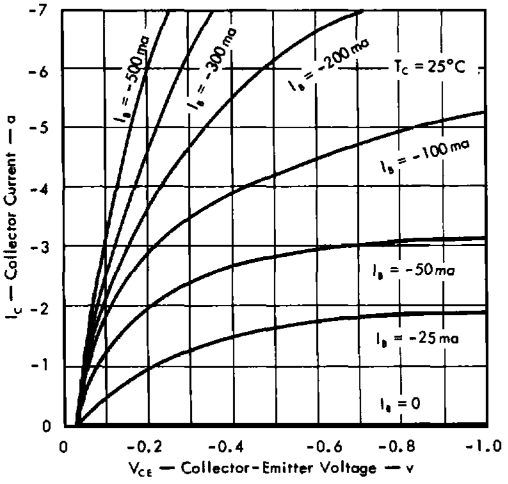
1. Relay S_1 has mercury wetted contacts and provides rise times less than 1/10 of the switching times measured.
2. Duty cycle of S_1 is such that the transistor is ON 4 msec and OFF 12 msec in both turn-on and turn-off tests.
3. Waveforms monitored on scope with following characteristics: (a) Rise time 14 nsec max, (b) Input capacitance 11.5 pf max, (c) Input resistance 10 megohms min.
4. All resistors 5% tolerance, noninductive type.

TYPICAL CHARACTERISTICS

COMMON-EMITTER COLLECTOR CHARACTERISTICS
(Active Region)



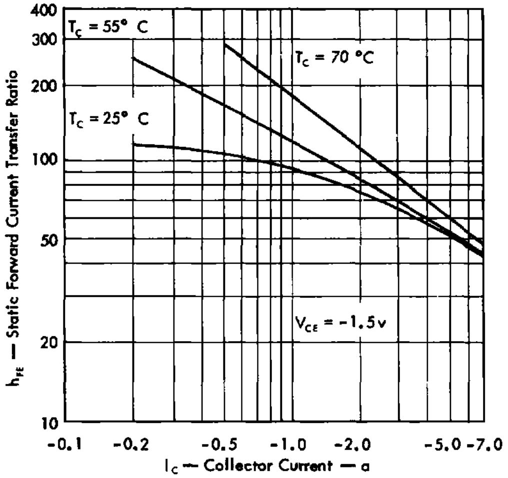
COMMON-EMITTER COLLECTOR CHARACTERISTICS
(Saturation Region)



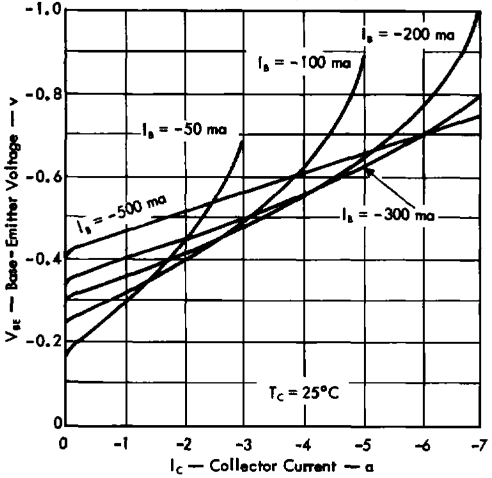
TYPES 2N456B, 2N457B, 2N458B, 2N1021A AND 2N1022A P-N-P ALLOY-JUNCTION GERMANIUM POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT



BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT



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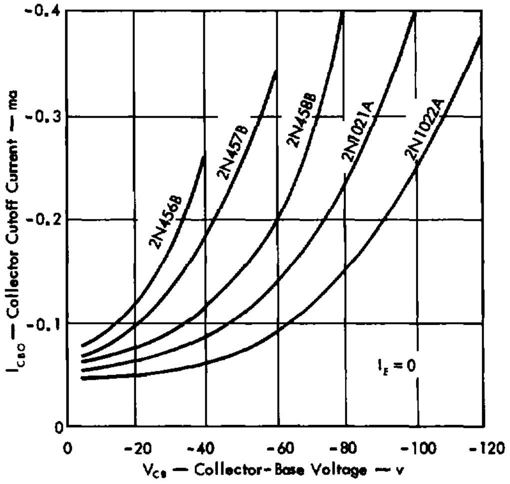
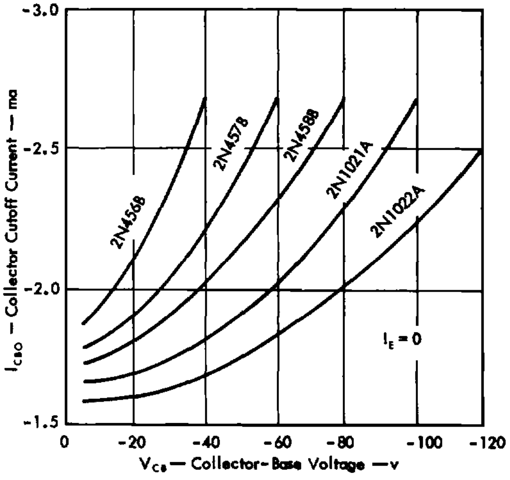
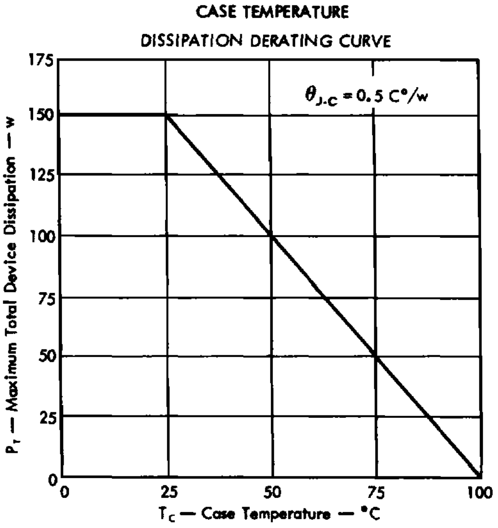
COLLECTOR CUTOFF CURRENT
vs
COLLECTOR-BASE VOLTAGE
T_C = 25°C

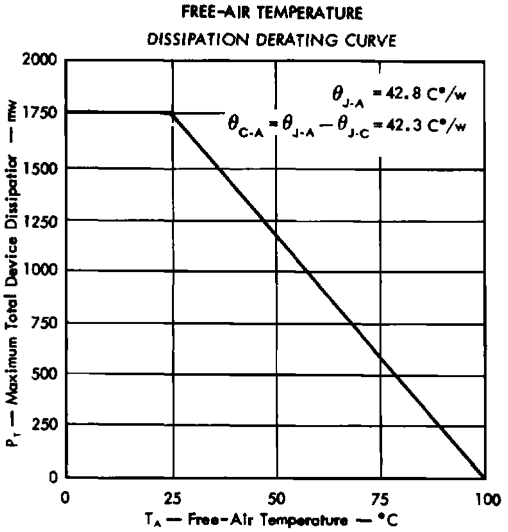


COLLECTOR CUTOFF CURRENT
vs
COLLECTOR-BASE VOLTAGE
T_C = 70°C



THERMAL CHARACTERISTICS


CASE TEMPERATURE
DISSIPATION DERATING CURVE


FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

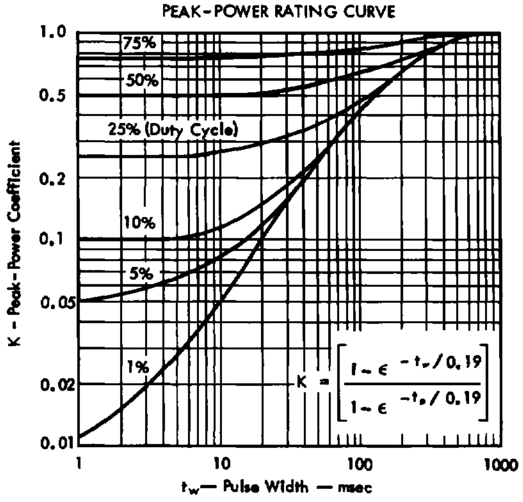

PEAK-POWER RATING CURVE

Figure 1

TYPES 2N456B, 2N457B, 2N458B, 2N1021A AND 2N1022A
P-N-P ALLOY-JUNCTION GERMANIUM POWER TRANSISTORS

THERMAL INFORMATION

TABLE I

HEAT SINK		$\dagger\theta_{HS\text{-}A}$
Type	**Dimensions**	
Bright Copper	4″ x 4″ x 1/8″	3.8 C°/w
	6″ x 6″ x 1/8″	2.2 C°/w
	8″ x 8″ x 1/8″	1.8 C°/w
	10″ x 10″ x 1/8″	1.4 C°/w
Bright Aluminum	4″ x 4″ x 1/8″	6.5 C°/w
	6″ x 6″ x 1/8″	4.5 C°/w
	8″ x 8″ x 1/8″	3.5 C°/w
	10″ x 10″ x 1/8″	2.8 C°/w
Delbert Blinn #113 or Modine 1E1155B, Unfinished (or Equivalents)		3.7 C°/w
Delbert Blinn #113 or Modine 1E1155B, Black Anodized (or Equivalents)		3.2 C°/w

† $\theta_{HS\text{-}A}$ are typical values based on convection cooling; plates and fins mounted in vertical position.

‡All transistors mounted in the center of the heat sink with two 6-32 screws at 6 inch-pounds of torque.

TABLE II

DEFINITION OF TERMS

Symbol	Definition	Unit	Value
P_T	Average Power Dissipation	w	
p_T	Peak Power Dissipation	w	
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	C°/w	0.5
$\theta_{J\text{-}A}$	Junction-to-Ambient Thermal Resistance	C°/w	42.8
$\theta_{C\text{-}A}$	Case-to-Ambient Thermal Resistance	C°/w	42.3
‡$\theta_{C\text{-}HS}$	Case-to-Heat Sink Thermal Resistance — Typical w/o DC-11 Grease	C°/w	0.65
	Typical with DC-11 Grease		0.45
$\theta_{HS\text{-}A}$	Heat-Sink Thermal Resistance	C°/w	see Table 1
T_A	Ambient Temperature	C°	
T_J	Average Junction Temperature	C°	
T_j	Peak Junction Temperature	C°	
T_c	Case Temperature	C°	
K	Peak-Power Coefficient		see Fig. 1
t_w	Pulse Width	msec	
t_p	Pulse Period	msec	
d	Duty Cycle (t_w/t_p)		

The PEAK–POWER RATING CURVE shows the ratio of maximum instantaneous junction-to-case temperature rise at any pulse width and duty cycle to the rise which occurs at 100% duty cycle. Use of this curve is best explained by the equations and examples below. See Table II for a definition of terms.

Equation No. 1 — Application: D.C. power dissipation, heat sink used.

$$P_T = \frac{T_J - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}}$$

Equation No. 2 — Application: D.C. power dissipation, no heat sink used.

$$P_T = \frac{T_J - T_A}{\theta_{J\text{-}A}}$$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$p_T = \frac{T_j - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$p_T = \frac{T_j - T_A}{d\,\theta_{C\text{-}A}\;K\,\theta_{J\text{-}C}}$$

Example A — Find $P_{T(max)}$

OPERATING CONDITIONS:

Heat Sink = 4″ x 4″ x 1/8″ copper, $\theta_{HS\text{-}A} = 3.8$ C°/w
$T_{J(max)}$ (design limit) = 100 C°
$T_A = 30$ C°
d = 100% (1.0)
with DC-11 grease, $\theta_{C\text{-}HS} = 0.45$ C°/w

SOLUTION:

By use of equation No. 1

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}}$$

$$P_{T(max)} = \frac{100 - 30}{0.5 + 0.45 + 3.8} = 14.7 \text{ w}$$

Example B — Find $p_{T(max)}$

OPERATING CONDITIONS:

Heat Sink = 8″ x 8″ x 1/8″ copper,
$\theta_{HS\text{-}A} = 1.8$ C°/w
with DC-11 grease, $\theta_{C\text{-}HS} = 0.45$ C°/w
$T_{j(max)}$ (design limit) = 100 C°
$T_A = 35$ C°
d = 5% (0.05)
$t_w = 40$ msec

SOLUTION:

From Figure 1, Peak-Power Coefficient,
K = 0.2, and by use of equation No. 3

$$p_{T(max)} = \frac{T_{j(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$

$$p_{T(max)} = \frac{100 - 35}{0.05\,(0.45 + 1.8) + 0.2\,(0.5)} = 306 \text{ w}$$

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