

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

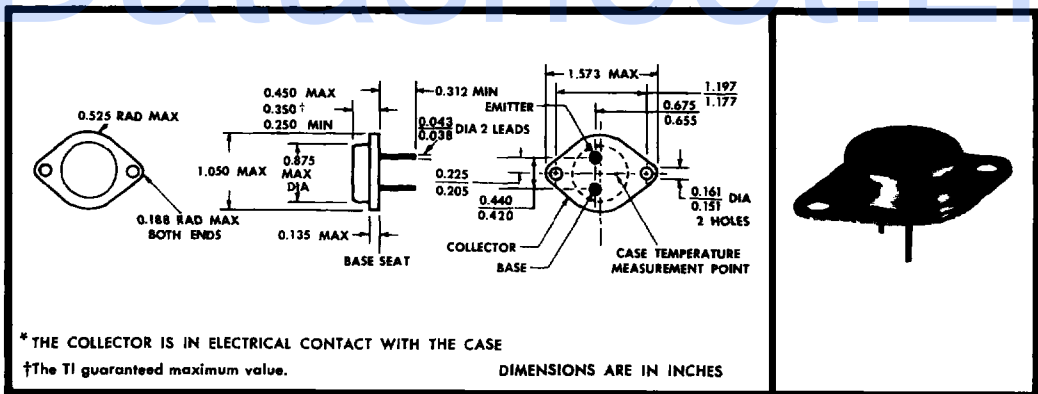
High-Power Transistors for Military and Industrial Applications

TYPES 2N456B, 2N457B, 2N458B, 2N1021A, AND 2N1022A
BULLETIN NO. DLS-63454, FEBRUARY 1963

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.



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*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.

TYPES 2N456B, 2N457B, 2N458B, 2N1021A AND 2N1022A

P-N-P ALLOY-JUNCTION GERMANIUM POWER TRANSISTORS

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

PARAMETER	TEST CONDITIONS	TYPE	MIN	TYP	MAX	UNIT
BV_{CBO} Collector-Base Breakdown Voltage	$I_C = -2 \text{ ma}$, $I_E = 0$	2N456B 2N457B 2N458B 2N1021A 2N1022A	-40 -60 -80 -100 -120			v
BV_{CEO} Collector-Emitter Breakdown Voltage	$I_C = -500 \text{ ma}$, $I_B = 0$ (see Note 3)	2N456B 2N457B 2N458B 2N1021A 2N1022A	-30* -40* -45* -50* -55*			v
BV_{CES} Collector-Emitter Breakdown Voltage	$I_C = -200 \text{ ma}$, $V_{BE} = 0$ (see Note 3)	2N456B 2N457B 2N458B 2N1021A 2N1022A	-50* -60* -65* -70* -75*			v
BV_{CEX} Collector-Emitter Breakdown Voltage	$I_C = -2 \text{ ma}$, $V_{BE} = +0.2 \text{ v}$	2N456B 2N457B 2N458B 2N1021A 2N1022A	-40* -60* -80* -100* -120*			v
BV_{EBO} Emitter-Base Breakdown Voltage	$I_E = -2 \text{ ma}$, $I_C = 0$	All	-30			v
I_{CBO} Collector Cutoff Current	$V_{CB} = -20 \text{ v}$, $I_E = 0$ $V_{CB} = -40 \text{ v}$, $I_E = 0$ $V_{CB} = -40 \text{ v}$, $I_E = 0$, $T_C = 70^\circ\text{C}$	2N456B			-0.5* -2.0* -7.0*	ma
	$V_{CB} = -30 \text{ v}$, $I_E = 0$ $V_{CB} = -60 \text{ v}$, $I_E = 0$ $V_{CB} = -60 \text{ v}$, $I_E = 0$, $T_C = 70^\circ\text{C}$	2N457B			-0.5* -2.0* -7.0*	ma
	$V_{CB} = -40 \text{ v}$, $I_E = 0$ $V_{CB} = -80 \text{ v}$, $I_E = 0$ $V_{CB} = -80 \text{ v}$, $I_E = 0$, $T_C = 70^\circ\text{C}$	2N458B			-0.5* -2.0* -7.0*	ma
	$V_{CB} = -50 \text{ v}$, $I_E = 0$ $V_{CB} = -100 \text{ v}$, $I_E = 0$ $V_{CB} = -100 \text{ v}$, $I_E = 0$, $T_C = 70^\circ\text{C}$	2N1021A			-0.5* -2.0* -7.0*	ma
	$V_{CB} = -60 \text{ v}$, $I_E = 0$ $V_{CB} = -120 \text{ v}$, $I_E = 0$ $V_{CB} = -120 \text{ v}$, $I_E = 0$, $T_C = 70^\circ\text{C}$	2N1022A			-0.5* -2.0* -7.0*	ma
	I_{EBO} Emitter Cutoff Current	$V_{EB} = -30 \text{ v}$, $I_C = 0$	All			-2.0*
h_{FE} Static Forward Current Transfer Ratio	$V_{CE} = -1.5 \text{ v}$, $I_C = -7 \text{ a}$	All	22*	45	90*	—
	$V_{CE} = -1.5 \text{ v}$, $I_C = -5 \text{ a}$		30*	55		
	$V_{CE} = -1.5 \text{ v}$, $I_C = -3 \text{ a}$		35*	60		
	$V_{CE} = -1.5 \text{ v}$, $I_C = -1 \text{ a}$		40*	100		
V_{BE} Base-Emitter Voltage	$V_{CE} = -1.5 \text{ v}$, $I_C = -7 \text{ a}$	All		-1.2	-1.5*	v
	$V_{CE} = -1.5 \text{ v}$, $I_C = -5 \text{ a}$			-0.9		
	$V_{CE} = -1.5 \text{ v}$, $I_C = -3 \text{ a}$			-0.7		
	$V_{CE} = -1.5 \text{ v}$, $I_C = -1 \text{ a}$			-0.4		
$V_{CE(sat)}$ Collector-Emitter Saturation Voltage	$I_B = -700 \text{ ma}$, $I_C = -7 \text{ a}$	All		-0.3	-0.5*	v
	$I_B = -500 \text{ ma}$, $I_C = -5 \text{ a}$			-0.2		
	$I_B = -300 \text{ ma}$, $I_C = -3 \text{ a}$			-0.1		
	$I_B = -100 \text{ ma}$, $I_C = -1 \text{ a}$			-0.05		
f_T Transition Frequency	$V_{CE} = -2 \text{ v}$, $I_C = -1 \text{ a}$ (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 $f = 100 \text{ kc}$ to the frequency at which $|h_{fe}| = 1$.

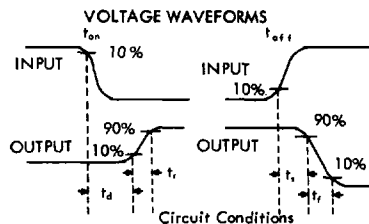
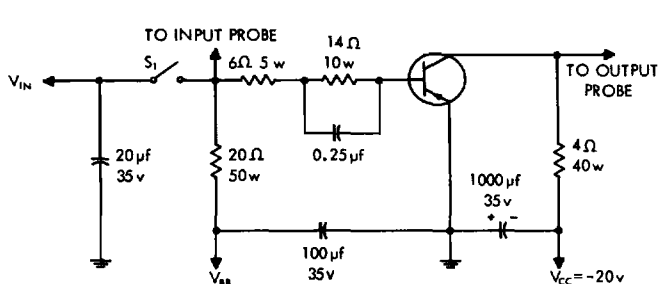
TYPES 2N456B, 2N457B, 2N458B, 2N1021A AND 2N1022A P-N-P ALLOY-JUNCTION GERMANIUM POWER TRANSISTORS

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 Figures 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



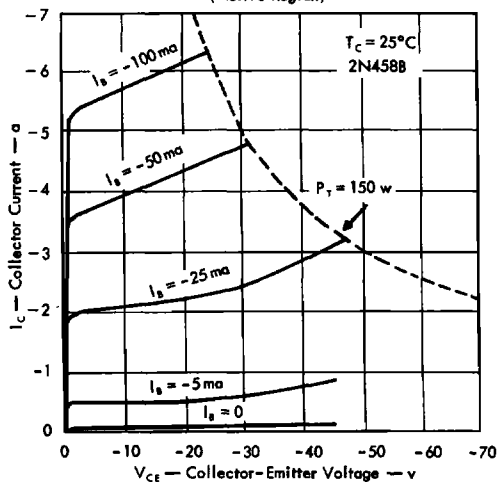
Test	V_{BS}	V_{IN}
Turn-On (t_d, t_r)	+9v	-11v
Turn-Off (t_f, t_r)	-21v	+9v

NOTES:

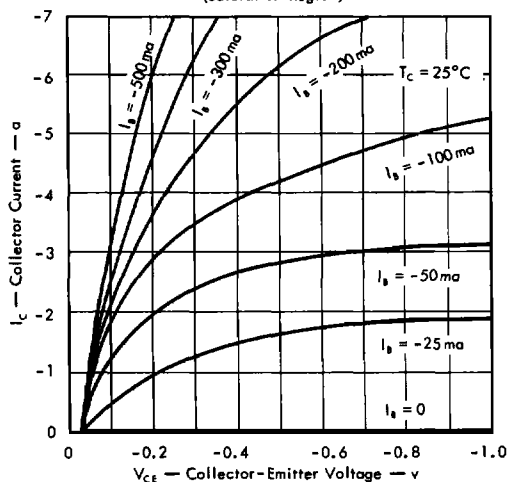
- Relay S_1 has mercury wetted contacts and provides rise times less than 1/10 of the switching times measured.
- Duty cycle of S_1 is such that the transistor is ON 4 msec and OFF 12 msec in both turn-on and turn-off tests.
- Waveforms monitored on scope with following characteristics: (a) Rise time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

TYPICAL CHARACTERISTICS

COMMON-EMITTER COLLECTOR
CHARACTERISTICS
(Active Region)

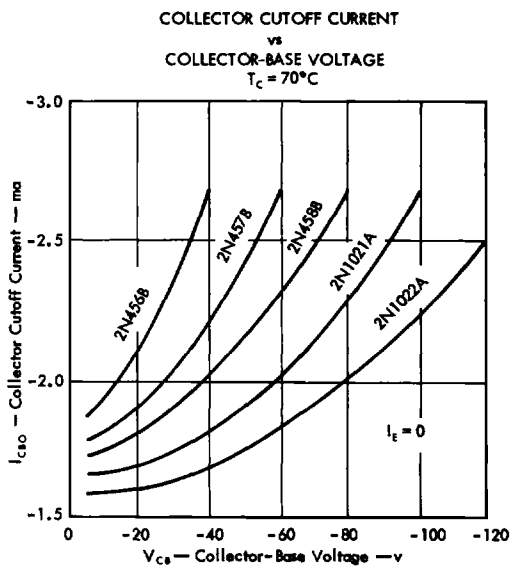
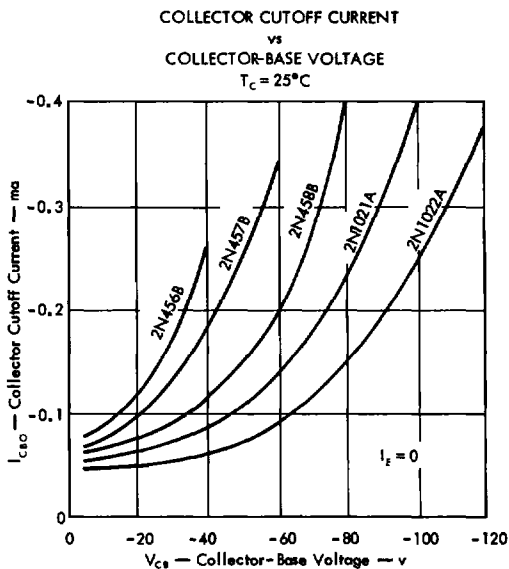
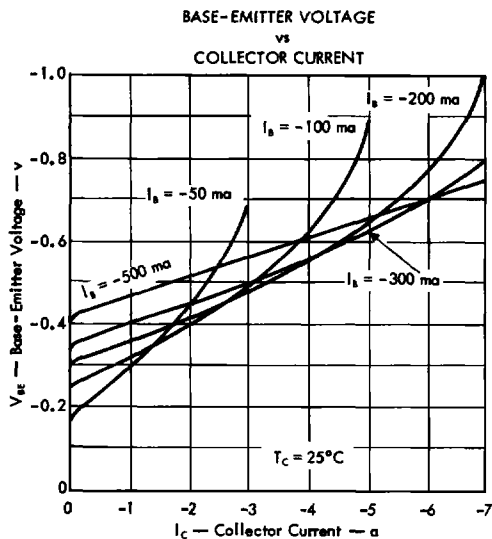
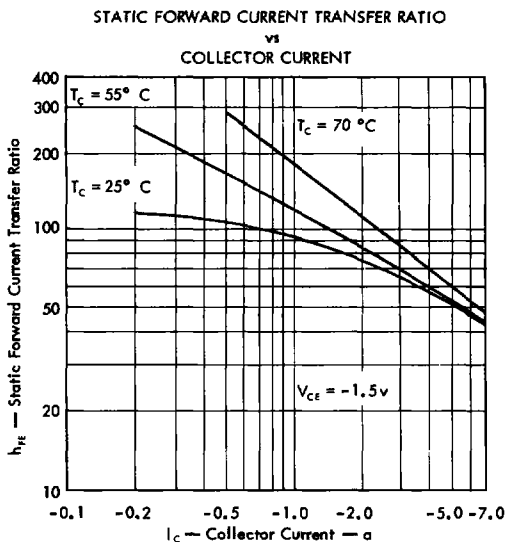


COMMON-EMITTER COLLECTOR
CHARACTERISTICS
(Saturation Region)



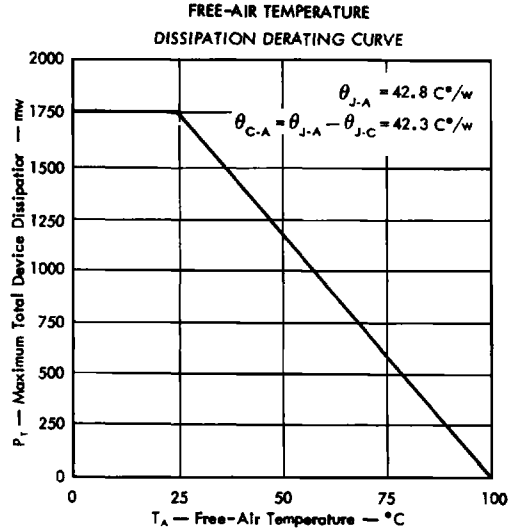
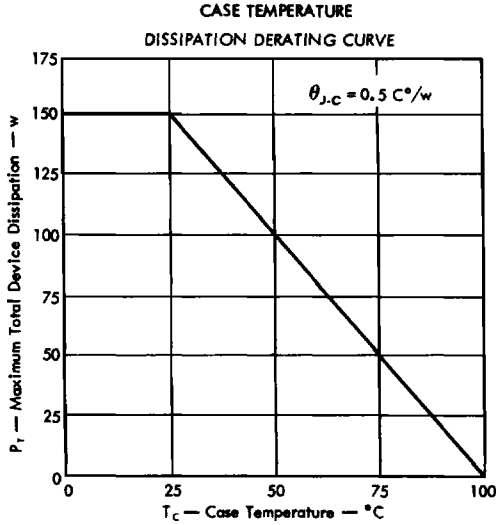
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TYPICAL CHARACTERISTICS



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

THERMAL CHARACTERISTICS



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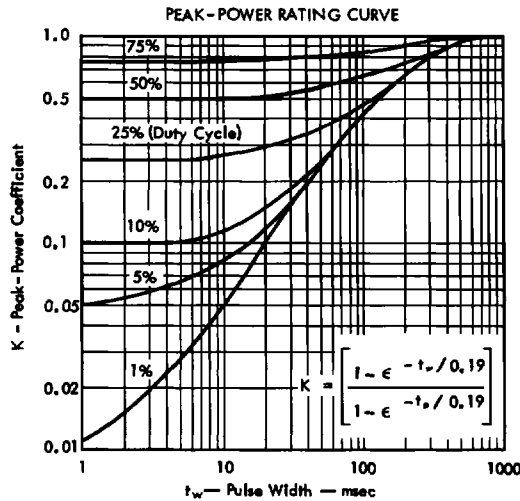


Figure 1

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

THERMAL INFORMATION

TABLE I

HEAT SINK		$\dagger \theta_{HS-A}$
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

$\dagger \theta_{HS-A}$ 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	
θ_{J-C}	Junction-to-Case Thermal Resistance	C°/w	0.5
θ_{J-A}	Junction-to-Ambient Thermal Resistance	C°/w	42.8
θ_{C-A}	Case-to-Ambient Thermal Resistance	C°/w	42.3
$\ddagger \theta_{C-HS}$	Case-to-Heat Sink Thermal Resistance — Typical w/o DC-11 Grease	C°/w	0.65
	Typical with DC-11 Grease		0.45
θ_{HS-A}	Heat-Sink Thermal Resistance	C°/w	see Table I
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.

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

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

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

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

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

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

$$P_T = \frac{T_j - T_A}{d \theta_{C-A} + K \theta_{J-C}}$$

Example A — Find $P_{T(max)}$

OPERATING CONDITIONS:

Heat Sink = 4" x 4" x 1/8" copper, $\theta_{HS-A} = 3.8$ C°/w

$T_{j(max)}$ (design limit) = 100 C°

$T_A = 30$ C°

$d = 100\%$ (1.0)

with DC-11 grease, $\theta_{C-HS} = 0.45$ C°/w

SOLUTION:

By use of equation No. 1

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

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

Example B — Find $P_{T(max)}$

OPERATING CONDITIONS:

Heat Sink = 8" x 8" x 1/8" copper,

$\theta_{HS-A} = 1.8$ C°/w

with DC-11 grease, $\theta_{C-HS} = 0.45$ 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

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

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