ALPHANUMERIC INDEX — CROSS-REFERENCE (Continued)

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number
2N5068		2N5758	3-116
2N5069		2N5758	3-116
2N5083		2N5339	3-97
2N5084		2N5339	3-97
2N5085		2N5339	3-97
2N5147		2N6191	3-158
2N5148		2N5337	3-97
2N5149		2N6191	3-158
2N5150		2N5337	3-97
2N5151		2N6191	3-158
2N5152		2N5337	3-97
2N5153		2N6191	3-158
2N5154		2N5337	3-97
2N5157		2N6545	3-221
2N5190	2N5190		3-85
2N5191	2N5191		3-85
2N5192	2N5192		3-85
2N5193	2N5193		3-89
2N5194	2N5194		3-89
2N5195	2N5195		3-89
2N5202		2N5428	3-101
2N5239		2N6306	3-181
2N5240		2N6545	3-221
2N5241		2N3902	3-60
2N5264		2N6249	3-164
2N5284		2N5339	3-97
2N5285		2N5339	3-97
2N5286		2N6191	3-158
2N5287		2N6191	3-158
2N5293		2N6123	3-154
2N5294		2N6123	3-154
2N5295		2N6121	3-154
2N5296		2N6121	3-154
2N5297		2N6122	3-154
2N5298		2N6122	3-154
2N5301	2N5301		3-93
2N5302	2N5302		3-93
2N5302JAN	2N5302JAN		3-93
2N5302JTX	2N5302JTX		3-93
2N5302JTXV	2N5302JTXV		3-93
2N5303	2N5303		3-93
2N5303JAN	2N5303JAN		3-93
2N5303JTX	2N5303JTX		3-93
2N5303JTXV	2N5303JTXV		3-93
2N5325		2N5339	3-97
2N5333		2N6303	3-32
2N5334		2N5337	3-97
2N5335		2N5337	3-97
2N5336	2N5336		3-97
2N5337	2N5337		3-97
2N5338	2N5338		3-97
2N5339	2N5339		3-97
2N5339JAN	2N5339JAN		3-97
2N5339JTX	2N5339JTX		3-97
2N5339JTXV	2N5339JTXV		3-97
2N5344		2N6211	3-161
2N5345		2N6212	3-161
2N5346		2N5339	3-97
2N5347		2N5339	3-97
2N5348		2N5339	3-97
2N5349		2N5339	3-97
2N5384		2N6191	3-158
2N5385		2N6191	3-158
2N5386		2N5038	3-83
2N5387		2N6546	3-225
2N5388		2N6546	3-225
2N5389		2N6546	3-225
2N5404		2N6191	3-158
2N5405		2N6191	3-158
2N5406		2N6191	3-158
2N5407		2N6193	3-158
2N5408		2N6191	3-158
2N5409		2N6193	3-158
2N5410		2N6191	3-158
2N5411		2N6193	3-158
2N5427	2N5428		3-101
2N5428	2N5428		3-101
2N5429	2N5429		3-101
2N5430	2N5430		3-101
2N5466		2N6545	3-221
2N5467		2N6545	3-221
2N5477		2N5339	3-97
2N5478		2N5339	3-97
2N5479		2N5339	3-97
2N5480		2N5339	3-97
2N5490		MJE3055T	3-904
2N5491		MJE3055T	3-904
2N5492		2N6292	3-151
2N5493		2N6292	3-151
2N5494		MJE3055T	3-904
2N5495		MJE3055T	3-904
2N5496		2N6292	3-151
2N5497		2N6292	3-151
2N5508		2N5428	3-101
2N5539		2N6379	3-191
2N5559		MJ15001	3-710
2N5575		2N5685	3-112
2N5578		2N5685	3-112
2N5598		2N5428	3-101
2N5600		2N5428	3-101
2N5602		2N5428	3-101
2N5604		2N5430	3-101
2N5606		2N5428	3-101
2N5610		2N5428	3-101
2N5612		2N5430	3-101
2N5614		2N3448	3-18
2N5616		2N3448	3-18
2N5618		2N3448	3-18
2N5629	2N5629		3-105
2N5630	2N5630		3-105
2N5631	2N5631		3-105
2N5632		2N5882	3-123
2N5633		MJ15001	3-710
2N5634		MJ15001	3-710
2N5651		2N3585	3-20
2N5655	2N5655		3-109
2N5656	2N5656		3-109
2N5657	2N5657		3-109
2N5660		2N3585	3-20
2N5661		2N3584	3-20

*Consult Motorola if a direct replacement is necessary.

1

TABLE 7 — PLASTIC TO-225 Type (continued)

I_CCont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s μs Max	t_f μs Max	@ I_C Amp		
3	45		BD176	40/250	0.15				3	30
			BD176.6	40/100	0.15				3	30
			BD176.10	63/160	0.15				3	30
			BD176.16	100/250	0.15				3	30
	60	MJE181	MJE171	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	80	BD179	BD180	40/250	0.15				3	30
		BD179.6	BD180.6	40/100	0.15				3	30
		BD179.10	BD180.10	63/160	0.15				3	30
		BD179.16	BD180.16	100/250	0.15				3	30
		MJE182	MJE172	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	200	BUY49P		30 min	0.5				25	20
4	30	BD185		15 min	2				20	40
	40	2N5190	2N5193	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		MJE521	MJE371	40 min	1					40
		2N6037##	2N6034##	750/18k	2	1.7 typ	1.2 typ	2	25	40
	45	BD437	BD438	40 min	2				3	36
		BD675##	BD676##	750 min	1.5					40
		BD675A##	BD676A##	750 min	2					40
		BD785	BD786	20 min	2				50	15
			BD776##	750 min	2				20	15
	60	BD189		15 min	2				20	40
			BD440	25 min	2				3	36
		BD677##	BD678##	750 min	1.5					40
		BD677A##	BD678A##	750 min	2					40
		BD787	BD788	20 min	2				50	15
		BD777##	BD778##	750 min	2				20	15
		2N5191	2N5194	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		MJE800##	MJE700##	750 min	1.5				1#	40
		MJE801##	MJE701##	750 min	2				1#	40
		2N6038##	2N6035##	750/18k	2	1.7 typ	1.2 typ	2	25	40
	80	2N5192	2N5195	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		BD441	BD442	15 min	2				3	36
		BD679##	BD680##	750 min	1.5					40
		BD679A##	BD680A##	750 min	2					40
		BD789	BD790	10 min	2				40	15
		BD779##	BD780##	750 min	2				20	15
		MJE240	MJE250	40/200	0.2	0.15 typ	0.07 typ	2	40	15
		MJE241	MJE251	40/120	0.2	0.15 typ	0.07 typ	2	40	15
		MJE802##	MJE702##	750 min	1.5				1#	40
		MJE803##	MJE703##	750 min	2				1#	40
		2N6039##	2N6036##	750/18k	2	1.7 typ	1.2 typ	2	25	40
	100	BD681##	BD682##	750 min	1.5					40
		BD791	BD792	10 min	2				40	15
		MJE243	MJE253	40/120	0.2	0.15 typ	0.07 typ	2	40	15
		MJE244	MJE254	25 min	0.2	0.15 typ	0.07 typ	2	40	15
5	25	MJE200	MJE210	45/180	2	0.13 typ	0.035 typ	2	65	15

● Case 77 (Style 3), # $|h_{fe}|$ @ 1 MHz, ## Darlington

2

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

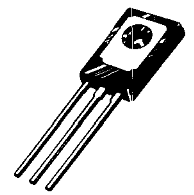
2N5190 thru 2N5192

SILICON NPN POWER TRANSISTORS

. . . for use in power amplifier and switching circuits, — excellent safe area limits. Complement to PNP 2N5193, 2N5194, 2N5195

4 AMPERE POWER TRANSISTORS SILICON NPN

40-80 VOLTS
40 WATTS



*MAXIMUM RATINGS

Rating	Symbol	2N5190	2N5191	2N5192	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}		5.0		Vdc
Collector Current	I_C		4.0		Adc
Base Current	I_B		1.0		Adc
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		40 320		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		-65 to +150		°C

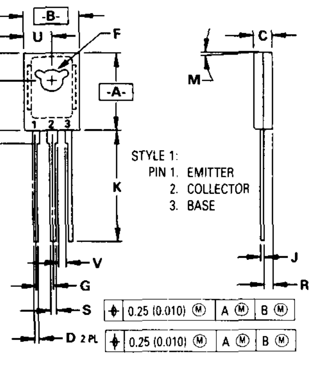
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	°C/W

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 0.1 Adc, I_B = 0)	2N5190 2N5191 2N5192	$V_{CEO(sus)}$	40 60 80	- - –	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0) (V_{CE} = 80 Vdc, I_B = 0)	2N5190 2N5191 2N5192	I_{CEO}	– – –	1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C) (V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5190 2N5191 2N5192 2N5190 2N5191 2N5192	I_{CEX}	– – – – – –	0.1 0.1 0.1 2.0 2.0 2.0	mAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	2N5190 2N5191 2N5192	I_{CBO}	– – –	0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 1.5 Adc, V_{CE} = 2.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	2N5190 2N5191 2N5192 2N5190 2N5191 2N5192	h_{FE}	25 25 20 10 10 7.0	100 100 80 – –	–
Collector-Emitter Saturation Voltage (1) (I_C = 1.5 Adc, I_B = 0.15 Adc) (I_C = 4.0 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$	– –	0.6 1.4	Vdc
Base-Emitter On Voltage (1) (I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.
*Indicates JEDEC Registered Data



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.04	0.425	0.435
B	7.50	7.74	0.295	0.305
C	2.42	2.66	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.93	3.17	0.115	0.125
G	2.39 BSC		0.094 BSC	
H	1.27	2.41	0.050	0.095
J	0.39	0.63	0.015	0.025
K	14.61	16.63	0.575	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.15	1.39	0.045	0.055
S	0.64	0.88	0.025	0.035
U	3.69	3.93	0.145	0.155
V	1.02	–	0.040	–

CASE 77-06
TO-225AA TYPE

3

FIGURE 1 — DC CURRENT GAIN

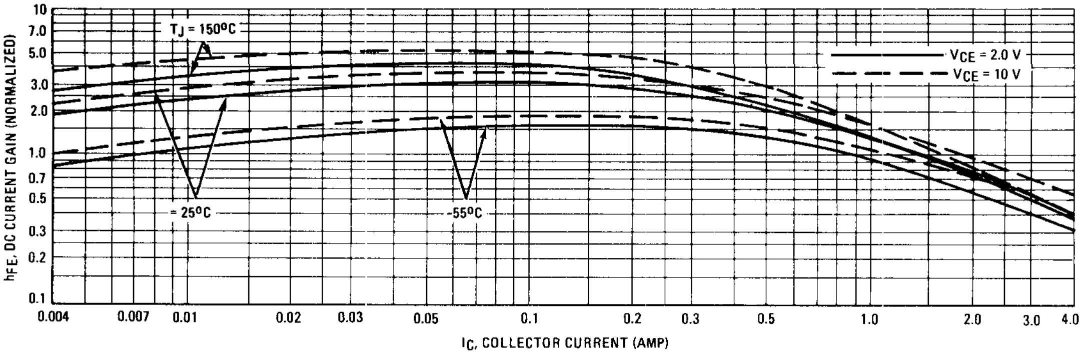


FIGURE 2 — COLLECTOR SATURATION REGION

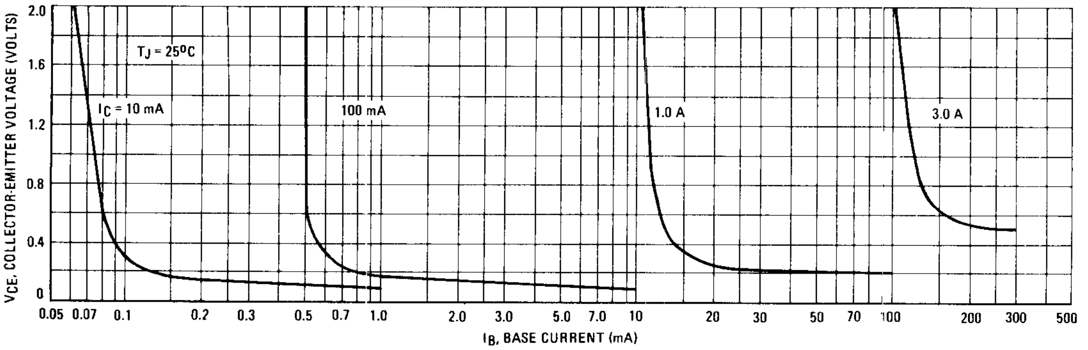


FIGURE 3 — "ON" VOLTAGES

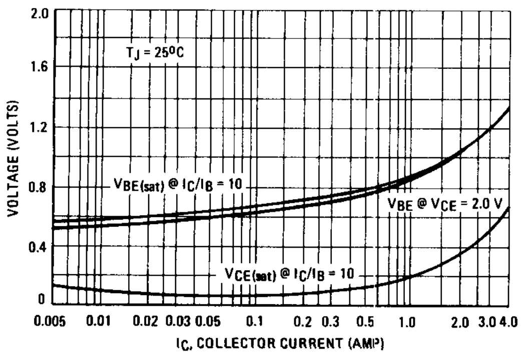


FIGURE 4 — TEMPERATURE COEFFICIENTS

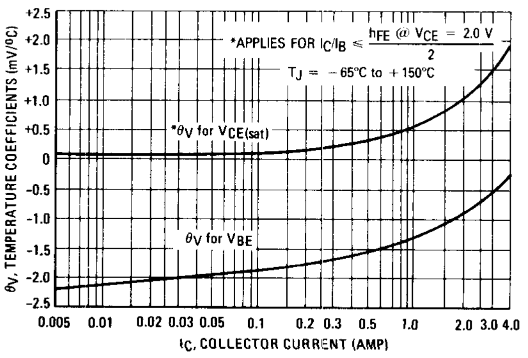


FIGURE 5 – COLLECTOR CUT-OFF REGION

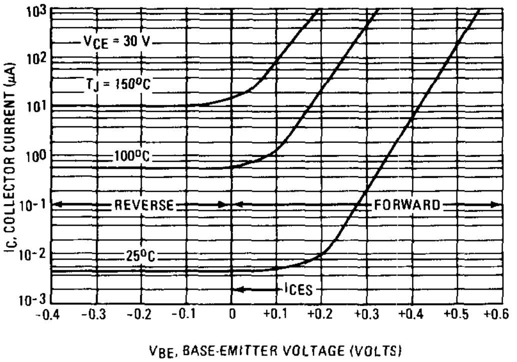


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE

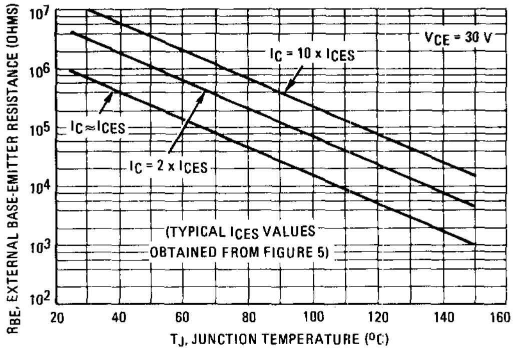


FIGURE 7 – SWITCHING TIME EQUIVALENT CIRCUIT

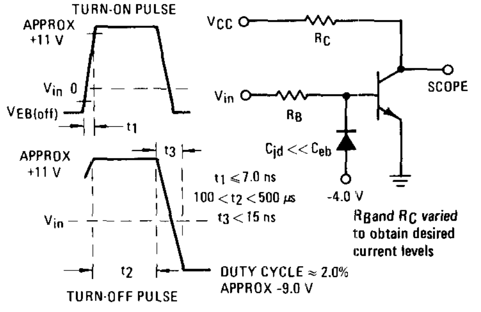
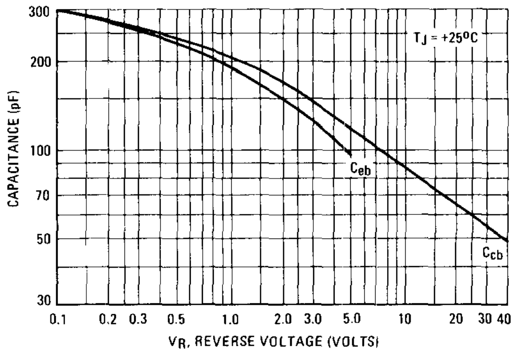


FIGURE 8 – CAPACITANCE



3

FIGURE 9 – TURN-ON TIME

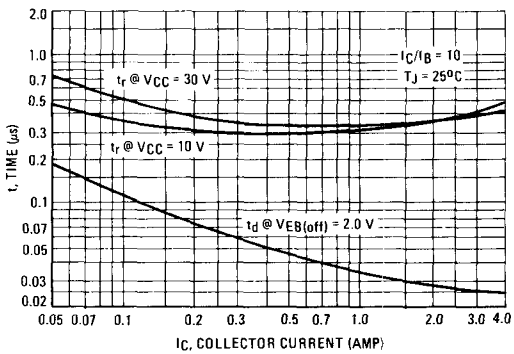


FIGURE 10 – TURN-OFF TIME

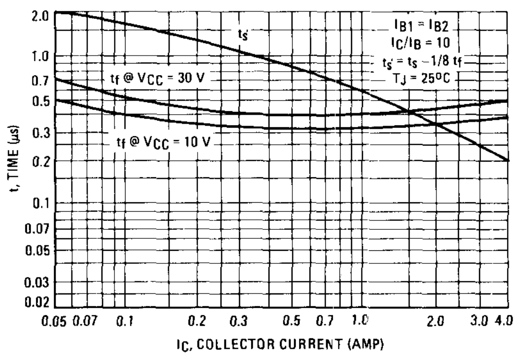
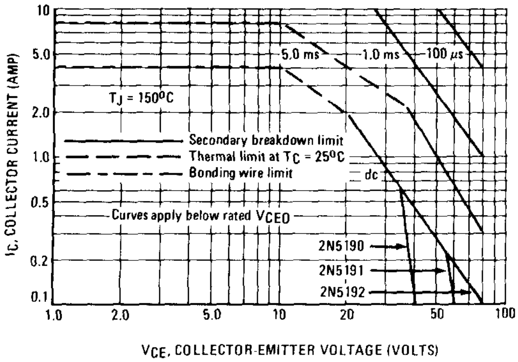


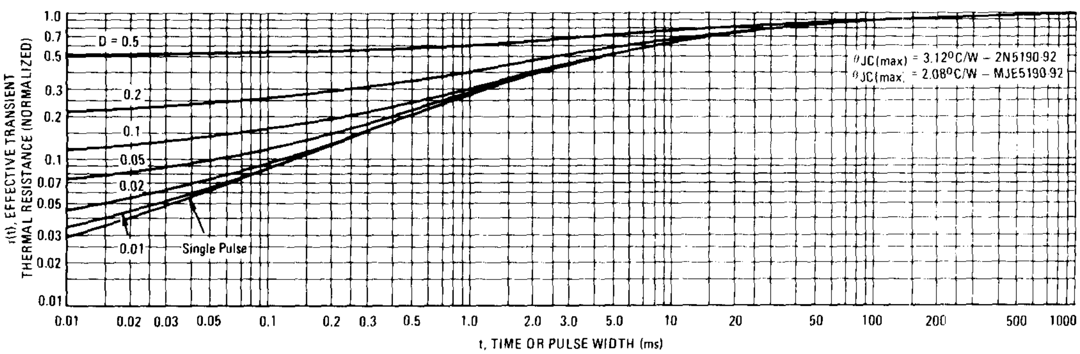
FIGURE 11 RATING AND THERMAL DATA
ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

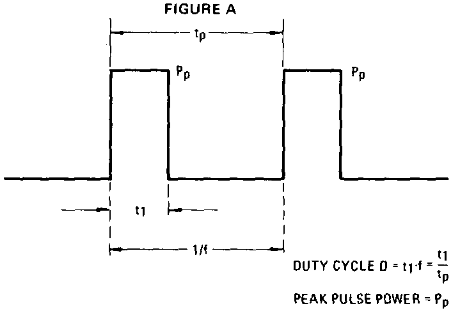
The data of Figure 11 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 12 — THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N5190 is dissipating 50 watts under the following conditions: t_1 = 0.1 ms, tp = 0.5 ms. (D = 0.2).

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of r(t_1, D) is 0.27.

The peak rise in junction temperature is therefore:

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2°C$$

3