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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number
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BF380	MPS-U10		3-1052
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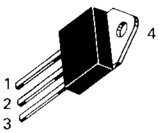
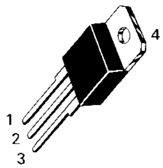
*Consult Motorola if a direct replacement is necessary.

TABLE 4 — PLASTIC TO-218



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

CASE 340-02 (TO-218AC)

I_C Cont 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	750	MJH16032		4 min	3	2	1.5	2		125
	850	MJH16034		4 min	3	2	1.5	2		125
5	400	BUW11		6 min	3	4	0.8	3		125
	450	BUW11A MJH16002 MJH16004		6 min 5 min 7 min	2.5 5 5	4 3 2.7	0.8 0.3 0.35	2.5 3 3		125 100 100
	500	MJH16002A		5 min	5	3	0.3	3		100
	1500*	MJH12004		2.5 min	4.5	—	1	4.5	4	100
6	375	BU426†		30 typ	0.6	2 typ	0.5 typ	2.5	6 typ	113
	400	BU426A†		30 typ	0.6	2 typ	0.5 typ	2.5	6 typ	113
8	400	BUW12 MJH16106		6 min 6/25	6 8	4 2 typ	0.8 0.1 typ	5 5		125 125
	450	BUW12A MJH16006 MJH16008		6 min 5 min 7 min	5 8 8	4 2.5 2.2	0.8 0.25 0.25	5 5 5		125 125 125
	500	BUT50P##† MJH16006A		30 min 5 min	2 8	0.75 typ 2.5	0.1 typ 0.25	5 5		100 125
	700	BU508,A BU508D,AD		2.25 min 2.25 min	4.5 4.5	8 typ 8 typ	0.5 typ 0.5 typ	4.5 4.5	7 7	125 125
	750	MJH12005					0.4 typ	5	4	100
9	400	BUV47†		7 min	5	2	0.4	6		128
	450	BUV47A†		7 min	6	2	0.4	6		128
10	40	TIP33	TIP34	20 min	3				3	80
	60	BDV65##† TIP33A TIP140##	BDV64##† TIP34A TIP145##	1k min 20 min 500 min	5 3 10	 2.5 typ	 2.5 typ	 5	 3 4#	125 80 125
	80	BDV65A##† TIP33B TIP141##	BDV64A##† TIP34B TIP146##	1k min 20 min 500 min	5 3 10	 2.5 typ	 2.5 typ	 5	 3 4#	125 80 125
	100	BDV65B##† TIP33C TIP142##	BDV64B##† TIP34C TIP147##	1k min 20 min 500 min	5 3 10	 2.5 typ	 2.5 typ	 5	 3 4#	125 80 125
	120	BDV65C##†	BDV64C##†	1k min	5					125
	200	BU323P##†		150 min	6	15	15	6		125
	250	BU323AP##†		150 min	6	15	15	6		125
	400	MJH10012##		100/2k	6	15	15	6		118
	800	MJH16018		4 min	5	4.5 typ	0.2 typ	5		150
15	60	TIP3055	TIP2955	5 min	10				2.5	80
	150	MJH11018##	MJH11017##	400/15k	10				3#	150
	200	MJH11020##	MJH11019##	400/15k	10				3#	150
	250	MJH11022##	MJH11021##	400/15k	10				3#	150

$|h_{fe}|$ @ 1 MHz, ## Darlington
* $V_{(BR)CEX}$ or $V_{(BR)CES}$
† These devices supplied in Case 340D-01. Consult Motorola for details.

(continued)

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TABLE 14 — SWITCHMODE POWER TRANSISTORS (continued)

$V_{CEO(sus)}$ Volts Min	I_C Cont Amps Max	V_{CEV} Volts Min	Device Type NPN unless otherwise noted	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	t_f μs Max	@ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C	Case JEDEC/MOT
750	3	1500	MJE16032	4 min	3	2	1.5	2		80	TO-220/221A
		1500	MJH16032	4 min	3	2	1.5	2		125	TO-218/340
	2.5	1500	MJ12002★	1.11 min	2		1	2	4 typ		TO-204/1
		1500	MJE12007★	1.1 min	2		1	2	4 typ		TO-220/221A
700	40	1000	BUT35##	15 min	24	4	1.2	24		250	TO-204/197
	20	1000	BUT15##	15 min	12	2.5	0.8	12		175	TO-204/1
	10	1200	MJ8504★	7.5 min	1.5	4	2	5			TO-204/1
	8	1400	MJ10011#	20 min	4		1	4			TO-204/1
		1500	BU508,A	2.25 min	4.5	8 typ	0.5 typ	4.5	7	125	TO-218/340
		1500	BU508D,AD	2.25 min	4.5	8 typ	0.5 typ	4.5	7	125	TO-218/340
	5	1200	MJ8502★	7.5 min	1	4	2	2.5			TO-204/1
		1200	MJE8502★	7.5 min	1	4	2	2.5			TO-220/221A
		1500	BU208A	2.25 min	4.5	8 typ	0.4 typ	4.5	4 typ	90	TO-204/1
		1500	BU208D	2.25 min	4.5		0.6 typ	4.5			TO-204/1
	2.5	1200	MJE8500★	7.5 min	0.5	4	2	1			TO-220/221A
600	10	700	MJ10014##★	10/250	10	2.5	0.8	10			TO-204/1
500	50	750	MJ10016##★	10 min	40	2.5	1	20			TO-204/197
		850	BUT34##	15 min	32	3	1.5	32		250	TO-204/197
	25	850	BUT14##	15 min	16	2.8	0.8	16		175	TO-204/1
	20	600	MJ10009##★	30/300	10	2	0.6	10	8**		TO-204/1
		800	MJ13335★	10/60	5	4	0.7	10			TO-204/1
	15	850	BUT51P##	40 min	5	1.1	0.16	10		125	TO-218/340D
		1000	MJ16010A★	5 min	15	3	0.4	10			TO-204/1
		1000	MJH16010A★	5 min	15	3	0.4	10			TO-218/340
	8	850	BUT50P##	30 min	2	0.75 typ	0.1 typ	5		100	TO-218/340D
		1000	MJ16006A★	5 min	15	3	0.4	10			TO-204/1
		1000	MJH16006A★	5 min	15	3	0.4	10			TO-218/340
	5	1000	MJ16002A★	5 min	15	3	0.3	3			TO-204/1
		1000	MJH16002A★	5 min	15	3	0.3	3			TO-218/340
450	30	850	MJ16020	5 min	30	1.8	0.2	20		250	TO-204/1
		850	MJ16022	7 min	30	1.5	0.15	20		250	TO-204/1
		1000	BUS98A	8 min	16	2.3	0.4	16		250	TO-204/197
	20	650	MJ10008##★	30/300	10	2	0.6	10	8**		TO-204/1
		850	2N6837★	10/30	15	2.5	0.25	15	15		TO-204/1
		850	MJ16014★	5 min	20	2.7	0.35	20			TO-204/197
		850	MJ16016★	7 min	20	2.2	0.25	20			TO-204/197
	15	850	2N6836★	10/30	10	3	0.35	10	10		TO-204/1
		850	MJ12022★	5 min	15		0.1 typ	10			TO-204/1
		850	MJ16010★	5 min	15	1.2 typ	0.2 typ	10			TO-204/1
		850	MJ16012★	7 min	15	0.9 typ	0.15 typ	10			TO-204/1
		850	MJH16010★	5 min	15	1.2	0.2	10		175	TO-218/340
		850	MJH16012★	7 min	15	0.9	0.15	10		150	TO-218/340
		1000	BUX48A	8 min	10	2	0.4	10		175	TO-204/1

★ Designers Data Sheet characterization

Darlington   ## Darlington with speed-up diode   * t_{off} ** $|h_{fe}|$ @ 1 MHz

(continued)

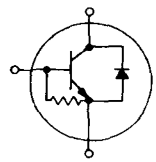
MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

BU508
BU508D
BU508A
BU508AD

NPN Silicon Power Transistors
Horizontal Deflection

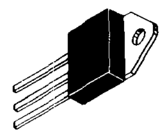
. . . specifically designed for use in large screen color deflection circuits.

- Glass Passivated (Patented Photoglass)
- Triple Diffused Mesa Technology for Long Term Stability
- Collector-Emitter Voltage — V_{CE} = 1500 Vdc
- Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 700 Vdc
- Switching Times with Inductive Loads, t_f = 0.5 μs (Typ) @ I_C = 4.5 A
- Optimum Drive Condition Curves
- Glass Base-Collector Junction
- TO-218 Package for Low Cost Mounting
- Available with Internal Flyback Diode, "D" Suffix



"D" SUFFIX

POWER TRANSISTORS
8 AMPERES
1500 VOLTS



CASE 340-02
TO-218AC

MAXIMUM RATINGS

Rating	Symbol	All Parts	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	700	Vdc
Collector-Emmiter Voltage	V_{CES}	1500	Vdc
Emitter Base Voltage	V_{EB}	5	Vdc
Collector Current — Continuous Peak(1)	I_C I_{CM}	8 15	Adc
Base Current — Continuous Peak(1)	I_B I_{BM}	4 6	Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1	Watts W/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8" from Case for 5 seconds	T_L	275	°C

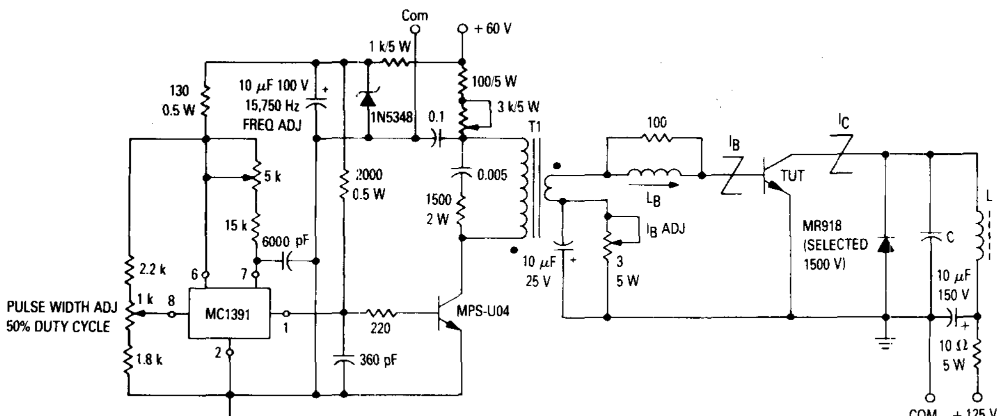
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

3

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS[1]						
Collector-Emitter sustaining voltage (I_C = 100 mAdc, I_B = 0)		$V_{CEO(sus)}$	700	—	—	Vdc
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 1500 Vdc, V_{BE} = 0, T_C = 25°C)			—	—	0.1	
(V_{CE} = 1500 Vdc, V_{BE} = 0, T_C = 125°C)			—	—	2	
Emitter Base Leakage (V_{EB} = 6 V, I_C = 0)	BU508, A	I_{EBO}		—	10	mAdc
	BU508D, AD				300	
ON CHARACTERISTICS[1]						
DC Current Gain (I_C = 4.5 Adc, V_{CE} = Vdc)		h_{FE}	2.25	—	—	—
Collector-Emitter Saturation Voltage (I_C = 4.5 Adc, I_B = 2 Adc)	BU508, D	$V_{CE(sat)}$	—	—	3	Vdc
	BU508A, AD				1	
Base Emitter Saturation Voltage (I_C = 4.5 Adc, I_B = 2 Adc)		$V_{BE(sat)}$	—	—	1.3	Vdc
Second Breakdown Collector Current with Base Forward Biased		$I_{S/b}$		See Figure 11		
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 0.1 Adc, V_{CE} = 5 Vdc, f_{test} = 1 MHz)		f_T	—	7	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	—	125	—	pF
SWITCHING CHARACTERISTICS						
Fall Time	(I_C = 4.5 Adc, I_B = 1.8 Adc, LB = 10 μH, see Figure 1)	t_s		8		μs
		t_f		0.5		

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



I_C A	L mH	C μF
3.5	0.87	0.013
4.5	0.67	0.017

DRIVER TRANSFORMER (T1)

- Ferrox cube pot core #4229P-L00-3C8
- Adjust gap for primary inductance Lp = 70 mH (approximately 5 mil spacer)
- Primary 230T #28 AWG (5 layers)
- Secondary 15T #22 AWG (1 layer)
- Secondary leakage inductance should be less than 3 μH
- Use 3 mil mylar tape between each winding layer

Figure 1. Switching Times Test Circuit

3

BASE DRIVE: The Key to Performance

By now, the concept of controlling the shape of the turn-off base current is widely accepted and applied in horizontal deflection design. The problem stems from the fact that good saturation of the output device, prior to turn-off, must be assured. This is accomplished by providing more than enough I_{B1} to satisfy the lowest gain output device h_{FE} at the end of scan I_{CM}. Worst-case component variations and maximum high voltage loading must also be taken into account.

If the base of the output transistor is driven by a very low impedance source, the turn-off base current will reverse very quickly as shown in Figure 2. This results in rapid, but only partial, collector turn-off, because excess carriers become trapped in the high resistivity collector and the transistor is still conductive. This is a high dissipation mode, since the collector voltage is rising very rapidly. The problem is overcome by adding inductance to the base circuit to slow the base current reversal as shown in Figure 3, thus allowing excess carrier recombination in the collector to occur while the base current is still flowing.

Choosing the right L_B is usually done empirically, since the equivalent circuit is complex, and since there are several important variables (I_{CM}, I_{B1}, and h_{FE} at I_{CM}). One method is to plot fall time as a function of L_B, at the desired conditions, for several devices within the h_{FE} specification. A more informative method is to plot power dissipation versus I_{B1} for a range of values of L_B. This kind of analysis shows the parameter which really matters is dissipation, whether caused by switching or by saturation. The negative slope of these curves at the left (low I_{B1}) is caused by saturation losses. The positive slope portion at higher I_{B1}, and low values of L_B is due to switching losses as described above. For very low L_B a very narrow optimum is obtained. This occurs when $I_{B1}\, h_{FE} = I_{CM}$, and therefore would be acceptable only for the "typical" device with constant I_{CM}. As L_B is increased, the curves become broader and flatter above the $I_{B1}\, h_{FE} = I_{CM}$ point as the turn-off "tails" are brought under control. Eventually, if L_B is raised too far, the dissipation all across the curve will rise, due to poor *initiation* of switching rather than tailing. Plotting this type of curve family for devices of different h_{FE}, essentially moves the curves to the left or right according to the relation $I_{B1}\, h_{FE}$ = constant. It then becomes obvious that, for a specified I_{CM}, an L_B can be chosen which will give low dissipation over a range of h_{FE} and/or I_{B1}. The only remaining decision is to pick I_{B1} high enough to accommodate the lowest h_{FE} part specified. Neither L_B nor I_{B1} are absolutely critical, and should be selected for the specific required condition. Similar curves relating to this discussion can be found on Motorola's data sheet for the BU207.

TEST CIRCUIT WAVEFORMS

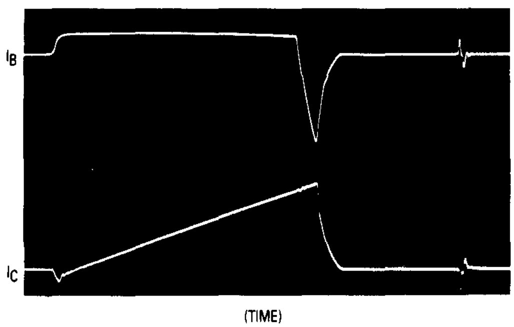


Figure 2.

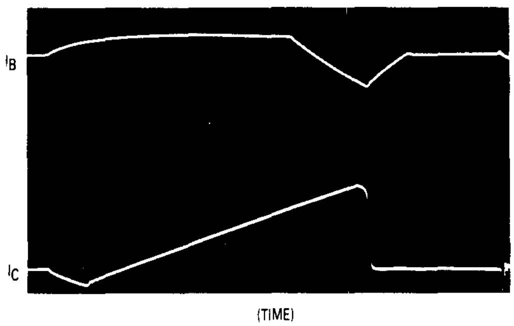


Figure 3.

TEST CIRCUIT OPTIMIZATION

The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance. Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

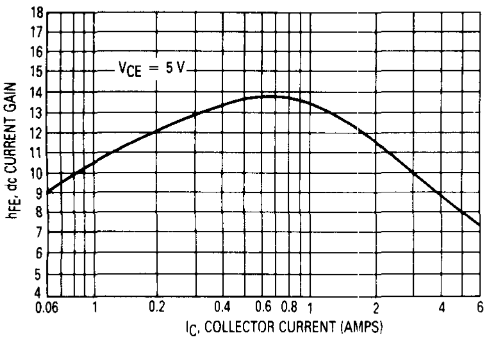


Figure 4. Typical dc Current Gain

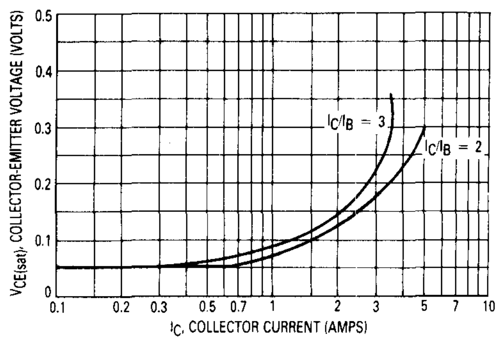


Figure 5. Typical Collector Saturation Voltage

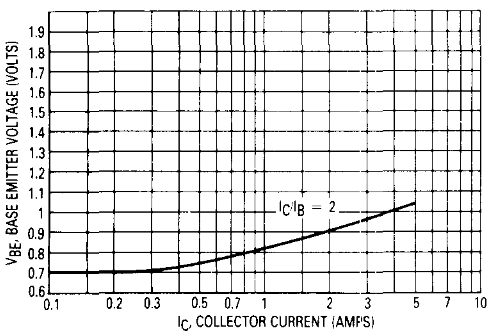


Figure 6. Typical Base Emitter Saturation Voltage

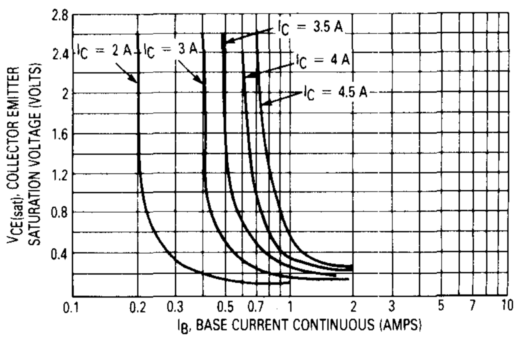


Figure 7. Typical Collector Saturation Region

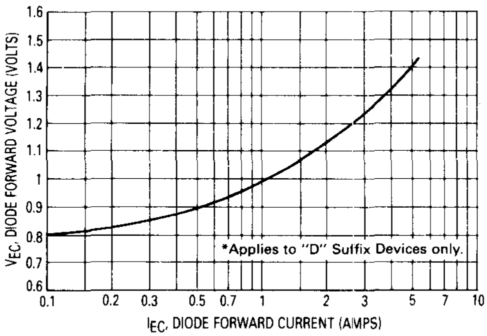


Figure 8. Typical Damper Diode Forward Voltage*

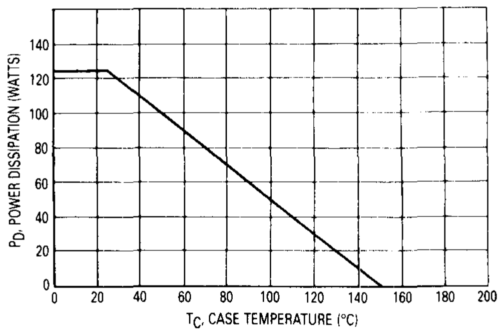


Figure 9. Power-Temperature Derating Curve

3

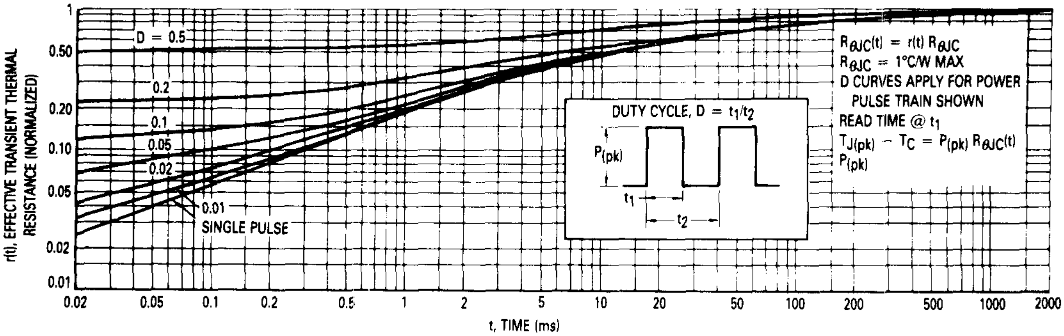


Figure 10. Thermal Response

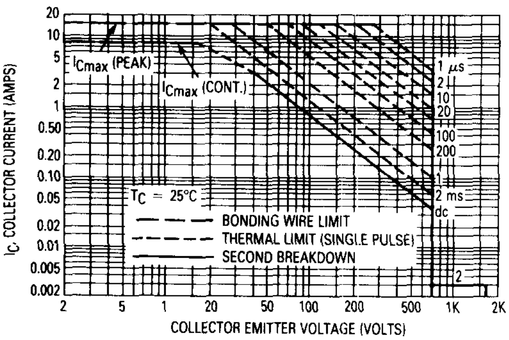
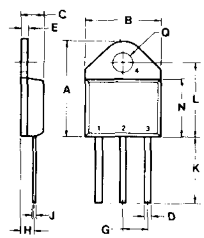


Figure 11. Maximum Forward Biased Safe Operating Area

Note (2) Operation in this area limited to Pulse Width < 20 μs, Duty Cycle < 0.25, R_{BE} < 100 ohms

CASE 340-02
TO-218AC

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	20.32	21.08	0.800	0.830
B	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
H	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

3