ON Semiconductor ™

Amplifier Transistors
## NPN Silicon

P2N2222A

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	40	Vdc
Collector–Base Voltage	V_{CBO}	75	Vdc
Emitter–Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

CASE 29–11, STYLE 17
TO–92 (TO–226AA)
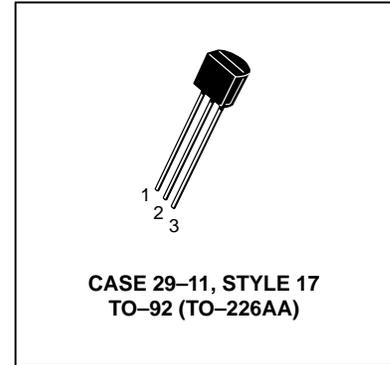
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

COLLECTOR
1

2
BASE

3
EMITTER
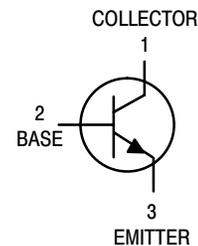
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	75	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	—	10	nAdc

Collector Cutoff Current
    (V_{CB} = 60 Vdc, I_E = 0)
    (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)
	I_{CBO}	—
		—
			0.01
			10
				μAdc

Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BEX}	—	20	nAdc

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ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)[1] ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)[1] ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)[1]	h_{FE}	35 50 75 35 100 50 40	— — — — 300 — 	—
Collector–Emitter Saturation Voltage[1] ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	— —	0.3 1.0	Vdc
Base–Emitter Saturation Voltage[1] ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	0.6 —	1.2 2.0	Vdc
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product[2] ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	25	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	2.0 0.25	8.0 1.25	kΩ
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	— —	8.0 4.0	X 10^{-4}
Small–Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	50 75	300 375	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{oe}	5.0 25	35 200	μmhos
Collector Base Time Constant ($I_E = 20$ mAdc, $V_{CB} = 20$ Vdc, f = 31.8 MHz)	$rb'C_c$	—	150	ps
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ kΩ, f = 1.0 kHz)	N_F	—	4.0	dB
SWITCHING CHARACTERISTICS				
Delay Time	($V_{CC} = 30$ Vdc, $V_{BE(off)} = -2.0$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
2. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

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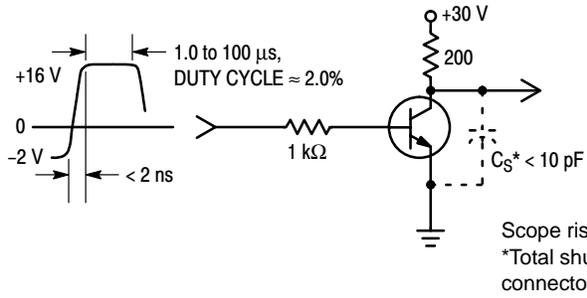## SWITCHING TIME EQUIVALENT TEST CIRCUITS

Figure 1. Turn–On Time

Scope rise time < 4 ns
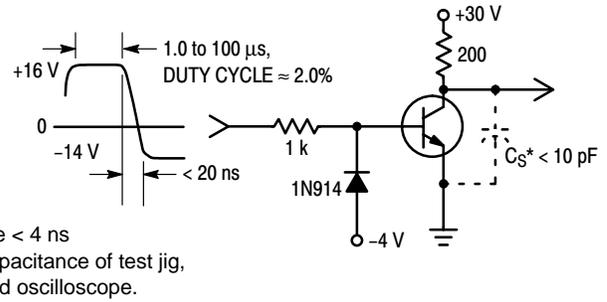*Total shunt capacitance of test jig,
connectors, and oscilloscope.
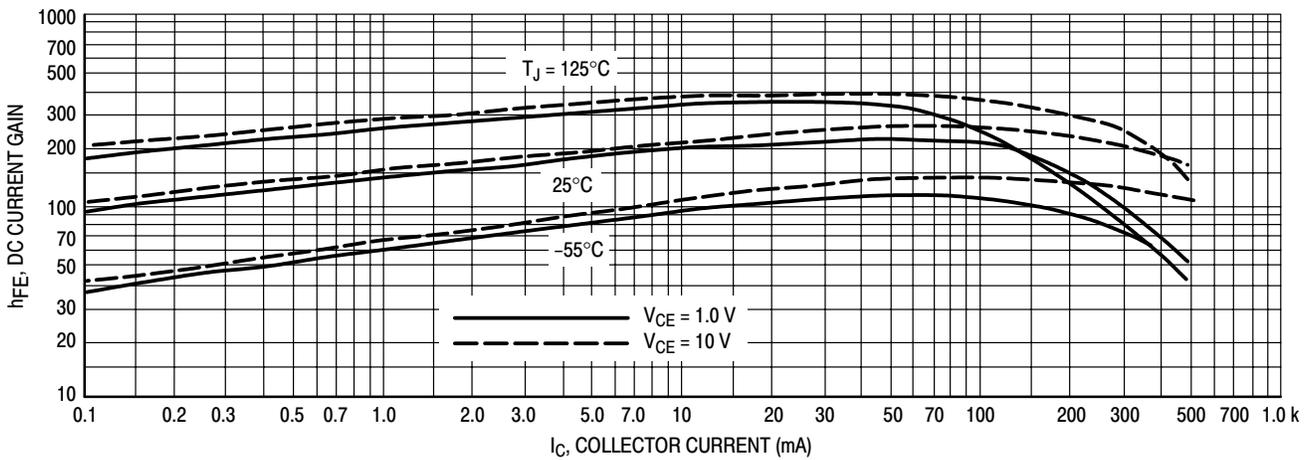
Figure 2. Turn–Off Time

Figure 3. DC Current Gain
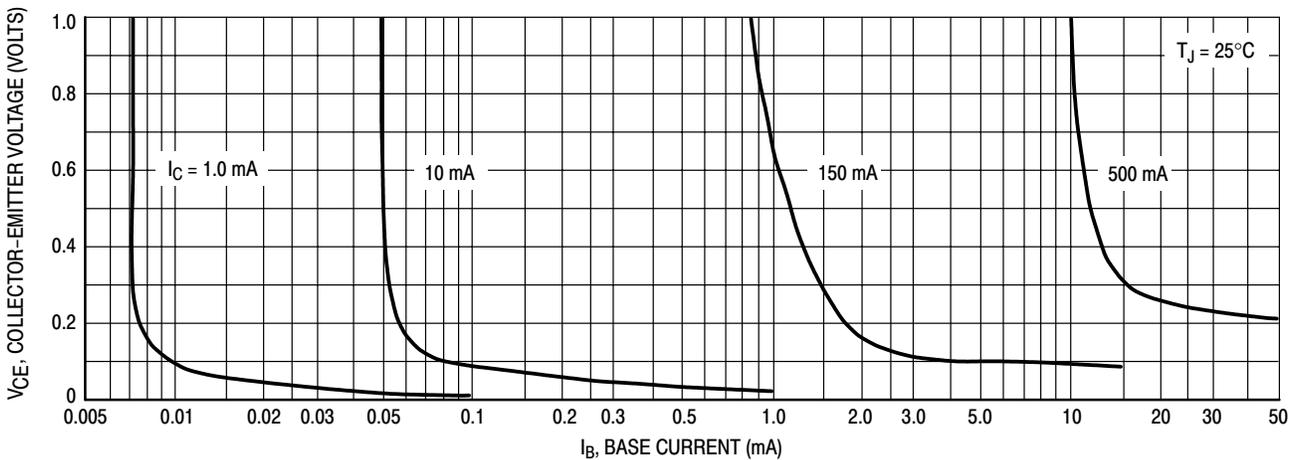
Figure 4. Collector Saturation Region

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Figure 5. Turn–On Time
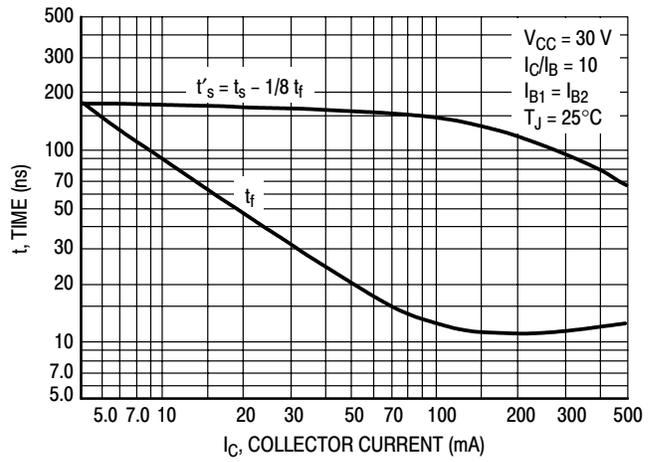
- $I_C/I_B = 10$
- $T_J = 25°C$
- t_r @ $V_{CC} = 30$ V
- t_d @ $V_{EB(off)} = 2.0$ V
- t_d @ $V_{EB(off)} = 0$

t, TIME (ns) vs I_C, COLLECTOR CURRENT (mA)

Figure 6. Turn–Off Time

- $V_{CC} = 30$ V
- $I_C/I_B = 10$
- $I_{B1} = I_{B2}$
- $T_J = 25°C$
- $t'_s = t_s - 1/8\ t_f$
- t_f

t, TIME (ns) vs I_C, COLLECTOR CURRENT (mA)
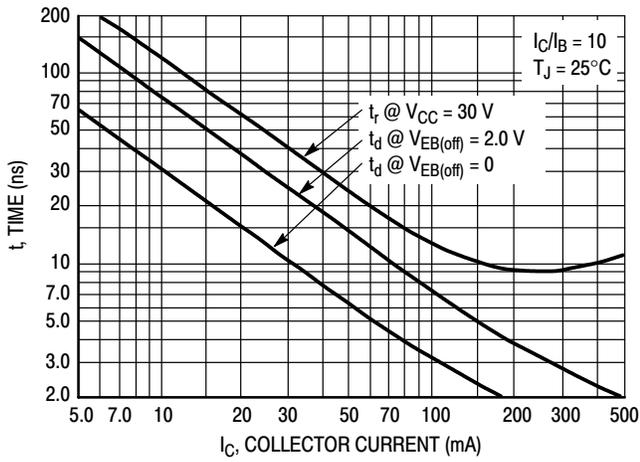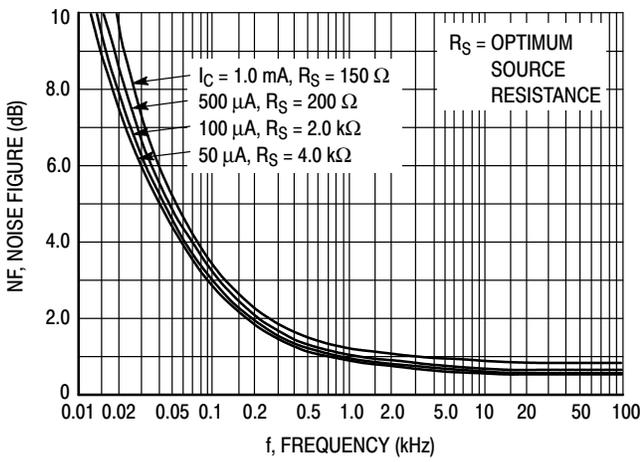
Figure 7. Frequency Effects

- R_S = OPTIMUM SOURCE RESISTANCE
- $I_C = 1.0$ mA, $R_S = 150\ \Omega$
- $500\ \mu A$, $R_S = 200\ \Omega$
- $100\ \mu A$, $R_S = 2.0$ kΩ
- $50\ \mu A$, $R_S = 4.0$ kΩ

NF, NOISE FIGURE (dB) vs f, FREQUENCY (kHz)
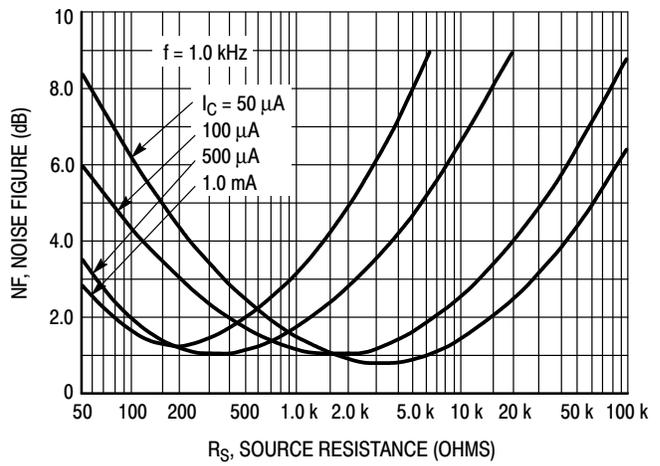
Figure 8. Source Resistance Effects

- $f = 1.0$ kHz
- $I_C = 50\ \mu A$
- $100\ \mu A$
- $500\ \mu A$
- 1.0 mA

NF, NOISE FIGURE (dB) vs R_S, SOURCE RESISTANCE (OHMS)

Figure 9. Capacitances

- C_{eb}
- C_{cb}
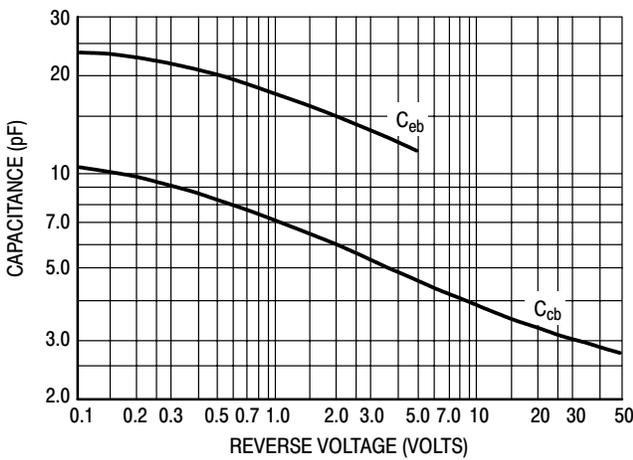
CAPACITANCE (pF) vs REVERSE VOLTAGE (VOLTS)
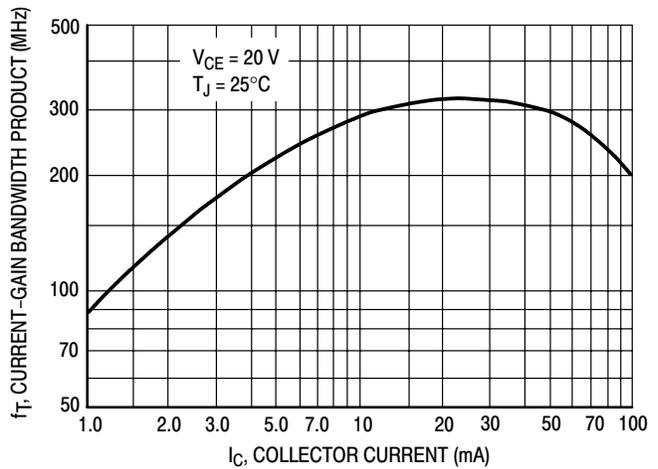
Figure 10. Current–Gain Bandwidth Product

- $V_{CE} = 20$ V
- $T_J = 25°C$

f_T, CURRENT–GAIN BANDWIDTH PRODUCT (MHz) vs I_C, COLLECTOR CURRENT (mA)

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Figure 11. "On" Voltages

T_J = 25°C

$V_{BE(sat)}$ @ I_C/I_B = 10

1.0 V

$V_{BE(on)}$ @ V_{CE} = 10 V

$V_{CE(sat)}$ @ I_C/I_B = 10

V, VOLTAGE (VOLTS)

I_C, COLLECTOR CURRENT (mA)
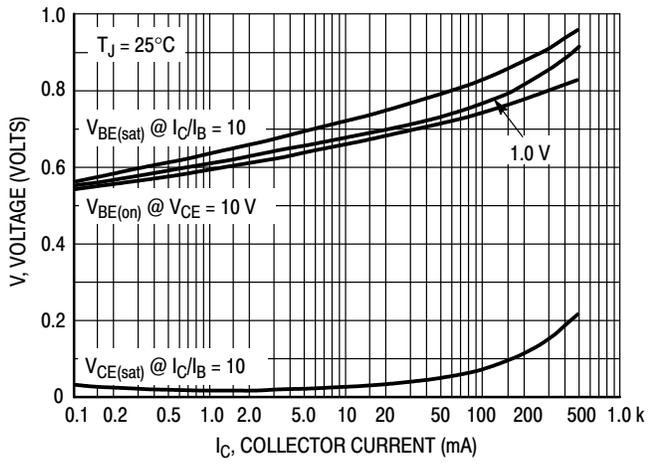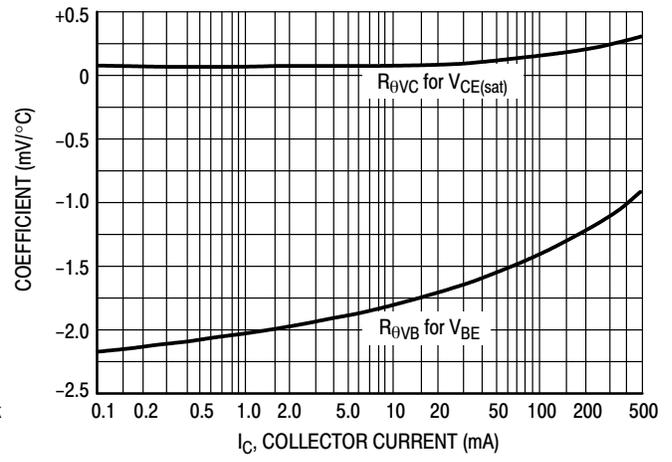
Figure 12. Temperature Coefficients

$R_{\theta VC}$ for $V_{CE(sat)}$

$R_{\theta VB}$ for V_{BE}

COEFFICIENT (mV/°C)

I_C, COLLECTOR CURRENT (mA)

PACKAGE DIMENSIONS

TO–92 (TO–226)
CASE 29–11
ISSUE AL
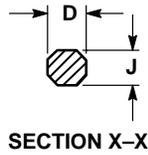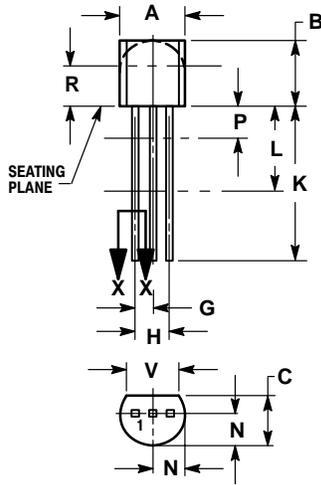
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	---	12.70	---
L	0.250	---	6.35	---
N	0.080	0.105	2.04	2.66
P	---	0.100	---	2.54
R	0.115	---	2.93	---
V	0.135	---	3.43	---

SECTION X–X

STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

<u>Notes</u>

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P2N2222A/D