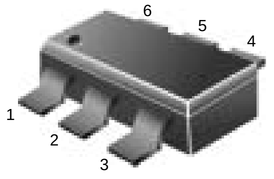
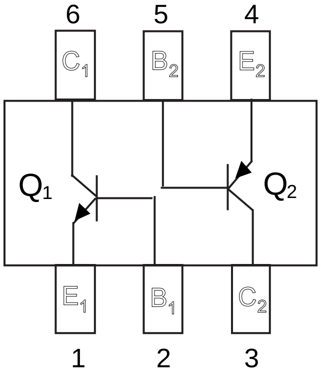
SEMICONDUCTOR
TECHNICAL DATA

FFB4413D

DUAL SMALL SIGNAL SURFACE MOUNT TRANSISTOR



SOT- 363/SC- 88



FEATURE

- We declare that the material of product is ROHS compliant and halogen free.

DEVICE MARKING AND ORDERING INFORMATION

Device	Marking	Shipping
FFB4413D	K13	3000/Tape&Reel

MAXIMUM RATINGS – NPN

Rating	Symbol	Value	Unit
Collector–EmitterVoltage	V_{CEO}	40	Vdc
Collector–BaseVoltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

MAXIMUM RATINGS – PNP

Rating	Symbol	Value	Unit
Collector–EmitterVoltage	V_{CEO}	- 40	Vdc
Collector–BaseVoltage	V_{CBO}	- 60	Vdc
Emitter–Base Voltage	V_{EBO}	- 5.0	Vdc
Collector Current — Continuous	I_C	- 600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR– 5 Board, (1) T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate, (2) T_A= 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J , T_{stg}	–55 to +150	°C

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

ELECTRICAL CHARACTERISTICS (T$_A$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Q1(NPN) OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (3) (I_C = 1.0 mAdc, I_B= 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E= 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C= 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)	I_{CEX}	—	0.1	μAdc
Q2(PNP) OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (3) (I_C = -1.0 mAdc , I_B = 0)	$V_{(BR)CEO}$	-40	—	Vdc
Collector–Base Breakdown Voltage (I_C = -0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	-60	—	Vdc
Emitter–Base Breakdown Voltage (I_E = -0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	-5.0	—	Vdc
Base Cutoff Current (V_{CE} = -35 Vdc, V_{EB} = -0.4 Vdc)	I_{BEV}	—	-0.1	μAdc
Collector Cutoff Current (V_{CE} = -35 Vdc, V_{EB} = -0.4 Vdc)	I_{CEX}	—	-0.1	μAdc

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width $\leq$300 μs; Duty Cycle $\leq$2.0%.

Q1(NPN) ELECTRICAL CHARACTERISTICS (T $_A$ = 25°C unless otherwise noted)

ON CHARACTERISTICS (3)

Characteristic	Symbol	Min	Max	Unit
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		20	––	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		40	––	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		80	––	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		100	300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		40	––	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		––	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		––	0.75	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)		––	1.2	

SMALL–SIGNAL CHARACTERISTICS

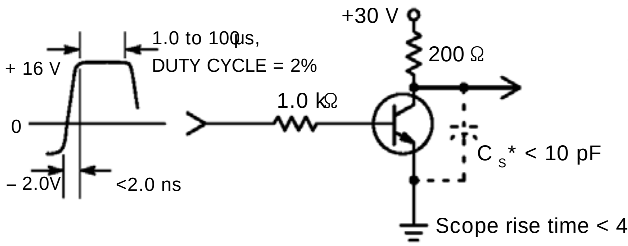
Current–Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10Vdc, f = 100 MHz)	f_T	250	––	MHz
Collector–Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	––	6.5	pF
Emitter–Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	––	30	pF
Input Impedance (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{ie}	1.0	15	kΩ
Voltage Feedback Ratio (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{re}	0.1	8.0	X 10^{-4}
Small–Signal Current Gain (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{fe}	40	500	—
Output Admittance (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{oe}	1.0	30	µmhos

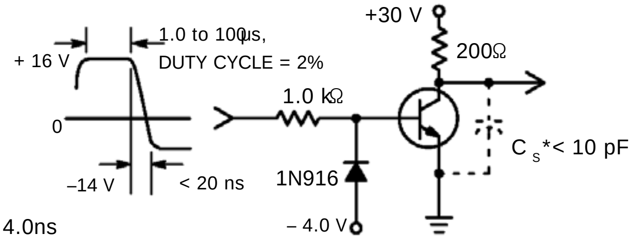
SWITCHING CHARACTERISTICS

Delay Time	(V_{CC} = 30 Vdc, V_{EB} = 2.0 Vdc	t_d	—	15	
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc)	t_f	—	30	

3. Pulse Test: Pulse Width ≤ 300 µs; Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS (Q1 NPN)





Scope rise time < 4.0ns

*Total shunt capacitance of test jig connectors, and oscilloscope

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

Q2(PNP) ELECTRICAL CHARACTERISTICS (T $_A$ = 25°C unless otherwise noted)

ON CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
DC Current Gain	h_{FE}			—
(I $_C$ = –0.1 mAdc, V_{CE} = –1.0 Vdc)		30	––	
(I $_C$ = –1.0 mAdc, V_{CE} = –1.0 Vdc)		60	––	
(I $_C$ = –10 mAdc, V_{CE} = –1.0 Vdc)		100	––	
(I $_C$ = –150 mAdc, V_{CE} = –2.0 Vdc)(3)		100	300	
(I $_C$ = –500 mAdc, V_{CE} = –2.0 Vdc)(3)		20	––	
Collector–Emitter Saturation Voltage(3)	$V_{CE(sat)}$			Vdc
(I $_C$ = –150mAdc, I_B = –15 mAdc)		––	– 0.4	
(I $_C$ = –500 mAdc, I_B = –50 mAdc)		––	– 0.75	
Base–Emitter Saturation Voltage (3)	$V_{BE(sat)}$			Vdc
(I $_C$ = –150 mAdc, I_B = –15 mAdc)		– 0.75	– 0.95	
(I $_C$ = –500 mAdc, I_B = –50 mAdc)		––	– 1.3	

SMALL–SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Current–Gain — Bandwidth Product (I $_C$ = –20mAdc, V_{CE}= –10 Vdc, f = 100 MHz)	f $_T$	200	––	MHz
Collector–Base Capacitance (V $_{CB}$= –10 Vdc, I_E = 0, f = 1.0 MHz)	C $_{cb}$	––	8.5	pF
Emitter–Base Capacitance (V $_{BE}$ = –0.5 Vdc, I_C = 0, f = 1.0 MHz)	C $_{eb}$	––	30	pF
Input Impedance (V $_{CE}$= –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	h $_{ie}$	1.5	15	kΩ
Voltage Feedback Ratio (V $_{CE}$= –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	h $_{re}$	0.1	8.0	X 10^{-4}
Small–Signal Current Gain (V $_{CE}$= –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	h $_{fe}$	60	500	—
Output Admittance (V $_{CE}$= –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	h $_{oe}$	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Delay Time	(V $_{CC}$ = – 30 Vdc, V_{EB} = –2.0 Vdc, I $_C$ = –150mAdc, I_{B1} = –15 mAdc)	t_d	—	15	ns
Rise Time		t_d	—	20	
Storage Time	(V $_{CC}$ = –30 Vdc, I_C = –150 mAdc, I $_{B1}$ = I $_{B2}$ = –15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	

3. Pulse Test: Pulse Width≤300 μs; Duty Cycle≤2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS (Q2 PNP)

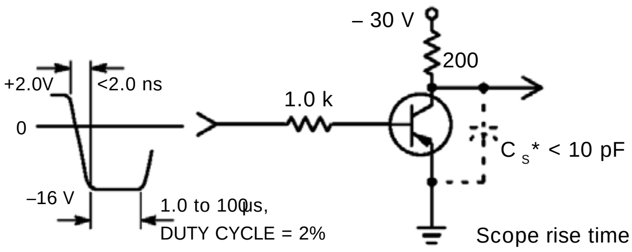
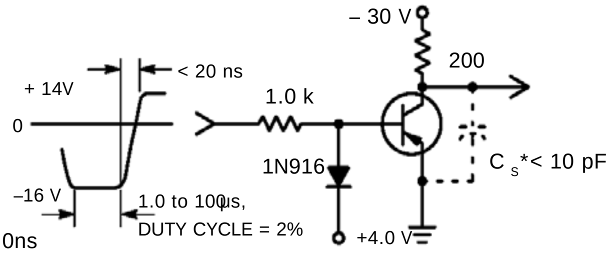


Figure 3. Turn–On Time



Scope rise time < 4.0ns

*Total shunt capacitance of test jig connectors, and oscilloscope

Figure 4. Turn–Off Time

TRANSIENT CHARACTERISTICS (Q1 NPN)

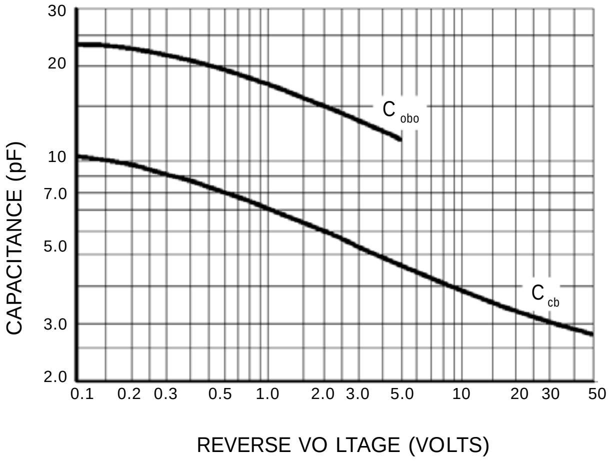


Figure 5. Capacitance

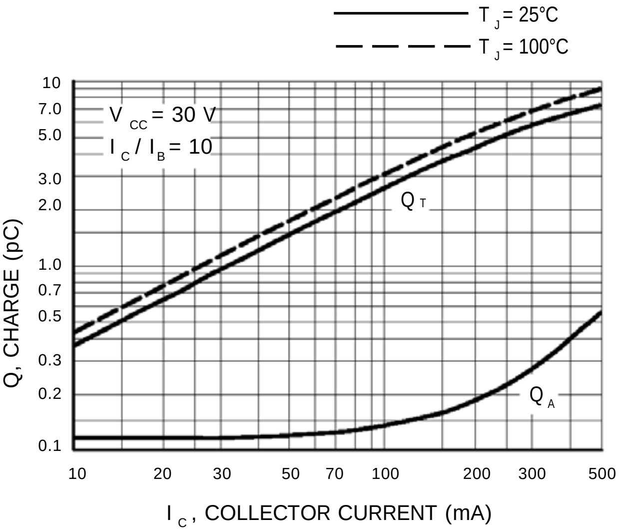


Figure 6. Charge Data

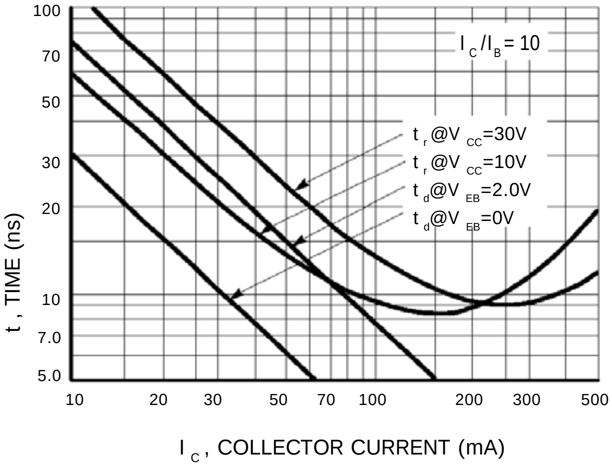


Figure 7. Turn–On Time

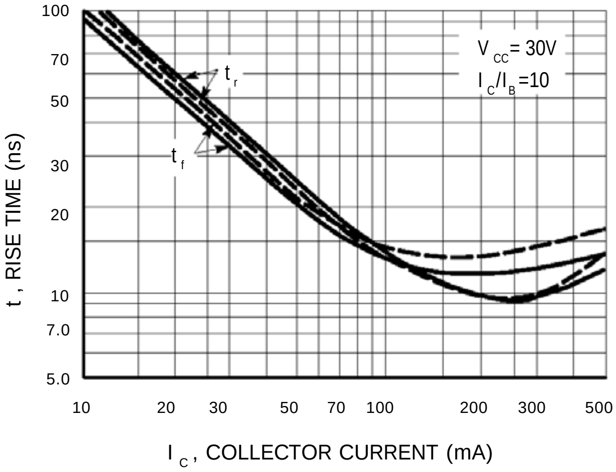


Figure 8. Rise and Fall Time

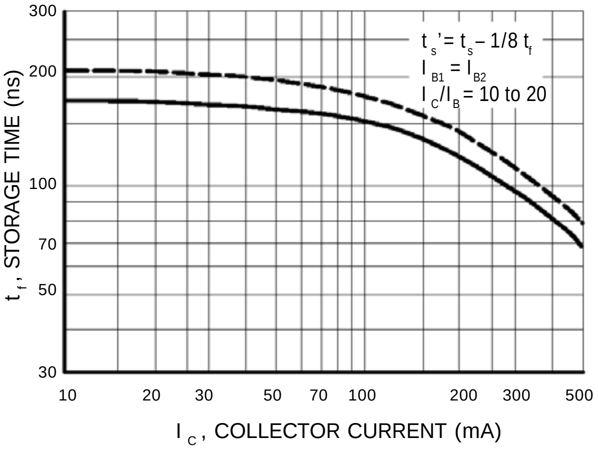


Figure 9. Storage Time

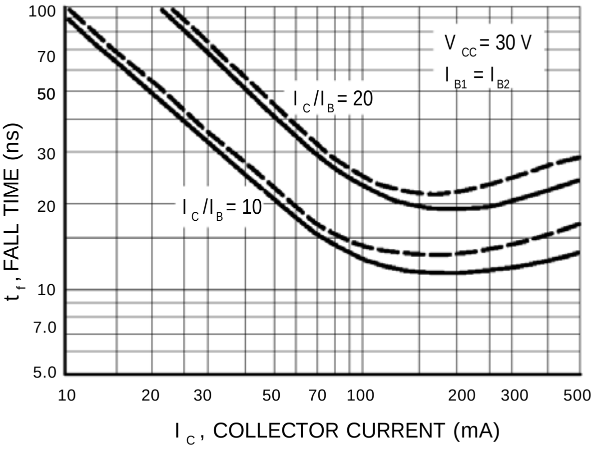


Figure 10. Fall Time

SMALL–SIGNAL CHARACTERISTICS(Q1 NPN)

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

Bandwidth = 1.0 Hz

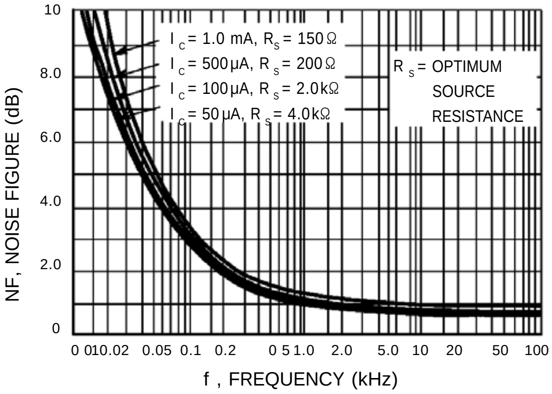


Figure 11. Frequency Effects

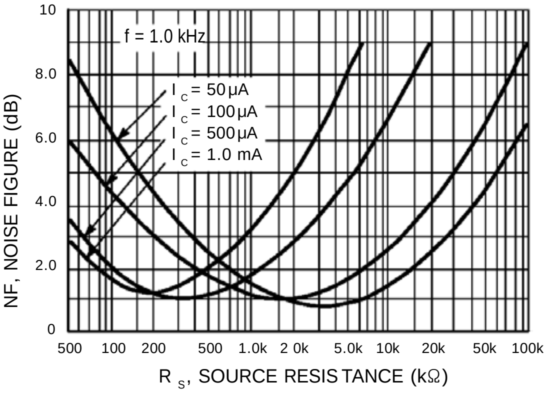


Figure 12. Source Resistance Effects

h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

This group of graphs illustrates the relationship between h fe and other “h” parameters for this series of ransistors.To obtain these curves, a high–gain and a low–gain unit were selected from the LMBT4413DW1T1G lines, and the same units were used to develop the correspondingly numbered curves on each graph.

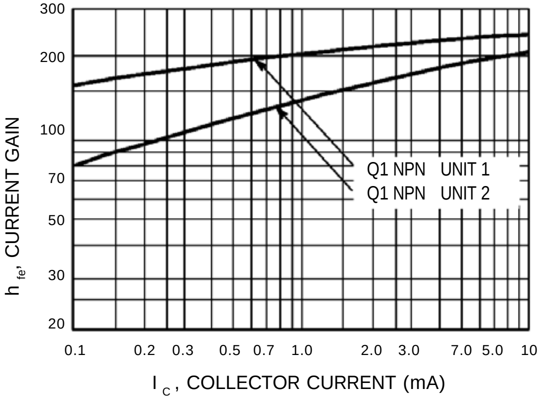


Figure 13. Current Gain

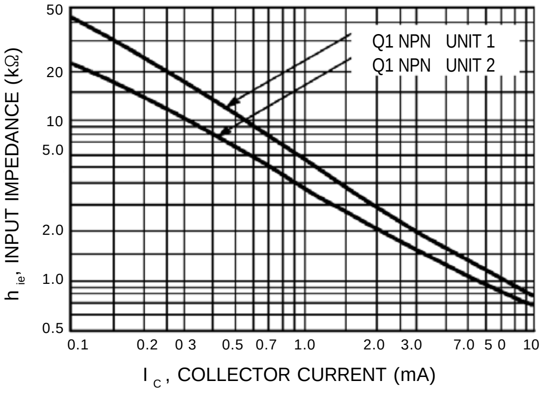


Figure 14. Input Impedance

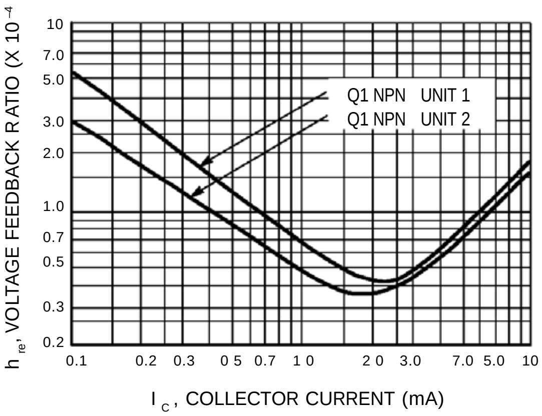


Figure 15. Voltage Feedback Ratio

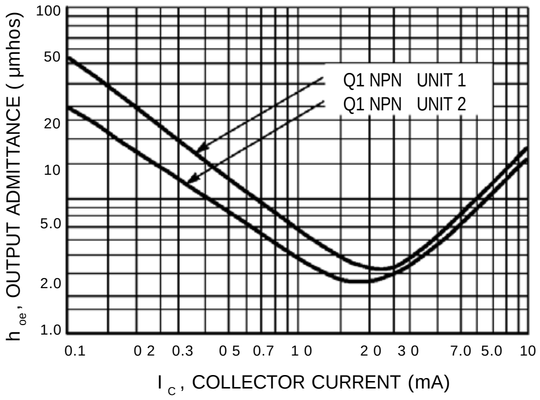


Figure 16. Output Admittance

STATIC CHARACTERISTICS (Q1 NPN)

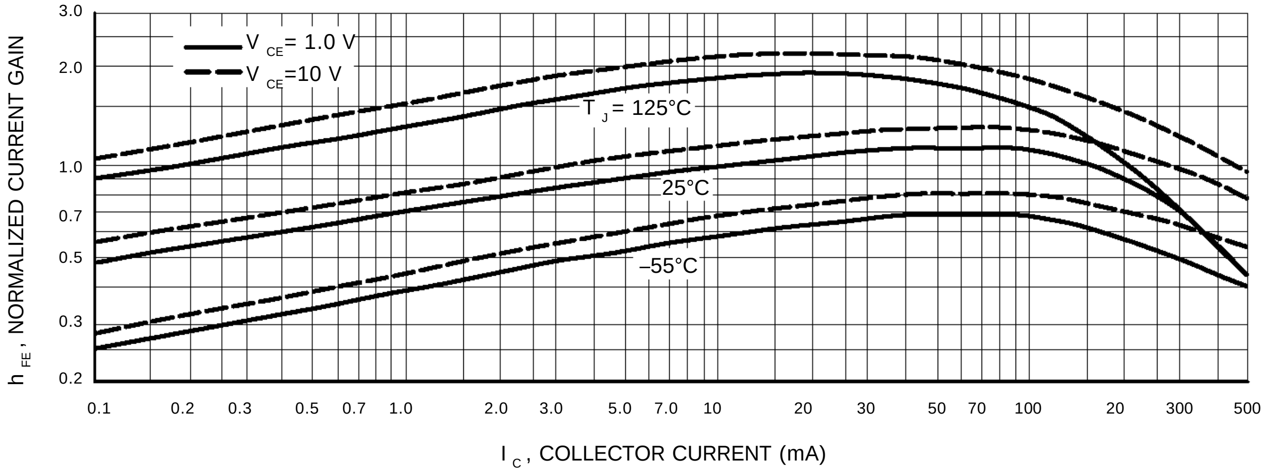


Figure 17. DC Current Gain

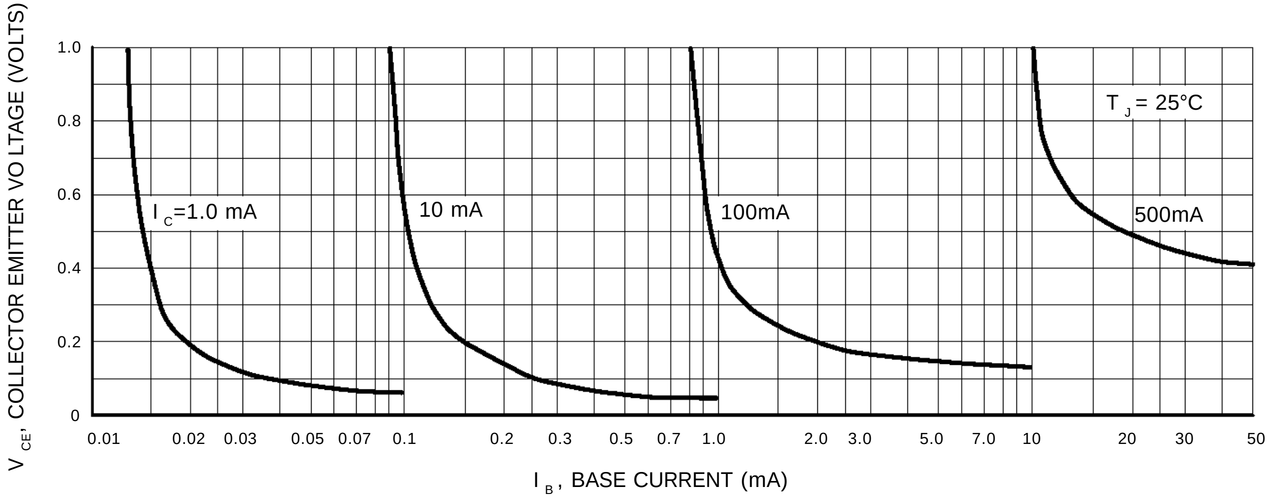


Figure 18. Collector Saturation Region

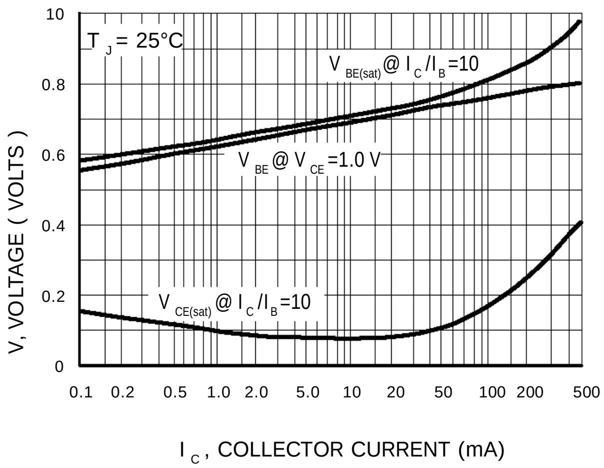


Figure 17. "On" Voltages

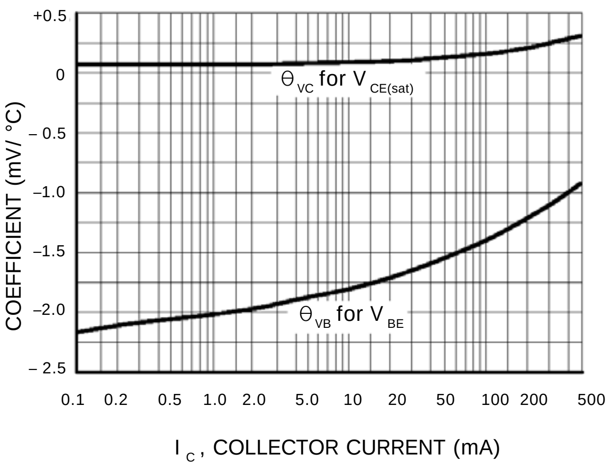


Figure 20. Temperature Coefficients

TYPICAL TRANSIENT CHARACTERISTICS (Q2 PNP)

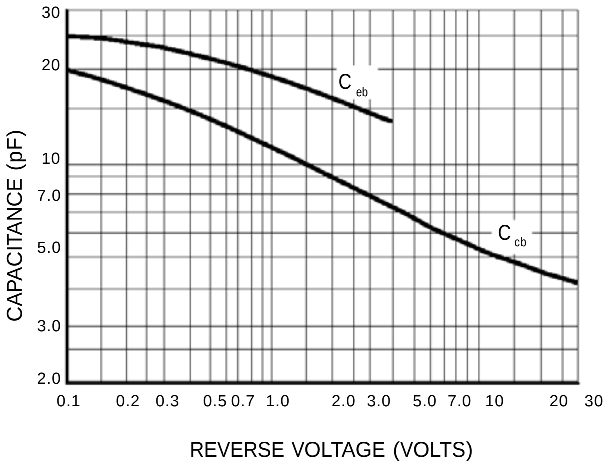


Figure 3. Capacitance

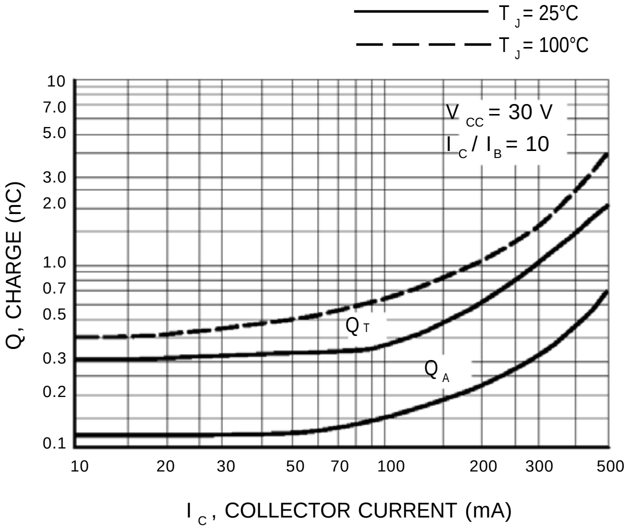


Figure 4. Charge Data

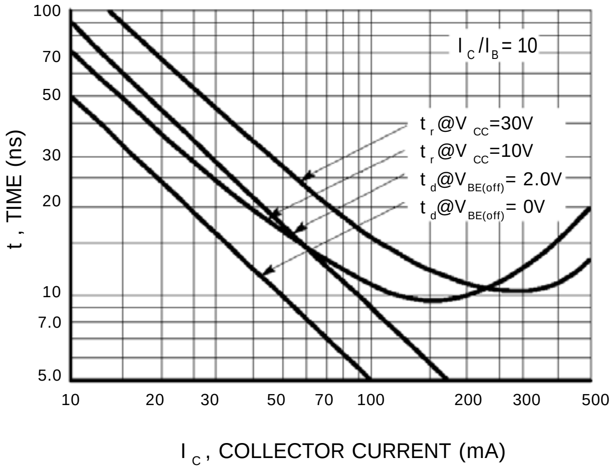


Figure 5. Turn–On Time

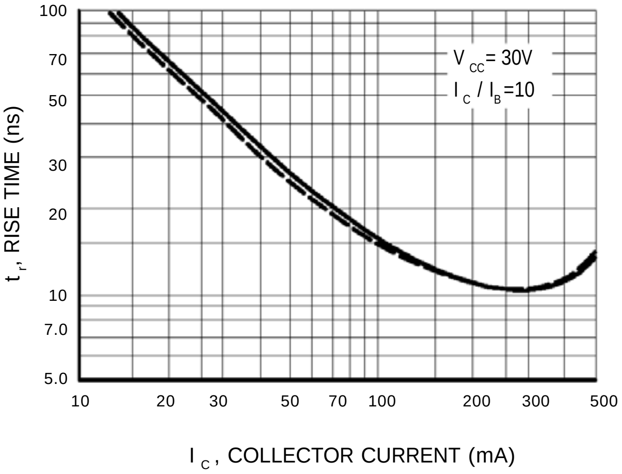


Figure 6. Rise Time

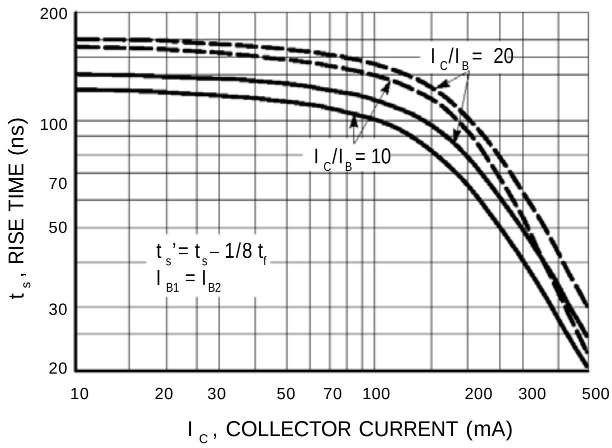


Figure 7. Storage Time

SMALL–SIGNAL CHARACTERISTICS (Q2 PNP)

NOISE FIGURE

V_{CE} = –10 Vdc, T_A = 25°C
Bandwidth = 1.0 Hz

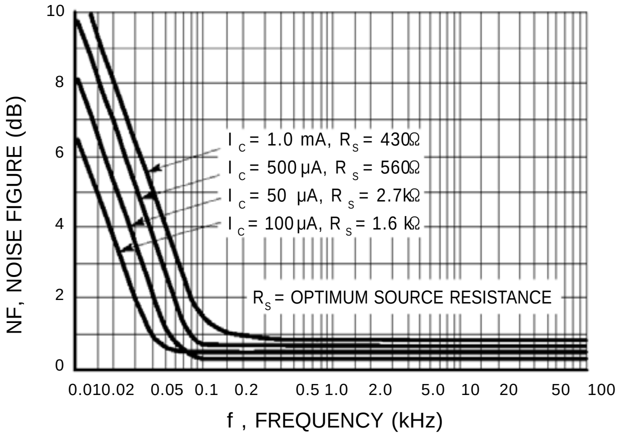


Figure 8. Frequency Effects

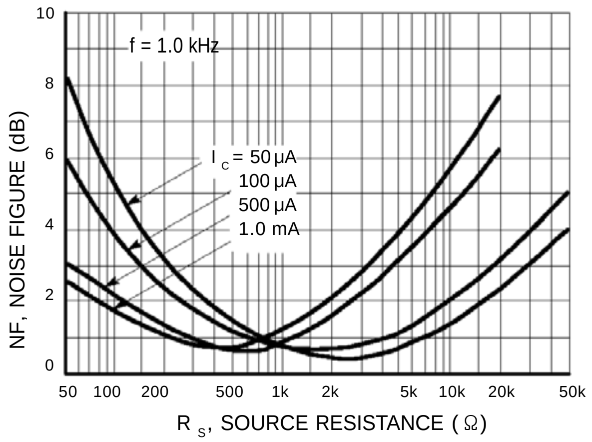


Figure 9. Source Resistance Effects

h PARAMETERS

(V_{CE} = –10 Vdc, f = 1.0 kHz, T_A = 25°C)

This group of graphs illustrates the relationship between h fe and other “h” parameters for this series of transistors. To obtain these curves, a high–gain and a low–gain unit were selected from the LMBT4413DW1T1G lines, and the same units were used to develop the correspondingly numbered curves on each graph.

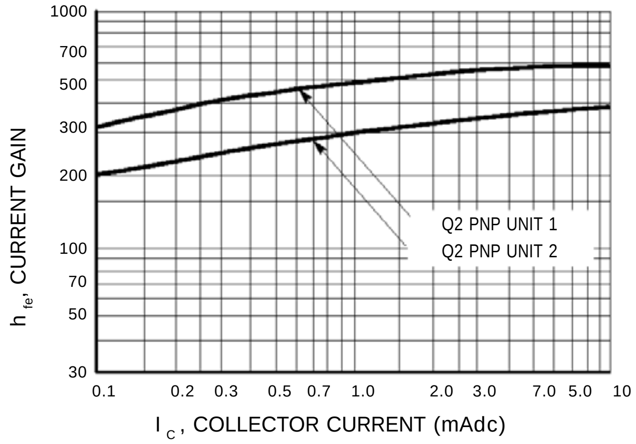


Figure 10. Current Gain

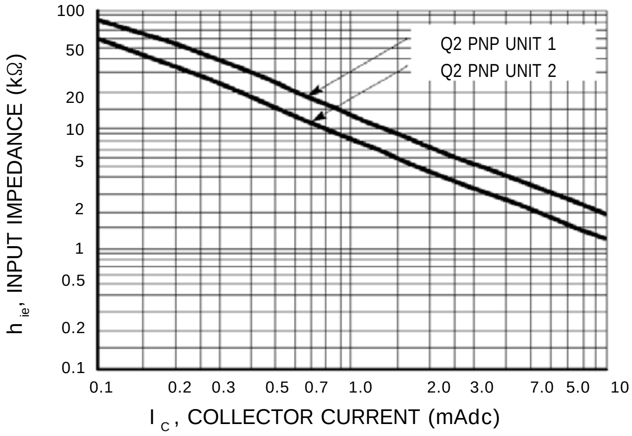


Figure 11. Input Impedance

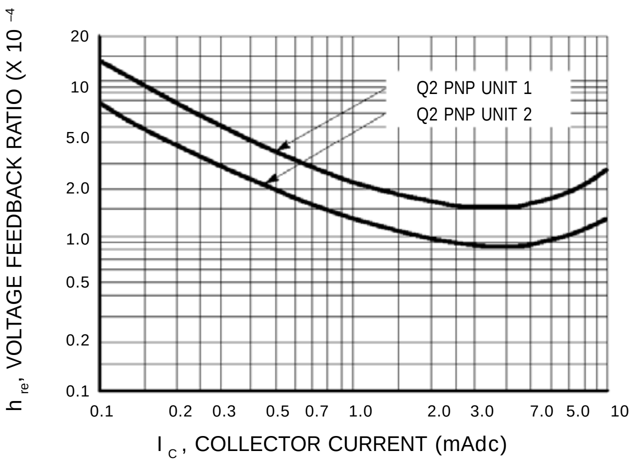


Figure 12. Voltage Feedback Ratio

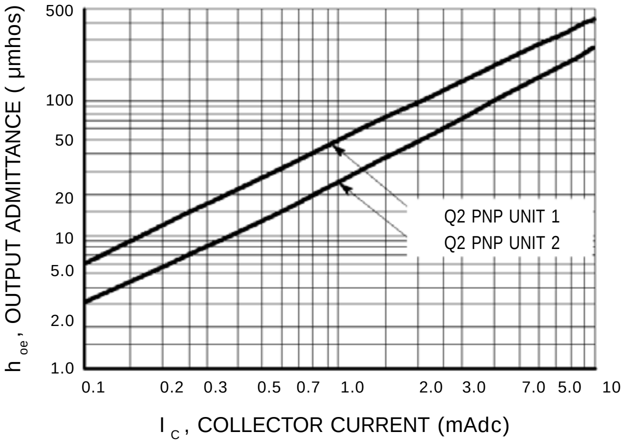


Figure 13. Output Admittance

STATIC CHARACTERISTICS (Q2 PNP)

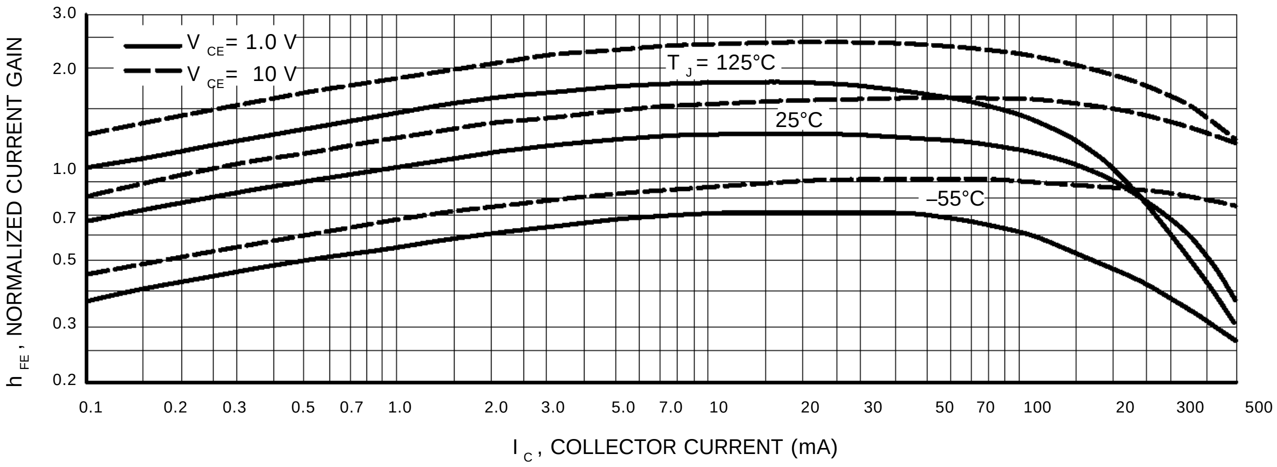


Figure 14. DC Current Gain

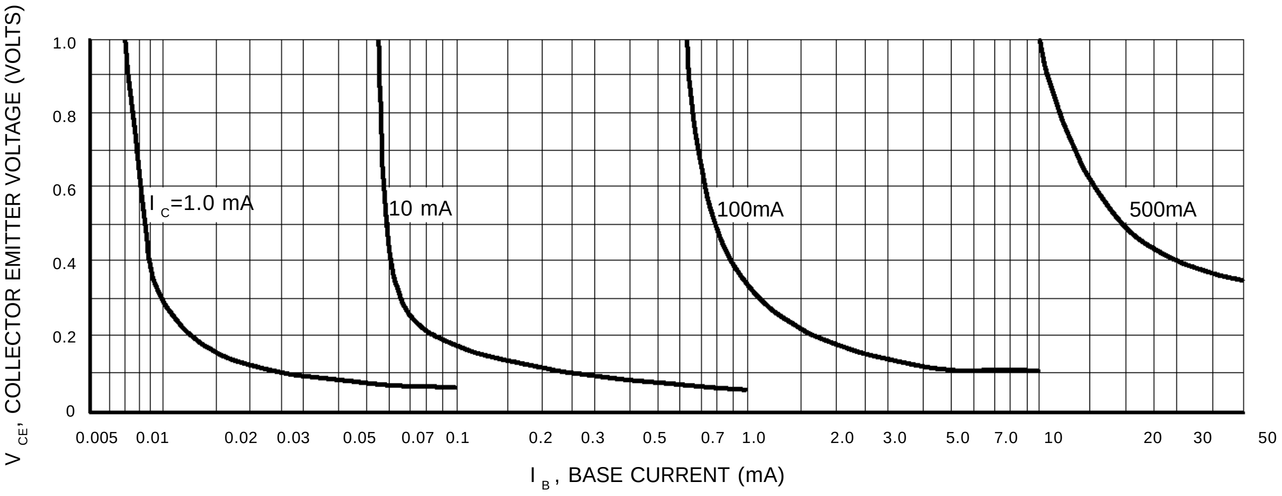


Figure 15. Collector Saturation Region

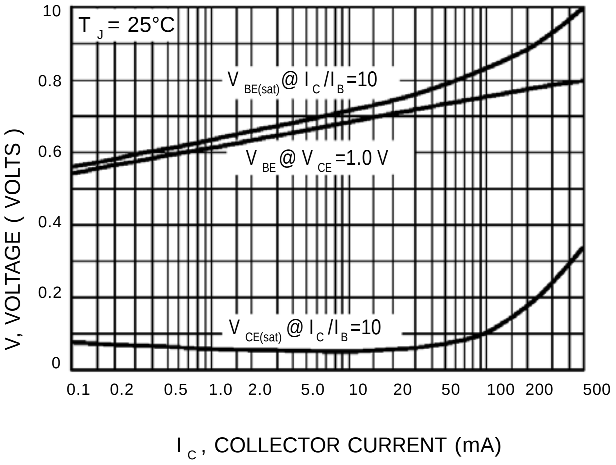


Figure 16. “On” Voltages

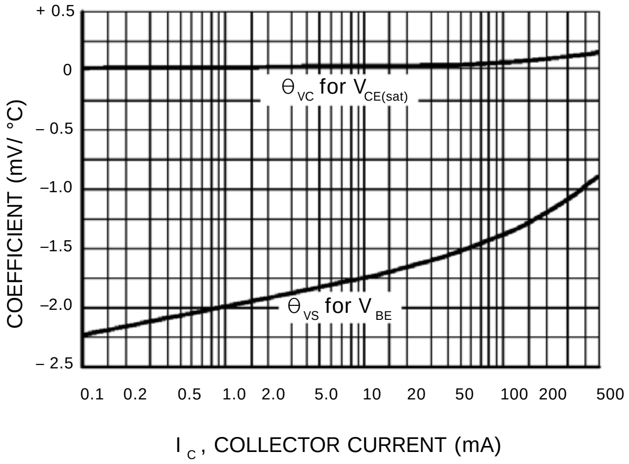
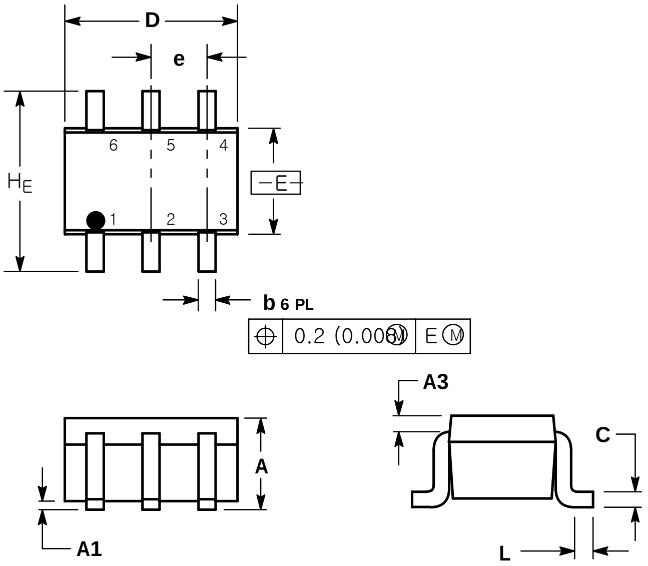


Figure 17. Temperature Coefficients

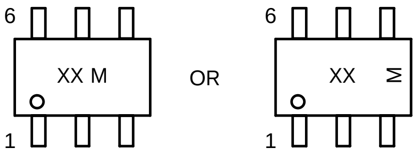
SC−88



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419B−01 OBSOLETE, NEW STANDARD 419B−02.

	MILLIMETERS			INCHES		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	0.95	1.10	0.031	0.037	0.043
A1	0.00	0.05	0.10	0.000	0.002	0.004
A3	0.20 REF			0.008 REF		
b	0.10	0.21	0.30	0.004	0.008	0.012
C	0.10	0.14	0.25	0.004	0.005	0.010
D	1.80	2.00	2.20	0.070	0.078	0.086
E	1.15	1.25	1.35	0.045	0.049	0.053
e	0.65 BSC			0.026 BSC		
L	0.10	0.20	0.30	0.004	0.008	0.012
H_E	2.00	2.10	2.20	0.078	0.082	0.086

GENERIC MARKING DIAGRAM*



XX = Specific Device Code
M = Date Code