

FMBT4413DW1

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FMBT4413DW1

Dual Small Signal Surface Mount Transistor NPN + PNP

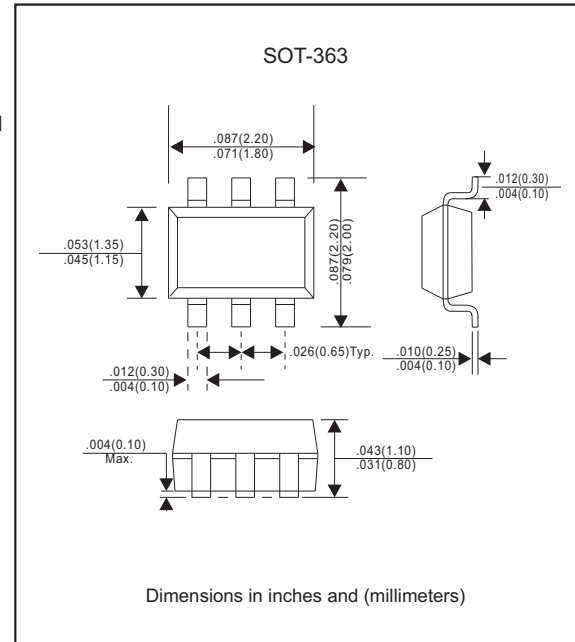
Features

- Lead-free parts meet RoHS requirements
- Suffix "-H" indicates Halogen-free part, ex.FMBT4413DW1-H

Mechanical data

- Epoxy:UL94-V0 rated flame retardant
- Case : Molded plastic, SOT-363
- Terminals : Solder plated, solderable per MIL-STD-750, Method 2026
- Polarity : See Diagram
- Mounting Position : Any
- Weight : Approximated 0.006 gram

Package outline



Maximum ratings-NPN (AT $T_A=25^{\circ}\text{C}$ unless otherwise noted)

Parameter	Symbol	Value	Unit
Collector-base voltage	V_{CB0}	60	Vdc
Collector-emitter voltage	V_{CE0}	40	Vdc
Emitter-base voltage	V_{EB0}	6	Vdc
Collector current -continuous	I_C	600	mAdc

Maximum ratings-PNP (AT $T_A=25^{\circ}\text{C}$ unless otherwise noted)

Parameter	Symbol	Value	Unit
Collector-base voltage	V_{CB0}	-60	Vdc
Collector-emitter voltage	V_{CE0}	-40	Vdc
Emitter-base voltage	V_{EB0}	-5	Vdc
Collector current -continuous	I_C	-600	mAdc

Thermal characteristics

Parameter	Symbol	Max.	Unit
Total device dissipation FR- 5 board, (1) $T_A=25^{\circ}\text{C}$	P_D	225	mW
Derate above 25°C		1.8	mW/ $^{\circ}\text{C}$
Thermal resistance junction to ambient (Note 1)	$R_{\theta JA}$	556	$^{\circ}\text{C}/\text{W}$
Total device dissipation Alumina substrate, (2) $T_A=25^{\circ}\text{C}$	P_D	300	mW
Derate above 25°C		2.4	mW/ $^{\circ}\text{C}$
Thermal resistance junction to ambient (Note 2)	$R_{\theta JA}$	417	$^{\circ}\text{C}/\text{W}$
Operating junction temperature range	T_J	-55 to +150	$^{\circ}\text{C}$
Storage temperature range	T_{STG}	-55 to +150	$^{\circ}\text{C}$

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.

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Q1(NPN) Electrical characteristics (AT $T_A=25^\circ\text{C}$ unless otherwise noted)

Off characteristics

Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
Collector-base breakdown voltage	$I_C = 0.1\text{mA}$, $I_E = 0$	$V_{(BR)CBO}$	60			V
Collector-emitter breakdown voltage (Note 2)	$I_C = 1\text{mA}$, $I_B = 0$	$V_{(BR)CEO}$	40			V
Emitter-base breakdown voltage	$I_E = 0.1\text{mA}$, $I_C = 0$	$V_{(BR)EBO}$	6.0			V
Base cutoff current	$V_{CE} = 35\text{Vdc}$, $V_{EB} = 0.4\text{Vdc}$	I_{BEV}			0.1	μA
Collector cutoff current	$V_{CE} = 35\text{Vdc}$, $V_{EB} = 0.4\text{Vdc}$	I_{CEX}			0.1	μA

On characteristics (note 2)

Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
DC current gain	$I_C = 0.1\text{mA}$, $V_{CE} = 1.0\text{V}$	h_{FE}	20			
	$I_C = 1.0\text{mA}$, $V_{CE} = 1.0\text{V}$		40			
	$I_C = 10\text{mA}$, $V_{CE} = 1.0\text{V}$		80			
	$I_C = 150\text{mA}$, $V_{CE} = 1.0\text{V}$		100		300	
	$I_C = 500\text{mA}$, $V_{CE} = 2.0\text{V}$		40			
Collector-emitter saturation voltage	$I_C = 150\text{mA}$, $I_B = 15\text{mA}$	$V_{CE(sat)}$			0.4	V
	$I_C = 500\text{mA}$, $I_B = 50\text{mA}$				0.75	
Base-emitter saturation voltage	$I_C = 150\text{mA}$, $I_B = 15\text{mA}$	$V_{BE(sat)}$	0.75		0.95	V
	$I_C = 500\text{mA}$, $I_B = 50\text{mA}$				1.2	

Small-signal characteristics

Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
Current-gain-bandwidth product	$I_C = 20\text{mA}$, $V_{CE} = 10\text{V}$, $f = 100\text{MHz}$	f_T	250			MHz
Collector-base capacitance	$V_{CB} = 5.0\text{V}$, $I_E = 0$, $f = 1.0\text{MHz}$	C_{cb}			6.5	pF
Emitter-base capacitance	$V_{EB} = 0.5\text{V}$, $I_C = 0$, $f = 1.0\text{MHz}$	C_{eb}			30	pF
Input impedance	$V_{CE} = 10\text{V}$, $I_C = 1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{ie}	1.0		15	k Ω
Voltage feedback ratio	$V_{CE} = 10\text{V}$, $I_C = 1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{re}	0.1		8.0	$\times 10^{-4}$
Small-signal current gain	$V_{CE} = 10\text{V}$, $I_C = 1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{fe}	40		500	
Output admittance	$V_{CE} = 10\text{V}$, $I_C = 1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{oe}	1.0		30	μmhos

Switching characteristics

Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
Delay time	$V_{CC} = 30\text{V}$, $V_{EB} = 2\text{V}$, $I_C = 150\text{mA}$, $I_{B1} = 15\text{mA}$	t_d			15	ns
Rise time		t_r			20	
Storage time	$V_{CC} = 30\text{V}$, $I_C = 150\text{mA}$, $I_{B1} = I_{B2} = 15\text{mA}$	t_s			225	
Fall time		t_f			30	

Note 2: Pulse test: Pulse width $\leq 300\mu\text{s}$, Duty cycle $\leq 2.0\%$.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

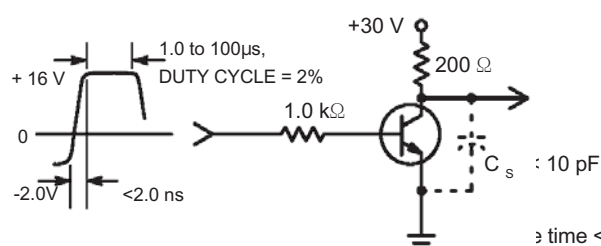


Figure 1. Turn-On Time

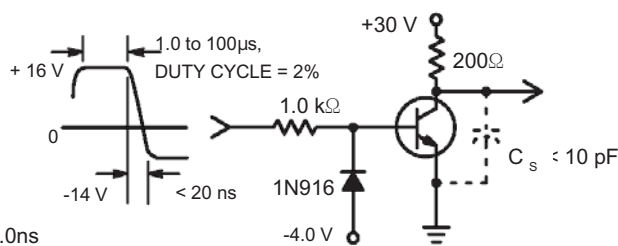


Figure 2. Turn-Off Time

FMBT4413DW1

Q2(PNP) Electrical characteristics (AT $T_A=25^\circ\text{C}$ unless otherwise noted)**Off characteristics**

Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
Collector-base breakdown voltage	$I_C = -0.1\text{mA}$, $I_E = 0$	$V_{(BR)CBO}$	-60			V
Collector-emitter breakdown voltage (Note 2)	$I_C = -1\text{mA}$, $I_B = 0$	$V_{(BR)CEO}$	-40			V
Emitter-base breakdown voltage	$I_E = -0.1\text{mA}$, $I_C = 0$	$V_{(BR)EBO}$	-5.0			V
Base cutoff current	$V_{CE} = -35\text{Vdc}$, $V_{EB} = -0.4\text{Vdc}$	I_{BEV}			-0.1	μA
Collector cutoff current	$V_{CE} = -35\text{Vdc}$, $V_{EB} = -0.4\text{Vdc}$	I_{CEX}			-0.1	μA

On characteristics

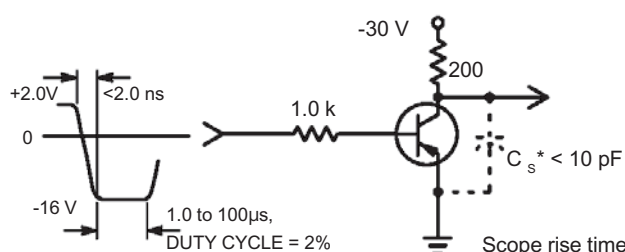
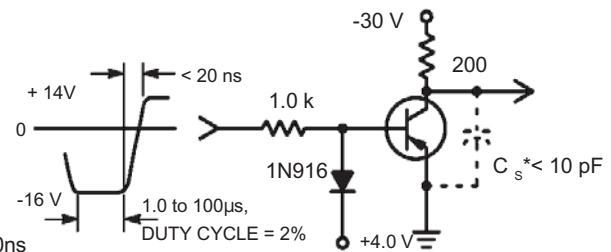
Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
DC current gain	$I_C = -0.1\text{mA}$, $V_{CE} = -1.0\text{V}$	h_{FE}	30			
	$I_C = -1.0\text{mA}$, $V_{CE} = -1.0\text{V}$		60			
	$I_C = -10\text{mA}$, $V_{CE} = -1.0\text{V}$		100			
	$I_C = -150\text{mA}$, $V_{CE} = -2.0\text{V}$ (note 2)		100		300	
	$I_C = -500\text{mA}$, $V_{CE} = -2.0\text{V}$ (note 2)		20			
Collector-emitter saturation voltage	$I_C = -150\text{mA}$, $I_B = -15\text{mA}$ (note 2)	$V_{CE(sat)}$			-0.4	V
	$I_C = -500\text{mA}$, $I_B = -50\text{mA}$ (note 2)				-0.75	
Base-emitter saturation voltage	$I_C = -150\text{mA}$, $I_B = -15\text{mA}$ (note 2)	$V_{BE(sat)}$	-0.75		-0.95	V
	$I_C = -500\text{mA}$, $I_B = -50\text{mA}$ (note 2)				-1.3	

Small-signal characteristics

Parameter	Conditions	Symbol	MIN.	TYP.	MAX.	Unit
Current-gain-bandwidth product	$I_C = -20\text{mA}$, $V_{CE} = -10\text{V}$, $f = 100\text{MHz}$	f_r	200			MHz
Collector-base capacitance	$V_{CB} = -10\text{V}$, $I_E = 0$, $f = 1.0\text{MHz}$	C_{cb}			8.5	pF
Emitter-base capacitance	$V_{EB} = -0.5\text{V}$, $I_C = 0$, $f = 1.0\text{MHz}$	C_{eb}			30	pF
Input impedance	$V_{CE} = -10\text{V}$, $I_C = -1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{ie}	1.5		15	k Ω
Voltage feedback ratio	$V_{CE} = -10\text{V}$, $I_C = -1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{re}	0.1		8.0	$\times 10^{-4}$
Small-signal current gain	$V_{CE} = -10\text{V}$, $I_C = -1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{fe}	60		500	
Output admittance	$V_{CE} = -10\text{V}$, $I_C = -1.0\text{mA}$, $f = 1.0\text{KHz}$	h_{oe}	1.0		100	μmhos

Switching characteristics

Parameter	Condotions	Symbol	MIN.	TYP.	MAX.	Unit
Delay time	$V_{CC} = -30\text{V}$, $V_{EB} = -2\text{V}$, $I_C = -150\text{mA}$, $I_{B1} = -15\text{mA}$	t_d			15	ns
Rise time		t_r			20	
Storage time	$V_{CC} = -30\text{V}$, $I_C = -150\text{mA}$, $I_{B1} = I_{B2} = -15\text{mA}$	t_s			225	
Fall time		t_f			30	

Note 2: Pulse test: Pulse width $\leq 300\mu\text{s}$, Duty cycle $\leq 2.0\%$.**SWITCHING TIME EQUIVALENT TEST CIRCUITS****Figure 3. Turn-On Time****Figure 4. Turn-Off Time**

Rating and characteristic curves (FMBT4413DW1)

TRANSIENT CHARACTERISTICS (Q1 NPN)

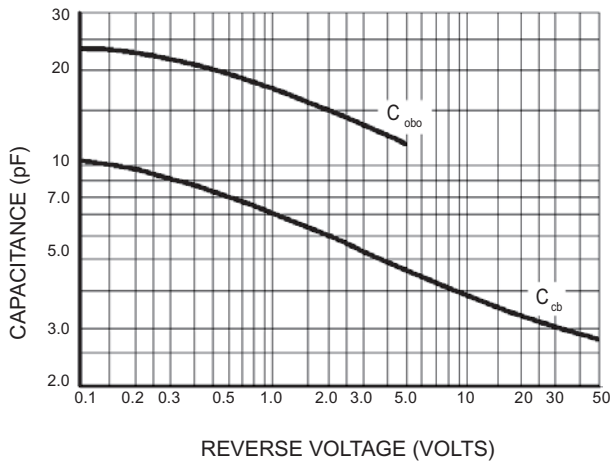


Figure 5. Capacitance

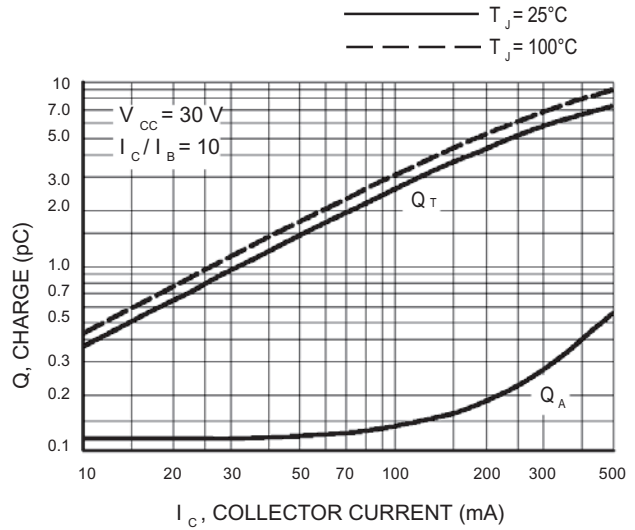


Figure 6. Charge Data

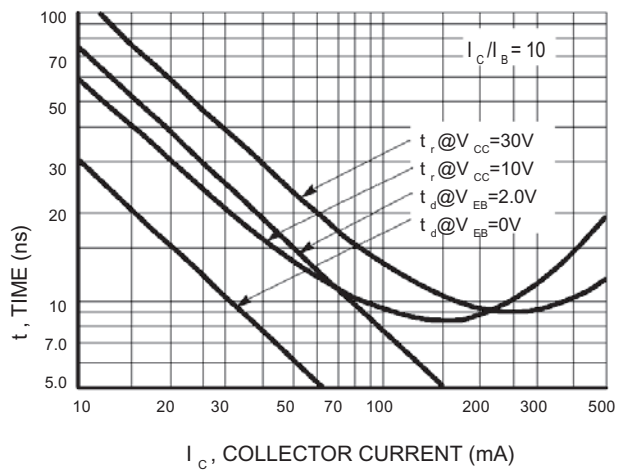


Figure 7. Turn-On Time

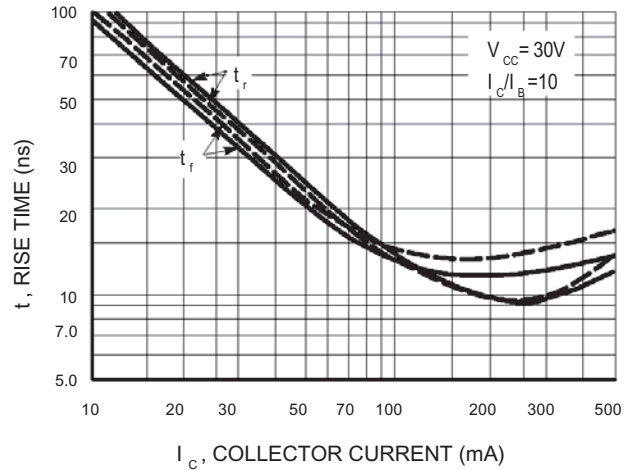


Figure 8. Rise and Fall Time

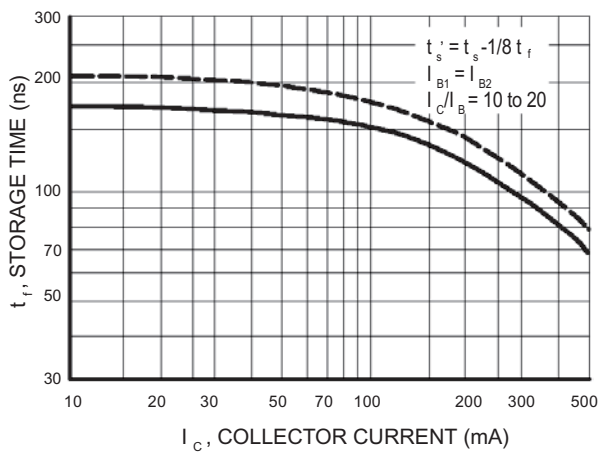


Figure 9. Storage Time

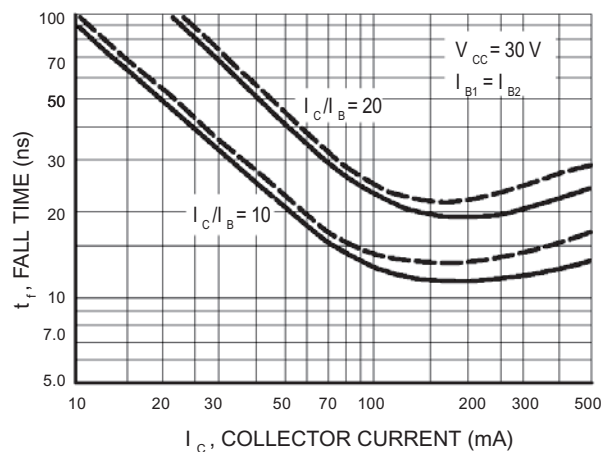


Figure 10. Fall Time

Rating and characteristic curves (FMBT4413DW1)

SMALL-SIGNAL CHARACTERISTICS (Q1 NPN)

NOISE FIGURE

NOISE FIGURE

$V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$

Bandwidth = 1.0 Hz

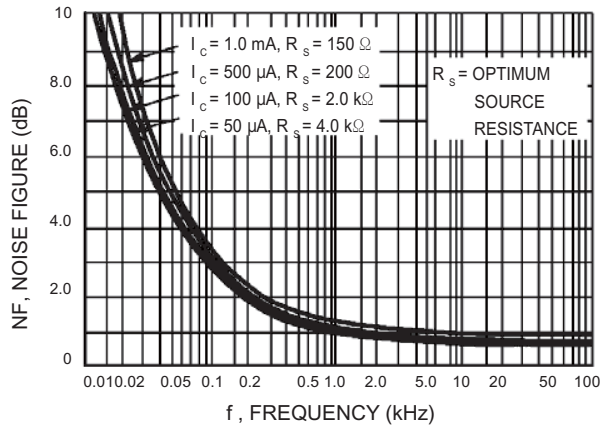


Figure 11. Frequency Effects

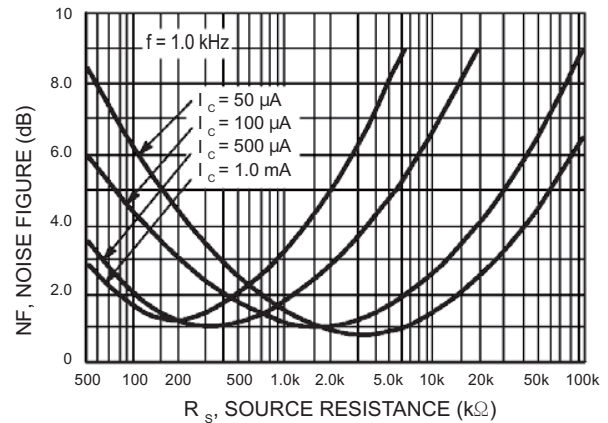


Figure 12. Source Resistance Effects

h PARAMETERS

($V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$)

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 FMBT4413DW1 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

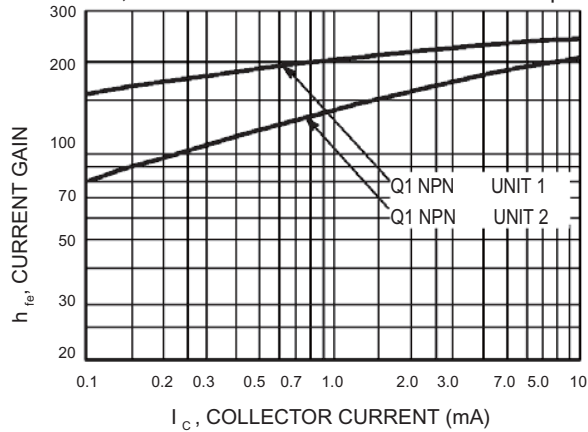


Figure 13. Current Gain

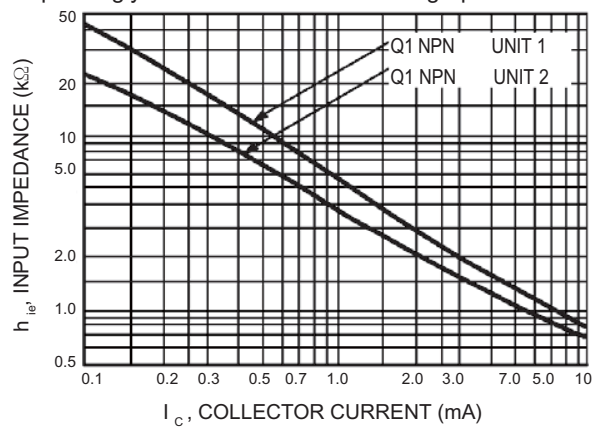


Figure 14. Input Impedance

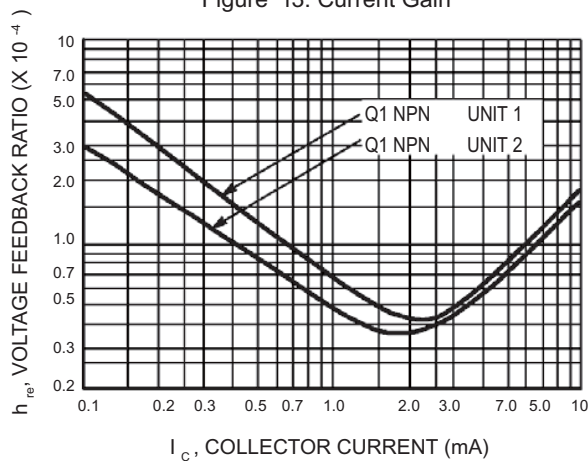


Figure 15. Voltage Feedback Ratio

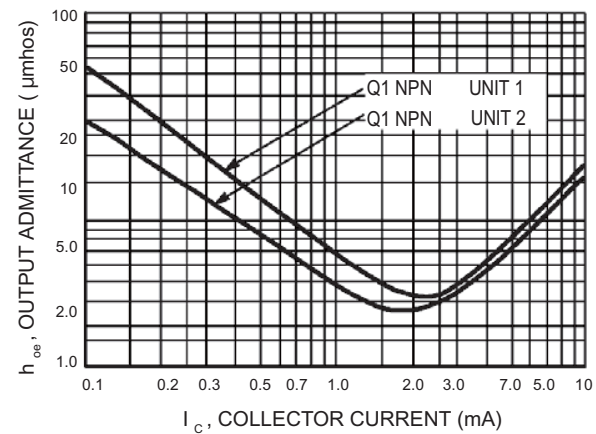
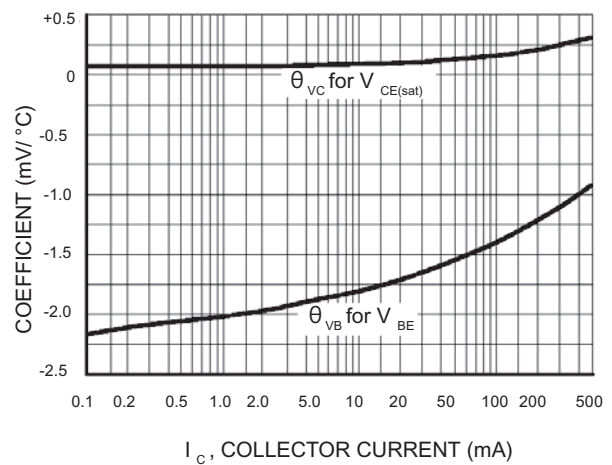
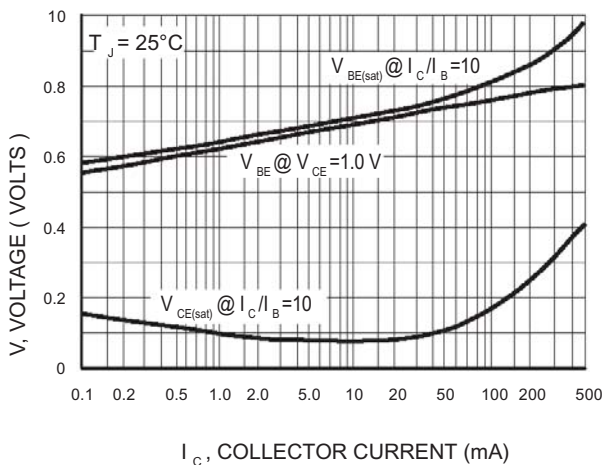
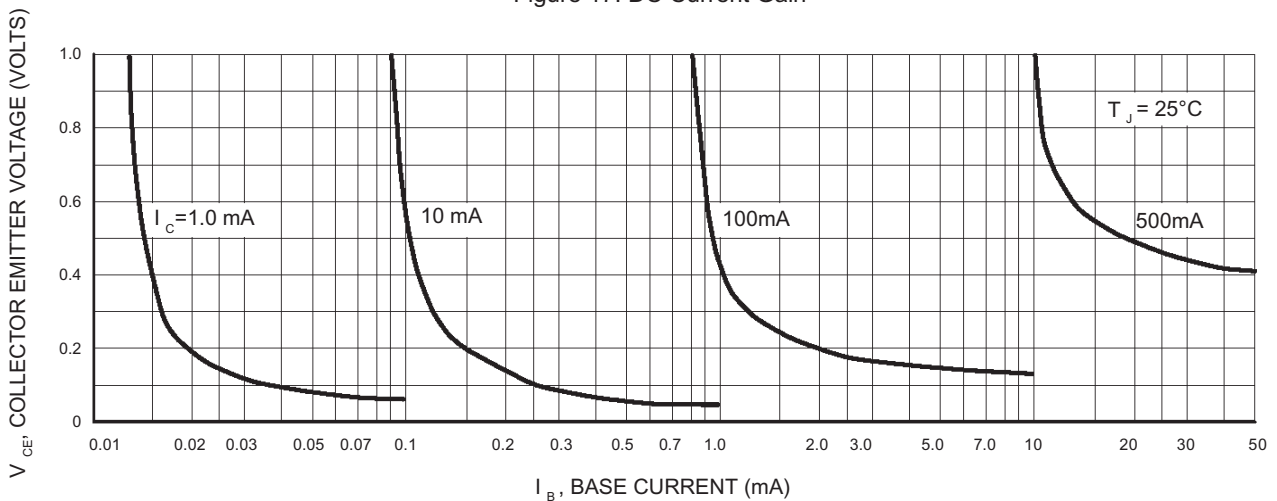
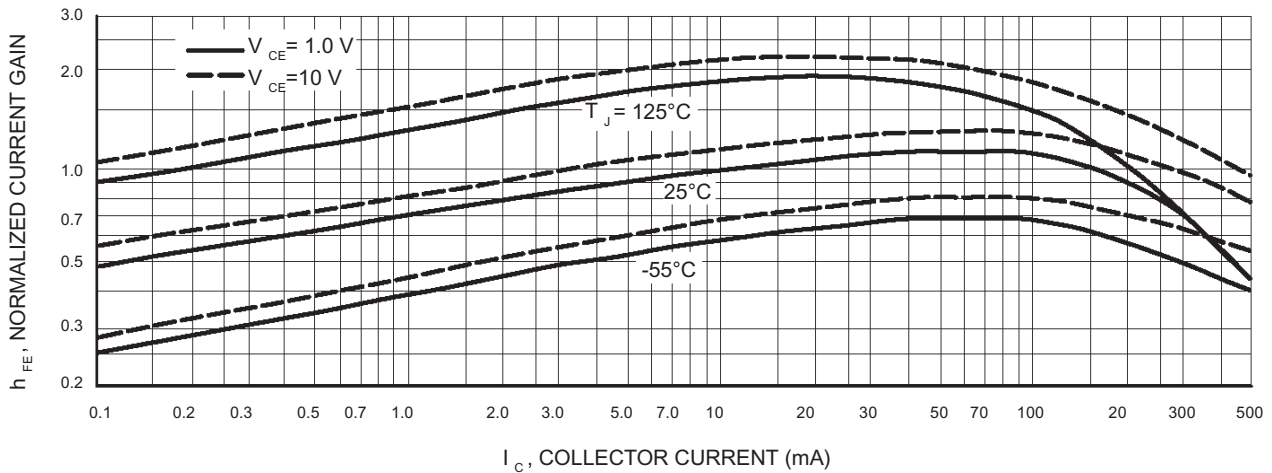


Figure 16. Output Admittance

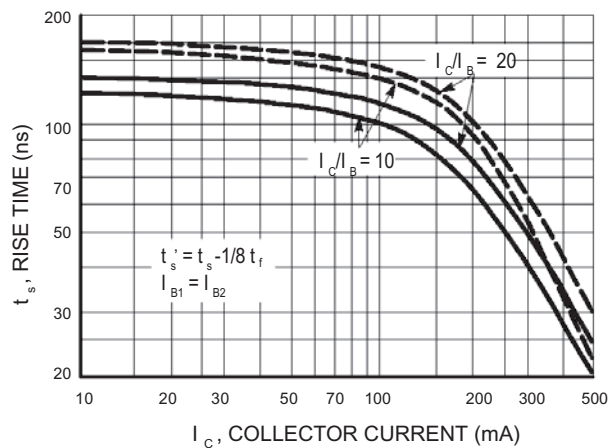
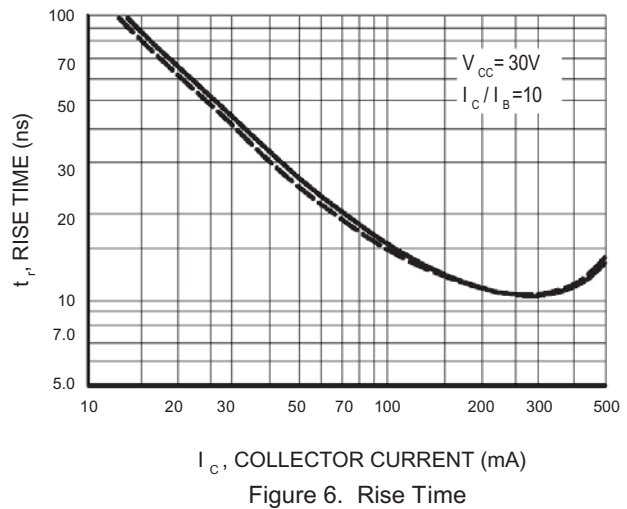
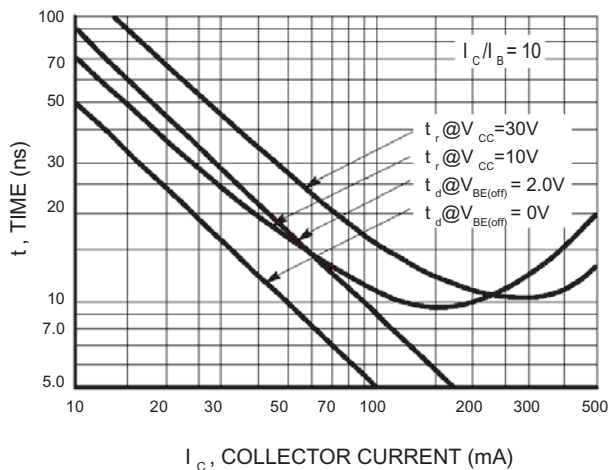
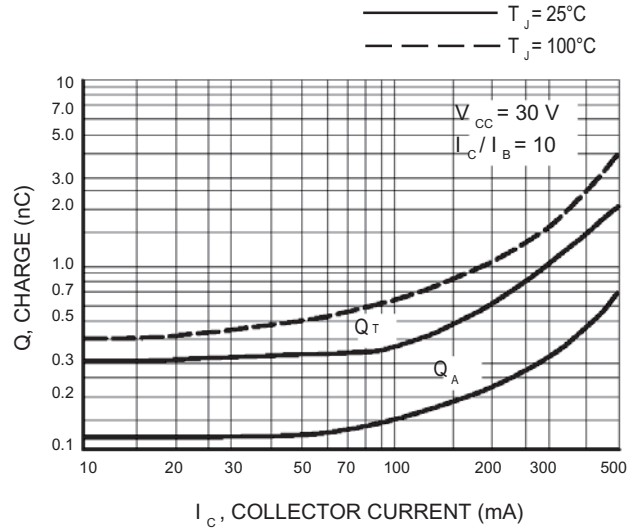
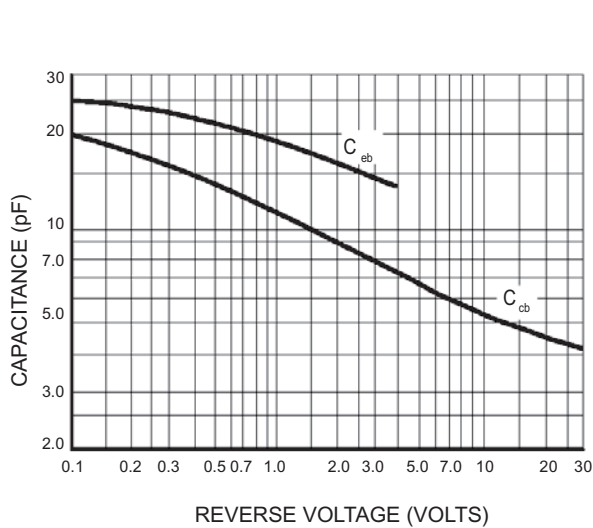
Rating and characteristic curves (FMBT4413DW1)

STATIC CHARACTERISTICS (Q1 NPN)



Rating and characteristic curves (FMBT4413DW1)

TYPICAL TRANSIENT CHARACTERISTICS (Q2 PNP)



Rating and characteristic curves (FMBT4413DW1)

SMALL-SIGNAL CHARACTERISTICS (Q2 PNP)

NOISE FIGURE

$V_{CE} = -10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$

Bandwidth = 1.0 Hz

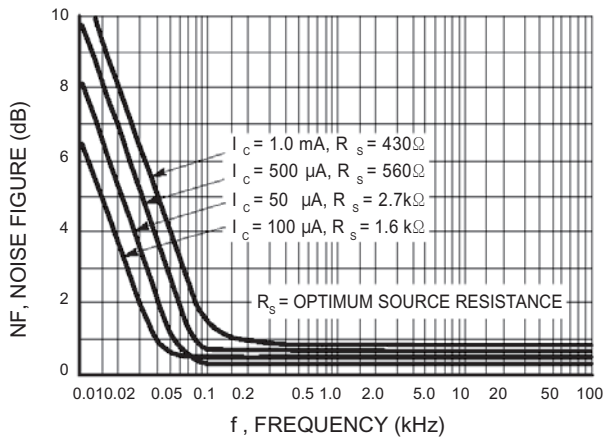


Figure 8. Frequency Effects

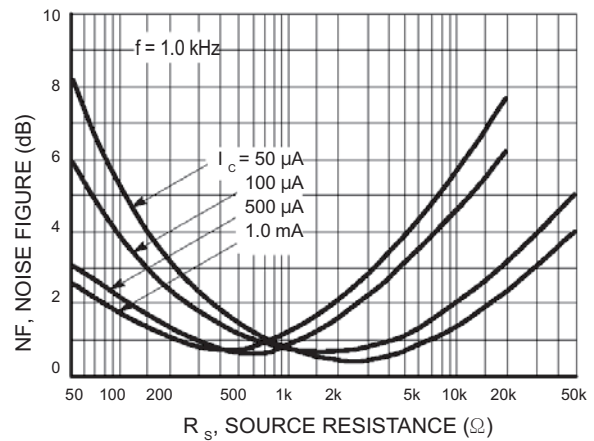


Figure 9. Source Resistance Effects

h PARAMETERS

($V_{CE} = -10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$)

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 FMBT4413DW1 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

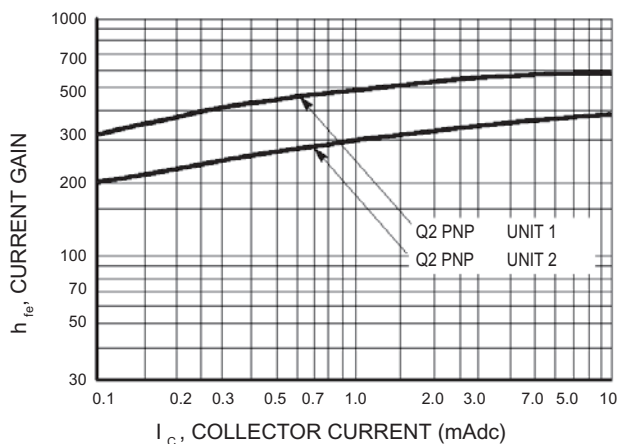


Figure 10. Current Gain

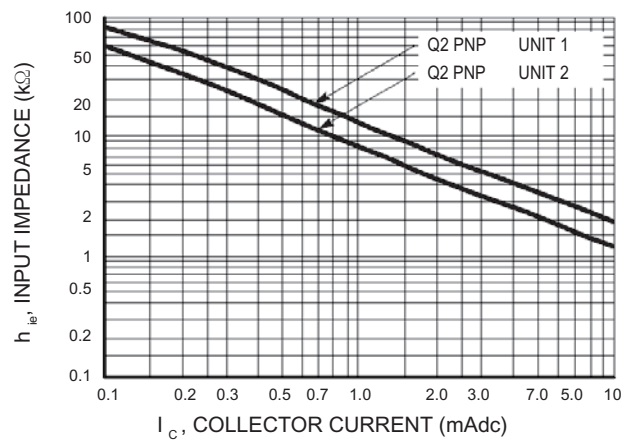


Figure 11. Input Impedance

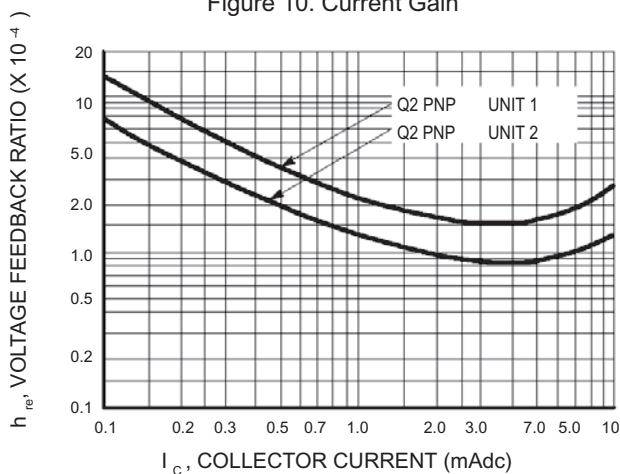


Figure 12. Voltage Feedback Ratio

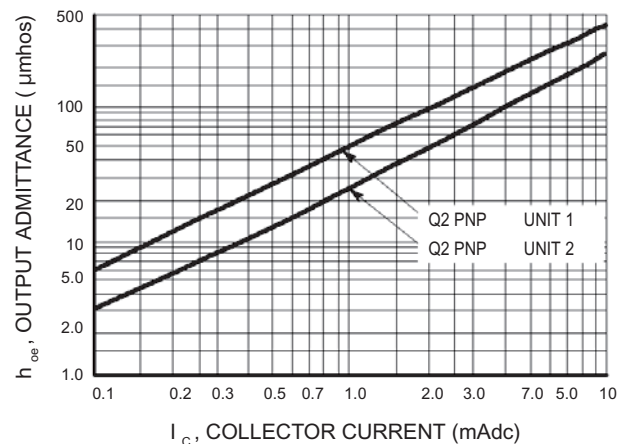
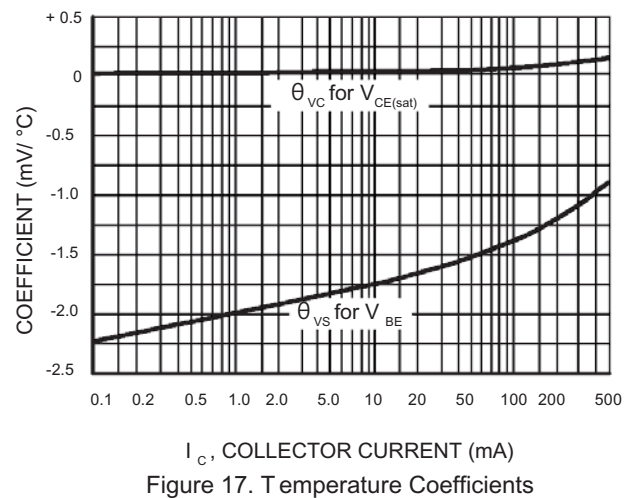
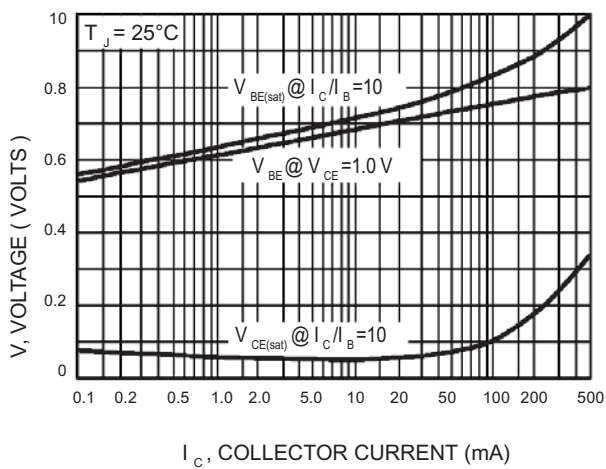
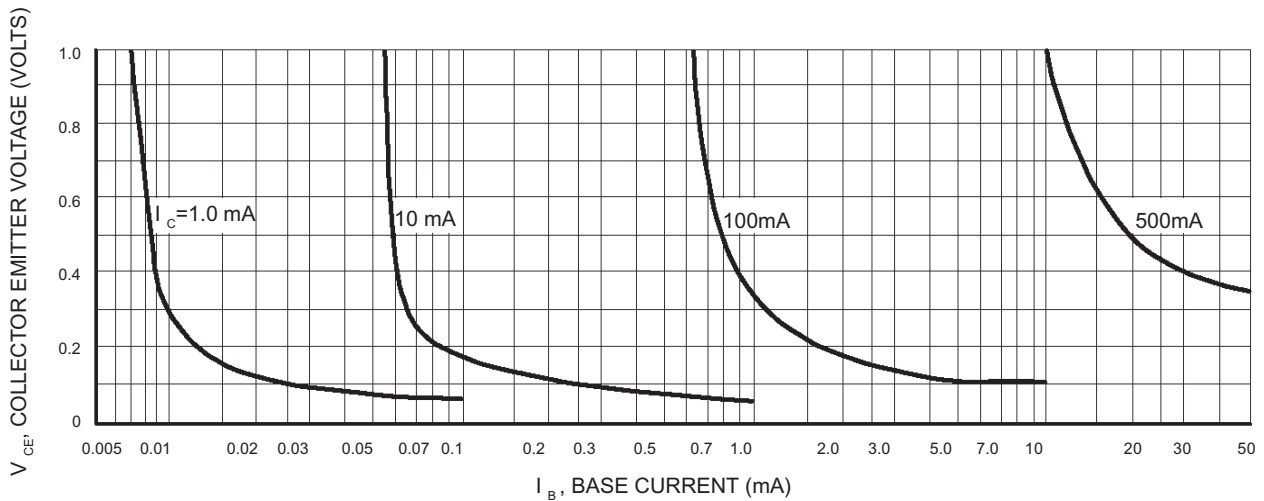
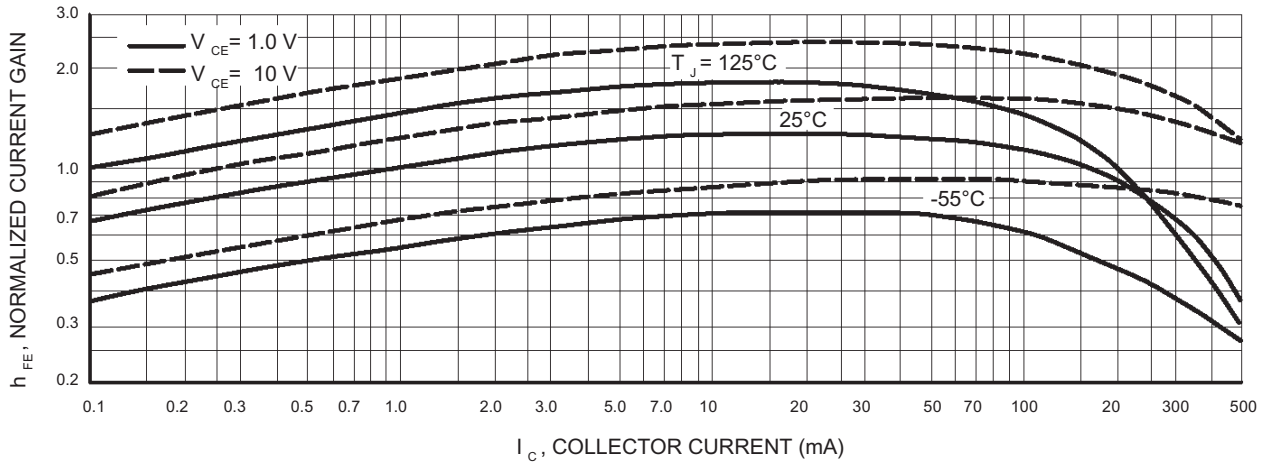


Figure 13. Output Admittance

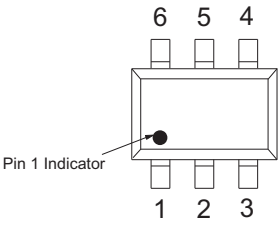
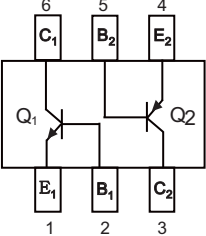
Rating and characteristic curves (FMBT4413DW1)

STATIC CHARACTERISTICS (Q2 PNP)



FMBT4413DW1

Pinning information

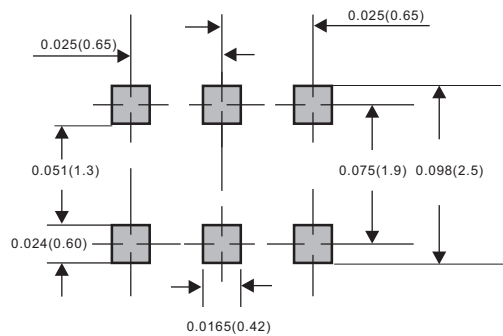
Pin	Simplified outline	Symbol
Pin1 Emitter1 Pin2 Base1 Pin3 Collector2 Pin4 Emitter2 Pin5 Base2 Pin6 Collector1		

Marking

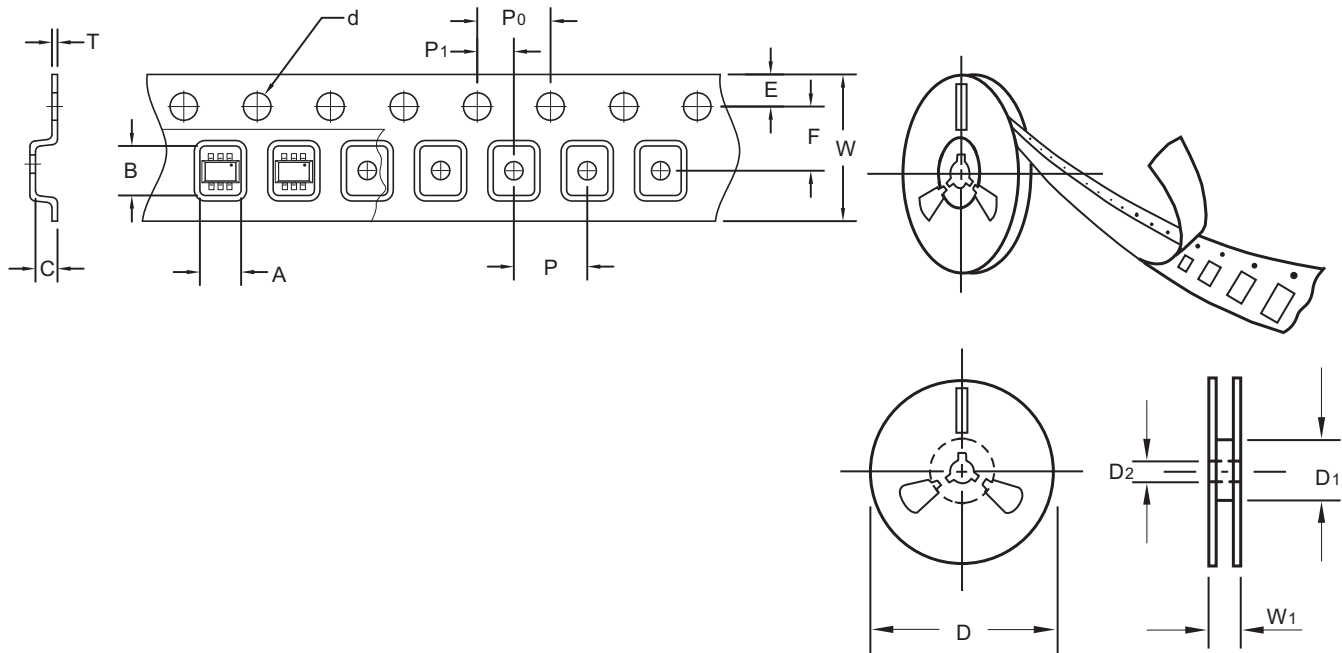
Type number	Marking code
FMBT4413DW1	K13

Suggested solder pad layout

SOT-363



Dimensions in inches and (millimeters)

FMBT4413DW1**Packing information**

unit:mm

Item	Symbol	Tolerance	SOT-363
Carrier width	A	0.1	2.36
Carrier length	B	0.1	2.40
Carrier depth	C	0.1	1.20
Sprocket hole	d	0.1	1.50
13" Reel outside diameter	D	2.0	-
13" Reel inner diameter	D ₁	min	-
7" Reel outside diameter	D	2.0	178.00
7" Reel inner diameter	D ₁	min	62.00
Feed hole diameter	D ₂	0.5	13.00
Sprocket hole position	E	0.1	1.75
Punch hole position	F	0.1	3.50
Punch hole pitch	P	0.1	4.00
Sprocket hole pitch	P ₀	0.1	4.00
Embossment center	P ₁	0.1	2.00
Overall tape thickness	T	0.1	0.23
Tape width	W	0.3	8.00
Reel width	W ₁	1.0	11.40

Note: Devices are packed in accordance with EIA standard RS-481-A and specifications listed above.

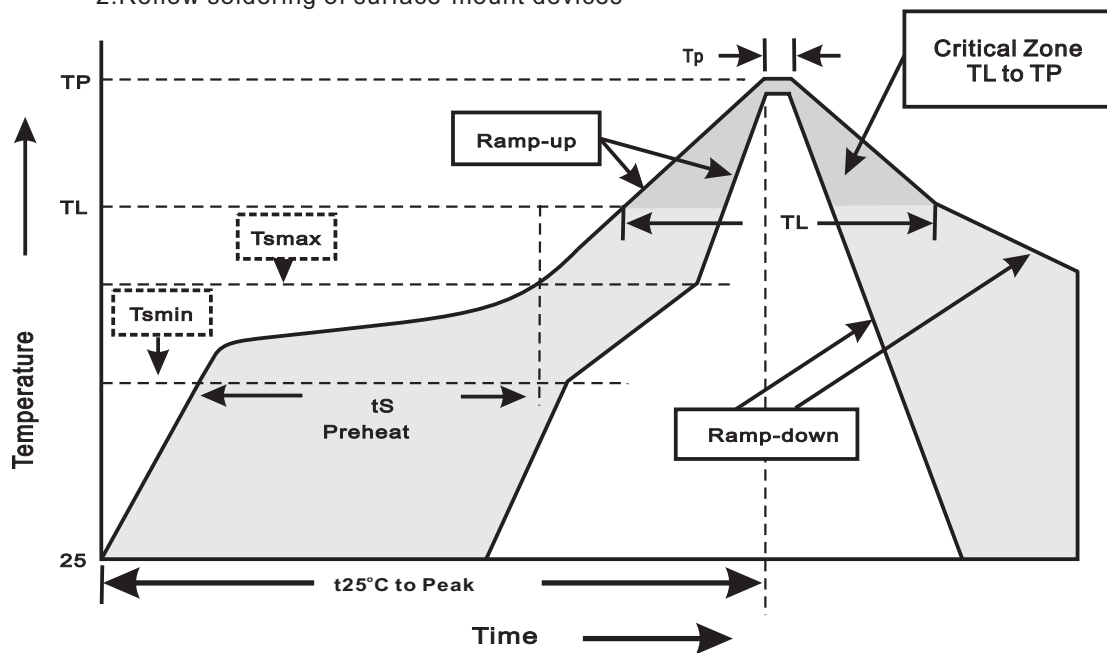
FMBT4413DW1

Reel packing

PACKAGE	REEL SIZE	REEL (pcs)	COMPONENT SPACING (m/m)	BOX (pcs)	INNER BOX (m/m)	REEL DIA, (m/m)	CARTON SIZE (m/m)	CARTON (pcs)	APPROX. GROSS WEIGHT (kg)
SOT-363	7"	3,000	4.0	30,000	183*123*183	178	382*257*387	240,000	9.5

Suggested thermal profiles for soldering processes

- 1.Storage environment: Temperature=5°C~40°C Humidity=55%±25%
- 2.Reflow soldering of surface-mount devices



3.Reflow soldering

Profile Feature	Soldering Condition
Average ramp-up rate(TL to TP)	<3°C/sec
Preheat -Temperature Min(Tsmin) -Temperature Max(Tsmax) -Time(min to max)(ts)	150°C 200°C 60~120sec
Tsmax to TL -Ramp-upRate	<3°C/sec
Time maintained above: -Temperature(TL) -Time(tL)	217°C 60~260sec
Peak Temperature(TP)	255°C-0/+5°C
Time within 5°C of actual Peak Temperature(tp)	10~30sec
Ramp-down Rate	<6°C/sec
Time 25°C to Peak Temperature	<6minutes