N-P-N SILICON PLANAR EPITAXIAL U.H.F. TRANSISTOR

BFW16A

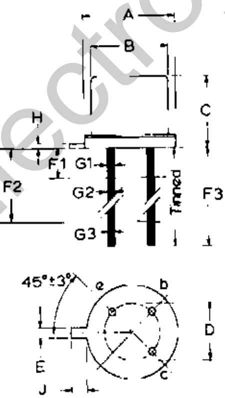
N-P-N silicon planar epitaxial, multi-emitter transistor with extremely good intermodulation properties and a high power gain. The BFW16A is primarily intended for the final and driver stages of channel and band aerial amplifiers with high output power in bands I to V (40-860MHz), and for the final stage of wideband vertical deflection amplifiers in high speed oscilloscopes. Encapsulated in a metal TO-39 envelope with the collector connected to case. The BFW16A is a ruggedized version of BFW16, which it succeeds.

QUICK REFERENCE DATA

V_{CBOM} max.		40	V
V_{CEO} max.		25	V
I_{CM} max. (f > 1.0MHz)		300	mA
P_{tot} max. ($T_{case} \leq 125^oC$)		1.5	W
T_j max.		200	^oC
f_T typ. (I_C = 150mA, V_{CE} = 15V, f = 500MHz)		1.2	GHz
$-C_{re}$ typ. (I_C = 10mA, V_{CE} = 15V, f = 1.0MHz)		1.7	pF
G_p typ. (I_C = 70mA, V_{CE} = 18V)	f = 200MHz	16	dB
	f = 800MHz	6.5	dB
P_o typ. (I_C = 70mA, V_{CE} = 18V)	f = 200MHz	150	mW
	f = 800MHz	90	mW

OUTLINE AND DIMENSIONS

Conforms to B.S. 3934 SO-3/SB3-3B
J.E.D.E.C. TO-39



	Millimetres		
	Min.	Typ.	Max.
A	9.10	-	9.40
B	8.2	-	8.5
C	6.15	-	6.60
D	-	5.08	-
E	0.71	-	0.86
F1	-	-	0.51
F2	12.7	-	-
F3	12.7	-	15
G1	-	-	1.01
G2	0.41	-	0.48
G3	-	-	0.53
H	-	0.4	-
J	0.74	-	1.01

Collector connected to case
Accessories available:- 56218, 56245, 56265

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBOM} max. (peak)	40	V
V_{CERM} max. (peak, $R_{BE} \leq 50\Omega$, $I_C = 10mA$)	40	V
V_{CEO} max. ($I_C = 10mA$)	25	V
V_{EBO} max.	2.0	V
I_C max.	150	mA
I_{CM} max. (f > 1.0MHz)	300	mA
P_{tot} max. ($T_{case} \leq 125^oC$)	1.5	W

Temperature

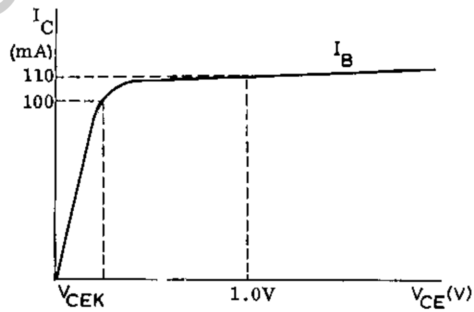
T_{stg} min.	-65	^oC
T_{stg} max.	200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	in free air	250	degC/W
$R_{th(j-case)}$		50	degC/W
$R_{th(case-h)}$	when mounted with a top clamping washer of accessory 56218 and a boron nitride washer for electrical insulation	1.2	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current $V_{CB} = 20V$, $I_E = 0$, $T_j = 150^oC$	-	-	20	μA
V_{CEK}	Collector-emitter knee voltage $I_C = 100mA$, I_B = the value for which $I_C = 110mA$, at $V_{CE} = 1.0V$	-	-	0.75	V



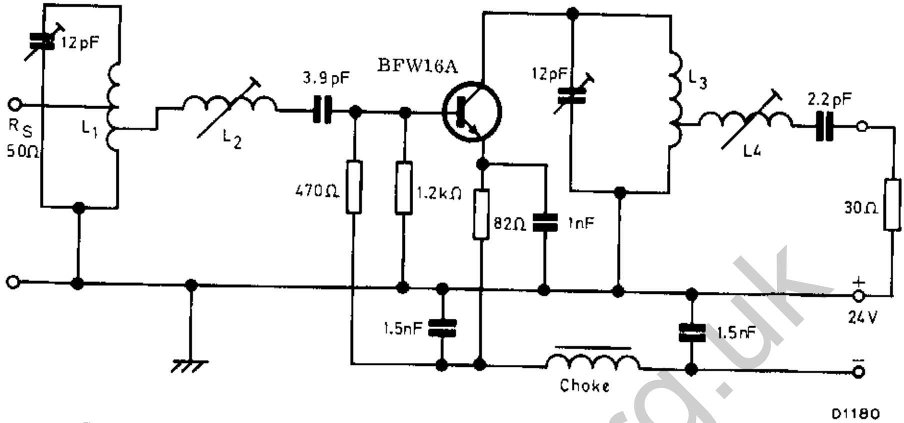
ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio				
	$I_C = 50mA$, $V_{CE} = 5.0V$	25	-	-	
	$I_C = 150mA$, $V_{CE} = 5.0V$	25	-	-	
f_T	Transition frequency $I_C = 150mA$, $V_{CE} = 15V$, $f = 500MHz$	-	1.2	-	GHz
C_{Tc}	Collector capacitance $V_{CB} = 15V$, $I_E = I_e = 0$, $f = 1.0MHz$	-	-	4.0	pF
$-C_{re}$	Feedback capacitance $I_C = 10mA$, $V_{CE} = 15V$, $f = 1.0MHz$, $T_{amb} = 25^oC$	-	1.7	-	pF
N	Noise figure $I_C = 30mA$, $V_{CE} = 15V$, $f = 200MHz$, $R_s = 75\Omega$, $T_{amb} = 25^oC$	-	-	6.0	dB
G_p	Power gain (not neutralised) $I_C = 70mA$, $V_{CE} = 18V$, $T_{amb} = 25^oC$				
	$f = 200MHz$	-	16	-	dB
	$f = 800MHz$	-	6.5	-	dB

Intermodulation characteristics

		Min.	Typ.	Max.	
P_o	Output power (see test circuits) $I_C = 70mA$, $V_{CE} = 18V$, v.s.w.r. at output <2, intermodulation factor = -30dB, $T_{amb} = 25^oC$				
	$f = 200MHz$, $f_p = 202MHz$, $f_q = 205MHz$, $f_{(2q-p)} = 208MHz$ (channel 9)	130	150	-	mW
	$f = 800MHz$, $f_p = 798MHz$, $f_q = 802MHz$, $f_{(2q-p)} = 806MHz$ (channel 62)	70	90	-	mW

POWER OUTPUT TEST CIRCUIT (f=200MHz)



L_1 = 3 turns of 1.4mm silver plated copper wire, winding pitch 2.7mm, int. dia. 8mm, taps 1.5 and 0.5 turns from earth.

L_2 = 5.5 turns of 1.4mm silver plated copper wire, winding pitch 2.2mm, int. dia. 8mm.

L_3 = 3 turns of 1.4mm silver plated copper wire, winding pitch 3.3mm, int. dia. 8mm.

L_4 = 5.5 turns of 1.4mm silver plated copper wire, winding pitch 2.2mm, int. dia. 11mm.

ADJUSTMENT OF TEST CIRCUIT

Basis of adjustment

Intermodulation distortion at d_{im} = -30dB is caused by clipping in h.f. output current and voltage.
The maximum undistorted output power is attained when

a) Clipping in current and voltage is simultaneous; this occurs if

$$R_{load} = (V_{CE} - V_{cek})/I_C$$

Where V_{cek} is the high frequency knee voltage

b) The h.f. collector current is as low as possible; this occurs if

$$-C_{load} = +C_{oe}$$

Where C_{oe} is the output capacitance of the transistor with short-circuited input.

Experimentally obtained values of R_{load} and C_{load}, for maximum output power at an intermodulation factor of -30dB, are:

$$R_{load} = 220\Omega, \ C_{load} = -5.6pF$$

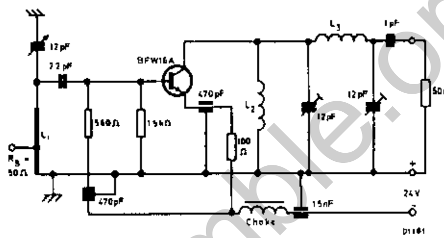
In this case 4pF are provided by C_{oe} of the transistor itself and 1.6pF by the mounting system, with the boron nitride washer between the transistor and the chassis.

ADJUSTMENT OF TEST CIRCUIT (contd.)

Procedure

1. Remove the transistor and connect a dummy, consisting of a 220Ω resistor in parallel with a 5.6pF capacitor, between the collector and the emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205MHz (i.e., v.s.w.r. = 1).
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good bandpass curve. The v.s.w.r. of the output will then be ≤2 over most of the channel. Corrections can be made by tuning L_2.

POWER OUTPUT TEST CIRCUIT (f = 800MHz)



L_1 = 25 × 7 × 0.85mm silver plated copper strip, input tap at 5mm from earth.
L_2 = 13 turns of 0.6mm enamelled copper wire, int. dia. 8mm.
L_3 = 1.5 turns of 1.3mm copper wire, int. dia. 8mm.

ADJUSTMENT OF TEST CIRCUIT

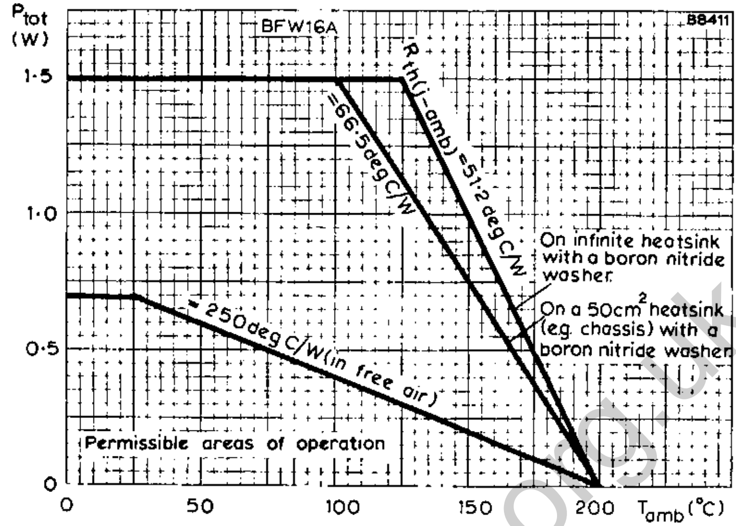
At 800MHz a dummy cannot be used to adjust for optimum collector load, because at these frequencies the impedance transformations of the dummy are too high.
A small signal with a frequency of the midchannel 802MHz is fed to the input. The signal is increased until clipping occurs, that is until the output power no longer increases linearly with increasing input signal. Care should be taken not to allow the voltage swing to exceed the V_{CER} value as this may result in the destruction of the transistor by second breakdown.
The output circuit is then tuned to eliminate clipping.

The output P_o is given by

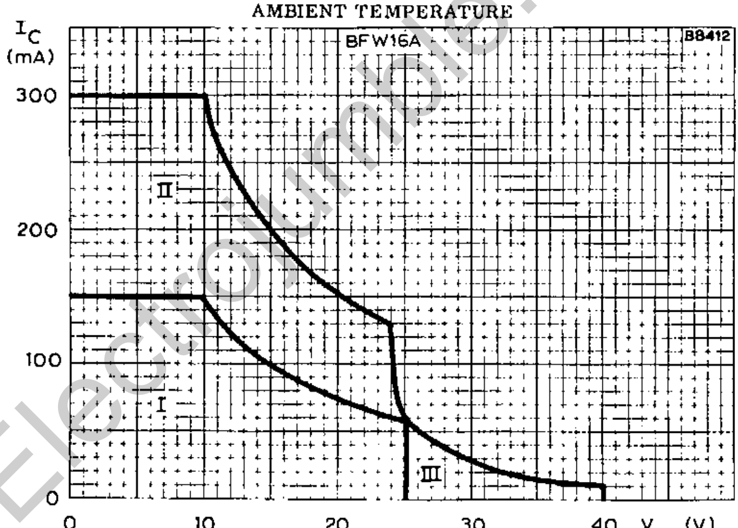
$$P_o = I_C(V_{CE} - V_{cek})/2 \approx 480mW$$

where V_{cek} is the high frequency knee voltage

Keeping the input signal as small as possible at P_o = 480mW, the output circuit is adjusted for minimum intermodulation. The input circuit is then adjusted for maximum gain and good bandpass curve. The v.s.w.r. is found to be ≤2 over the whole channel.



MAXIMUM PERMISSIBLE TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

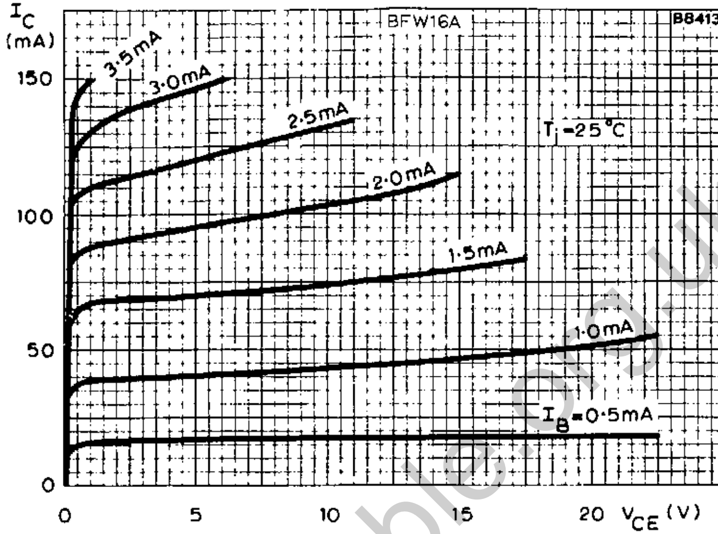


AREAS OF SAFE OPERATION

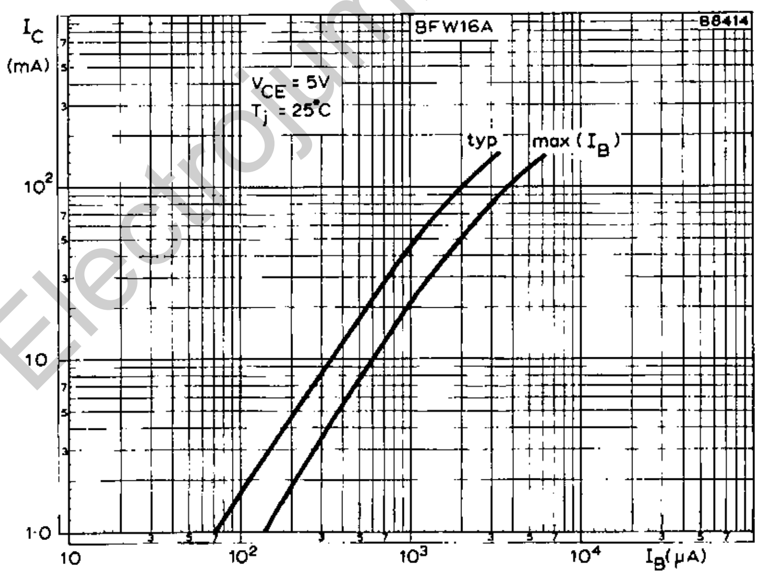
I. D.C. and A.C. operation is allowed under all base-emitter conditions, provided no limiting values are exceeded.

II. Operation is allowed under all base-emitter conditions at $f \geq 1MHz$, provided no limiting values are exceeded.

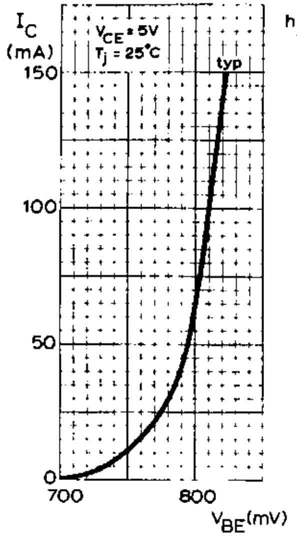
III. Operation is allowed under pulse conditions, provided the transistor is cut-off, $R_{BE} \leq 50\Omega$, and $f \geq 1MHz$.



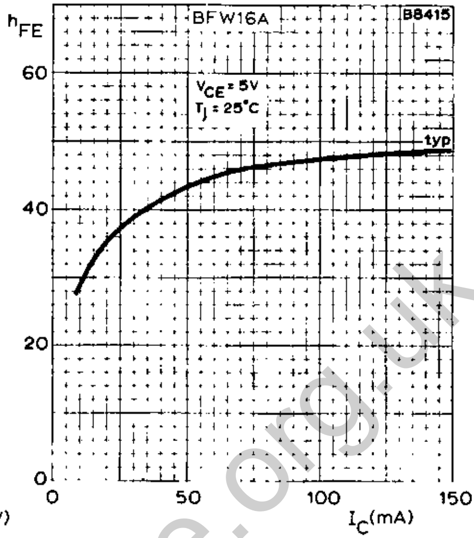
TYPICAL OUTPUT CHARACTERISTICS



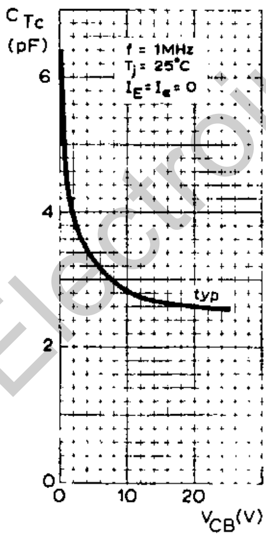
TRANSFER CHARACTERISTICS



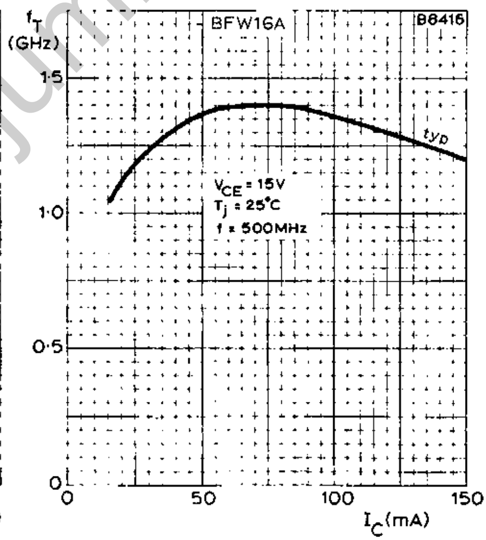
Typical mutual characteristics



Typical static forward current transfer ratio versus collector current



Typical collector capacitance versus collector-base voltage



Typical transition frequency versus collector current

APPLICATION INFORMATION

Performance of channel and band amplifiers

Frequency range	channel 4 61-68	channel 9 202-209	channel 55 742-750	band I 47-68	band II 87.5-108	band III 174-230	MHz
Transistor used in:							
final stage	BFW16A	BFW16A	BFW16A	BFW16A	BFW16A	BFW16A	
driver stage		BFW16A	BFW16A			BFW16A	
second stage			BFY90				
first stage	BFY90	BFY90	BFY90	BFY90	BFY90	BFY90	
Output power at:							
d_{im} = -30dB	150*	150*	100				mW
d_{im} = -50dB					30		mW
d_{im} = -60dB				10		10	mW
Power gain	50	44	26.5	51	43	39	dB
Noise figure	7	6	8	6.0-6.5	6.5	6.5	dB
V.S.W.R. over the whole channel or band							
for the input	<2	<2	<2	<2	<2	<2	
for the output	<2	<2	<2	<2	<2	<2	
Load impedance	30	30	50	30	30	30	Ω
Source impedance	60	60	50	60	60	60	Ω

*V_o = 2.2V over R_L = 30Ω or

V_o = 3V over R_L = 60Ω