HEWLETT PACKARD T-33-05

Linear Power Transistors HXTR-5002 Chip

Technical Data

HXTR-4103
HXTR-5102, TX and TXV
HXTR-5104, TX and TXV

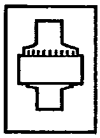
Features

- **High Output Power**
  29 dBm Typical P_{1dB} at 2 GHz
  27.5 dBm Typical P_{1dB} at 4 GHz
- **High Gain**
  11.5 dB Typical G_{1dB} at 2 GHz
  7 dB Typical G_{1dB} at 4 GHz
- **P_{osc} +30 dBm at 2 GHz** (Common Collector)
- **Emitter Ballast Resistors**
- **Hermetic Package**

Recommended Die Attach and Bonding Procedures

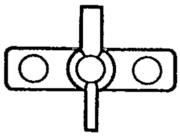
Eutectic Die Attach at a stage temperature of 410 ± 10°C under an N_2 ambient. Chip should be lightly scrubbed using a tweezer or collet and eutectic should flow within five seconds.

Thermocompression Wire Bond at a stage temperature of 310 ± 10°C, using a tip force of 30 ± 5 grams with 0.7 or 1.0 mil gold wire. A one mil minimum wire clearance at the passivation edge is recommended. (Ultrasonic bonding is not recommended.)



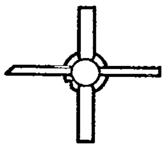
Generic Chip

HXTR-5002



HPAC-200GB/GT

HXTR-4103
HXTR-5102



HPAC-200

HXTR-5104

Note: See the Package Outline section, page 16-7, for complete dimensions.

Description

The HXTR-5002 is an NPN silicon bipolar transistor chip designed for high output power and gain at VHF, UHF, and microwave frequencies. The chip is silicon nitride passivated, and has TaN ballast resistors for ruggedness.

The HXTR-5002 chip is available in two package styles. Both the common-collector HXTR-4103 and the common-emitter HXTR-5102 are supplied in the HPAC-200 GB/GT, while the common-emitter HXTR-5104 is supplied in an HPAC-200. Both the HPAC-200GB/GT and HPAC-200 are metal/ceramic hermetic packages with a BeO heat conductor. All of these parts are capable of meeting the environmental requirements of MIL-S-19500 and the test requirements of MIL-STD-750/883.

The HXTR-5102 contains partial internal matching which makes it ideal for broad bandwidth designs in the 2 to 5 GHz range. The excellent power, gain and distortion performance of the devices make them ideal for use in radar, ECM, space, and other commercial and military communication applications.

Electrical Specifications (HXTR-5002, HXTR-5102)

Symbol	Parameters and Test Conditions	Test Method MIL-STD-750	Units	HXTR-5002 [1]			HXTR-5102 [2]		
				Min.	Typ.	Max.	Min.	Typ.	Max.
BV_{CBO}	Collector-Base Breakdown Voltage at $I_C = 10$ mA	3001*	V	40			40		
BV_{CEO}	Collector-Emitter Breakdown Voltage at $I_C = 50$ mA	3011*	V	24			24		
BV_{EBO}	Emitter-Base Breakdown Voltage at $I_E = 100$ µA	3026*	V	3.3			3.3		
I_{EBO}	Emitter-Base Leakage Current at $V_{EB} = 2$ V	3061	µA			5			5
I_{CES}	Collector-Emitter Leakage Current at $V_{CE} = 32$ V	3041**	nA			200			200
I_{CBO}	Collector-Base Cutoff Current at $V_{CB} = 20$ V	3036**	nA			100			100
h_{FE}	Forward Current Transfer Ratio $V_{CE} = 18$ V, $I_C = 110$ mA	3076*		15	40	85	15	40	85
P_{1dB}	Power Output at 1 dB Gain Compression f = 2 GHz 4 GHz $V_{CE} = 18$ V, $I_C = 110$ mA		dBm		29.0 27.5		 26.5	29.0 27.5	
G_{1dB}	Associated 1 dB Compressed Gain f = 2 GHz $V_{CE} = 18$ V, $I_C = 110$ mA 4 GHz		dB		11.5 7.5		 6.0	11.5 7.0	
P_{SAT}	Saturated Power Output (8 dB Gain) f = 2 GHz $V_{CE} = 18$ V, $I_C = 110$ mA (3 dB Gain) f = 4 GHz		dBm		31.0 29.5			31.0 29.5	
η	Power-Added Efficiency at f = 2 GHz 1 dB Compression 4 GHz $V_{CE} = 18$ V, $I_C = 110$ mA		%		38 23			37 23	
IP_3	Third Order Intercept Point f = 4 GHz $V_{CE} = 18$ V, $I_C = 110$ mA		dBm		37			36	
C_{rb}	Reverse Transfer Capacitance f = 1 MHz HXTR-5002, -5102: $I_C = 0$ mA, $V_{CB} = 10$ V		pF					0.73	

*300 µs wide pulse measurement at ≤ 2% duty cycle
**Measured under low ambient light conditions, for chip only.

Notes:
1. $T_A = 25°C$
2. $T_{CASE} = 25°C$

Electrical Specifications (HXTR-5104, HXTR-4103)

Symbol	Parameters and Test Conditions	Test Method MIL-STD-750	Units	HXTR-5104 [1]			HXTR-4103 [1]		
				Min.	Typ.	Max.	Min.	Typ.	Max.
BV_{CBO}	Collector-Base Breakdown Voltage at $I_C = 10$ mA	3001*	V	40			40		
BV_{CEO}	Collector-Emitter Breakdown Voltage at $I_C = 50$ mA	3011*	V	24					
BV_{EBO}	Emitter-Base Breakdown Voltage at $I_B = 100$ µA	3026*	V	3.3					
I_{EBO}	Emitter-Base Leakage Current at $V_{EB} = 2$ V	3061	µA			10			5
I_{CES}	Collector-Emitter Leakage Current at $V_{CE} = 32$ V	3041**	nA			200			
I_{CBO}	Collector-Base Cutoff Current at $V_{CB} = 20$ V	3036**	nA			100			100
h_{FE}	Forward Current Transfer Ratio $V_{CE} = 18$ V, $I_C = 110$ mA	3076*		15	40	85	15		75
f_T	Gain Bandwidth Product at $V_{CE} = 18$ V, $I_C = 110$ mA		GHz					4	
P_{1dB}	Power Output at 1 dB Gain Compression $V_{CE} = 18$ V, $I_C = 110$ mA; f = 2 GHz		dBm	28.0	29.0				
G_{1dB}	Associated 1 dB Compressed Gain $V_{CE} = 18$ V, $I_C = 110$ mA; f = 2 GHz		dB	8.0	9.0				
P_{OSC}	Oscillation Power at $V_{CE} = 18$ V, $I_C = 130$ mA; f = 2 GHz		dBm					30	
P_{SAT}	Saturated Power Output (8 dB Gain) $V_{CE} = 18$ V, $I_C = 110$ mA; f = 2 GHz		dBm		31.0				
ηC	Collector Efficiency at $V_{CE} = 18$ V, $I_C = 130$ mA; f = 2 GHz		%					43	
η	Power-Added Efficiency at 1 dB Compression $V_{CE} = 18$ V, $I_C = 110$ mA; f = 2 GHz		%		35				
IP_3	Third Order Intercept Point $V_{CE} = 18$ V, $I_C = 110$ mA; f = 2 GHz		dBm		37				
C_{rb}	Reverse Transfer Capacitance f = 1 MHz; HXTR-5104: $I_C = 0$ mA, $V_{CB} = 10$ V; HXTR-4103: $I_C = 0$ mA; $V_{CB} = 18$ V		pF		0.70			2.7	

*300 µs wide pulse measurement at ≤ 2% duty cycle
**Measured under low ambient light conditions, for chip only.

Notes:
1. $T_{CASE} = 25°C$

Absolute Maximum Ratings*

Symbol	Parameter	HXTR-5002[1] (T_A = 25°C)	HXTR-4103/5102/5104[2] (T_{CASE} = 25°C)
V_{CBO}	Collector to Base Voltage	45 V	45 V
V_{CEO}	Collector to Emitter Voltage	27 V	27 V
V_{EBO}	Emitter to Base Voltage	4 V	4 V
I_C	DC Collector Current	250 mA	250 mA
P_T	Total Device Dissipation	4 W	4 W
T_J	Junction Temperature	200°C	200°C
T_{STG}	Storage Temperature	-65°C to 300°C	-65°C to 200°C
–	Lead Temperature (Soldering 10 seconds each lead)		250°C

*Operation in excess of any one of these conditions may result in permanent damage to this device.

Notes:

1. Power dissipation derating for the HXTR-5002 should include a θ_{JB} (Junction-to-Back contact thermal resistance) of 35°C/W. Total θ_{JA} (Junction to Ambient) will be dependent upon the heat sinking provided in the individual application.
2. A θ_{JC} maximum of 35°C/W for the HXTR-5102/4103, and 40°C/W for the HXTR-5104 should be used for derating and junction temperature calculations ($T_J = P_D \times \theta_{JC} + T_{CASE}$).

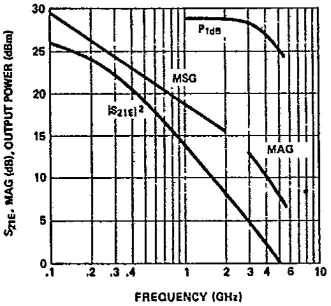


Figure 1. Typical $|S_{21E}|^2$, MAG and P_{1dB} Linear Power vs. Frequency (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5002.

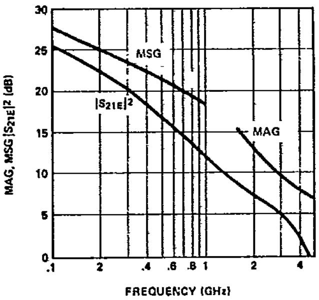


Figure 2. Typical MAG, Maximum Stable Gain (MSG) and $|S_{21E}|^2$ vs. Frequency (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5102.

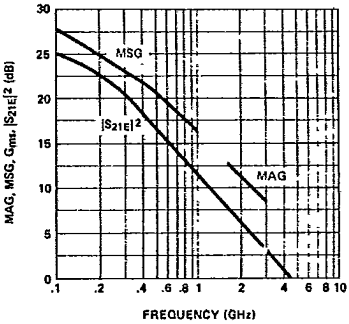


Figure 3. Typical MAG, Maximum Stable Gain (MSG), and $|S_{21E}|^2$ vs. Frequency (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5104.

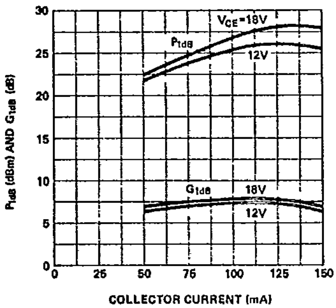


Figure 4. Typical P_{1dB} Linear Power and Associated 1 dB Compressed Gain vs. Collector Current (V_{CE} = 12 V and 18 V at 4 GHz), for the HXTR-5002.

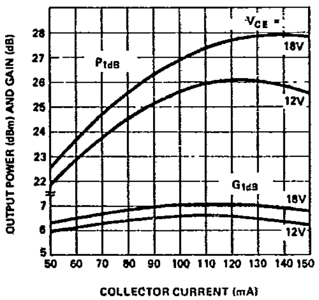


Figure 5. Typical P_{1dB} and Associated 1 dB Compressed Gain vs. Collector Current (V_{CE} = 12 V and 18 V at 4 GHz), for the HXTR-5102.

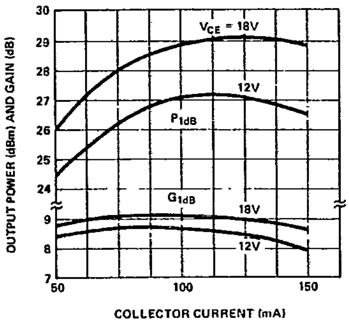


Figure 6. Typical P_{1dB} and Associated 1 dB Compressed Gain vs. Collector Current (V_{CE} = 12 V and 18 V at 2 GHz), for the HXTR-5104.

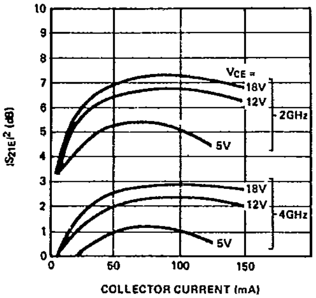


Figure 7. Typical $|S_{21E}|^2$ vs. Collector Current at 2 and 4 GHz, for the HXTR-5102.

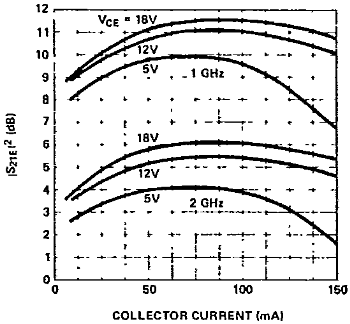


Figure 8. Typical $|S_{21E}|^2$ vs. Collector Current at 1 and 2 GHz, for the HXTR-5104.

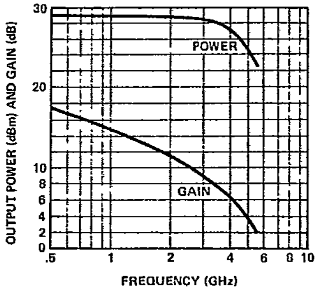


Figure 9. Typical P_{1dB} and Associated 1 dB Compressed Gain vs. Frequency (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5102.

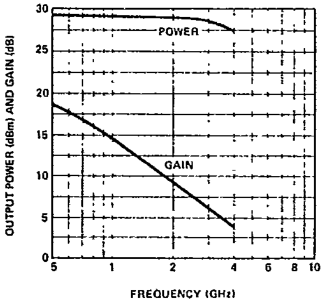


Figure 10. Typical P_{1dB} Linear Power and Associated 1 dB Compressed Gain vs. Frequency at V_{CE} = 18 V, I_C = 110 mA, for the HXTR-5104.

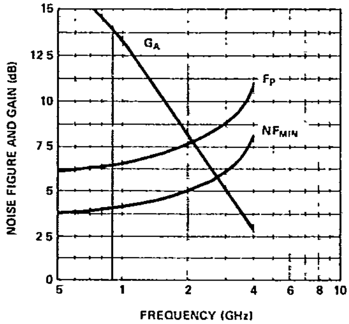


Figure 11. Typical Noise Figure (NF_{MIN}) and Associated Gain (G_A) vs. Frequency when Tuned for Minimum Noise at V_{CE} = 18 V, I_C = 25 mA. Typical Noise Figure (Fp) when Tuned for Max P_{1dB}, (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5104.

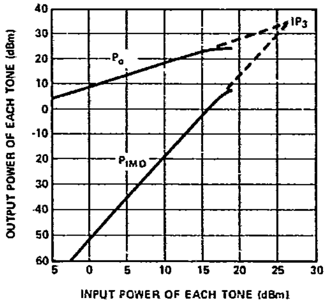


Figure 12. Typical Two Tone Third Order Intermodulation Distortion at 4 GHz for the HXTR-5102 at a Frequency Separation of 5 MHz (V_{CE} = 18 V, I_C = 110 mA).

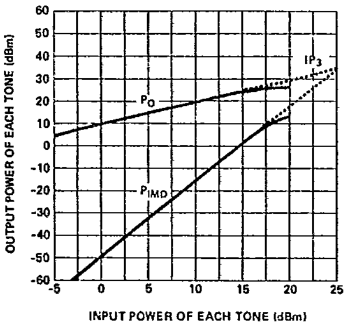


Figure 13. Typical Two Tone Third Order Intermodulation Distortion at 2 GHz for the HXTR-5104 at a Frequency Separation of 5 MHz (V_{CE} = 18 V, I_C = 110 mA).

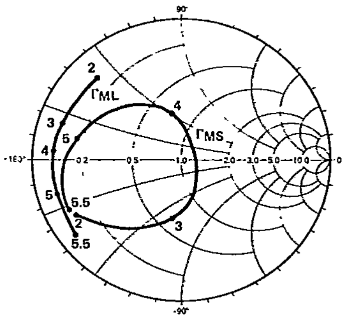


Figure 14. Typical Γ_{MS}, Γ_{ML} (Calculated from the Average S-Parameters) in the 2 to 5.5 GHz Frequency Range (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5102.

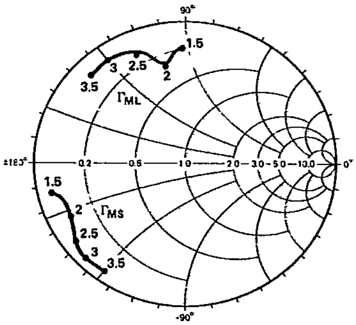


Figure 15. Typical Γ_{MS}, Γ_{ML} (Calculated from the Average S-Parameters) in the 1.5 to 3.5 GHz Frequency Range (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5104

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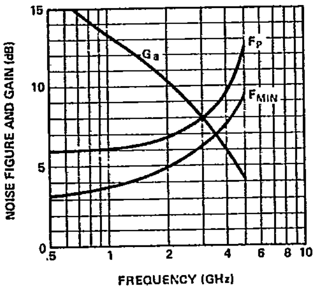

Figure 16. Typical Noise Figure (NF_{MIN}) and Associated Gain (G_A) when Tuned for Minimum Noise vs. Frequency V_{CE} = 18 V, I_C = 25 mA), Typical Noise Figure (Fp) when Tuned for Max P1dB (V_{CE} = 18 V, I_C = 110 mA), for the HXTR-5102.

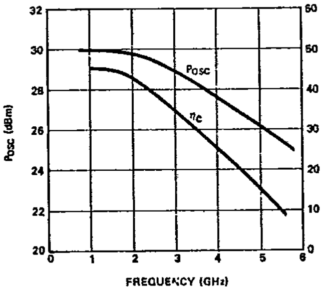

Figure 17. Typical Oscillator Power and Efficiency vs. Frequency at V_{CE} = 18 V, I_C = 130 mA, for the HXTR-4103.

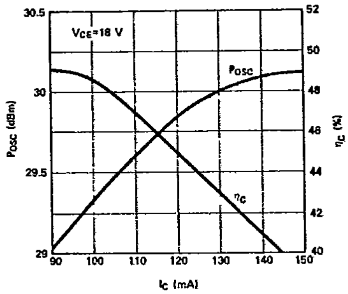

Figure 18. Typical Oscillator Power and Efficiency vs. Collector Current at f = 2 GHz, for the HXTR-4103.

HXTR-5002 Typical Common Emitter S-Parameters (V_{CE} = 18 V, I_C = 110 mA)*

Freq. (MHz)	S_{11}		S_{21}			S_{12}			S_{22}	
	Mag.	Ang.	(dB)	Mag.	Ang.	(dB)	Mag.	Ang.	Mag.	Ang.
0.100	0.55	-61	25.4	19.7	156	-31.6	0.03	68	0.93	-26
0.200	0.65	-98	24.2	16.2	133	-27.3	0.04	50	0.76	-48
0.300	0.72	-119	22.3	13.1	125	-25.6	0.05	39	0.63	-50
0.400	0.76	-132	20.6	10.7	117	-24.8	0.06	32	0.53	-71
0.500	0.79	-141	19.1	9.01	111	-24.4	0.06	27	0.45	-78
0.600	0.80	-147	17.8	7.73	106	-24.1	0.06	24	0.40	-84
0.700	0.81	-151	16.6	8.74	102	-24.0	0.06	22	0.38	-89
0.800	0.81	-155	15.5	5.97	99	-23.8	0.06	20	0.33	-93
0.900	0.82	-158	14.6	5.35	97	-23.7	0.06	19	0.31	-98
1.000	0.82	-160	13.7	4.84	94	-23.7	0.06	18	0.30	-99
1.500	0.83	-167	10.3	3.29	86	-23.4	0.07	16	0.25	-109
2.000	0.83	-170	7.9	2.49	80	-23.3	0.07	16	0.24	-114
2.500	0.83	-173	6.0	2.00	74	-23.1	0.07	17	0.24	-117
3.000	0.83	-174	4.5	1.68	69	-22.9	0.07	18	0.25	-118
3.500	0.83	-175	3.2	1.44	64	-22.6	0.07	19	0.27	-119
4.000	0.83	-176	2.1	1.27	60	-22.4	0.08	20	0.28	-120
4.500	0.83	-177	1.1	1.13	55	-22.1	0.08	21	0.30	-121
5.000	0.83	-177	0.3	1.03	51	-21.9	0.08	21	0.32	-121
5.500	0.83	-178	-0.5	0.94	47	-21.6	0.08	22	0.34	-122
6.000	0.83	-178	-1.2	0.87	43	-21.4	0.08	22	0.35	-123

*Values do not include any parasitic bonding inductances and were generated by use of a computer mdel.

RF Equivalent Circuit See page 3-7.

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HXTR-5102 Typical Common Emitter S-Parameters (V_{CE} = 18 V, I_C = 110 mA)

Freq. (MHz)	S_{11}		S_{21}			S_{12}			S_{22}	
	Mag.	Ang.	(dB)	Mag.	Ang.	(dB)	Mag.	Ang.	Mag.	Ang.
100	0.55	-74	25.4	18.60	146	-31	0.03	56	0.85	-29
200	0.65	-109	22.7	13.60	123	-28	0.04	39	0.68	-47
300	0.70	-134	20.8	10.90	108	-27	0.05	28	0.55	-59
400	0.72	-144	18.8	8.47	97	-26	0.05	21	0.48	-65
500	0.74	-158	17.2	7.22	88	-26	0.05	17	0.42	-74
600	0.73	-160	15.6	5.99	81	-25	0.05	13	0.41	-75
700	0.74	-167	14.6	5.39	76	-25	0.05	11	0.39	-79
800	0.74	-170	13.4	4.66	69	-25	0.06	8	0.39	-82
900	0.74	-175	12.7	4.32	64	-25	0.06	8	0.38	-86
1000	0.74	-178	11.8	3.91	59	-25	0.06	7	0.37	-92
1500	0.71	166	9.0	2.82	34	-24	0.06	-2	0.43	-107
2000	0.64	153	7.3	2.32	10	-23	0.07	-8	0.51	-119
2500	0.52	140	6.3	2.07	-17	-22	0.08	-22	0.61	-133
3000	0.32	129	5.4	1.86	-49	-21	0.09	-42	0.73	-148
3500	0.15	158	3.8	1.55	-83	-20	0.09	-67	0.77	-165
4000	0.32	-145	2.8	1.38	-113	-22	0.08	-98	0.80	-177
4500	0.52	-158	0.0	1.00	-142	-24	0.06	132	0.82	171
5000	0.70	176	-1.9	0.81	-170	-28	0.04	50	0.87	159
5500	0.78	155	-3.0	0.71	161	-28	0.04	85	0.83	142
6000	0.85	119	-3.9	0.64	121	-19	0.11	16	0.93	121

HXTR-5104 Typical Common Emitter S-Parameters (V_{CE} = 18 V, I_C = 110 mA)

Freq. (MHz)	S_{11}		S_{21}			S_{12}			S_{22}	
	Mag.	Ang.	(dB)	Mag.	Ang.	(dB)	Mag.	Ang.	Mag.	Ang.
100	0.48	-68	24.8	17.30	140	-31	0.03	82	0.86	-27
200	0.54	-109	22.6	13.50	127	-27	0.04	48	0.69	-46
300	0.59	-132	20.4	10.50	112	-26	0.05	40	0.55	-58
400	0.61	-146	18.5	8.43	102	-25	0.06	38	0.47	-66
500	0.63	-155	16.9	7.02	94	-24	0.06	34	0.41	-71
600	0.64	-162	15.5	5.98	88	-24	0.06	33	0.38	-76
700	0.65	-168	14.3	5.21	83	-24	0.07	33	0.35	-80
800	0.65	-172	13.3	4.62	78	-23	0.07	33	0.34	-84
900	0.65	-176	12.4	4.15	73	-23	0.07	33	0.32	-87
1000	0.64	179	11.5	3.70	69	-22	0.08	32	0.32	-90
1500	0.65	169	8.2	2.57	50	-20	0.10	31	0.32	-104
2000	0.65	151	6.0	1.99	33	-19	0.11	30	0.33	-118
2500	0.66	139	4.3	1.64	17	-17	0.14	25	0.39	-130
3000	0.65	128	2.9	1.40	2	-16	0.16	20	0.42	-140
3500	0.64	115	1.8	1.23	-13	-15	0.19	14	0.46	-152
4000	0.63	103	0.9	1.11	-27	-13	0.22	5	0.51	-161
4500	0.61	87	0.2	1.03	-41	-12	0.26	-2	0.53	-172
5000	0.59	72	-0.7	0.93	-54	-11	0.29	-12	0.57	179
5500	0.58	53	-1.6	0.84	-67	-10	0.34	-22	0.57	167
6000	0.58	38	-2.3	0.77	-79	-9	0.37	-31	0.60	155

HXTR-4103 Typical Common Collector S-Parameters (V_{CE} = 18 V, I_C = 130 mA)

Freq. (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
1000	0.96	-79	1.67	-56	0.30	24	0.79	130
2000	1.01	-144	1.32	-104	0.47	-24	0.80	95
3000	1.06	164	1.02	-146	0.58	-69	0.50	77
4000	1.10	120	0.84	177	0.60	-111	0.45	68
5000	1.20	74	0.85	142	0.80	-148	0.41	45
6000	1.23	-37	1.08	68	1.32	136	0.11	164
7000	0.84	157	0.15	-8	0.48	58	0.59	76
8000	0.67	99	0.36	78	0.41	68	0.36	64

High Reliability Testing*

Two basic levels of High-Reliability testing are offered.

1. The TX suffix indicates a part that is preconditioned and screened to the program shown in Table II and III, and is marked with an orange dot.
2. The TXV suffix indicates that an internal visual inspection per MIL-STD-750 Method 2072 is included as part of the preconditioning screening and is marked with a green dot.

Group B quality conformance inspections are performed on each inspection lot in accordance with Table IVb. Group C quality conformance inspections are performed periodically at six month intervals in accordance with Table V.

*Please refer to MIL-S-19500 for Tables II, III, IVb, and V. High power visual performed on die prior to assembly.

Part Number System for Order and RFQ Information

Part Number Prefix	Screening Level
HXTR-5102 HXTR-5104	Commercial
HXTR-5102TX HXTR-5104TX	100% Screen (per Tables II and III)
HXTR-5102TXV HXTR-5104TXV	100% Screen and Internal Visual

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100% Screen	Screened per MIL-S-19500, Table II, TX or TXV with the following specified tests and conditions:	
	Pre Burn In Tests (Screen 11)*	All DC parameters; BV_{CBO}, BV_{CEO}, I_{CBO}, I_{CEO} and h_{FE} at 25°C, per data sheet Electrical Specifications table
	Burn In Conditions (Screen 12)*	HXTR-5102 $P_T = 2500$ mW, $T_A = 25°C$
		HXTR-5104 $P_T = 1130$ mW, $T_A = 25°C$
	Post Burn In Tests and Deltas (Screen 13)*	All DC parameters; BV_{CBO}, I_{CBO}, I_{CEO}, and h_{FE} at 25°C, per data sheet Electrical Specifications table
		Delta Limits: $\Delta I_{CES} = \pm 50$ nA or 100%, whichever is greater $\Delta I_{CBO} = \pm 25$ nA or 100%, whichever is greater $\Delta h_{FE} = \pm 25\%$
Group A	Per MIL-S-19500, Table III, and the following:	
	Subgroup 2	BV_{CBO}, BV_{CEO}, BV_{EBO}, I_{EBO}, I_{CES}, I_{CBO} and h_{FE} per data sheet Electrical Specifications table
	Subgroup 3	$T_A = +150°C$, $I_{CBO} = 10\ \mu A$ at $V_{CB} = 20$ V $T_A = -55°C$, $h_{FE} = 5$ minimum at $I_C = 110$ mA, $V_{CE} = 10$ V
	Subgroup 4	P_{1dB} and G_{1dB} per data sheet Electrical Specifications table
	Subgroups 5, 6, and 7 are not applicable.	
Group B	Per MIL-S-19500, Table IVb. End point tests per Group A Subgroup 2, and with the following conditions and exceptions:	
	Subgroup 3	Operating Life conditions same as 100% burn-in.
	except Subgroup 4	SEM, done prior to assembly HXTR-5102 Bond pull done at assembly, slygard at sealing covers chip
	except Subgroup 5	Thermal resistance, per MIL-STD-750 Method 3151
Group C	Per MIL-S-19500, Table V. No exceptions. End point tests per Group A Subgroup 2, and with the following conditions:	
	Subgroup 6	Operating Life conditions same as 100% burn-in.

*Refer to MIL-S-19500 screen numbers.