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Reference Charts for RF & μ Wave Communications

Band Designation, Old and New

Band Designation		Frequency GHz	Wavelength
OLD	New		
HF	3-30MHz	A	0.15 - 2m
VHF	30-300MHz	B	1m - 100cm
UHF	300-1000MHz	C	100cm - 30cm
L	1-2GHz	D	30cm - 15cm
S	2-4GHz	E	15cm - 10cm
C	4-8GHz	F	10cm - 7.5cm
X	8-12GHz	G	7.5cm - 5cm
J	12-18GHz	H	5cm - 3.75cm
K	18-27GHz	I	3.75cm - 3cm
Q	27-40GHz	J	3cm - 2cm
L	40-60GHz	K	2cm - 1.5cm
O	60-90GHz	L	1.5cm - 10mm
E	60-100GHz	M	10mm - 7.5mm
			7.5mm - 6mm
			6mm - 5mm
			5mm - 4mm
			4mm - 3mm

RF Measurement Conversion Tables

Conversion tables for return loss, reflection coefficient, and SWR with values for interaction of a small phasor (utility reference) expressed in dB related to the reference.

Relative to Unity Reference		SWR	Ref. Coeff. (dB)	Retn. Loss (dB)	X dB Below Ref.	Ref + X (dB)	Ref - X (dB)	Ref $\pm$ X Pk to Pk Ripple
17.391	0.8913	1	1	5.5350	19.2715	24.8065		
8.7242	0.7943	2	2	5.0780	13.7365	18.8145		
5.8480	0.7079	3	3	4.6495	10.8907	15.3402		
4.4194	0.6310	4	4	4.2489	8.6585	12.9073		
3.5698	0.5623	5	5	3.8755	7.1773	11.0528		
3.0095	0.5012	6	6	3.5287	6.0412	9.5699		
2.6146	0.4467	7	7	3.2075	5.1405	8.3480		
2.3229	0.3981	8	8	2.9108	4.4096	7.3204		
2.0999	0.3548	9	9	2.6376	3.8063	6.4439		
1.9250	0.3162	10	10	2.3866	3.3018	5.6884		
1.7849	0.2818	11	11	2.1567	2.8756	5.0322		
1.6709	0.2512	12	12	1.9465	2.5126	4.4590		
1.5769	0.2239	13	13	1.7547	2.2013	3.9561		
1.4985	0.1995	14	14	1.5802	1.9331	3.5133		
1.4326	0.1778	15	15	1.4216	1.7007	3.1224		
1.3767	0.1585	16	16	1.2778	1.4988	2.7766		
1.3290	0.1413	17	17	1.1476	1.3227	2.4703		
1.2880	0.1259	18	18	1.0299	1.1687	2.1986		
1.2528	0.1122	19	19	0.9237	1.0337	1.9574		
1.2222	0.1000	20	20	0.8279	0.9151	1.7430		
1.1957	0.0891	21	21	0.7416	0.8108	1.5524		
1.1726	0.0794	22	22	0.6639	0.7189	1.3828		
1.1524	0.0708	23	23	0.5941	0.6378	1.2319		
1.1347	0.0631	24	24	0.5314	0.5661	1.0975		
1.1192	0.0562	25	25	0.4752	0.5027	0.9779		
1.1055	0.0501	26	26	0.4248	0.4466	0.8714		
1.0935	0.0447	27	27	0.3796	0.3969	0.7765		
1.0829	0.0398	28	28	0.3391	0.3529	0.6919		
1.0736	0.0355	29	29	0.3028	0.3138	0.6166		
1.0653	0.0316	30	30	0.2704	0.2791	0.5495		
1.0580	0.0282	31	31	0.2414	0.2493	0.4897		
1.0515	0.0251	32	32	0.2155	0.2210	0.4365		
1.0458	0.0224	33	33	0.1923	0.1967	0.3890		
1.0407	0.0200	34	34	0.1716	0.1751	0.3467		
1.0362	0.0178	35	35	0.1531	0.1558	0.3090		
1.0322	0.0158	36	36	0.1366	0.1388	0.2753		
1.0287	0.0141	37	37	0.1218	0.1236	0.2454		
1.0255	0.0126	38	38	0.1087	0.1100	0.2187		
1.0227	0.0112	39	39	0.0969	0.0980	0.1949		
1.0202	0.0100	40	40	0.0864	0.0873	0.1737		
1.0180	0.0089	41	41	0.0771	0.0778	0.1548		
1.0160	0.0079	42	42	0.0687	0.0683	0.1380		
1.0143	0.0071	43	43	0.0613	0.0617	0.1230		
1.0127	0.0063	44	44	0.0546	0.0550	0.1096		
1.0113	0.0056	45	45	0.0487	0.0490	0.0977		
1.0101	0.0050	46	46	0.0434	0.0436	0.0871		
1.0090	0.0045	47	47	0.0387	0.0389	0.0776		
1.0080	0.0040	48	48	0.0345	0.0346	0.0692		
1.0071	0.0035	49	49	0.0308	0.0309	0.0616		
1.0063	0.0032	50	50	0.0274	0.0275	0.0549		
1.0057	0.0028	51	51	0.0244	0.0245	0.0490		
1.0050	0.0025	52	52	0.0218	0.0218	0.0436		
1.0045	0.0022	53	53	0.0194	0.0195	0.0389		
1.0040	0.0020	54	54	0.0173	0.0173	0.0347		
1.0036	0.0018	55	55	0.0154	0.0155	0.0309		
1.0032	0.0016	56	56	0.0138	0.0138	0.0277		
1.0028	0.0014	57	57	0.0123	0.0123	0.0245		
1.0025	0.0013	58	58	0.0109	0.0109	0.0219		
1.0022	0.0011	59	59	0.0097	0.0098	0.0195		
1.0020	0.0010	60	60	0.0087	0.0087	0.0174		

RF Spectrum Bands

UHF		SHF		EHF	
Ultra-high frequency		Microwave		Millimeter wave	
A	B	C	D	E	F
G	H	I	J	K	L
New name					
Old name					
Public switched line					
Business communications					
Satellite communications					
Broadcast communications					
Terrestrial communications					
Satellite communications					
Radio LAN					
VICS, Collision prevention					
Optical fibre micro system					
Radar					
HBT					
MESFET					
HEMT					



RF Connector Comparison Table

DETAILS		CONNECTOR TYPES							
FREQUENCY LIMIT (GHz)	20	18	18	18	26.5	40	50	67	110
MATING TYPE	MALE/ FEMALE	MALE/ FEMALE	SEXLESS	SMF	M/F	M/F	M/F	M/F	M/F
TYPE MATES WITH	N/PRECISION N	N ONLY	SELF	3.5 & K	SMA & K	SMA & 3.5	V	2.4	W
INCH DIMENSIONS									
OUTER CONDUCTOR	0.2756	0.2756	0.166	0.1378	0.1151	0.0945	0.0728		
CENTRE CONDUCTOR	0.1197	0.1197	0.05	0.0598	0.05	0.041	0.0316		
DIELECTRIC	AIR	AIR	TEFLON	AIR	AIR	AIR	AIR		
MALE PIN	0.065	N/A	0.036	0.036	0.02	0.02	0.02		
FEMALE THREAD	5/8-24		1/4-36	1/4-36		METRIC	METRIC		
GLASS BEAD PIN SIZE	N/A	N/A	N/A	N/A	0.012	N/A	0.009	N/A	
METRIC mm DIM'S									
OUTER CONDUCTOR	7	7	4.2	3.5	2.92	2.4	1.85	1	
CENTRE CONDUCTOR	3.04	3.04	1.27	1.52	1.27	1.042	0.8036		
MALE PIN							0.25	0.25	
FEMALE THREAD	INCHES	INCHES	INCHES	INCHES	INCHES	M7-75	M7-75	M4-7	
GLASS BEAD PIN SIZE					0.3		0.23		
IMPORTANT TERMS									
PIN DEPTH	The axial distance between the Reference Plane (typically Outer Conductor), and the Centre Conductor								
SPARK PLUG	A Screw-In Connector								
FLANGE MOUNT	A Screw-On Connector								
BACK SIDE	The Interface between the connector and the internal circuit.Location of most connector problems								
GLASS BEAD	Used to create a Hermetic package.A large source of Connector mismatch.								

S-Parameters

In microwave circuit design S-parameters are very useful for the full characterisation of any 2 port Network. In contrast to z, y and h-parameters, which require broadband short circuited and open circuited connections at the TEST ITEM for the measurement, S-parameters are determined with input and output terminated with the resistive characteristic impedance of test systems (generally 50 ohms in a coaxial line system). Parasitic oscillations in active devices are minimised when these devices are terminated in resistive loads. S-parameters are complex, having a magnitude and a phase relationship, and are measured in terms of incident and reflected voltages using a VECTOR VOLT-METER or VECTOR NETWORK ANALYSER (VNA).

The four S-parameters are:

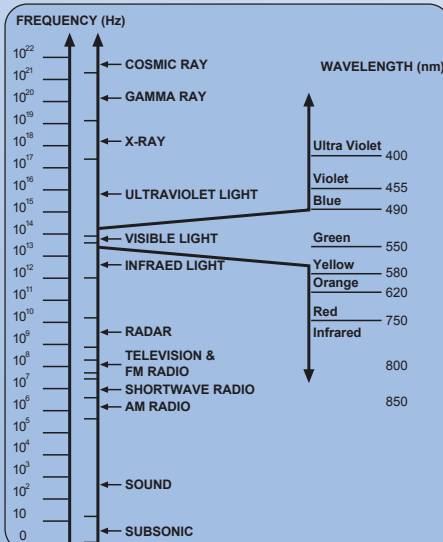
INPUT-REFLECTION COEFFICIENT $S_{11} = \frac{b_1}{a_1}$
Looking into port 1 when port 2 is perfectly matched.

REVERSE-TRANSMISSION COEFFICIENT $S_{21} = \frac{b_2}{a_1}$
Voltage transmission coefficient from port 2 to port 1 when port 1 is perfectly matched.

FORWARD-TRANSMISSION COEFFICIENT $S_{21} = \frac{b_2}{a_1}$
Voltage transmission coefficient from port 1 to port 2 when port 2 is perfectly matched.

OUTPUT-REFLECTION COEFFICIENT $S_{22} = \frac{b_2}{a_2}$
Looking into port 2 when port 1 is perfectly matched.

The Electromagnetic Spectrum



Waveguide Designation

Frequency Range (Ghz)	British WG	IEC R	EIA WR
1.14 - 1.73	6	14	650
1.72 - 2.61	8	22	430
2.60 - 3.95	10	32	284
3.30 - 4.90	11A	40	229
3.94 - 5.99	12	48	187
4.64 - 7.05	13	58	159
5.38 - 8.18	14	70	137
6.58 - 10.0	15	84	112
8.20 - 12.5	16	100	90
9.84 - 15.0	17	120	75
11.9 - 18.0	18	140	62
14.5 - 22.0	19	180	51
17.6 - 26.7	20	220	42
21.7 - 33.0	21	260	34
26.4 - 40.1	22	320	28
33.0 - 50.1	23	400	22
39.3 - 59.7	24	500	19
49.9 - 75.8	25	620	15
60.5 - 92.0	26	740	12
73.8 - 112.0	27	900	10
92.3 - 140.0	28	1200	8
114.0 - 173.0	29	1400	6
145.0 - 220.0	30	1800	5
172.0 - 261.0	31	2200	4
217.0 - 330.0	32	2600	3

Power to Voltage Conversion

dBm	mW	VoltsRMS	Volts Pk/Pk	dBV	dBuV
-40	0.0001	0.0022	0.0063	-53.01	66.99
-39	0.0001	0.0025	0.0071	-52.01	67.99
-38	0.0002	0.0028	0.0080	-51.01	68.99
-37	0.0002	0.0032	0.0089	-50.01	69.99
-36	0.0003	0.0035	0.0100	-49.01	70.99
-35	0.0003	0.0040	0.0112	-48.01	71.99
-34	0.0004	0.0045	0.0126	-47.01	72.99
-33	0.0005	0.0050	0.0142	-46.01	73.99
-32	0.0006	0.0056	0.0159	-45.01	74.99
-31	0.0008	0.0063	0.0178	-44.01	75.99
-30	0.0010	0.0071	0.0200	-43.01	76.99
-29	0.0013	0.0079	0.0224	-42.01	77.99
-28	0.0016	0.0089	0.0252	-41.01	78.99
-27	0.0020	0.0100	0.0283	-40.01	79.99
-26	0.0025	0.0112	0.0317	-39.01	80.99
-25	0.0032	0.0126	0.0356	-38.01	81.99
-24	0.0040	0.0141	0.0399	-37.01	82.99
-23	0.0050	0.0158	0.0448	-36.01	83.99
-22	0.0063	0.0178	0.0502	-35.01	84.99
-21	0.0079	0.0199	0.0564	-34.01	85.99
dBm	mW	VoltsRMS	Volts Pk/Pk	dBV	dBuV
-20	0.010	0.022	0.063	-33.01	86.99
-19	0.013	0.025	0.071	-32.01	87.99
-18	0.016	0.028	0.080	-31.01	88.99
-17	0.020	0.032	0.089	-30.01	89.99
-16	0.025	0.035	0.100	-29.01	90.99
-15	0.032	0.040	0.112	-28.01	91.99
-14	0.040	0.045	0.126	-27.01	92.99
-13	0.050	0.050	0.142	-26.01	93.99
-12	0.063	0.056	0.159	-25.01	94.99
-11	0.079	0.063	0.178	-24.01	95.99
-10	0.100	0.071	0.200	-23.01	96.99
-9	0.126	0.079	0.224	-22.01	97.99
-8	0.159	0.089	0.252	-21.01	98.99
-7	0.200	0.100	0.283	-20.01	99.99
-6	0.251	0.112	0.317	-19.01	100.99
-5	0.316	0.126	0.356	-18.01	101.99
-4	0.398	0.141	0.399	-17.01	102.99
-3	0.501	0.158	0.448	-16.01	103.99
-2	0.631	0.178	0.502	-15.01	104.99
-1	0.794	0.199	0.564	-14.01	105.99
dBm	mW	VoltsRMS	Volts Pk/Pk	dBV	dBuV
0	1.00	0.22	0.63	-13.01	106.99
1	1.26	0.25	0.71	-12.01	107.99
2	1.59	0.28	0.80	-11.01	108.99
3	2.00	0.32	0.89	-10.01	109.99
4	2.51	0.35	1.00	-9.01	110.99
5	3.16	0.40	1.12	-8.01	111.99
6	3.98	0.45	1.26	-7.01	112.99
7	5.01	0.50	1.42	-6.01	113.99
8	6.31	0.56	1.59	-5.01	114.99
9	7.94	0.63	1.78	-4.01	115.99
10	10.00	0.71	2.00	-3.01	116.99
11	12.59	0.79	2.24	-2.01	117.99
12	15.85	0.89	2.52	-1.01	118.99
13	19.95	1.00	2.83	-0.01	119.99
14	25.12	1.12	3.17	0.99	120.99
15	31.62	1.26	3.56	1.99	121.99
16	39.81	1.41	3.99	2.99	122.99
17	50.12	1.58	4.48	3.99	123.99
18	63.10	1.78	5.02	4.99	124.99
19	79.43	1.99	5.64	5.99	125.99
dBm	mW	VoltsRMS	Volts Pk/Pk	dBV	dBuV
20	100.0	2.24	6.32	6.99	126.99
21	126	2.51	7.10	7.99	127.99
22	159	2.82	7.96	8.99	128.99
23	200	3.16	8.93	9.99	129.99
24	251	3.54	10.02	10.99	130.99
25	316	3.98	11.25	11.99	131.99
26	398	4.46	12.62	12.99	132.99
27	501	5.01	14.16	13.99	133.99
28	631	5.62	15.89	14.99	134.99
29	794	6.30	17.83	15.99	135.99
30	1000	7.07	20.00	16.99	136.99
31	1259	7.93	22.44	17.99	137.99
32	1585	8.90	25.18	18.99	138.99
33	1995	9.99	28.25	19.99	139.99
34	2512	11.21	31.70	20.99	140.99
35	3162	12.57	35.57	21.99	141.99
36	3981	14.11	39.91	22.99	142.99
37	5012	15.83	44.77	23.99	143.99
38	6310	17.76	50.24	24.99	144.99
39	7943	19.93	56.37	25.99	145.99
dBm	W	VoltsRMS	Volts Pk/Pk	dBV	dBuV
40	10.00	22.36	63.25	26.99	146.99
41	12.59	25.09	70.96	27.99	147.99
42	15.85	28.15	79.62	28.99	148.99
43	19.95	31.59	89.34	29.99	149.99
44	25.12	35.44	100.24	30.99	150.99
45	31.62	39.76	112.47	31.99	151.99
46	39.81	44.62	126.19	32.99	152.99
47	50.12	50.06	141.59	33.99	153.99
48	63.10	56.17	158.87	34.99	154.99
49	79.43	63.02	178.25	35.99	155.99
50	100.00	70.71	200.00	36.99	156.99

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Spectrum Analyser Conversion Factors

50 Ohms Input Impedance				
TO FROM	dBm	dBV	dBmV	dBμV
dBm	0	-13	+47	+107
dBV	+13	0	+60	+120
dBmV	-47	-60	0	+60
dBμV	-107	-120	-60	0

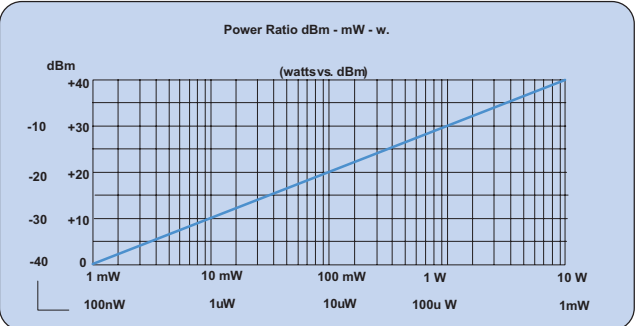
75 Ohms Input Impedance				
TO FROM	dBm	dBV	dBmV	dBμV
dBm	0	-11.25	+48.7	+108.7
dBV	+11.25	0	+60	+120
dBmV	-48.75	-60	0	+60
dBμV	-108.75	-120	-60	0

SWR & Reflection Coefficient & Return Loss

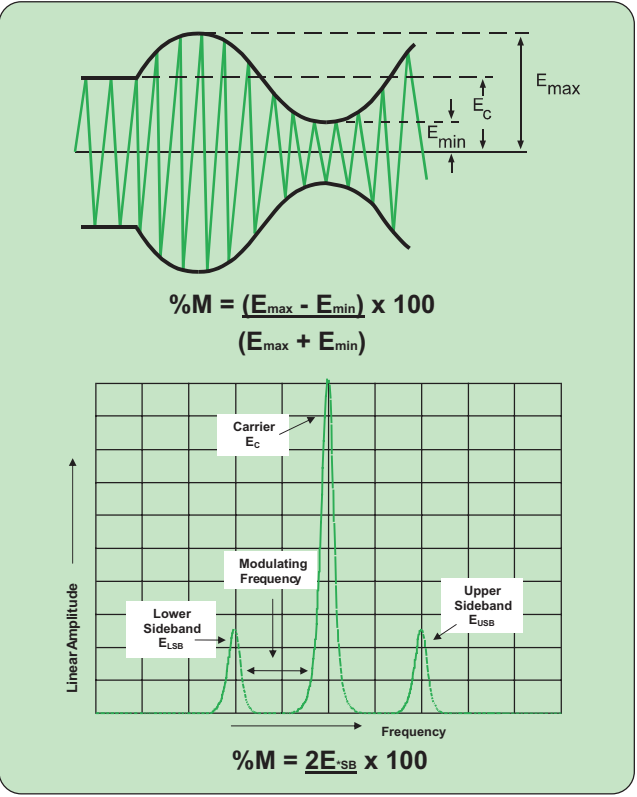
SWR	Ref. Coeff.	Return Loss (dB)	SWR	Ref. Coeff.	Return Loss (dB)
1.7391	0.8913	1	1.0580	0.0282	31
8.7242	0.7943	2	1.0515	0.0251	32
5.8480	0.7079	3	1.0458	0.0224	33
4.4194	0.6310	4	1.0407	0.0200	34
3.5698	0.5623	5	1.0362	0.0178	35
3.0095	0.5012	6	1.0322	0.0158	36
2.6146	0.4467	7	1.0287	0.0141	37
2.3229	0.3981	8	1.0255	0.0126	38
2.0999	0.3548	9	1.0227	0.0112	39
1.9250	0.3162	10	1.0202	0.0100	40
1.7849	0.2818	11	1.0180	0.0089	41
1.6709	0.2512	12	1.0160	0.0079	42
1.5769	0.2239	13	1.0143	0.0071	43
1.4985	0.1995	14	1.0127	0.0063	44
1.4326	0.1778	15	1.0113	0.0056	45
1.3767	0.1585	16	1.0101	0.0050	46
1.3290	0.1413	17	1.0090	0.0045	47
1.2880	0.1259	18	1.0080	0.0040	48
1.2528	0.1122	19	1.0071	0.0035	49
1.2222	0.1000	20	1.0063	0.0032	50
1.1957	0.0891	21	1.0057	0.0028	51
1.1726	0.0794	22	1.0050	0.0025	52
1.1524	0.0708	23	1.0045	0.0022	53
1.1347	0.0631	24	1.0040	0.0020	54
1.1192	0.0562	25	1.0036	0.0018	55
1.1055	0.0501	26	1.0032	0.0016	56
1.0935	0.0447	27	1.0028	0.0014	57
1.0829	0.0398	28	1.0025	0.0013	58
1.0736	0.0355	29	1.0022	0.0011	59
1.0653	0.0316	30	1.0020	0.0010	60



Power Measurement

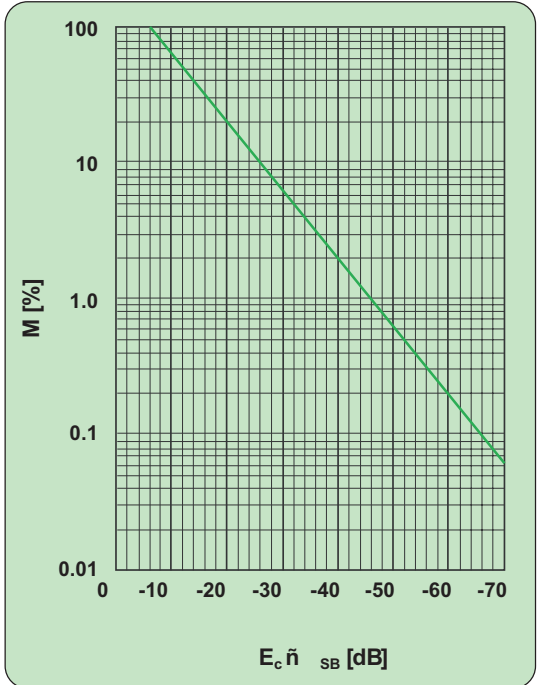


Amplitude Modulation



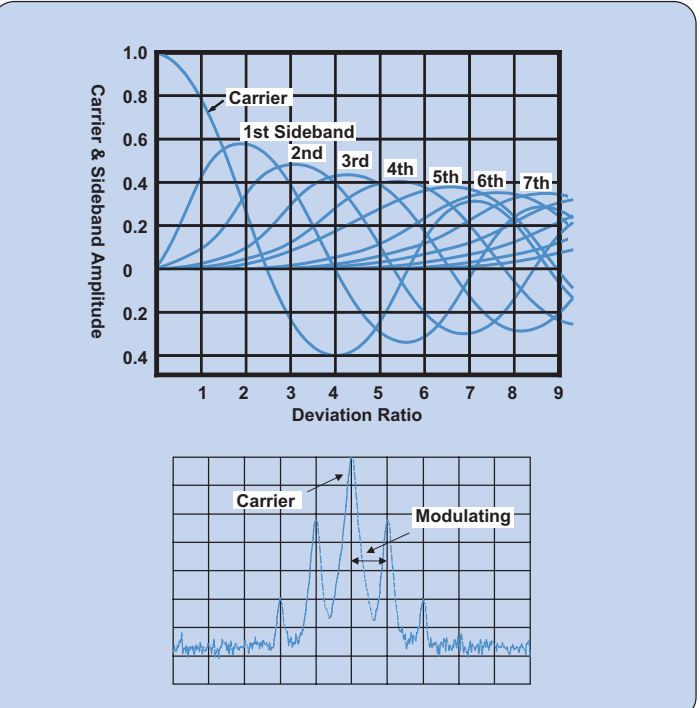
% modulation	Ec Sideband level below carrier (dB)
1	46
2	40
10	26
20	20
30	16.5
40	14
50	12
60	10.4
70	9.1
80	7.9
90	6.9
100	6.0

Sideband level below carrier (dB)	% modulation
10	63
20	20
30	6.3
40	2.0
50	0.63
60	0.2
70	0.063
80	0.02



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Frequency Modulation



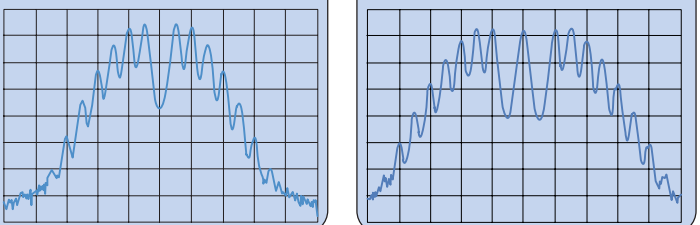
Bessel Functions

Carrier Bessel NULL Number	M = ΔF/f
1st	2.4048
2nd	5.5201
3rd	8.6531
4th	11.7915
5th	14.9309
6th	18.0711
7th	21.2116
8th	24.3525
9th	27.4935
10th	30.6346

Where M = modulation index
ΔF = deviation
f = modulating frequency

1st Sideband Bessel NULL number	M = ΔF/f
1st	3.83
2nd	7.02
3rd	10.17
4th	13.32
5th	16.47
6th	19.62
7th	22.76
8th	25.90
9th	29.05

Where M = modulation index
ΔF = deviation
f = modulating frequency



Pulse Modulation

