

BAWs

Catalog Products (EAR99/Non-ITAR)



TELEDYNE MICROWAVE SOLUTIONS
Everywhere you look™

BAW Delay Lines



Teledyne's Bulk Acoustic Wave (BAW) Product Line has been producing BAW delay devices since the early 1960's. Over the years, Teledyne Microwave has constantly improved BAW technology and is currently the world's only supplier of microwave bulk acoustic wave delay devices.

Principle of Operation

The basic microwave acoustic delay device form, shown in Fig. 1, consists of a cylindrical rod of suitable transmission material (usually sapphire or quartz crystals) for the propagation of the acoustic wave. At the ends of the rod are transducers for converting electromagnetic energy to acoustic energy. Electrical matching networks, or filters, are attached to each of the transducers for coupling to the external microwave circuit.

Thus, a microwave signal is coupled through the matching network to the input transducer which in turn transmits this signal into the acoustic delay medium. Reconversion to electromagnetic form occurs at the output transducer and the signal appears at the output electrical network delayed by the propagation time through the acoustic medium. The slow velocity of elastic waves in solids provides approximately one microsecond delay per centimeter of delay material, which is

more than a factor of 10,000 shorter than the equivalent path length for a microwave signal in free space.

Acoustic delay devices can be manufactured either as two-port (transmission) or one-port (reflection) devices (see Figures 1 and 2). The two-port delay device employs two electroacoustics transducers, one at the input and one at the output. This is usually the simplest type to use when only one output signal is required for each input.

A one-port delay device uses only one transducer for both input and output (the signal being reflected from a polished surface at the opposite end of the rod). One-port delay devices can also produce several echoes spaced at 0,1,2,3, (etc.) times the basic delay, a feature which

allows calibration at multiple ranges. For example, when radar equipment has only one antenna used both for transmission and reception, the one-port delay device is a logical choice for calibration and self-test applications.

Figures 1 and 2 define the principal performance parameters for the acoustic delay device: insertion loss, multiple travel suppression, and feed-through suppression. Note that multiple travel suppression is measured with respect to the output's delayed signal.



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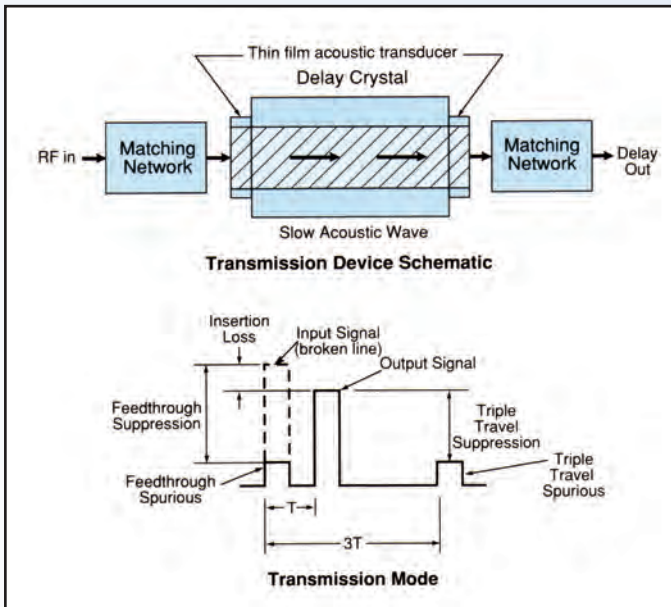


Figure 1

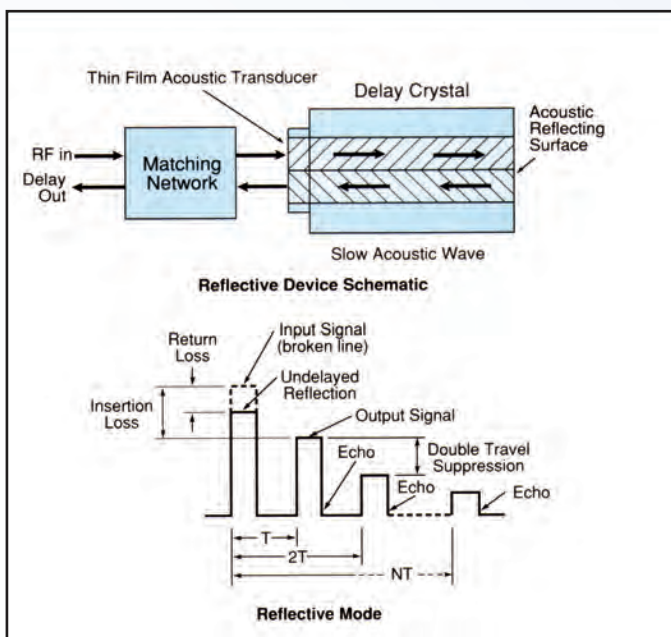


Figure 2

Piezoelectric Transducer

The piezoelectric transducer located on the end of the cylindrical crystal is made up of basically three layers—a metallized counter-electrode, a piezoelectric layer, and a metallized top electrode (see Fig. 3). The counter-electrode is composed of a Cr-Au composite metallization which acts as the ground plane of the transducer. This piezoelectric film is a sputtered ZnO thin film which converts electromagnetic energy to acoustic energy (and also reconverts acoustic energy back into electromagnetic energy after the energy is delayed in the acoustic crystal). The top electrode is also a Cr-Au composite metallization.

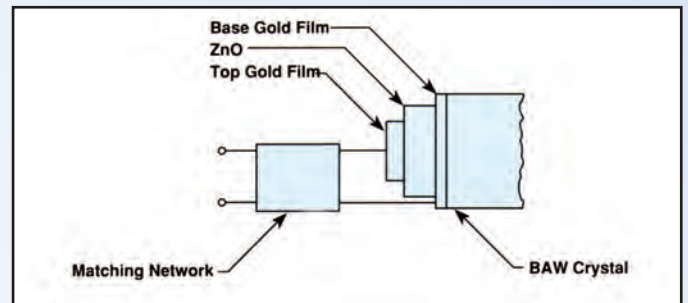


Figure 3: Layers of Composite Metallization sandwiched around a Piezoelectric Layer.

The diameter of the top electrode defines the diameter of the acoustic wave launched within a crystal. As an acoustic wave propagates through the crystal, cross dimensions enlarge due to diffraction—the input transducer acts like an antenna and the energy diffracts when it reaches the far field of the antenna pattern. In addition, the piezoelectric film is a dielectric film located between two metal films. These three films behave electrically like a capacitor; the top electrode diameter along with the thickness and dielectric constant of the piezoelectric film determine the capacitance. In general, to improve the electrical match into the transducer, it is desirable to have this capacitance as small as possible—that is, to have the electrode diameter small. Small electrode diameters, however, result in larger diffraction loss for the acoustic wave. Consequently, there is a trade off between the electrical match and diffraction loss. An improved electrical match reduces transducer conversion losses. Transducer conversion loss and diffraction loss both affect insertion loss levels of the delay device. Diffraction loss depends not only on the top electrode diameter relative to the wavelength (and hence frequency) of the acoustic wave, but also on the distance that an acoustic wave propagates into the crystal which relates to the time delay.



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Hence, optimum top electrode diameter is dependent on frequency of operation, bandwidth, and time delay. VSWR, insertion loss, and triple transit suppression of a delay device are all dependent on the choice of the top electrode diameter.

Typical Performance

The following summarizes the performance parameters of BAW's:

FREQUENCY RANGE: Delay devices using bulk acoustic waves can be built operating within the 300 MHz to 18 GHz frequency band. Bandwidths in excess of one octave have been achieved, but the narrower the bandwidth, the lower the insertion loss.

TIME DELAY RANGE: Time delays between 100 nanoseconds and 30 microseconds are achievable with a single crystal acting as a two-port device. The longer time delays can be realized only at lower frequencies since acoustic propagation losses increase with frequency and insertion losses become prohibitive at higher frequencies for long delays. For example, for a delay device with 0.5 microsecond delay with center frequency at 16 GHz and a bandwidth of 1 GHz, the insertion loss is 60 dB.

TIME DELAY TOLERANCE: The typical tolerance on time delay, T, at room ambient temperature is $\pm [10 + (t/1000)]$ nanoseconds. This allows for lot to lot variations in crystal length and also in ease of realizing exact crystal lengths for a given polishing lot. Tighter tolerances can be held but at a reduced crystal processing yield.

TIME DELAY SPURIOUS OUTPUTS: There are two time spurious outputs of main interest. One is the undelayed signal due to electromagnetic coupling between input and output circuits. This spurious output is normally at least 80 dB below the level of the input signal. Second is the three-times delayed signal (two-times in the case of a single port device) due to internal mismatches in the device. Suppression of this spurious output is directly related to device insertion loss since higher suppression inevitably results in increased insertion loss. The required suppression of these spurious signals depends on the system applications.

TIME DELAY DISTORTION: The time delay of a microwave delay device using bulk acoustic waves is independent of frequency (is non-dispersive) as far as the main acoustic propagation mechanism. Deviation from linear phase over the operating bandwidth results from the matching networks associated with the transducers and from the interaction of the main signal with the triple delayed

signal. Phase linearity of better than $\pm 5^\circ$ can be achieved if triple travel suppression (TTS) is sufficiently high and the bandwidth is sufficiently narrow.

TIME DELAY STABILITY: Time delay variation, with temperature, is less than 30 ppm per Celsius degree with a sapphire crystal, or less than 90 ppm per Celsius degree with a quartz crystal. For a sapphire crystal of 1 microsecond delay over a temperature range of -54°C to $+71^\circ\text{C}$, this translates to less than 4 nanoseconds variation.

INSERTION LOSS STABILITY: The insertion loss of a typical delay device at a fixed frequency will change by less than ± 3 dB as the temperature is varied over the range of -54°C to $+71^\circ\text{C}$.

INSERTION LOSS SHAPE: The shape of insertion loss, versus frequency response, is nominally half-sine with the least loss at band center and the most loss at band edges. On wide band devices, this shape can be flattened using Teledyne Microwave equalizers.

POWER: There is no minimum power threshold at the input port necessary to produce a detectable signal at the output port. As long as the input power remains below 0 dBm, there will be a linear relationship between input and output power levels. As input power is increased above 0 dBm, compression becomes measurable. Standard devices are rated at +20 dBm input power; this is approximately the 1 dB compression point. Very high power ratings can be achieved using attenuators and/or limiters.

VSWR: Devices of moderate center frequency and narrow bandwidth are typically tuned to better than 2.5:1 VSWR. For higher frequencies or broader bandwidths, Teledyne Microwave isolators are commonly incorporated as part of the unit to improve VSWR.



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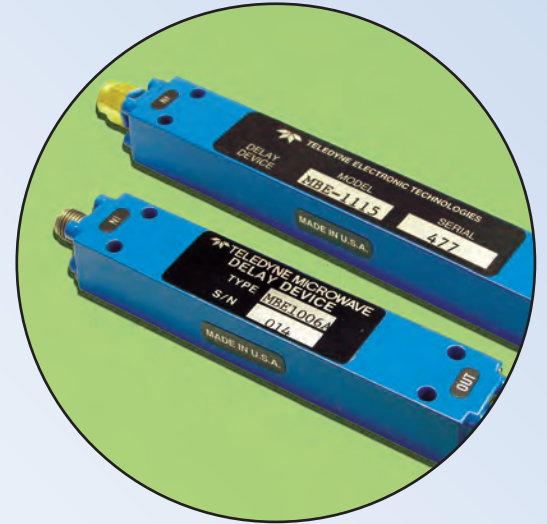
Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
M7055E	0.338	0.02	29.52	30	25	SMA
MBB-1095	0.35	0.030	12	25	10	SMA
MBB-1103	0.38	0.038	27.5	25	17	
MBB-1096	0.425	0.04	10.0	16	10	SMA
MBB-1097	0.425	0.05	15	20	12	SMA
MBB-1090	0.425	0.15	2.5	23	8	SMA
MBB-1091	0.425	0.15	4.0	26	11	SMA
MBB-1092	0.425	0.15	8.0	28	11	SMA
MBB-1098	0.465	0.046	27.5	30	23	SMA
MBB-1001	0.476	0	6.0	20		SMA
MBC-1029	0.5	0.05	40	40	20	
MBC-1006C	0.6125	0.025	8.0	15	25	SMA
MBC-1013B	0.6125	0.025	29.0	35	25	SMA
MBC-1006D	0.6125	0.025	8.0	15	29	SMA
MBC-1006	0.615	0.03	8.0	21	26	PIN
MBC-1006A	0.615	0.03	8.0	21	20	PIN
MBC-1006B	0.615	0.03	8.0	21	25	SMA
MDC-1000	.615	0.3	0.15	-	-	
MBC-1015A	0.7	0.06	10	30	20	SMA
MBC-1015	0.7	0.12	10.0	30	20	SMA
MBC-1016	0.714	0	4.064	20	N/S	SMA
MBC-1005	0.75	0.07	0.473	20	NS	SMA
MBC-1010	0.750	0.5	0.5	30	10	SMA
MBC-1011	0.750	0.5	1.0	30	10	SMA
MBC-1012	0.750	0.5	2.0	30	10	SMA
MBC-1014	0.750	0.5	4.0	30	10	SMA
MBB-1093	0.787	0.1	0.5	12		SMA
MBB-1094	0.787	0.1	0.5	0		SMA
MBC-1002	0.8	0.16	4.0	15	10	SMA
MBC-1024	0.837	0.025	2	25	20	SMA
MBC-1025	0.837	0.025	4	25	20	SMA
MBC-1026	0.837	0.025	6	30	20	SMA
MBC-1007	0.845	0.09	0.5	15	10	SMA
MBC-1003	0.88	0.176	15.0	30	10	SMA
MBC-1004	0.9	0.6	1.25	40	5	SMA

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBC-1000	0.9	0.6	5.0	40	5	SMA
MBC-1022	0.915	0.05	10	31	30	SMA
MBC-1021	1.0	0.05	1.5	32	10	SMA
MBD-1100	1.0	0.1	1.0	20		SMA
MBD-1104	1.000	0.200	1.240	35	15	SMA
MBC-1017	1.0	0.5	1.5	48	20	SMA
MBC-1018	1.0	0.5	4.0	47	17	SMA
MBD-1099	1.0	.5	.5	40	5	SMA
MBD-1075	1.075	-	8	35	30	SMA
MBD-1020	1.125	.2	2.56	30	20	SMA
MBD-1036	1.15	.22	11.5	43	20	SMA
MBD-1035	1.15	2.2	11.5	43	20	SMA
MBD-1023	1.182	0.445	1.6	40	20	SMA
MBD-1024	1.182	0.445	3.2	40	18	SMA
MBD-1108	1.205	0.112	6	32	9	SMA
MBD-1106	1.250	0.050	3.000	30	21	SMA
MBD-1098	1.25	.1	10	50	10	SMA
MBD-1125	1.25	0.32	15.00	58	20	SMA
MBD-1126	1.25	0.32	7.50	50	20	SMA
MBD-1114	1.275	0.1	2.5	20	16	SMA
MBD-1011	1.28	0.15	20	60	76	SMA
MBD-1118	1.299	0.05	10.00	35	30	SMA
MBD-1000	1.3	0.1	15.0	30	17	SMA
MBD-1028	1.3	.10	30	50	85	SMA
MBD-1087	1.30	.10	7	40	40	SMA
MBD-1000A	1.3	0.100	15.0	30	17	SMA
MBD-1033	1.3	0.1	10	30	15	SMA
MBD-1044	1.3	0.1	10	52	40	SMA
MBD-1044A	1.3	.1	10	40-44	40	SMA
MBD-1044B	1.3	0.1	10	52	40	SMA
MBD-1057	1.3	.1	10	27	15	SMA
MBD-1058	1.3	.1	10.16	27	15	SMA
MBD-1129	1.3	0.1	3.5	30	20	SMA
MBD-1130	1.3	0.1	3.9	30	20	SMA
MBD-1131	1.3	0.1	10.56	30	15	



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBD-1132	1.3	0.1	4.2	30	20	SMA
M7125A	1.3	0.2	5.0	40	25	SMA
MBD-1112	1.3	0.2	9.56	45	20	SMA
MBD-1128	1.3	0.4	15.00	60	30	SMA
MBD-1095	1.32	0.1	1.0	28	14	SMA
MBD-1096	1.32	0.1	3.0	33	20	SMA
MBD-1001	1.325	0.2	2.560	40	10	SMA
MBD-1003	1.325	0.2	1.230	40	10	SMA
MBD-1004	1.325	0.2	0.560	40	10	SMA
MBD-1013	1.33	.135	0.45	40	10	SMA
MBD-1014	1.33	.135	1.12	40	20	SMA
MBD-1015	1.33	0.135	2.45	40	20	SMA
MBD-1016	1.33	0.135	4.45	40	20	SMA
MBD-1026	1.33	0.135	5.9	45	20	SMA
MBD-1027	1.33	0.135	8.56	45	20	SMA
MBD-1116	1.345	0.120	2.667	35	20	SMA
MBD-1124	1.345	0.12	6.667	40	35	SMA
MBD-1133	1.345	0.12	6.667	35	20	SMA
MBD-1016A	1.35	0.135	4.45	40	20	SMA
MBD-1046A	1.35	0.135	5.9	40	20	SMA
MBD-1047A	1.35	0.135	8.56	40	20	SMA
MBD-1048A	1.35	0.135	9.56	40	20	SMA
MBD-1049A	1.35	0.135	7	40	20	SMA
MBD-1046	1.35	0.14	5.9	45	20	SMA
MBD-1047	1.35	0.14	8.56	50	20	SMA
MBD-1048	1.35	0.14	9.56	35	13	SMA
MBD-1049	1.35	0.14	7.0	42	25	SMA
MBD-1021	1.35	.2	2.56	30	20	SMA
MBD-1019	1.3875	.3	1.706	30	20	SMA
MBD-1113	1.4	0.4	5.00	40	10	SMA
MBD-1117	1.4	0.4	2.5	32	16	SMA
MBD-1022	1.405	0.89	0.8	45	15	SMA
MBD-1017A	1.42	.075	3.0	33	30	SMA
MBD-1017B	1.42	.075	6.0	35	30	SMA
MBD-1017C	1.42	.090	12.0	35	30	SMA



Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MDD-1000	1.42	0.8	4.0	-	-	
MDD-1001	1.42	0.8	-	0	30	
MDD-1002	1.42	0.8	96.0		30	
MBD-1029	1.440	.120	6	35	30	SMA
MBD-1030	1.440	.120	3.0	32	30	SMA
MBD-1031	1.440	.120	1.5	40	30	SMA
MBD-1017D	1.44	.150	12.0	40	30	SMA
MBD-1012A	1.5	0.1	3.0	30	20	SMA
MBD-1111	1.500	0.2	7.0	48	40	SMA
MBD-1052	1.5	.3	10.41	50	20	SMA
MBD-1053	1.5	.3	1.302	40	20	SMA
MBD-1054	1.5	.3	5.207	50	20	SMA
MBD-1032A	1.5	.4	2.5	23	15	SMA
MBD-1005	1.5	0.5	0.512	50	25	SMA
MBD-1006	1.5	0.5	1.024	45	25	SMA
MBD-1050	1.5	.5	2.5	33	20	SMA
MBD-1059	1.5	.5	.40	30	5	SMA
MBD-1103	1.500	0.500	0.290	25	5	SMA
MBD-1109	1.500	0.5	0.5	45	12	SMA
MBD-1109A	1.500	0.5	0.5	40	14	
MBD-1110	1.500	0.5	0.5	45	12	SMA



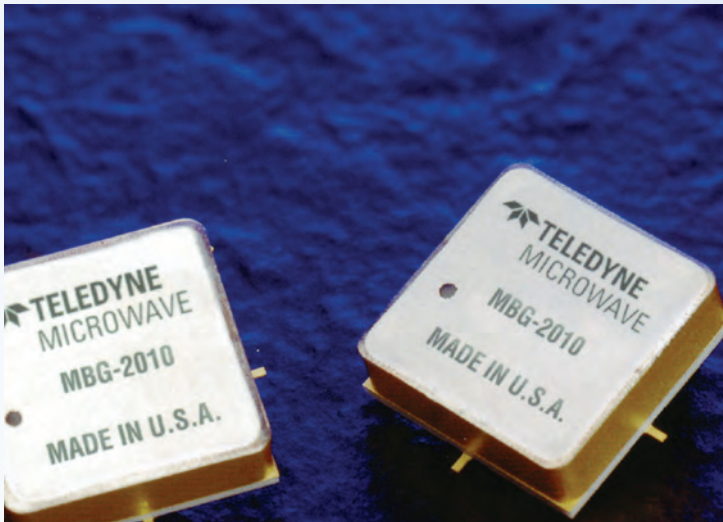
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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBD-1127	1.5	0.5	0.50	45	20	SMA
MBD-1101	1.5	0.600	1.5	40	5	SMA
MBD-1097	1.5	.6	.25	35	5	SMA
MBD-1105	1.500	0.600	5.400	40	10	SMA
MBD-1107	1.5	0.7	2	35	8	SMA
MBD-1010	1.5	0.75	6.4	45	18	SMA
MBD-1039A	1.5	.9	.4	38-44	10	SMA
MBD-1040A	1.5	.9	.8	38-44	15	SMA
MBD-1041A	1.5	.9	1.6	38-44	15	SMA
MBD-1042A	1.5	.9	3.2	38-44	20	SMA
MBD-1102	1.500	1.000	1.575	45	20	SMA
MBD-1051	1.525	0.650	5.0	40	8	SMA
MBD-1034	1.575	.3	2.0	25	18	SMA
MBD-1034A	1.575	.3	0.2	30	8	SMA
MBD-1123	1.6	0.1	5.00	40	30	SMA
MBD-1037	1.6	0.3	4.5	50	25	SMA
MBD-1038	1.6	0.3	2	40	13	SMA
MBD-1025	1.627	0.445	1.6	35	18	SMA
MBD-1007	1.7	0.17	15.0	40	25	SMA
MBD-1007A	1.7	0.17	15.0	45	22	SMA
MBD-1056	1.7	.17	7.5	23	15	SMA
MBD-1122	1.77	0.177	8.00	30	15	SMA
MBD-1018	1.85	.3	1.707	35	20	SMA
MBD-1076	1.85	-	4	39	30	SMA
MBD-1119	1.90	0.1	2.00	30	25	SMA
MBD-1120	1.90	0.1	4.00	32	25	SMA
MBD-1121	1.9	0.1	6.00	33	25	SMA
MBD-1008	2.0	0.2	4.34	30	15	SMA
MBD-1008A	2.0	0.2	4.370	30	15	SMA
MBD-1045	2.0	0.2	1.8	30	15	SMA
MBE-1005	2.00	0.2	2.00	30	17	SMA
MBE-1117	2.00	0.2	0.12	15		SMA
MBE-1118	2.00	0.2	1.2	25	18	SMA
MBE-1119	2.00	0.2	10	45	20	SMA
MBE-1120	2.00	0.2	15	55	25	SMA

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBE-1127	2.0	1.0	3.414	55	10	SMA
MBE-1128	2.0	1.0	6.826	60	12	SMA
MBE-1129	2.0	1.0	13.653	75	18	SMA
MBD-1077	2.15	-	4	39	30	SMA
MBE-1104	2.25	0.1	10.0	45	25	SMA
MBE-1107	2.25	0.2	6.0	45	15	SMA
MBE-1108	2.25	0.2	5.0	45	15	SMA
MBE-1006	2.25	0.5	3.0	40	14	SMA
MBE-1006A	2.25	0.5	3.0	30-40	14	SMA
MBE-1105	2.25	0.5	6.0	40	15	SMA
MBE-1106	2.25	0.5	6.0	45	15	SMA
MBE-1121	2.25	0.5	3	30	16	SMA



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBE-1114	2.8	0.2	15	65	50	SMA
MBE-1115	2.8	0.2	5	special	20	MALE
MBE-1133	2.8	2.0	1.565	58	20	
MBE-1022	2.85	0.3	10	50	38	SMA
MBE-1012	2.856	0	1.016	20	N/S	SMA
MBE-1023	2.875	0.25	10	55	35	SMA
MBE-1002	2.9	0.2	10.0	65	20	SMA
MBE-1008	2.9	0.2	5.0	60	20	SMA
MBE-1111	2.9	0.2	4.5	35	20	SMA
MBE-1097	2.95	0.25	1.0	36	28	
MBE-1135	2.95	0.295	15.0	70	15	
MBF-1002	3.0	0.2	6.096	40	15	SMA
MBE-1000	3.0	0.2	15.0	70	55	SMA
MBF-1006	3.0	0.4	8.0	60	20	SMA
MBF-1007	3.0	0.5	3.25	35	20	SMA
MBF-1005	3.0	0.6	3.0	30	20	SMA
MBF-1093	3.0	0.6	1.0	37	28	SMA
MBF-1082A	3.0	1.0	2.036	45	25	SMA
MBF-1083A	3.0	1.0	1.014	50	25	SMA
MBF-1084A	3.0	1.0	4.084	53	20	SMA
MBF-1085A	3.0	1.0	8.180	65	25	SMA
MBE-1101	3.0	1.5	0.5	45	20	SMA
MBF-1008	3.0	2.0	3.0	50	10	SMA
MBE-1009A	3.0	2.0	0.25	46	4	SMA
MBE-1010A	3.0	2.0	1.00	45-60	20	SMA
MBE-1010B	3.0	2.0	1.0	45-60	20	SMA
MBE-1099	3.0	2.0	2.0	53	12	SMA
MBE-1109	3.0	2.0	1.0	35	10	SMA
MBE-1110	3.0	2.0	1.0		15	SMA
MBF-1003	3.0	2.0	0.25	65	20	SMA
MBF-1086	3.0	2.0	0.95	50	15	SMA
MBF-1089	3.0	2.0	1.679	50	20	SMA
MBF-1091	3.0	2.0	3.373	60	15	SMA
MBF-1095	3.00	2.00	0.25	45	4	SMA
MBF-1096	3.00	2.00	0.21	45	10	

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBE-1004	2.35	0.6	1.235	40	20	SMA
MBE-1026	2.35	0.6	2.0	40	20	SMA
MBE-1026A	2.35	0.6	2	30-40	20	SMA
MBE-1027	2.35	0.6	2.0	35	20	SMA
MBF-1013	2.5	1.2	0.5	37	20	SMA
MBE-1113	2.55	0.1	0.24	20	5	SMA
MBE-1011	2.7	0.4	3.25	34	20	TAB
MBE-1131	2.725	0.050	1.0	30	28	N
MBE-1007	2.75	0.5	3.0	40	16	SMA
MBE-1130	2.75	0.5	0.85	37	22	SMA
MBE-1122	2.75	0.8	0.5	50	15	PIN
MBE-1103	2.8	0.2	10.0	65	20	SMA



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBF-1098	3.00	2.00	1.565	60	20	SMA
MBE-1100	3.0		1.75	50	12	SMA
MBF-1078	3.07	1.14	0.5	46	30	SMA
MBF-1081	3.07	1.14	0.5	46	30	SMA
MBF-1009	3.09	0.01	5.0	40	20	SMA
MBF-1001	3.1	0.2	6.12	43	30	SMA
MBF-1009A	3.15	0.01	5.0	40	20	SMA
MBF-1080	3.18	1.366	0.5	39	23	SMA
MBF-1009B	3.23	.01	5.0	40	20	SMA
MBF-1011	3.25	.500	3.0	40	20	SMA
MBF-1087	3.25	0.5	0.85	35	30	SMA
MBF-1097	3.25	0.5	5.00	50	23	SMA
MBF-1088	3.25	-	0.2	25	12	SMA
MBF-1010	3.3	0.3	3.2	35	20	SMA
MBE-1017A	3.40	0.9	0.5	55	19	SMA
MBF-1079	3.4	1.2	6.0	65	25	SMA
MBE-1018	3.4	-	0.5	47	10	SMA
MBF-1094	3.55	0.35	0.4	13	7	SMA
MBF-1090	3.6	0.2	3.0	35	12	SMA
MBF-1012	3.75	.500	3.0	45	20	SMA
MBF-1092	4.0	4.04	0.350	0	10	SMA
MBG-1004	4.2	0.2	2.032	30	12	SMA
MBG-1103	4.2	0.2	0.914	45	33	SMA
M7417	4.25	0.1	4.06	50	30	N
M7417A	4.3	0.02	3.980	55	30	SMA
M7417B	4.3	0.02	3.980	48-52	40	SMA
M7420B	4.3	0.03	1.830	55	30	SMA
M7307	4.3	.086	2.020	35	20	SMA
MBG-1010	4.3	0.1	3.457	33-37	35	SMA
M7428	4.3	0.1	0.653	35	40	TAB
MBG-1140	4.3	0.1	1.016	45	30	SMA
MBG-1028	4.3	0.15	2.867	50	20	SMA
MBG-1029	4.3	0.15	0.467	50	20	SMA
MBG-1000	4.3	0.2	3.850	45	35	SMA
MBG-1003	4.3	0.2	0.650	37	35	SMA

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBG-1005	4.3	0.2	0.5	30	30	SMA
MBG-1007	4.3	0.2	1.525	30	20	N
MBG-1007A	4.3	0.2	1.525	35	20	N
MBG-1007B	4.3	0.2	1.525	30	20	SMA
MBG-1008	4.3	0.2	1.525	30	20	SMA
MBG-1011	4.3	0.2	10.16	75	25	SMA
MBG-1013	4.3	0.2	4.064	45	35	PIN
MBG-1013A	4.3	0.2	4.064	45	35	SMA
MBG-1013B	4.3	0.2	4.064	50	30	N
MBG-1014	4.3	0.2	0.508	35	20	SMA
MBG-1017	4.3	0.2	3.04	40	20	SMA
MBG-1018A	4.3	0.2	4.06	40	45	SMA
MBG-1025	4.3	0.2	1.016	55	30	SMA
MBG-1026	4.3	0.2	5.08	55	35	SMA
MBG-1026A	4.3	0.2	5.08	55	35	N
MBG-1026B	4.3	0.2	5.08	39-43	35	SMA
MBG-1039	4.3	0.2	0.710	30	10	SMA
MBG-1045	4.3	0.2	0.4064	30	25	SMA
MBG-1046	4.3	0.2	2.032	28	20	SMA
MBG-1047	4.3	0.2	9.5504	70	25	SMA
MBG-1100	4.3	0.2	2.867	40	30	SMA
MBG-1101	4.3	0.2	0.467	29	29	SMA
MBG-2000A	4.3	0.2	.610	38	3DTS	TO-8
MBG-2000B	4.3	0.2	.61	32	3DTS	TO-8
MBG-2000C	4.3	0.2	.61	38	5DTS	TO-8
M7307A	4.3	0.2	2.020	35	20	SMA
M7415A	4.3	0.2	5.080	65	20	SMA
M7415B	4.3	0.2	5.080	50	20	SMA
M7416	4.3	0.2	0.500	40-45	20	N
M7416A	4.3	0.2	0.500	35	20	SMA
M7416B	4.3	0.2	0.500	35	20	N
M7417C	4.3	0.2	3.980	50	40	SMA
M7417D	4.3	0.2	3.980	55	25	SMA
M7418D	4.3	0.2	0.203	25	10	SMA
M7419	4.3	0.2	0.406	30	25	SMA



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
M7419P	4.3	0.2	0.406	30	25	SMA
M7420	4.3	0.2	1.016	28	20	SMA
M7420A	4.3	0.2	1.016	25	15	SMA
M7421	4.3	0.2	2.032	28	20	SMA
M7421B	4.3	0.2	2.032	35	25	SMA
M7422	4.3	0.2	3.048	35	30	SMA
M7422A	4.3	0.2	3.048	40	30	SMA
M7422B	4.3	0.2	2.987	40	30	SMA
M7423	4.3	0.2	4.064	40	45	SMA
M7423D	4.3	0.2	4.064	45	35	SMA
M7424A	4.3	0.2	0.142	35	25	SMA
M7424B	4.3	0.2	0.953	35	28	SMA
M7424C	4.3	0.2	1.968	35	28	SMA
M7432	4.3	0.2	1.524	35	20	SMA
M7432A	4.3	0.2	1.524	30	20	SMA
M7433	4.3	0.2	2.775	35	20	SMA
M7435	4.3	0.2	10.15	85	80	N
M7436	4.3	0.2	4.064	45	30	SMA
M7437	4.3	0.2	10.16	70	25	SMA
MBG-1005A	4.3	0.2	0.5	30	30	SMA
MBG-1011A	4.3	0.2	10.16	75	35	SMA
MBG-1011B	4.3	0.2	10.16	60-80	25	SMA
MBG-1011C	4.3	0.2	10.16	75	20	SMA
MBG-1014A	4.3	0.2	0.508	35	20	SMA
MBG-1014B	4.3	0.2	0.508	35	20	N
MBG-1016	4.3	0.2	0.5	35	20	SMA
MBG-1016A	4.3	0.2	0.5	35	20	N
MBG-1017B	4.3	0.2	3.04	39	30	SMA
MBG-1018	4.3	0.2	4.06	45	35	SMA
MBG-1018B	4.3	0.2	4.06	45	35	N
MBG-1025A	4.3	0.2	1.016	47	40	SMA
MBG-1025B	4.3	0.2	1.016	55	30	N
MBG-1032	4.3	0.2	2.032	35	20	SMA
MBG-1035	4.3	0.2	0.667	46	35	SMA
MBG-1036	4.3	0.2	5.0	56	40	SMA

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBG-1036A	4.3	0.2	5.0	50	40	SMA
MBG-1037	4.3	0.2	0.71	30	10	SMA
MBG-1049	4.3	0.2	10.0	75	40	SMA
MBG-1049A	4.3	0.2	10.0	75	35	SMA
MBG-1052	4.3	0.2	4.574	49	40	SMA
MBG-1073	4.3	0.2	9.76	75	45	SMA
MBG-1074	4.3	0.2	4.88	50	40	SMA
MBG-1081	4.3	0.2	0.333	27	20	SMA
MBG-1082	4.3	0.2	0.667	35	30	SMA
MBG-1083	4.3	0.2	1.333	25	18	SMA
MBG-1084	4.3	0.2	2.0	31	22	SMA
MBG-1085	4.3	0.2	2.667	36	25	SMA
MBG-1088	4.3	0.2	5.0	50	40	SMA
MBG-1088A	4.3	0.2	5.0	50	35	SMA
MBG-1089	4.3	0.2	10.0	75	40	SMA
MBG-1105	4.3	0.2	4.9	50	25	SMA
MBG-1106	4.3	0.2	0.2	25	10	SMA
MBG-1109	4.3	0.2	0.95	45	25	SMA
MBG-1110	4.3	0.2	0.31	25	15	SMA
MBG-1114	4.3	0.2	0.384	20	10	SMA
MBG-1115	4.3	0.2		30	20	SMA
MBG-1116	4.3	0.2		35	20	SMA
MBG-1117	4.3	0.2	0.2	25	15	SMA
MBG-1123	4.3	0.2	0.63	35	30	SMA
MBG-1124	4.3	0.2	0.79	40	35	SMA
MBG-1125	4.3	0.2	4.79	50	35	SMA
MBG-1126	4.3	0.2	1.0	45	30	SMA
MBG-1127	4.3	0.200	10.143	70	25	SMA
MBG-1128	4.3	0.2		25	18	SMA
MBG-1129	4.3	0.2	0.64	35	30	SMA
MBG-1130	4.3	0.2	1.28	25	15	SMA
MBG-1131	4.3	0.2	2.56	37	25	SMA
MBG-1132	4.3	0.2	5.12	50	30	SMA
MBG-1132A	4.3	0.2	5.12	50	30	SMA
MBG-1133	4.3	0.2	10.24	75	35	SMA



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBG-1137	4.3	0.2	1.645	34-40	20	SMA
MBG-1137A	4.3	0.2	1.615	27-33	19	SMA
MBG-1138	4.3	0.2	1.83	68-75	20	SMA
MBG-1139	4.3	0.2	3.25	35-40	20	SMA
MBG-1141	4.3	0.2	0.1016	20	7	SMA
MBG-1142	4.3	0.2	3.310	40	30	SMA
MBG-1143	4.3	0.2	1.615	30	19	SMA
MBG-1144	4.3	0.2	1.575	40	20	SMA
MBG-1149	4.3	0.2	8.128	70	35	SMA
MBG-1150	4.3	0.2	0.609	35	35	SMA
MBG-1151	4.3	0.2	0.203	20	10	SMA
MBG-1152	4.3	0.2	1.016	50	35	SMA
MBG-1152A	4.3	0.2	1.016	40	30	SMA
MBG-1153	4.3	0.2	2.032	35	25	SMA
MBG-1153A	4.3	0.2	2.032	30	20	SMA
MBG-1154	4.3	0.2	4.064	45	30	SMA
MBG-1154A	4.3	0.2	4.065	45	35	SMA
MBG-1155	4.3	0.2	6.496	60	40	SMA
MBG-1156	4.3	0.2	0.203	25	10	SMA
MBG-1157	4.3	0.2	3.333	40	30	SMA
MBG-1157A	4.3	0.2	3.333	40	30	SMA
MBG-1161	4.3	0.2	0.406	25	23	SMA
MBG-1163	4.3	0.2	3.251	40	30	SMA
MBG-1168	4.3	0.2	0.25	21	13	N
MBG-1169	4.3	0.2	1.0	46	44	N
MBG-1170	4.3	0.2	2.5	35	20	N
MBG-1171	4.3	0.2	4.0	45	35	N
MBG-1173	4.3	0.2	6.667	60	25	SMA
MBG-1174	4.3	0.2	13.334	90	25	SMA
MBG-1175	4.3	0.2	0.98	25	13	SMA
MBG-1176	4.3	0.2	1.996	30	20	SMA
MBG-1178	4.3	0.2	3.048	40	28	SMA
MBG-1179	4.3	0.2	0.334	25	18	SMA
MBG-1180	4.3	0.2	9.144	70	20	SMA
MBG-1181	4.3	0.2	0.483	30	27	SMA

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBG-1184	4.3	0.20	1.118	50	35	SMA
MBG-1187	4.3	0.2	1.8	32	19	SMA
MBG-1188	4.3	0.2	6.096	57	28	SMA
MBG-1189	4.3	0.2	0.139	20	5	SMA
MBG-1190	4.3	0.2	0.278	25	15	SMA
MBG-1191	4.3	0.2	4.978	50	35	SMA
MBG-1192	4.3	0.2	1.829	30	19	SMA
MBG-1193	4.3	0.2	3.658	43	32	SMA
MBG-1195	4.3	0.2	1.667	30	20	
MBG-1196	4.3	0.2	0.285	25	15	
MBG-1197	4.3	0.2	0.345	25	18	
MBG-1198	4.3	0.2	0.720	37	40	
MBG-1201	4.3	0.2	12.0	85	10	SMA
MBG-2001	4.3	0.2	.61	38	5DTS	TO-8
MBG-2002A	4.3	0.2				TO-8
MBG-3000	4.3	0.2	1.076	40-50	25-30	TO-8
MBG-3000A	4.3	0.2	1.016	40-50	25-30	TO-8
MDG-1000	4.3	0.2	7.833	98		
MDG-1001	4.3	0.2	-	-	-	
MDG-1001A	4.3	0.2	-	-	-	
MDG-1002	4.3	0.2	-	-	-	
MDG-1003	4.3	0.2	-	-	-	
MBG-1148	4.3	0.25	0.267	20	15	SMA
MBG-1061	4.3	0.3	0.934	28	14	SMA
MBG-1062	4.3	0.3	0.33	26	20	SMA
MBG-1066A	4.3	0.3	0.85	43	25	SMA
MBG-1067A	4.3	0.3	0.6	34	25	SMA
MBG-1068	4.3	0.3	4.7	50	25	SMA
MBG-1164	4.3	0.3	1.3	35	15	SMA
MBG-1166	4.3	0.4	1.524	70	30	SMA
MBG-1158	4.3	0.8	0.667	30	8	SMA
MBG-1159	4.3	0.8	2.668	46	23	SMA
MBG-1160	4.3	0.8	5.0	60	37	SMA
MBG-1048	4.3	1.2	3.0	55	20	SMA
MBG-1030	4.3	1.4	3.0	70	20	SMA



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBG-1102	4.3	1.9	0.5	39	23	SMA
MBG-2002	4.3					TO-8
MBG-1079	4.47	1.66	0.5	46	30	SMA
MBG-1006	4.5	1.0	1.1	45	25	SMA
MBG-1145	4.5	1.0	0.7	50	40	SMA
MBG-1146	4.5	1.0	2.61	50	24	SMA
MBG-1147	4.5	1.0	4.95	65	40	SMA
MBE-1017	4.50	1.6	0.5	50	10	SMA
MBG-1185	4.6	1.1	1.679	60	20	SMA
MBG-1194	5.0	2.0	1.669	60	20	
MBG-1199	5.0	2.0	3.365	60	20	
MBG-1012	5.08	0.2	5.0	70	N/S	SMA
MBH-1007	5.25	2.5	1.85	58	30	SMA
MBG-1019	5.25	2.5	1.079	65	40	SMA
MBG-1020	5.25	2.5	1.659	65	40	SMA
MBG-1021	5.25	2.5	0.423	65	40	SMA
MBG-1022	5.25	2.5	0.437	65	40	SMA
MBG-1023	5.25	2.5	1.934	65	40	SMA
MBG-1024	5.25	2.5	2.155	65	40	SMA
MBG-1033	5.25	2.5	1.576	65	35	SMA
MBG-1034	5.25	2.5	2.265	65	35	SMA
MBH-1006	5.25	2.5	1.7	55	30	SMA
MDG-1004	5.25	2.5	-	-	50	
MDG-1005	5.25	2.5	-	-	50	
MDG-1006	5.25	2.5	-	-	50	
MDG-1007	5.25	2.5	-	-	50	
MBG-1135	5.3	.05	4.0	50	35	SMA
MBG-1136	5.3	0.05	5.6	60	35	SMA
MBG-1134	5.3	0.1	2.0	40	30	SMA
MBG-1162	5.3	0.1	2.0	45	40	SMA
MBG-1172	5.3	0.1	1.8	40	45	SMA
MBG-1031	5.3	0.2	2.5	55	25	SMA
MBG-1186	5.34	1.23	1.679	60	20	SMA
MBG-1167	5.5	0.1	2.5	40	35	SMA
MDG-1008	5.5	0.6	0.4	45	37	

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MDG-1009	5.5	0.6	0.8	65	40	
MDG-1010	5.5	0.6	1.0	60	30	
MDG-1011	5.5	0.6	2.0	60	40	
MDG-1012	5.5	0.6	4.0	60	40	
MDG-1013	5.5	0.6	5.0	70	40	
MBG-1182	5.5	1.00	0.58	40	12	SMA
MBG-1183	5.5	1.00	1.227	50	18	SMA
MBG-1200	5.513	0.425	5.0	65	38	
MBG-1108	5.6	0.2	6.0	83	30	SMA
MBG-1038	5.625	0.05	3.0	55	40	SMA
MBG-1118	5.625	.05	3.012	50	30	SMA
MBG-1177	5.625	0.05	3.00	45	30	SMA
MBG-1099	5.66	0.51	1.0	36	20	SMA
MBG-1050	5.7	0.2	2.5	55		SMA
MBG-1113	5.765	0.05	2.5	43	35	SMA
MBH-1012	6.1	0.1	6.5	85	40	SMA
MBH-1013	6.18	1.45	1.679	60	20	SMA
MBH-1014	7.15	1.7	1.679	60	20	SMA
MBH-1015	7.8	1.0	0.5	38	19	STRIP
M7940C	8.0	1.0	0.55	63	15	SMA
MBI-1111	8.25	1.5	0.5	40	20	SMA
MBI-1017	8.45	1.1	0.5	55	20	SMA
MBI-1015	8.7	0.4	2.0	65	45	SMA
MBI-1016	8.7	0.6	1.0	55	35	SMA
MBI-1022	8.7		2.0	65	45	SMA
MBH-1001	8.75	4.5		0.5		SMA
MBI-1019	8.845	0.75	3.7	95	40	SMA
MBH-1005	8.9	4.2	0.5	52	15	SMA
MBH-1005A	8.9	4.2	0.5	52	15	SMA
MBI-1004	9.0	1.0	1.0	55	N/S	SMA
MBI-1005	9.0	1.0	1.0	50	20	
MBI-1024	9.0	2.0	.33	50	17	SMA
MBI-1025	9.0	2.0	0.5	55	20	SMA
MBI-1027	9.0	2.0	0.5	55	20	SMA
MBI-1028	9.0	2.0	1.0	55	30	SMA



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Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBI-1029	9.0	2.0	1.5	75	40	SMA
M7941A -	9.0	2.0	1.0	55	20	SMA
MBH-1009	9.0	3.0	0.98	60	30	SMA
MBH-1002	9.0	3.0	1.0	64	20	SMA
MBH-1000	9.0	4.0	0.47	61.4	N/S	SMA
MBH-1008	9.0	6.0	0.5	-	14	SMA
MBI-1023	9.1	1.0	2.0	80	50	SMA
M7928	9.1	1.8	0.195	40	12	SMA
MBI-1102	9.15	0.7	1.0	45	35	SMA
MBI-1099	9.2	0.050	2.0	65	30	
MBI-1108	9.2	0.6	2.00	68-72	35	SMA
MBI-1105	9.200	1.0	2.0	70	30	SMA
MBI-1094	9.225	.06	3.0	79	30	SMA
MBI-1006	9.275	0.1	1.33	55	25	SMA
MBI-1009	9.275	0.1	1.0	60	25	SMA
MBI-1010	9.275	0.1	2.0	60	25	SMA
MBI-1011A	9.275	0.3	0.5	43-49	25	SMA
MBI-1011	9.275	0.6	0.5	60	25	SMA
MBI-1012	9.275	0.6	1.5	60	25	SMA
M7923A	9.30	0.20	2.0	61-64	30	WG
MBI-1096	9.3	0.2	2.0	65	50	
MBI-1096A	9.3	0.2	2.0	65	50	
MBI-1098	9.3	0.2	2.0	65	60	
MBI-1097	9.3	0.4	2.0	70	70	
MBI-1114	9.35	1.1	1.25	60	25	SMA
MBI-1103	9.375	0.375	2.0	65	35	SMA
MBI-1101	9.4	0.2	3.0	85	10	SMA
MBI-1100	9.4	0.4	0.25			
MBI-1007	9.5	0.5	3.075	85	25	SMA
MBI-1013	9.5	0.5	0.764	55	20	SMA
MBI-1021	9.5	0.6	1.5	60	50	SMA
MBI-1086	9.5	0.6	2.0	70	35	SMA
MBI-1109	9.5	1.00	2.00	75	20	SMA
MBI-1110	9.55	0.4	1.00	45	35	SMA
MBI-1110A	9.55	0.4	1.00	45	35	SMA

Model Number	Fo (GHz)	BW (GHz)	T.D. (μS)	I.L. (dB)	TTS (dB)	Package
MBI-1112	9.55	0.4	1.53	55	30	SMA
MBI-1113	9.55	0.4	0.27	60	25	SMA
M7911B	9.60	0.50	2.0	78	20	WG
MBI-1104	9.650	0.5	0.5	35	18	SMA
MBI-1003	9.7	0.2	1.5	60	20	SMA
MBI-1018	9.7	0.6	1.9	65	35	SMA
MBI-1020	9.7	0.6	0.75	50	30	SMA
MBH-1010	9.75	5.5	0.98	70	35	SMA
M7938	10.00	0.5	0.50	40	20	SMA
MBJ-1015	10	2.00	0.5	50	17	SMA
MBJ-1015A	10	2.00	0.5	50	20	SMA
M7941B	10.0	4.0	1.0	65	20	SMA
M7936G	10.20	4.4	0.195	55	15	SMA
MBJ-1001	10.65	1.3	0.3783	50	N/S	SMA
MBJ-1001A	10.65	1.3	0.3783	50	N/S	SMA
MBH-1011	11.5	8.0	0.5	65	15	SMA
MBJ-1016	11.5	8.00	0.5	65	13	SMA
M7940B	11.55	7.7	0.55	63	15	SMA
MBJ-1014	12.0	10.0	0.1	60	5	SMA
MBW-1000	12.0	10.0	0.15	70	10	SMA
MBJ-1006	12.165	0.6	0.75	70	60	SMA
MBJ-1008	12.165	0.7	0.75	65	60	SMA
MBJ-1011	12.25	9.5	0.195	65	12	SMA
MBJ-1013	12.25	9.5	0.195	50	12	
MBJ-1017	13.3	0.2	0.2	45	15	SMA
M7936F	13.75	4.5	0.195	50	20	SMA
MBJ-1002	14.0	4.0	0.155	53.8	20	
M7936E	14.50	4.0	0.195	51	20	SMA
MBJ-1005	16.0	1.0	0.5	66	25	SMA
MBJ-1007	16.0	1.0	0.5	66	25	SMA
MBJ-1007A	16.0	1.0	0.500	60	25	SMA
MBJ-1010	16.4	0.6	0.15	55	20	
MBJ-1018	16.455	1.00	0.8	90		SMA
MBJ-1009	16.75	0.5	0.26	75	20	SMA
MBJ-1003	17.0	2.0	0.155	47.8		





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