



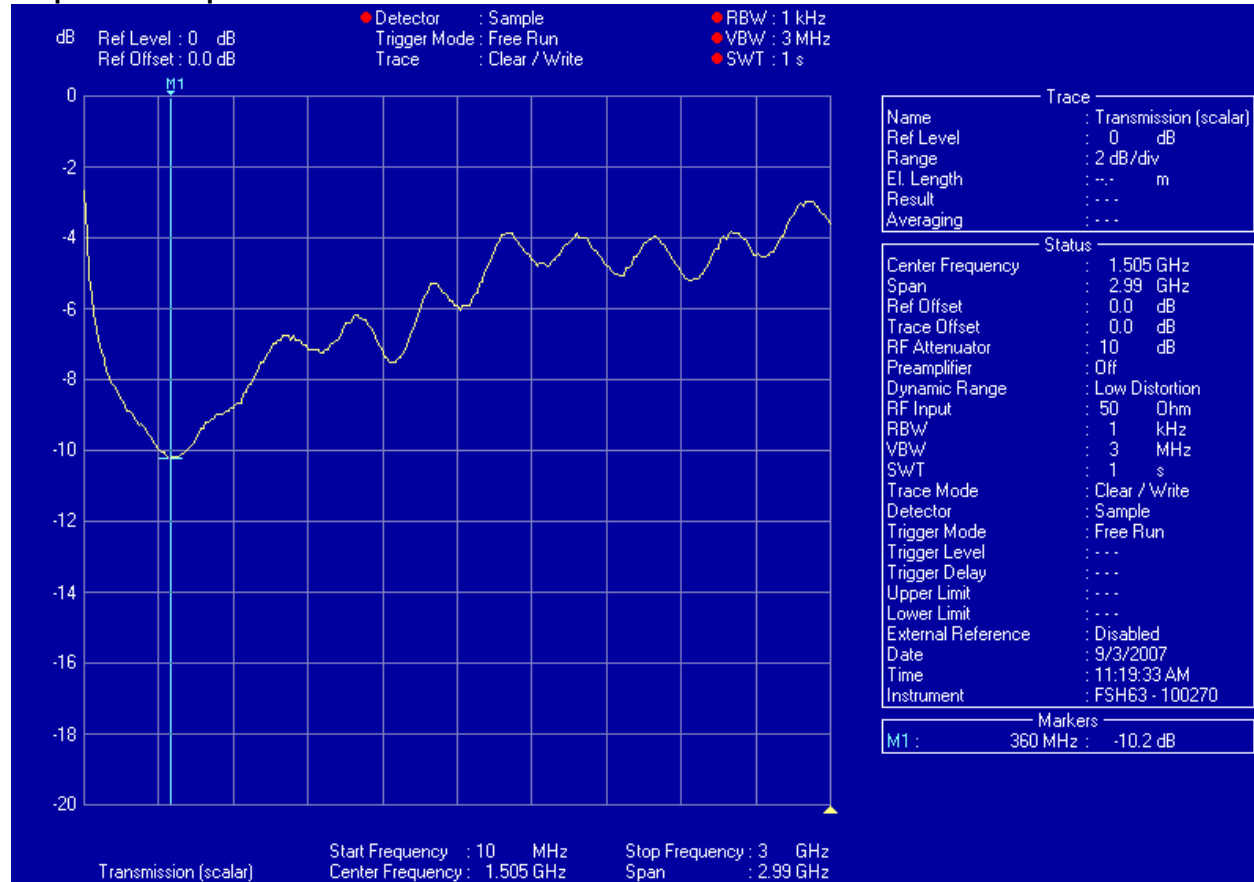
## Ferrite Chip Beads

### Introduction –

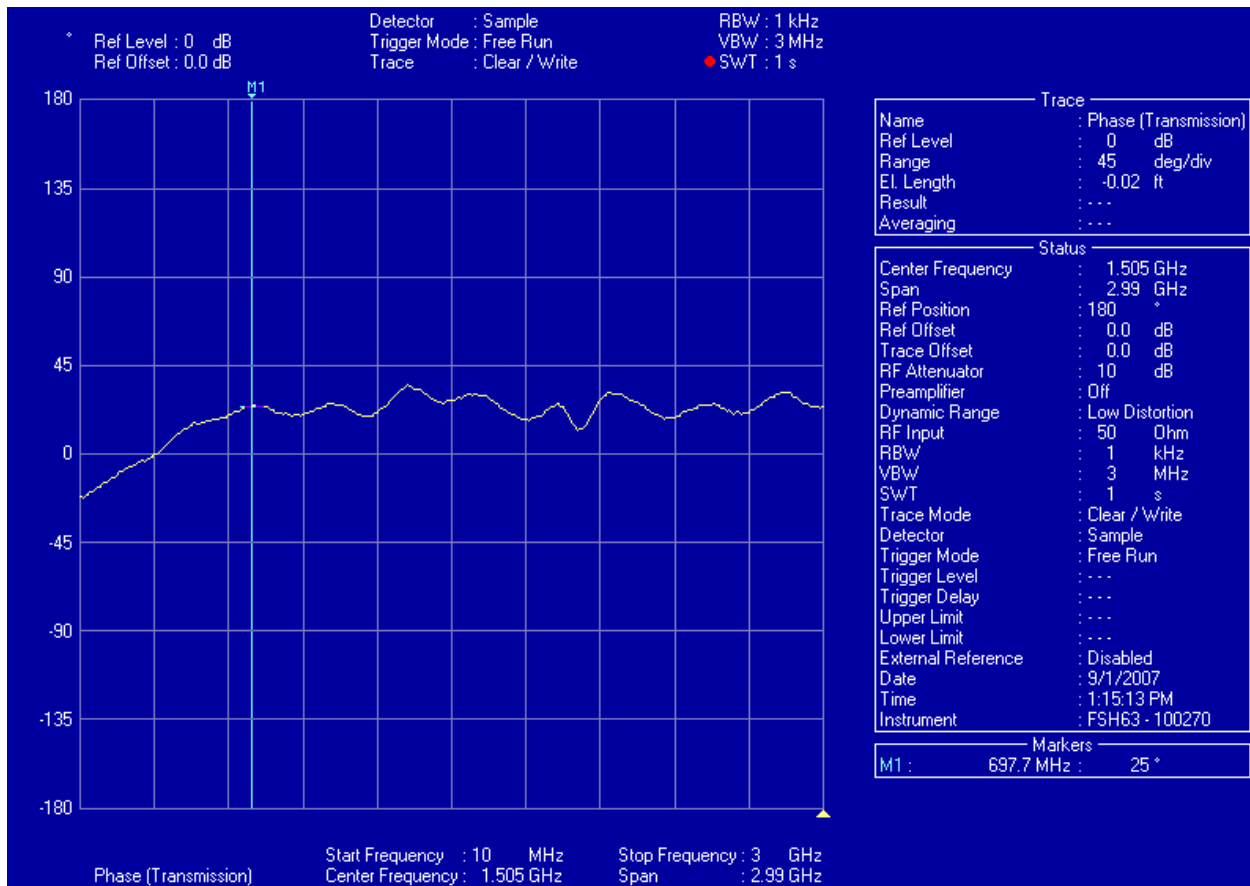
360° Test Labs has been retained to independently develop S-parameter data for 4-types of chip beads. For this testing process, a family of printed circuit boards were designed and fabricated specifically for testing these components. The boards included *short*, *open*, *load*, and *thru* versions of the same board to allow network analyzer calibration. This approach and process allows far higher phase accuracy that simply using typical calibration loads.

### Findings –

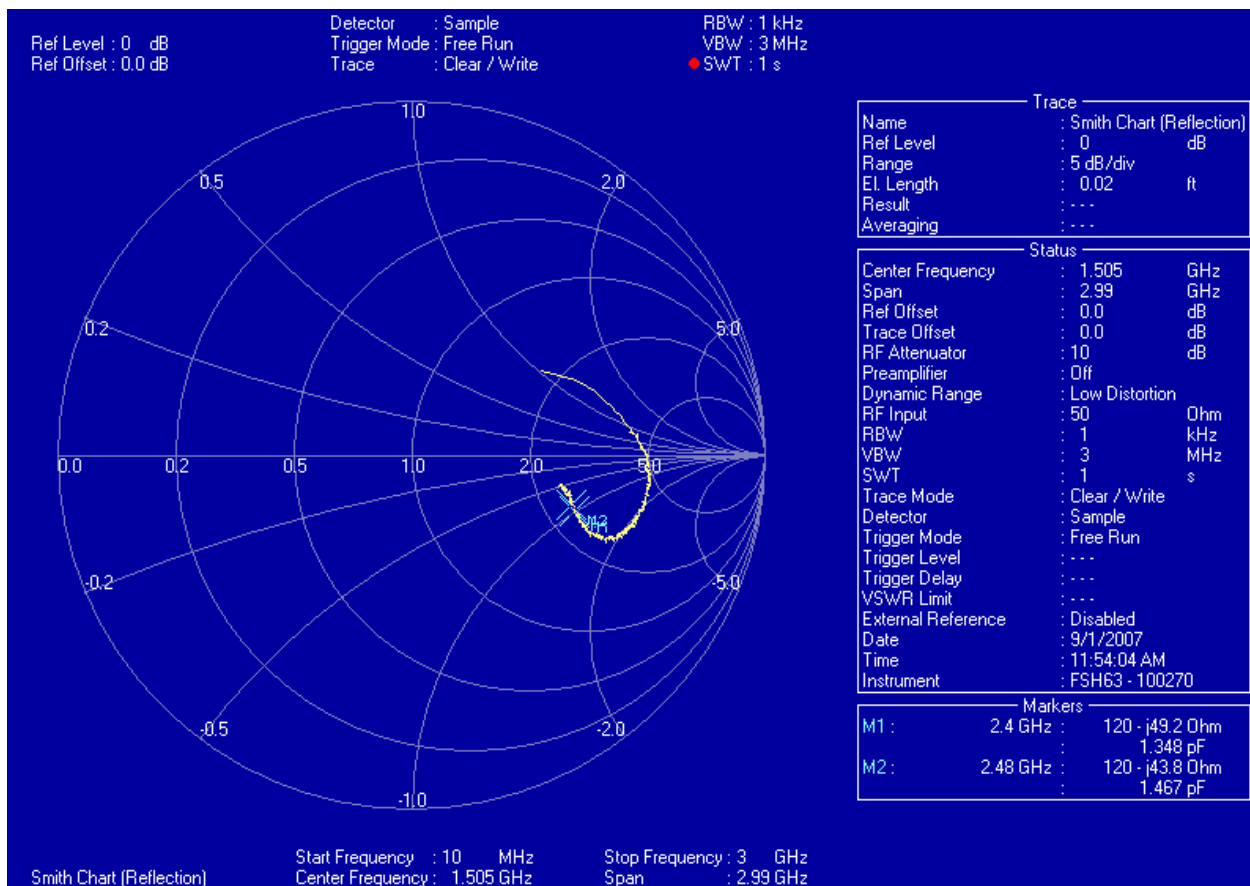
#### Chip Bead Sample #1



**Magnitude S21 Sweep 10 MHz - 3 GHz**



**S21 Shown as a 10 MHz to 3 GHz Phase Change Plot**

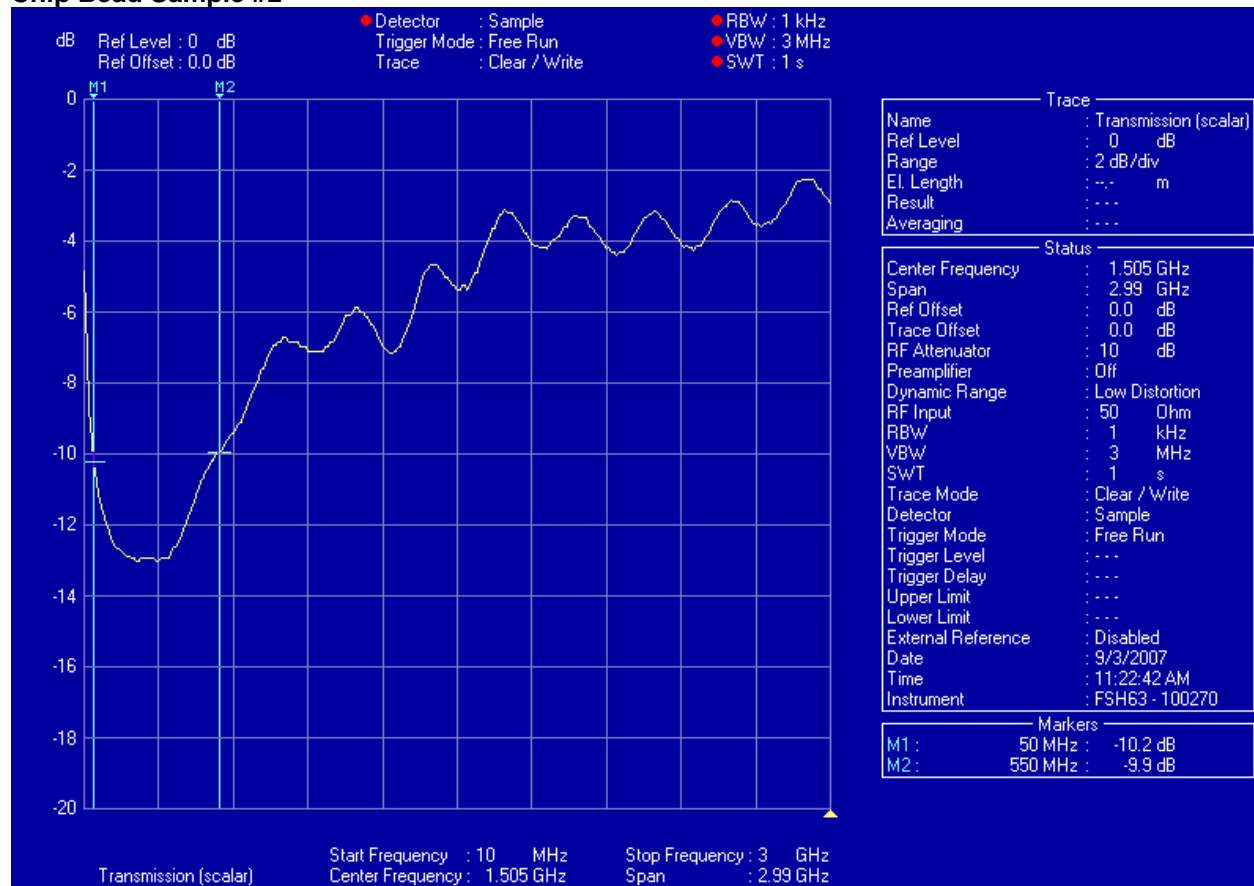


**Phase and Amplitude shown as a S11 Smith Chart 10 MHz - 3 GHz**

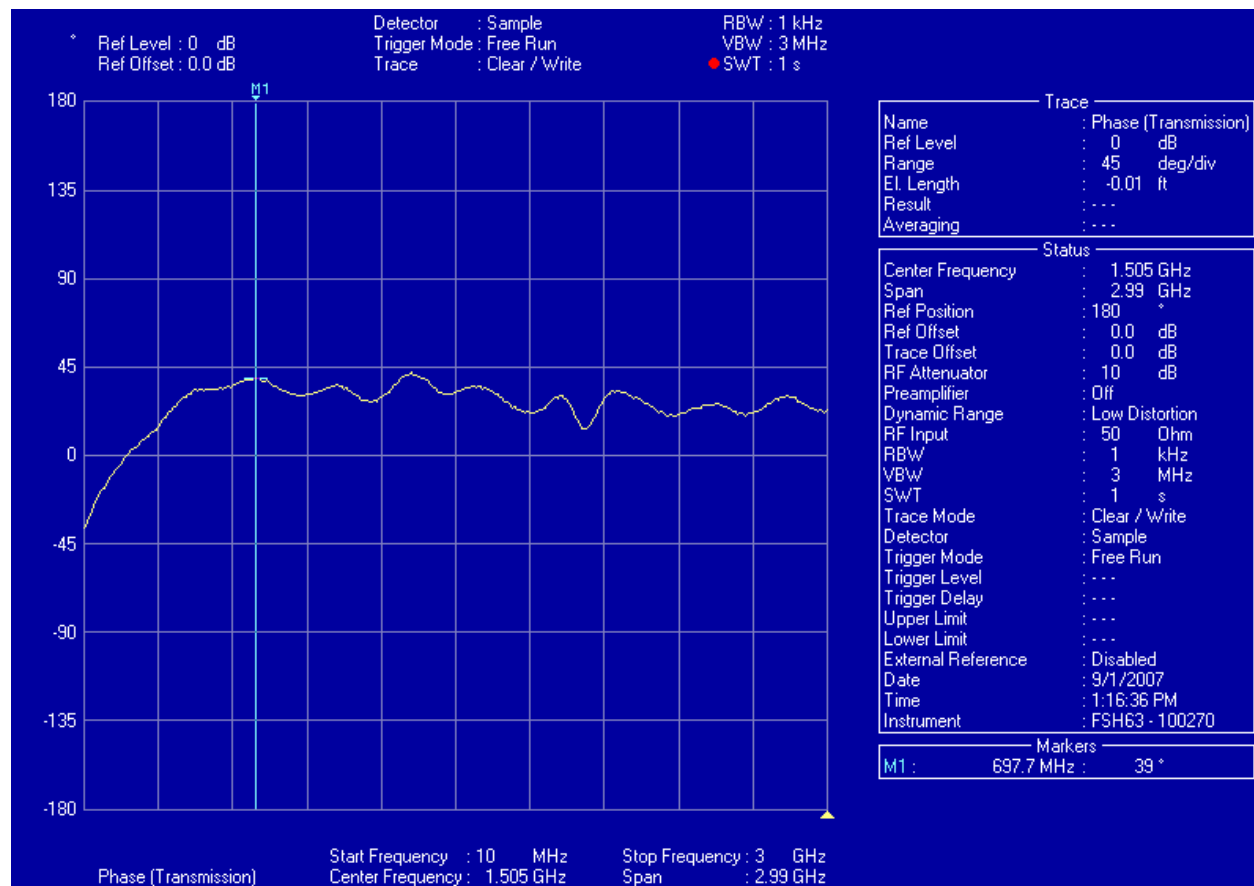
Component showed a maximum attenuation in a 50-Ohm system of 10.2 dB at 360 MHz.

Sample #1 MHz	CH1 S11		S21		S12		CH2 S22	
	Mag (Mu)	Angle°	Mag (Mu)	Angle°	Mag (Mu)	Angle°	Mag (Mu)	Angle°
1.00	127.850	16.088	994.530	-27.521	994.530	-27.521	127.850	16.088
11.00	410.830	34.442	782.200	-21.318	782.200	-21.318	410.830	34.442
20.99	506.480	22.320	622.550	-23.606	622.550	-23.606	506.480	22.320
30.99	559.090	15.627	549.180	-22.374	549.180	-22.374	559.090	15.627
40.98	590.570	10.232	508.570	-21.474	508.570	-21.474	590.570	10.232
50.98	605.490	5.604	473.730	-20.753	473.730	-20.753	605.490	5.604
60.97	609.780	1.956	446.750	-19.763	446.750	-19.763	609.780	1.956
70.97	607.870	-1.023	425.140	-18.398	425.140	-18.398	607.870	-1.023
80.96	607.220	-3.024	409.320	-16.787	409.320	-16.787	607.220	-3.024
90.96	608.820	-4.675	398.020	-15.233	398.020	-15.233	608.820	-4.675
100.95	615.280	-6.097	390.840	-13.749	390.840	-13.749	615.280	-6.097
110.95	623.640	-7.688	385.800	-12.590	385.800	-12.590	623.640	-7.688
120.94	634.180	-9.393	383.340	-11.750	383.340	-11.750	634.180	-9.393
130.94	640.830	-11.488	379.330	-11.348	379.330	-11.348	640.830	-11.488
140.93	645.400	-13.754	373.870	-11.033	373.870	-11.033	645.400	-13.754
150.93	646.980	-15.811	368.990	-10.607	368.990	-10.607	646.980	-15.811
160.92	646.450	-17.750	358.990	-9.912	358.990	-9.912	646.450	-17.750
170.92	646.400	-19.321	350.920	-8.845	350.920	-8.845	646.400	-19.321
180.91	648.560	-20.716	344.890	-7.402	344.890	-7.402	648.560	-20.716
190.91	655.200	-21.970	341.940	-5.787	341.940	-5.787	655.200	-21.970
200.90	665.460	-23.492	341.880	-4.330	341.880	-4.330	665.460	-23.492
210.90	676.450	-25.319	343.890	-3.161	343.890	-3.161	676.450	-25.319
220.89	686.460	-27.589	346.110	-2.362	346.110	-2.362	686.460	-27.589
230.89	692.490	-30.100	347.640	-1.984	347.640	-1.984	692.490	-30.100
240.88	694.180	-32.559	346.960	-1.673	346.960	-1.673	694.180	-32.559
250.88	692.300	-34.765	345.590	-1.145	345.590	-1.145	692.300	-34.765
260.87	689.400	-36.649	343.790	-0.460	343.790	-0.460	689.400	-36.649
270.87	688.440	-38.249	343.700	0.531	343.700	0.531	688.440	-38.249
280.86	692.480	-39.790	346.040	1.376	346.040	1.376	692.480	-39.790
290.86	698.790	-41.450	349.380	1.932	349.380	1.932	698.790	-41.450
300.85	705.590	-43.669	352.990	2.096	352.990	2.096	705.590	-43.669
310.85	710.250	-46.090	358.210	1.688	358.210	1.688	710.250	-46.090
320.84	709.780	-48.748	356.050	1.325	356.050	1.325	709.780	-48.748
330.84	705.080	-51.284	353.720	0.726	353.720	0.726	705.080	-51.284
340.83	693.990	-53.554	348.550	0.431	348.550	0.431	693.990	-53.554
350.83	683.390	-55.254	341.430	0.520	341.430	0.520	683.390	-55.254
360.82	675.880	-56.643	335.360	1.136	335.360	1.136	675.880	-56.643
370.82	671.300	-57.850	330.200	2.054	330.200	2.054	671.300	-57.850
380.81	670.770	-59.069	328.300	3.135	328.300	3.135	670.770	-59.069
390.81	672.050	-60.518	325.000	4.211	325.000	4.211	672.050	-60.518
400.80	674.200	-62.346	323.350	5.067	323.350	5.067	674.200	-62.346
410.80	673.430	-64.196	322.070	5.894	322.070	5.894	673.430	-64.196
420.79	669.220	-66.058	319.920	6.861	319.920	6.861	669.220	-66.058
430.79	663.050	-67.690	317.340	8.038	317.340	8.038	663.050	-67.690
440.78	657.950	-69.048	315.770	9.509	315.770	9.509	657.950	-69.048
450.78	654.600	-70.064	316.820	11.253	316.820	11.253	654.600	-70.064
460.77	654.740	-71.104	320.060	12.864	320.060	12.864	654.740	-71.104
470.77	659.390	-72.092	326.450	14.233	326.450	14.233	659.390	-72.092

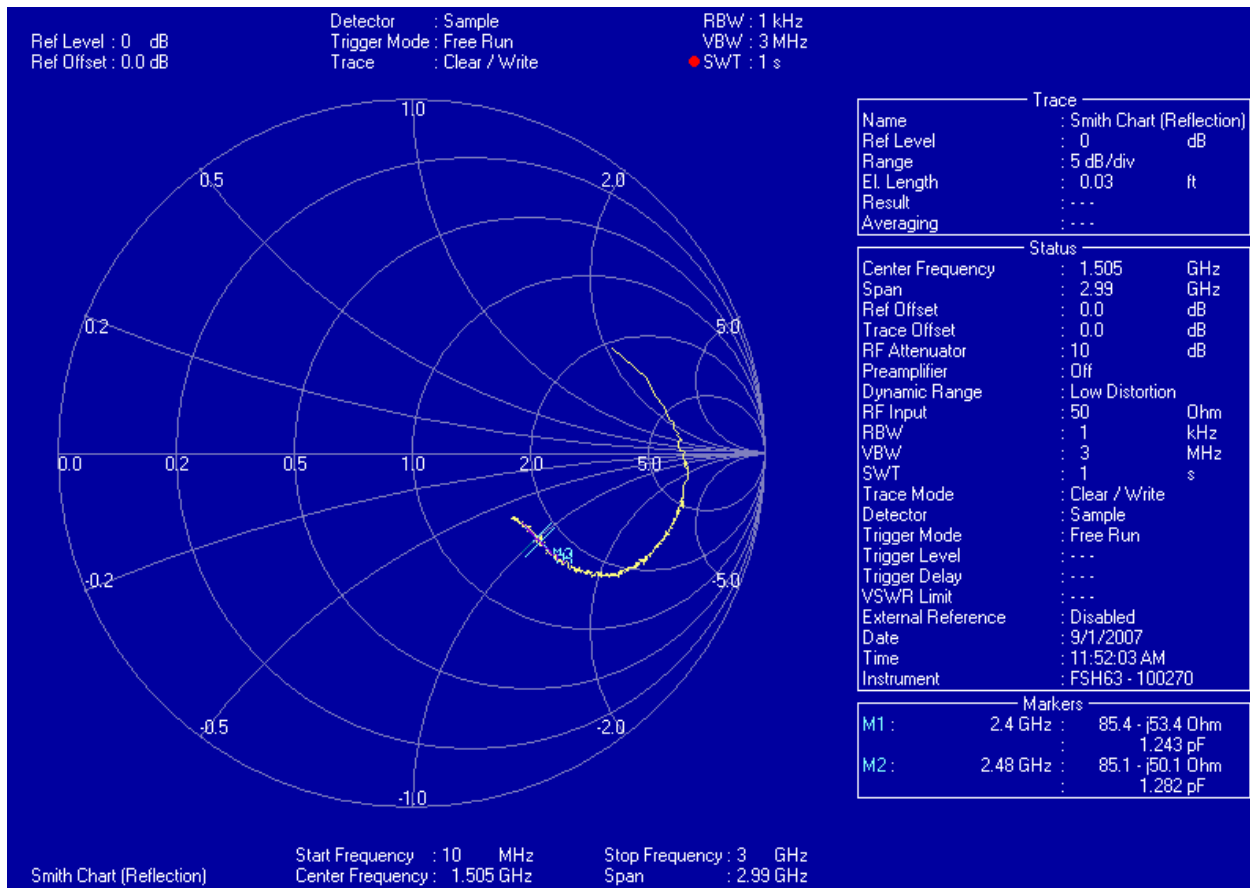
### Chip Bead Sample #2



**Magnitude S21 Sweep 10 MHz - 3 GHz**



**S21 Shown as a 10 MHz to 3 GHz Phase Change Plot**



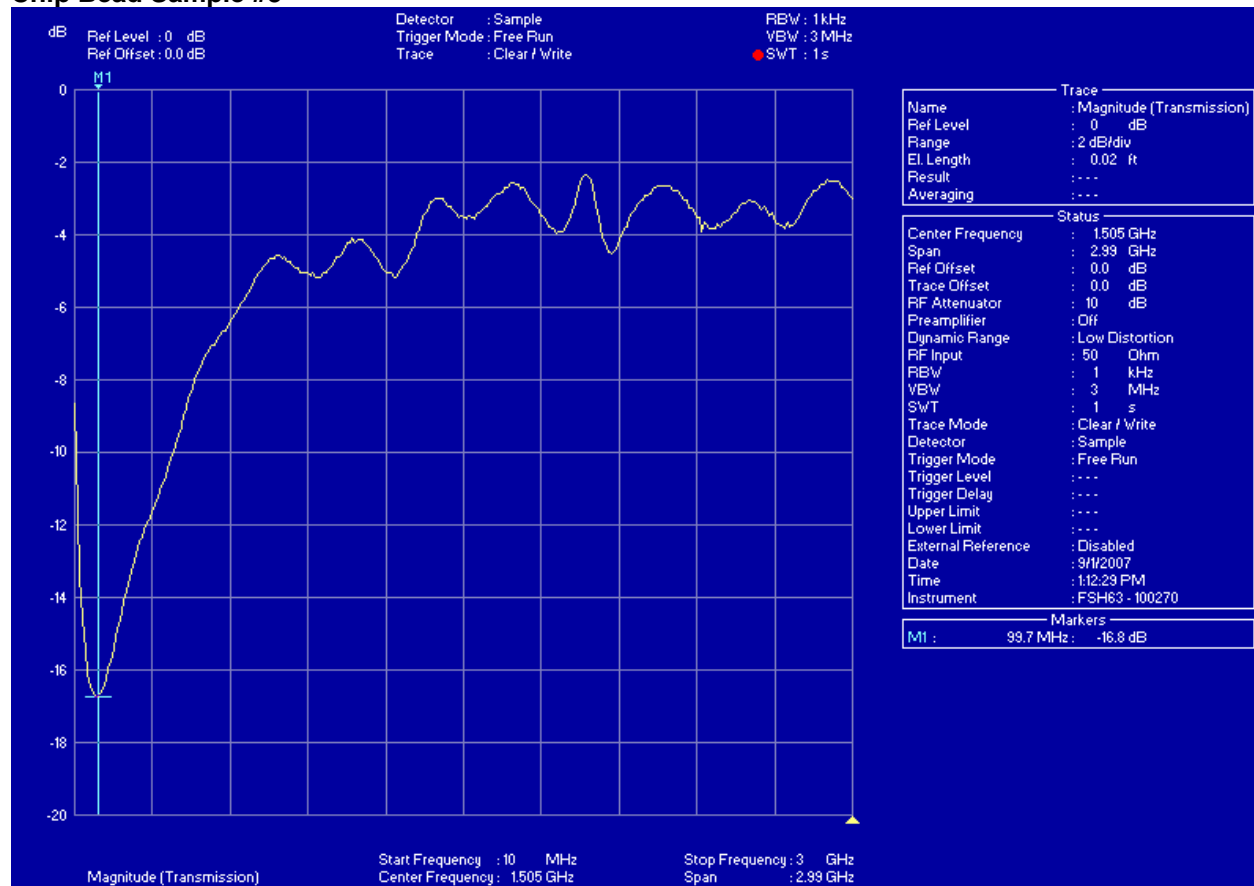
**Phase and Amplitude shown as a S11 Smith Chart 10 MHz - 3 GHz**

Component has a maximum attenuation at 13.1 dB at 350 MHz with good attenuation in a 50-Ohm system from 50 to 550 MHz.

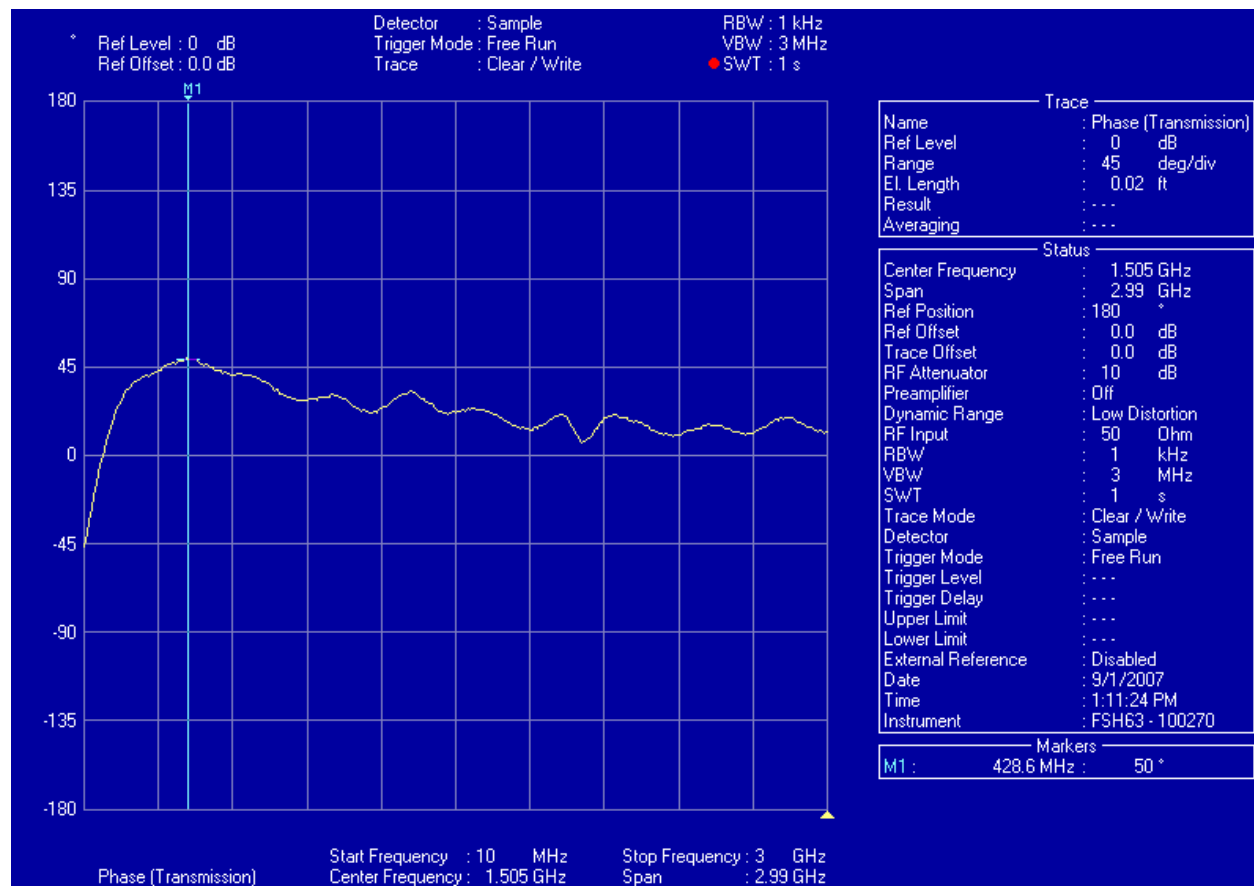
**Sample #2**

<b>MHz</b>	<b>CH1 S11</b>		<b>S21</b>		<b>S12</b>		<b>CH2 S22</b>	
	<b>Mag (Mu)</b>	<b>Angle°</b>	<b>Mag (Mu)</b>	<b>Angle°</b>	<b>Mag (Mu)</b>	<b>Angle°</b>	<b>Mag (Mu)</b>	<b>Angle°</b>
1.00	141.130	26.709	992.410	-4.570	992.410	-4.570	141.130	26.709
11.00	587.450	30.175	658.180	-34.794	658.180	-34.794	587.450	30.175
20.99	673.310	16.971	448.530	-37.057	448.530	-37.057	673.310	16.971
30.99	721.470	10.440	364.060	-33.479	364.060	-33.479	721.470	10.440
40.98	747.310	5.074	319.940	-30.304	319.940	-30.304	747.310	5.074
50.98	753.690	0.542	289.880	-27.416	289.880	-27.416	753.690	0.542
60.97	748.950	-2.999	268.100	-24.501	268.100	-24.501	748.950	-2.999
70.97	738.930	-5.646	251.800	-21.313	251.800	-21.313	738.930	-5.646
80.96	733.230	-7.436	240.660	-17.978	240.660	-17.978	733.230	-7.436
90.96	731.510	-8.764	232.930	-14.822	232.930	-14.822	731.510	-8.764
100.95	737.470	-10.032	228.550	-11.996	228.550	-11.996	737.470	-10.032
110.95	746.510	-11.507	226.290	-9.594	226.290	-9.594	746.510	-11.507
120.94	758.060	-13.181	225.460	-7.544	225.460	-7.544	758.060	-13.181
130.94	765.990	-15.353	223.520	-6.104	223.520	-6.104	765.990	-15.353
140.93	769.220	-17.677	220.810	-4.802	220.810	-4.802	769.220	-17.677
150.93	768.750	-19.851	217.250	-3.410	217.250	-3.410	768.750	-19.851
160.92	765.590	-21.754	212.780	-1.627	212.780	-1.627	765.590	-21.754
170.92	763.330	-23.235	209.250	0.560	209.250	0.560	763.330	-23.235
180.91	765.500	-24.549	207.050	3.189	207.050	3.189	765.500	-24.549
190.91	773.190	-25.771	207.540	5.904	207.540	5.904	773.190	-25.771
200.90	785.200	-27.287	210.240	8.304	210.240	8.304	785.200	-27.287
210.90	799.430	-29.240	214.410	10.280	214.410	10.280	799.430	-29.240
220.89	810.590	-31.711	218.710	11.770	218.710	11.770	810.590	-31.711
230.89	816.550	-34.335	222.400	12.553	222.400	12.553	816.550	-34.335
240.88	816.240	-36.966	224.310	13.453	224.310	13.453	816.240	-36.966
250.88	811.640	-39.323	225.680	14.606	225.680	14.606	811.640	-39.323
260.87	805.620	-41.188	227.190	15.852	227.190	15.852	805.620	-41.188
270.87	803.690	-42.196	230.500	17.244	230.500	17.244	803.690	-42.196
280.86	807.070	-44.339	234.750	18.615	234.750	18.615	807.070	-44.339
290.86	813.750	-46.147	240.560	19.512	240.560	19.512	813.750	-46.147
300.85	820.870	-48.385	247.000	19.863	247.000	19.863	820.870	-48.385
310.85	825.330	-51.016	252.130	19.575	252.130	19.575	825.330	-51.016
320.84	823.430	-53.196	254.580	19.015	254.580	19.015	823.430	-53.196
330.84	812.180	-56.437	254.770	18.667	254.770	18.667	812.180	-56.437
340.83	797.500	-58.618	252.780	18.587	252.780	18.587	797.500	-58.618
350.83	783.040	-60.410	249.870	18.928	249.870	18.928	783.040	-60.410
360.82	771.490	-61.658	247.180	19.742	247.180	19.742	771.490	-61.658
370.82	765.810	-62.176	245.650	20.955	245.650	20.955	765.810	-62.176
380.81	764.940	-63.946	245.830	22.249	245.830	22.249	764.940	-63.946
390.81	766.500	-65.440	246.710	23.486	246.710	23.486	766.500	-65.440
400.80	767.620	-67.258	248.450	24.483	248.450	24.483	767.620	-67.258
410.80	766.110	-69.217	249.850	25.420	249.850	25.420	766.110	-69.217
420.79	759.150	-71.139	250.330	26.505	250.330	26.505	759.150	-71.139
430.79	751.220	-72.681	250.760	27.760	250.760	27.760	751.220	-72.681
440.78	743.740	-73.891	252.370	29.435	252.370	29.435	743.740	-73.891
450.78	739.530	-74.879	256.090	31.277	256.090	31.277	739.530	-74.879
460.77	740.130	-75.726	262.070	32.932	262.070	32.932	740.130	-75.726
470.77	746.740	-76.713	270.670	34.349	270.670	<b>etc.</b>		

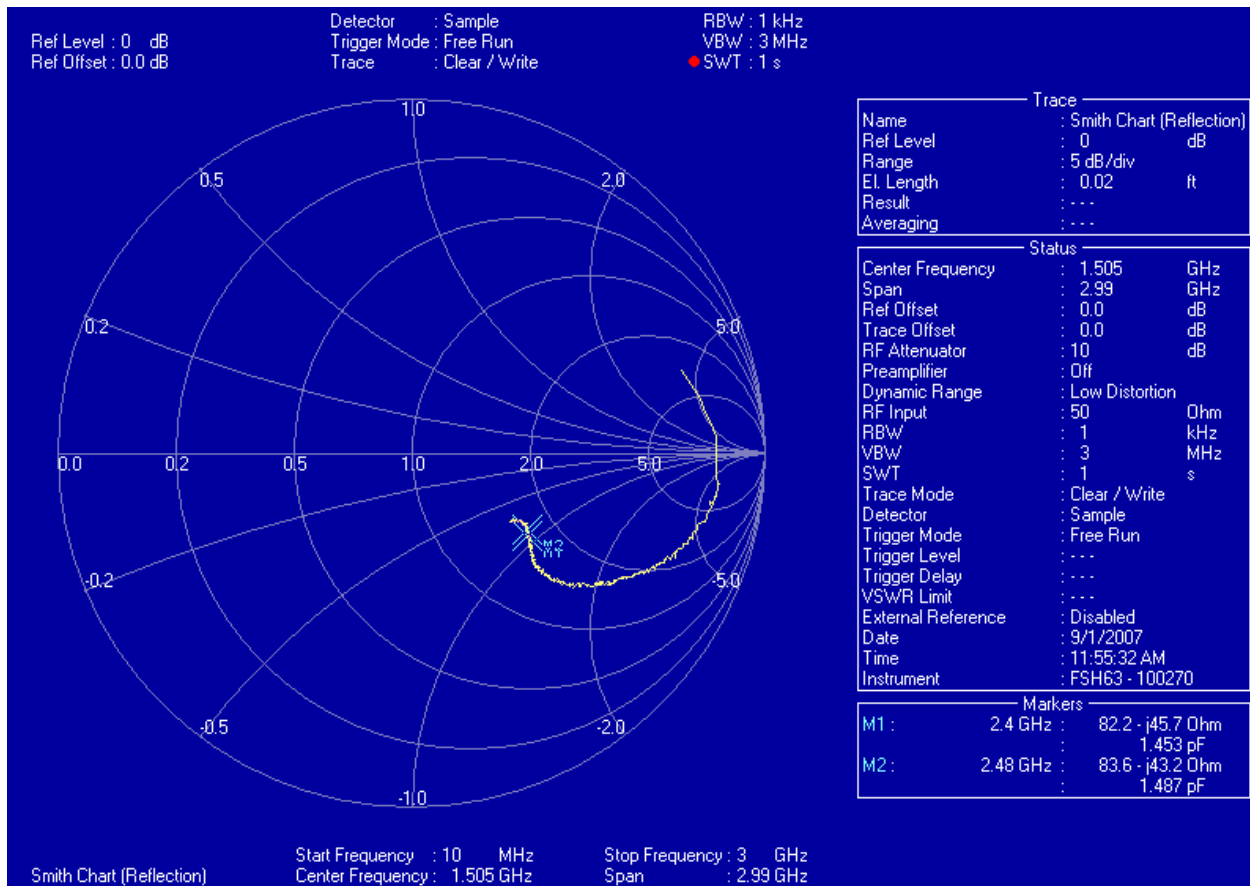
### Chip Bead Sample #3



**Magnitude S21 Sweep 10 MHz - 3 GHz**



**S21 Shown as a 10 MHz to 3 GHz Phase Change Plot**



**Phase and Amplitude shown as a S11 Smith Chart 10 MHz - 3 GHz**

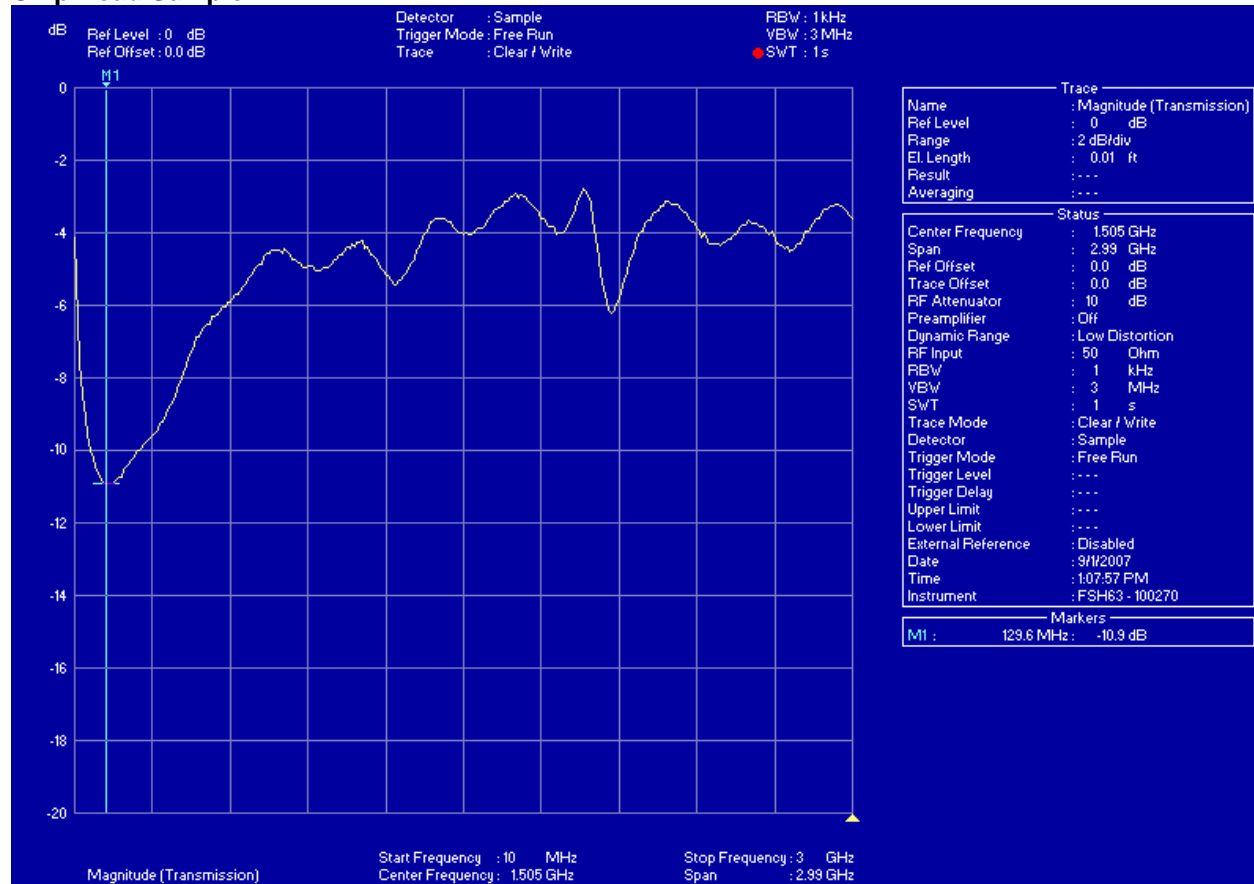
The component shows good attenuation in a 50-Ohm system from 10 to 600 MHz. Maximum attenuation was 16.8 MHz at 100 MHz.



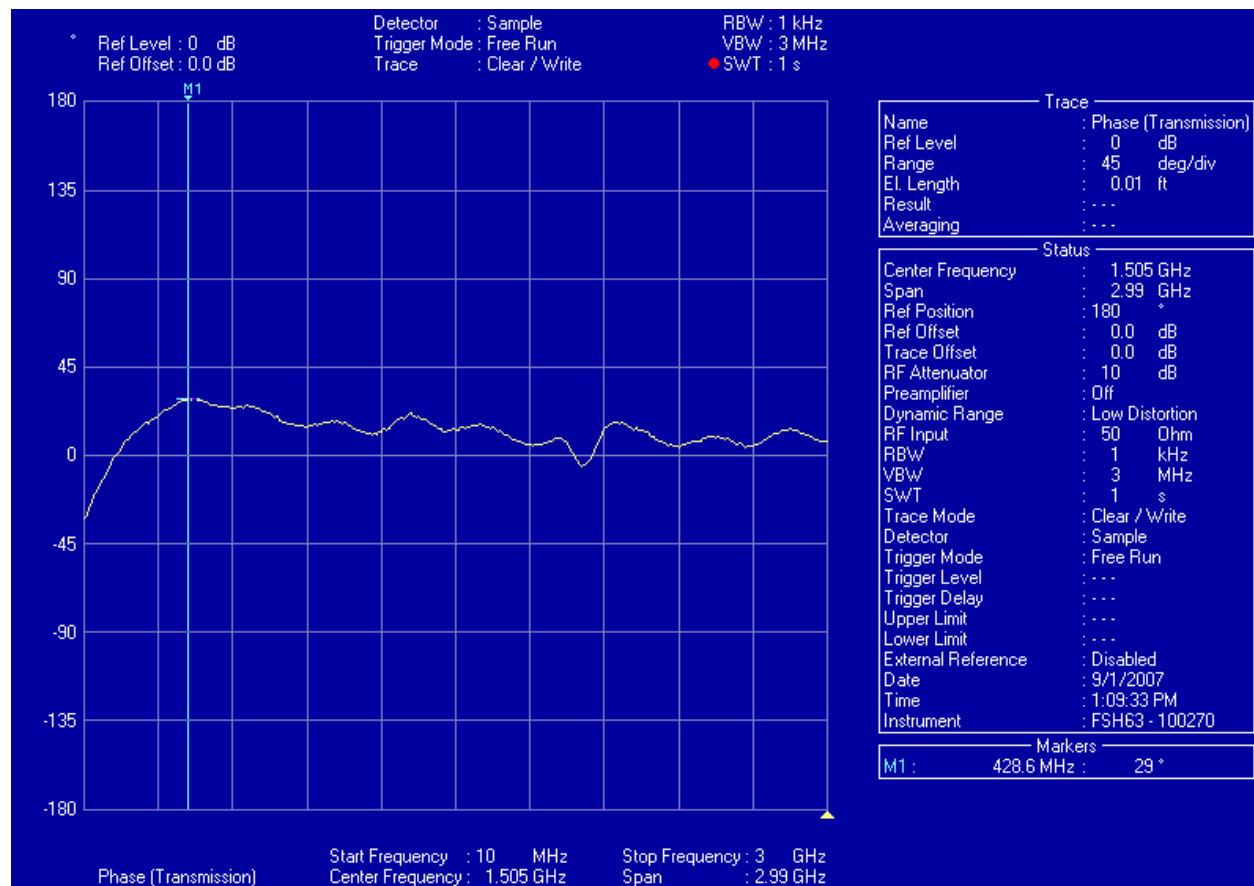
**Sample #3**

<b>MHz</b>	<b>CH1 S11</b>		<b>S21</b>		<b>S12</b>		<b>CH2 S22</b>	
	<b>Mag (Mu)</b>	<b>Angle°</b>	<b>Mag (Mu)</b>	<b>Angle°</b>	<b>Mag (Mu)</b>	<b>Angle°</b>	<b>Mag (Mu)</b>	<b>Angle°</b>
1.00	172.300	49.959	127.850	16.088	127.850	16.088	172.300	49.959
11.00	777.950	21.227	410.830	34.442	410.830	34.442	777.950	21.227
20.99	816.620	10.028	506.480	22.320	506.480	22.320	816.620	10.028
30.99	852.570	4.574	559.090	15.627	559.090	15.627	852.570	4.574
40.98	871.160	-0.297	590.570	10.232	590.570	10.232	871.160	-0.297
50.98	870.320	-4.577	605.490	5.604	605.490	5.604	870.320	-4.577
60.97	858.030	-7.912	609.780	1.956	609.780	1.956	858.030	-7.912
70.97	841.450	-10.464	607.870	-1.023	607.870	-1.023	841.450	-10.464
80.96	830.980	-12.104	607.220	-3.024	607.220	-3.024	830.980	-12.104
90.96	827.600	-13.384	608.820	-4.675	608.820	-4.675	827.600	-13.384
100.95	833.490	-14.663	615.280	-6.097	615.280	-6.097	833.490	-14.663
110.95	844.070	-16.263	623.640	-7.688	623.640	-7.688	844.070	-16.263
120.94	856.880	-18.184	634.180	-9.393	634.180	-9.393	856.880	-18.184
130.94	862.900	-20.572	640.830	-11.488	640.830	-11.488	862.900	-20.572
140.93	863.820	-23.108	645.400	-13.754	645.400	-13.754	863.820	-23.108
150.93	860.200	-25.447	646.980	-15.811	646.980	-15.811	860.200	-25.447
160.92	853.680	-27.493	646.450	-17.750	646.450	-17.750	853.680	-27.493
170.92	848.940	-29.078	646.400	-19.321	646.400	-19.321	848.940	-29.078
180.91	849.730	-30.490	648.560	-20.716	648.560	-20.716	849.730	-30.490
190.91	858.110	-31.821	655.200	-21.970	655.200	-21.970	858.110	-31.821
200.90	871.720	-33.600	665.460	-23.492	665.460	-23.492	871.720	-33.600
210.90	886.610	-35.857	676.450	-25.319	676.450	-25.319	886.610	-35.857
220.89	897.250	-38.643	686.460	-27.589	686.460	-27.589	897.250	-38.643
230.89	899.990	-41.715	692.490	-30.100	692.490	-30.100	899.990	-41.715
240.88	894.380	-44.587	694.180	-32.559	694.180	-32.559	894.380	-44.587
250.88	885.060	-47.063	692.300	-34.765	692.300	-34.765	885.060	-47.063
260.87	875.030	-49.062	689.400	-36.649	689.400	-36.649	875.030	-49.062
270.87	869.770	-50.799	688.440	-38.249	688.440	-38.249	869.770	-50.799
280.86	870.920	-52.483	692.480	-39.790	692.480	-39.790	870.920	-52.483
290.86	875.930	-54.489	698.790	-41.450	698.790	-41.450	875.930	-54.489
300.85	881.140	-57.005	705.590	-43.669	705.590	-43.669	881.140	-57.005
310.85	880.040	-59.859	710.250	-46.090	710.250	-46.090	880.040	-59.859
320.84	871.490	-62.805	709.780	-48.748	709.780	-48.748	871.490	-62.805
330.84	855.410	-65.510	705.080	-51.284	705.080	-51.284	855.410	-65.510
340.83	834.760	-67.681	693.990	-53.554	693.990	-53.554	834.760	-67.681
350.83	815.530	-69.337	683.390	-55.254	683.390	-55.254	815.530	-69.337
360.82	803.030	-70.565	675.880	-56.643	675.880	-56.643	803.030	-70.565
370.82	794.920	-71.712	671.300	-57.850	671.300	-57.850	794.920	-71.712
380.81	791.820	-72.964	670.770	-59.069	670.770	-59.069	791.820	-72.964
390.81	792.460	-74.641	672.050	-60.518	672.050	-60.518	792.460	-74.641
400.80	790.770	-76.554	674.200	-62.346	674.200	-62.346	790.770	-76.554
410.80	785.020	-78.533	673.430	-64.196	673.430	-64.196	785.020	-78.533
420.79	775.520	-80.424	669.220	-66.058	669.220	-66.058	775.520	-80.424
430.79	765.520	-81.961	663.050	-67.690	663.050	-67.690	765.520	-81.961
440.78	755.830	-83.183	657.950	-69.048	657.950	-69.048	755.830	-83.183
450.78	751.560	-84.128	654.600	-70.064	654.600	-70.064	751.560	-84.128
460.77	751.500	-85.178	654.740	-71.104	654.740	-71.104	751.500	-85.178
470.77	756.750	-86.310	659.390	-72.092	659.390	<b>etc.</b>		

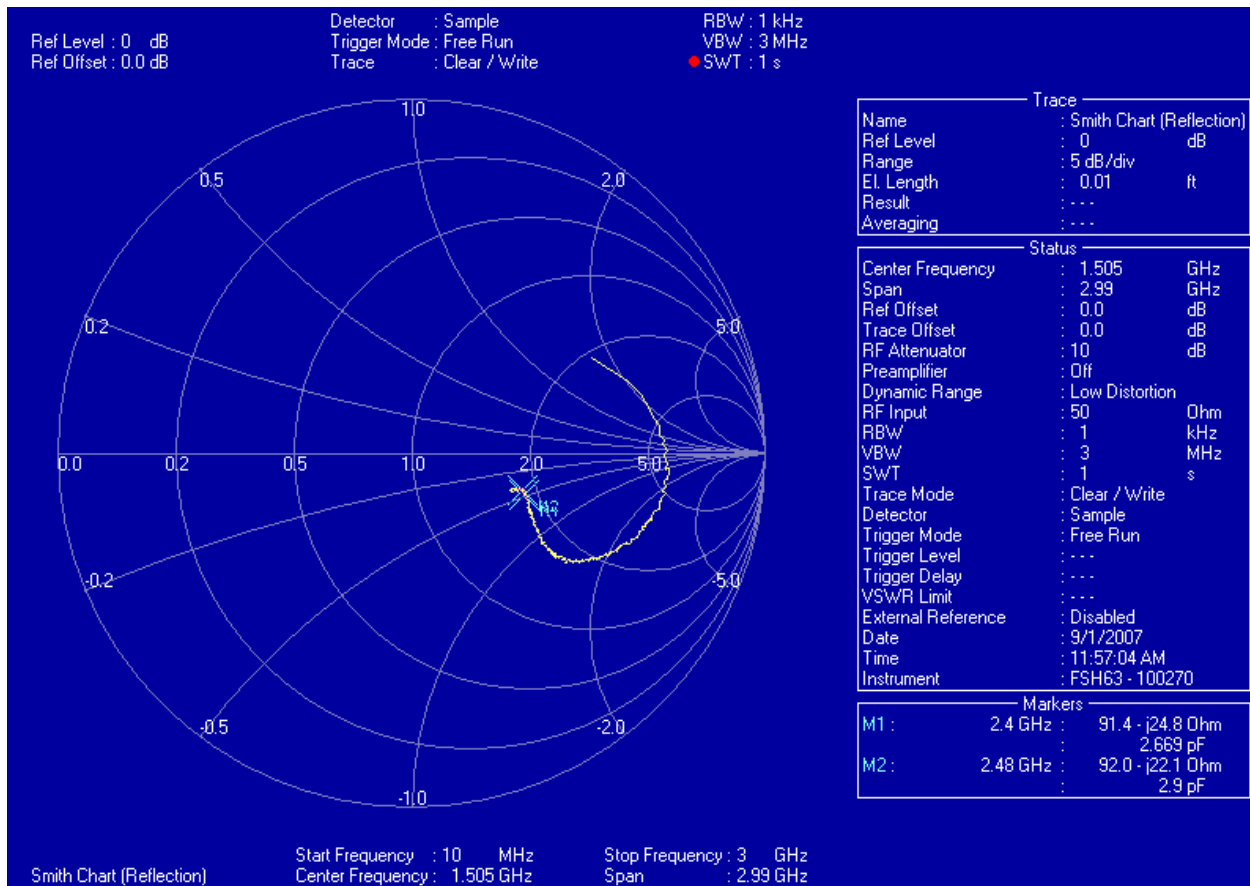
# Chip Bead Sample #4



**Magnitude S21 Sweep 10 MHz - 3 GHz**



**S21 Shown as a 10 MHz to 3 GHz Phase Change Plot**



**Phase and Amplitude shown as a S11 Smith Chart 10 MHz - 3 GHz**

The component shows good attenuation in a 50-Ohm system from 60 - 300 MHz with a maximum attenuation of 10.9 dB at 130 MHz.

Sample #4	CH1 S11		S21		S12		etcCH2 S22	
MHz	Mag (Mu)	Angle°	Mag (Mu)	Angle°	Mag (Mu)	Angle°	Mag (Mu)	Angle°
1.00	766.670	-1.474	995.560	-3.864	995.560	-3.864	766.670	-1.474
11.00	744.200	-3.874	692.620	-30.701	692.620	-30.701	744.200	-3.874
20.99	713.840	-5.923	493.320	-31.778	493.320	-31.778	713.840	-5.923
30.99	708.000	-6.692	412.270	-28.393	412.270	-28.393	708.000	-6.692
40.98	707.640	-7.868	368.230	-25.417	368.230	-25.417	707.640	-7.868
50.98	706.440	-9.522	337.290	-22.739	337.290	-22.739	706.440	-9.522
60.97	702.300	-11.154	313.590	-19.723	313.590	-19.723	702.300	-11.154
70.97	696.290	-12.695	296.050	-16.387	296.050	-16.387	696.290	-12.695
80.96	694.530	-13.773	284.250	-12.827	284.250	-12.827	694.530	-13.773
90.96	695.900	-14.782	276.890	-9.343	276.890	-9.343	695.900	-14.782
100.95	703.900	-15.907	273.220	-6.174	273.220	-6.174	703.900	-15.907
110.95	714.730	-17.341	271.930	-3.307	271.930	-3.307	714.730	-17.341
120.94	726.770	-19.098	272.630	-1.052	272.630	-1.052	726.770	-19.098
130.94	733.450	-21.377	272.850	0.718	272.850	0.718	733.450	-21.377
140.93	735.840	-23.725	272.210	2.466	272.210	2.466	735.840	-23.725
150.93	735.690	-25.994	270.840	4.157	270.840	4.157	735.690	-25.994
160.92	731.900	-28.007	268.590	6.229	268.590	6.229	731.900	-28.007
170.92	730.840	-29.641	267.610	8.578	267.610	8.578	730.840	-29.641
180.91	733.200	-31.145	268.630	11.224	268.630	11.224	733.200	-31.145
190.91	740.110	-32.666	272.520	13.883	272.520	13.883	740.110	-32.666
200.90	751.080	-34.562	280.300	16.247	280.300	16.247	751.080	-34.562
210.90	762.670	-36.781	288.960	18.034	288.960	18.034	762.670	-36.781
220.89	771.010	-39.538	298.370	19.130	298.370	19.130	771.010	-39.538
230.89	772.930	-42.477	306.460	19.859	306.460	19.859	772.930	-42.477
240.88	769.420	-45.249	313.040	20.446	313.040	20.446	769.420	-45.249
250.88	761.850	-47.699	318.250	21.239	318.250	21.239	761.850	-47.699
260.87	755.390	-49.742	324.010	22.081	324.010	22.081	755.390	-49.742
270.87	750.530	-51.571	331.700	23.074	331.700	23.074	750.530	-51.571
280.86	751.170	-53.343	341.060	23.810	341.060	23.810	751.170	-53.343
290.86	755.940	-55.378	352.060	24.105	352.060	24.105	755.940	-55.378
300.85	759.070	-57.844	362.850	23.866	362.850	23.866	759.070	-57.844
310.85	758.350	-60.639	371.630	23.198	371.630	23.198	758.350	-60.639
320.84	751.150	-63.523	376.160	22.364	376.160	22.364	751.150	-63.523
330.84	738.450	-66.131	377.980	21.611	377.980	21.611	738.450	-66.131
340.83	722.200	-68.364	377.190	21.205	377.190	21.205	722.200	-68.364
350.83	707.790	-70.056	374.990	21.357	374.990	21.357	707.790	-70.056
360.82	697.140	-71.461	374.110	21.701	374.110	21.701	697.140	-71.461
370.82	691.410	-72.688	374.290	22.466	374.290	22.466	691.410	-72.688
380.81	688.420	-74.126	376.320	23.154	376.320	23.154	688.420	-74.126
390.81	687.830	-75.756	379.930	23.820	379.930	23.820	687.830	-75.756
400.80	685.980	-77.749	384.140	24.259	384.140	24.259	685.980	-77.749
410.80	681.310	-79.769	387.080	24.638	387.080	24.638	681.310	-79.769
420.79	673.750	-81.703	389.540	25.161	389.540	25.161	673.750	-81.703
430.79	665.080	-83.297	392.370	25.815	392.370	25.815	665.080	-83.297
440.78	658.110	-84.619	395.610	26.868	395.610	26.868	658.110	-84.619
450.78	653.850	-85.739	402.520	27.918	402.520	27.918	653.850	-85.739
460.77	653.710	-86.843	411.750	28.819	411.750	28.819	653.710	-86.843
470.77	657.740	-88.176	424.280	29.295	424.280	<b>etc.</b>		