MWTC SEMICONDUCTOR MARKETING

APPLICATION NOTE #41

HMMC-5021/22/26 S-Parameter Performance as a Function of Bonding Configuration

1. Introduction

This report summarizes the performance of the Hewlett-Packard HMMC-5021/22/26 MMIC traveling wave amplifier with various IC bonding techniques. These bonding types include mesh bonds, 0.7 mil single and double bonds, 1.0 mil single bonds, and 4 mil ribbon bonds.

The various bonding topologies impose various characteristics on the performance of the device. As an example, decreasing the diameter of a single wire bond increases its inductance, whereas increasing the number of single bonds decreases the inductance. Therefore, it is desirable to determine this effect on the performance of the device. The findings of this evaluation are based on the small-signal test results (gain, isolation and return loss).

The HMMC-5021/22/26 is specified for operation from 2 GHz to 26.5 GHz. For this evaluation, arbitrary frequency points of interest are chosen at 2, 10, 20 and 26.5 GHz. It is these frequencies where the majority of the comparisons are made.

2. Gain and Isolation

In terms of small-signal gain, all bonding types deliver about the same performance. At the lower frequency (2 GHz) there is only a 0.1 dB difference between the highest gain measurement (1 mil single bond) and the lowest gain measurement (0.7 mil double bond). The highest frequency (26.5 GHz) shows the largest difference (0.31 dB) between the 4 mil ribbon and the 1 mil single bond. The mesh and 4 mil ribbon bonds have the highest minimum gain (10.2 dB) across the entire band (2-26.5 GHz). The 0.7 mil and 1 mil single bonds have the lowest minimum gain (10.05 dB) across the bond. This gives a difference of 0.15 dB worst case across the band. See Tables 1 and 2, respectively, for listings of gain and isolation at various frequencies.

The isolation results show that all bonding techniques are very competitive again. The greatest difference (0.52 dB) is shown at 26.5 GHz where the mesh bond has 32.4 dB of isolation, and the 0.7 mil single bond has 31.91 dB of isolation. The smallest difference (0.24 dB) appears at 2 GHz. At this frequency, the 0.7 mil double bond has 46.7 dB of isolation, and the 4 mil ribbon has 46.4 dB of isolation.

3. Input and Output Return Loss

The return loss measurements demonstrate the greatest performance degradation. In terms of the input return loss, the greatest difference (11.4 dB) is observed at 20 GHz where the 0.7 mil double bond has 27.33 dB of input return loss, and the 1 mil single bond has 15.97 dB of input return loss. Examining the worst cast condition over the entire band, the 1 mil single bond shows 8 dB, the 0.7 mil double bond and 4 mil ribbon bond have 12 dB, and the 0.7 mil single bond has 8.5 dB of input return loss. Therefore, the largest difference is 4 dB. See Tables 2 and 3, respectively, for listings of input and output return loss.

In terms of the output return loss, the greatest difference is observed at 20 GHz (10.41 dB). The 0.7 mil double bond has 27.95 dB of output return loss, and the 1 mil single bond has 17.54 dB of input return loss. The mesh, 0.7 mil double, and the 4 mil ribbon bonds have a worst case return loss of 10.2 dB while the 1 mil single bond has 10.0 dB of return loss. This represents highest and lowest minimum return loss across the entire band. Therefore, there is not a significant difference (0.2 dB) for the worst case analysis.

4. Conclusion

In summary, the results for the gain and isolation show only a minimal performance degradation of the HMMC-5021/22/26 for the various bonding types. Mesh and 4 mil ribbon bonding connections to the IC deliver the best overall performance. The greatest differences appear in the return loss measurements. Therefore, depending upon the VSWR requirement, the appropriate bonding can be chosen for the HMMC-5021/22/26.

TABLE 1

Bond Type	**Gain $|S_{21}|$ (dB)**				
	@ 2 GHz	**@ 10 GHz**	**@ 20 GHz**	**@ 26.5 GHz**	**Worst Case (2-26.5 GHz)**
Mesh	11.96	10.99	10.39	10.66	10.2
0.7 Mil (Single Bond)	11.98	10.96	10.28	10.44	10.1
0.7 Mil (Double Bond)	11.89	10.91	10.3	10.58	10.05
1 Mil (Single Bond)	11.99	11.00	10.26	10.36	10.05
4 Mil (Ribbon)	11.95	10.96	10.42	10.67	10.2

TABLE 2

Bond Type	**Isolation $|S_{12}|$ (dB)**				
	@ 2 GHz	**@ 10 GHz**	**@ 20 GHz**	**@ 26.5 GHz**	**Worst Case (2-26.5 GHz)**
Mesh	46.71	40.15	32.37	32.43	31
0.7 Mil (Single Bond)	46.72	40.37	32.52	31.91	32
0.7 mil (Double Bond)	46.73	40.12	32.37	32.28	32
1 Mil (Single Bond)	46.53	39.96	32.37	32.03	32
4 Mil (Ribbon)	46.49	39.86	32.08	32.32	31

TABLE 3

Bond Type	Input Return Loss $\lvert S_{11} \rvert$ (dB)				
	@ 2 GHz	**@ 10 GHz**	**@ 20 GHz**	**@ 26.5 GHz**	**Worst Case (2-26.5 GHz)**
Mesh	16.99	29.48	24.94	12.54	11.0
0.7 Mil (Single Bond)	17.57	25.42	16.63	10.4j9	8.5
0.7 mil (Double Bond)	16.94	29.30	27.33	13.08	12.0
1 Mil (Single Bond)	17.59	24.74	15.97	9.88	8.0
4 Mil (Ribbon)	16.90	28.76	27.37	12.71	12.0

TABLE 4

Bond Type	Output Return Loss $\lvert S_{22} \rvert$ (dB)				
	@ 2 GHz	**@ 10 GHz**	**@ 20 GHz**	**@ 26.5 GHz**	**Worst Case (2-26.5 GHz)**
Mesh	10.23	19.15	24.77	17.90	10.2
0.7 Mil (Single Bond)	10.18	18.64	20.13	16.59	10.1
0.7 mil (Double Bond)	10.21	19.17	27.95	18.69	10.2
1 Mil (Single Bond)	10.16	19.22	17.54	15.49	10.0
4 Mil (Ribbon)	10.20	18.90	27.21	19.46	10.2

Appendix:

The bonding on the input and output of the IC is the focus of this evaluation. Bias bonding is not considered. For consistency, all bonds are of the same length and arc. The drain bias was set to 7V and 150 mA for this evaluation.

All measurements for gain (S_{21}), isolation (S_{12}), input return loss (S_{11}), and output return loss (S_{22}) were performed on an HP8510B Network Analyzer. All raw data and plots are available.

In conclusion, this evaluation demonstrates the effect of various bonding types on the HMMC-5021/22/26. Despite the apparent performance advantage of the double 0.7 mil bonds, this assembly is <u>not</u> recommended due to pad adhesion limitations. Any questions concerning this report should be directed to Morgan Culver in the Semiconductor Marketing Group.