5.8 GHz Packaged Amplifier Implementation and Testing (July 2010)

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***Abstract*— The availability of small, high quality power amplifiers capable of operating in the relatively uncrowded 5.8 GHz band is critical to the continued expansion of the wireless communications market. One such power amplifier, the P1039-QJ 5.6-7.1 GHz linear 4W power amplifier by Mimix Broadband, was evaluated. An evaluation board for the amplifier was fabricated and gain measurements taken. The amplifier was shown to be capable of producing at least 13 dB of gain. Thermal dissipation limited higher gain testing and presents a significant challenge in the design of RF devices utilizing this amplifier.**

***Index Terms*— Power Amplifier, wireless communication,, Mimix Broadband**

I. Introduction

WITH the explosion of the wireless communications market, the need for small high power amplifiers is critical. The power amplifier is a critical component in any radio frequency (RF) system, and the gain and linearity of such an amplifier contribute significantly to the capability of the system as a whole. Furthermore, the rapid increase in the number of devices operating in the 2.4 GHz unlicensed band, has resulted in increased interference and decreased spectrum bandwidth availability. This rapid increase has made devices capable of operating in other, less utilized unlicensed bands, such as the 5.8 GHz band. This is critical if the wireless communications market is to continue to expand.

This paper explores the challenges and advantages of using a high power, fully packaged amplifier capable of operating at 5.8 GHz. The amplifier used in this design was the P1039-QJ 5.6-7.1 GHz linear 4W power amplifier by Mimix Broadband. The amplifier is packaged in a 6x6mm QFN package, which allows the device to be integrated into small, handheld devices. The amplifier is specified to provide 16.5 dB of gain with up to 4W of saturated RF power. The amplifier includes on-chip ESD protection structures, DC by-pass capacitors, and integrated power detection circuitry. The amplifier chip tested was an initial production run and was not certified to meet all listed specifications. A printed circuit board (PCB) was fabricated to allow the evaluation of the amplifier performance.

II. Amplifier Evaluation PCB Board Layout

A. Recommended Layout

Mimix Broadband provides a recommended layout for the P1039-QJ amplifier. The recommended layout consists of a two layer PCB board with connections for RF and DC connections on the top layer and a solid ground plane on the bottom layer. Additionally there are footprints for surface mount decoupling capacitors and vias to both ground traces and provide a thermal path for heat dissipating out of the bottom of the amplifier. The recommended layout is shown below in Figure 1. Details can be found in the P1039-QJ data sheet referenced below.

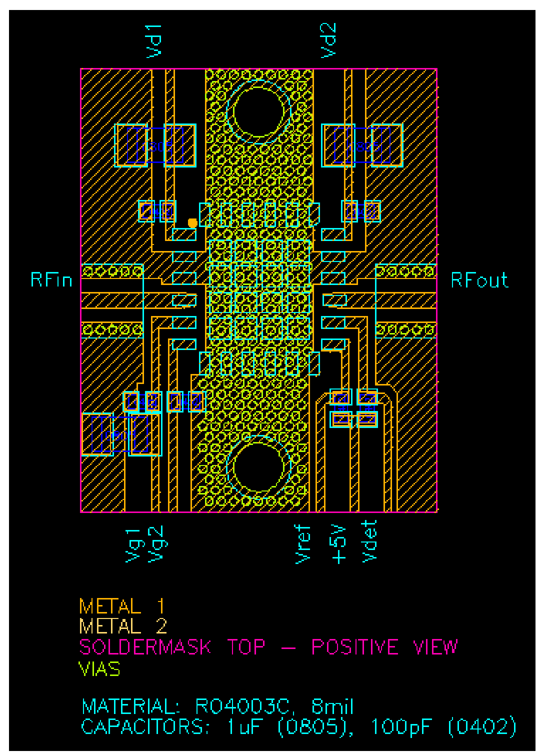

Fig. 1. Recommended Layout for P1039-QJ Amplifier

The recommended layout was chosen for the evaluation of the amplifier. The Mimix Broadband provided DXF layout file was converted to Eagle Layout format for in house fabrication at the Georgia Institute of Technology School of Electrical and Computer Engineering. In house fabrication capabilities prevented the use of the large number of very small vias, as suggested in the Mimix Broadband recommended layout. Instead, a smaller number of larger vias were used. These vias were filled with copper wire which extended below the board to aid heat dissipation. The final Eagle Layout file is shown below in Figure 2.

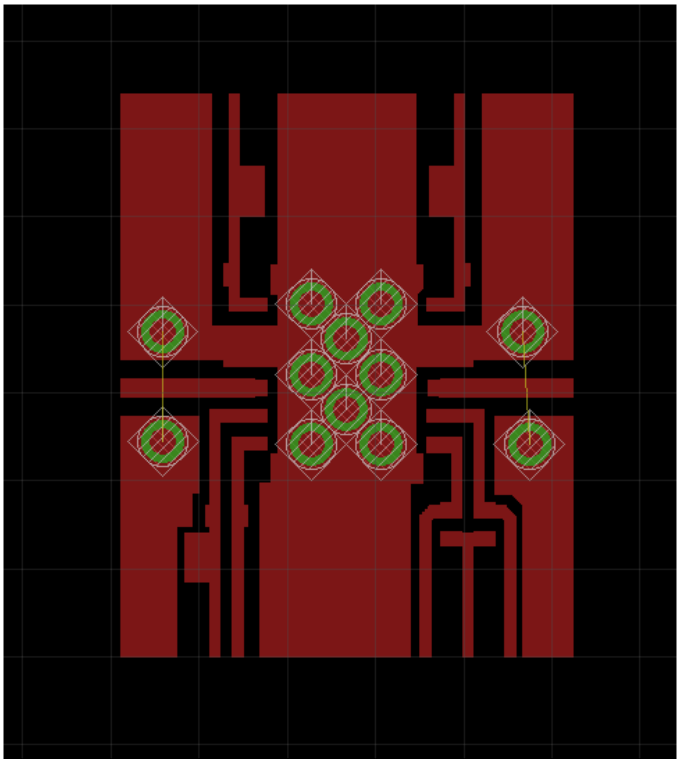

Fig. 2. Layout for P1039-QJ Amplifier (100 mil grid spacing)

III. Testing

Upon completion of the PCB fabrication, the amplifier and decoupling capacitors were placed by hand on the PCB along with solder paste. The populated board was then placed in a reflow oven, after which SMA connectors and DC supply wires were added. The completed amplifier evaluation circuit is shown below in Figure 3.

Fig. 3. Completed P1039-QJ Evaluation Circuit

The completed evaluation circuit was connected to a network analyser to provide an input signal consisting of a constant 5.8 GHz carrier signal at a power level of 0 dBm. The output of the amplifier was connected through a 30 dB attenuator to a spectrum analyzer to measure the amplifier's output power. The attenuator ensures that power output of the amplifier does not damage the network analyzer. The amplifier drains (Vd1 and Vd2) were connected to a power supply capable of providing variable voltage as well as constantly monitored current. The amplifier gates were connected to a second, identical power supply.

The gate voltage was initially set to -.7 V_{DC}, after which the drain voltage was slowly increased from 0 V_{DC}. The drain current was monitored as well as the temperature at the top of the amplifier package. The drain voltage was increased to achieve maximum gain with acceptable drain current and package temperature. The gate voltage was then decreased in steps of .1 V_{DC} and the process was repeated. The achieved gains and currents are shown below in Table 1. A maximum gain of 13 dB was achieved with a gate voltage of -1.1 V_{DC}. However, due to thermal concerns the drain current was immediately decreased after measuring the max gain.

TABLE I. Biasing of Power Amplifier and Resulting Gain.

P_{out}	V_{gs}	V_{ds}
10 dBm	-1.1 V_{DC}	1.892 V_{DC}
13 dBm	-1.1 V_{DC}	5 V_{DC}

Throughout the amplifier evaluation, heat dissipation was shown to be critical. The copper wires extending from the bottom of the amplifier package, through the PCB, and away from board were found to be successfully dissipating heat. Additionally an aluminum heat sync was mated to the top of the amplifier package with a small layer of thermal paste in between. This heat helped to sync additional heat from the amplifier. While the amplifier was run at maximum gain for a brief period of time with no damage, the long term reliability of the amplifier would be directly tied to ability to effectively dissipate the generated heat. This could provide a significant constraint to the form factor of any small devices in which the P1039-QJ amplifier might be used.

IV. Conclusion

The Mimix Broadband P1039-QJ 4W power amplifier provides and impressive amount of power in the 5.6-7.1 GHz band. This band, specifically the 5.8 GHz unlicensed band, has huge potential for future wireless communications devices needing access to large, low interference bandwidth. The small 6x6mm footprint of the power amplifier provides the potential for use in small handheld devices in applications such as point-to-point radio and satellite communications. However the small size and high power output of the P1039-QJ make heat dissipation a critical, and possibly limiting, factor in the design of RF devices utilizing the amplifier.

References

[1] http://www.mimixbroadband.com/Data/Document-Library/XP1039-QJ.pdf
[2] http://www.mimixbroadband.com/Data/Document-Library/XP1039-QJRecommendedLayout.dxf