An Improved 2 x MRF286 Power Amplifier for 1296 MHz

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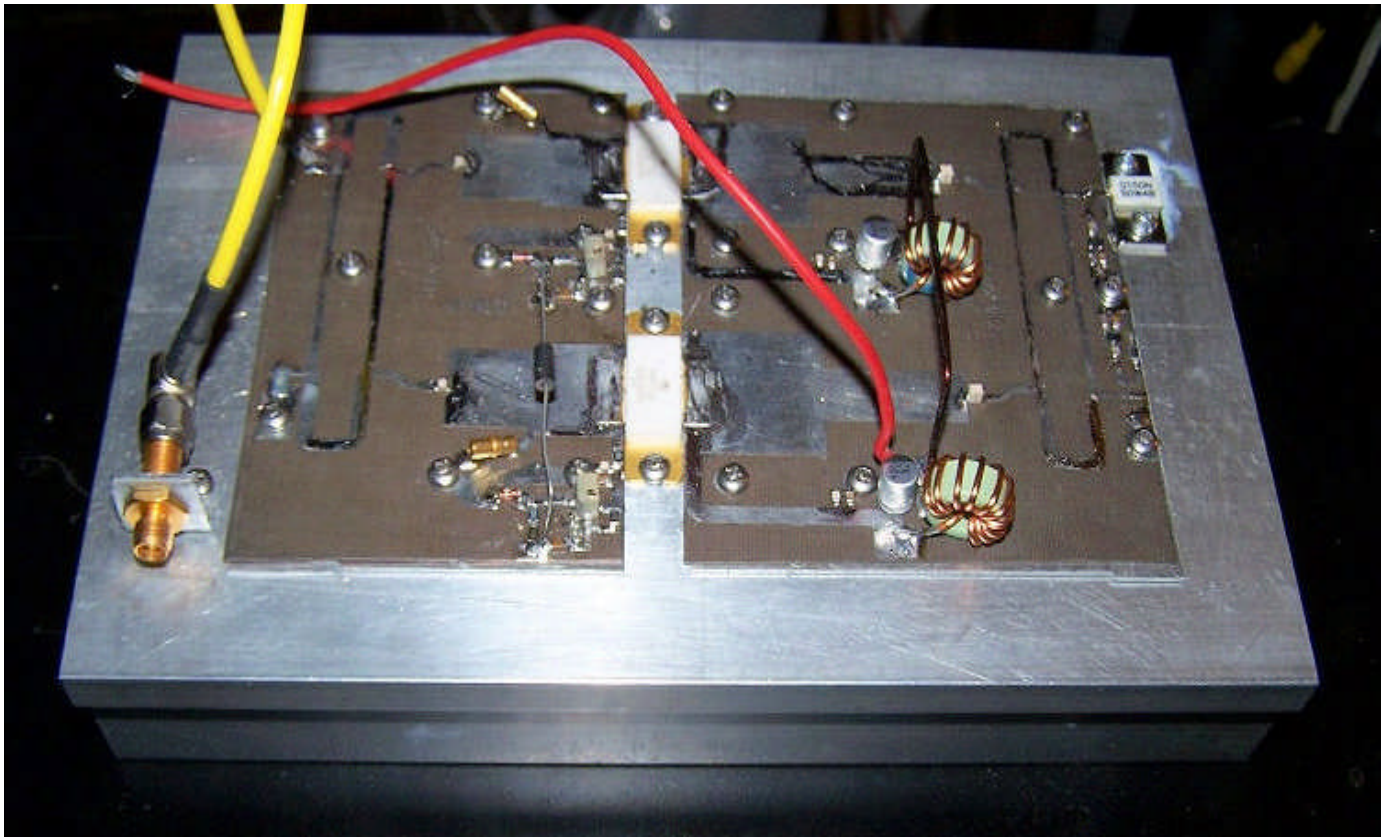

An Improved 2 x MRF286 Power Amplifier for 1296 MHz

- Much use of XRF286 transistors on 23 cm
- One and 2 Transistor Designs Producing ~12 dB gain @ 150 Watts Output
- Old Designs Empirically Produced and Computer Modelling Suggest Significantly Better Performance is Possible
- This Presentation Summarizes the Results of Darrell VE1ALQ and Dominique HB9BBD

Need for Improvements in Design

- Work was Stimulated by Problems encountered with Some Versions (7.2) of W6PQL Amplifier boards
- The problems appear in several areas:
  - Input match to each device
  - Lack of balance in the hybrid couplers
- HB9BBD made extensive modifications to W6PQL boards and achieved dramatic improvements

Input Match Improvements

- The input section on the version 7.2 W6PQL boards is too short to complete the matching.
- Some improvement was achieved by replacement of the single turn trimmer with a 4.5 pF high Q multi-turn piston trimmer.
  - The adjustment is very sharp.

Hybrid Couplers

- There is a problem with the design of the hybrid couplers in that all of the input and output ports should share a half each of the 35 and 50 Ohm legs of the hybrid.
  - When they do the hybrid balance of the output ports is upset.
- The design of these hybrids is not obviously different between different versions of the board, yet on an earlier version V7.11 used by VE4MA the hybrid balance was apparently not a problem and did meet W6PQL's specifications.

Choice of Substrates

- Fundamental choices to be made in the design is the choice of substrates.
- 1296 MHz is at a frequency where some of the lower frequency substrate choices are possible as well as the high frequency ones.
- Of course the amount of surface area is relatively large for almost any 1296 design which will have an impact on the production cost if the high frequency substrate is chosen. The substrate material chosen is Rogers 4003C (same as W6PQL) however others considered were Rogers RT-5889LZ and Taconic TLX-8-200.

Choice of Substrates cont'd

- The lower dielectric constant materials result in wider traces and subsequently larger circuit boards.
  - With the high current density on these circuit boards, there is some RF efficiency gained by using larger traces, but at the cost of the larger board and cost of the material.
- Modeling showed that there is also a significant disadvantage in the use of thicker 0.062 inch board material vs. the more common 0.020 or 0.032 inch material.
  - The thicker substrate material, i.e. 32mil results in wider copper traces and radiation loss from the board is not so much of an issue.

Choice of Substrates Cont'd

- The final consideration is the thickness of the copper plating on the boards.
- The skin depth for copper at 1296 MHz is about 0.0006 inches (or 0.6mil) and the copper thickness for 1oz copper is 1.377952755905mil and for 2oz copper is 2.75590551mil
- Therefore there is no advantage to the use of 2oz copper board material
- The Hybrids and matching lines are of sufficient width to handle the power capabilities of the active devices being used in this design.

Sources of Transistors

- The MRF286 / XRF286 transistors are no longer in production but can be obtained from:
  - Salvaging from surplus “PyroJoe” amplifier boards available on Ebay
  - Bought “New” from Chinese suppliers
- Note that Chinese devices are cosmetically excellent but the RF (and other) characteristics may not match the original device performance
  - “Buyer Beware”

Choice of Mounting

- There are 2 Mounting Styles
  - 2 Bolt Flange “MRF286F” mount
  - Flangeless “Solder down”MRF286S mount
- With 4-40 mounting bolts there is a thermal compound layer to conduct the device heat to heat sink
- Found the device was hotter around each bolt than the copper spreader was.
- Whereas the S version is soldered to the heat spreader allowing heat to be more evenly dispersed.

Design Results

- The designs were completed for several board materials but this report will concentrate on the .020 and .032 inch RO4003c substrates.
- The results with the 0.032 inch substrate were very interesting in that the **best power output** is **320W** with **13.5 dB gain** and a **DC power efficiency of 58%**.

Design Results Cont'd

- The results for the 0.020 inch substrate are similar except that the maximum output power at 1 dB gain compression is reduced to about 280 W.
- Nothing could be done to the design to improve the output power.
- Another big reason for using RO4003C 32mil material over the thinner 20mil substrate was that at 300+ Watts output the output Hybrid was heating and starting to shine like a Mirror and very certainly would have lifted from substrate over a period of time.

Design Results Cont'd

- The 2 stage amplifier design has been tested using the 0.020 inch Taconic's TLX substrate at a saturated power of 330 W.
- The Design work has been checked and confirmed by Mr. Dane Collins, the CEO of AWR/ Microwave Office and his design staff who provided excellent support and corrective pointers as the project developed.

High Power Output Coupler Design

- Based on Observation of the Dielectric heating on the 2 transistor boards it became apparent that 4 of these 330W modules could not be combined using a hybrid coupler made of even the 0.032 inch RO4003 substrate material.
- I did follow through with a design using 0.062 inch Taconite substrate (see Figures 6 & 7 below) which includes a directional coupler for forward and reflected power monitoring purposes.
- A sub-set of this 4 Stage combiner was extracted in order to combine 2 amplifier modules.

Improved MRF286 Power Amp for 1296 MHz Summary

- Significant Improvements made over W6PQL designs
- Best power output is 320W with 13.5 dB gain and a DC power efficiency of 58%.
- No Boards will be produced, however those interested can contact Darrell VE1ALQ for Drawing and Gerber files needed to get boards produced.