More 24 GHz Modules

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Using the same strategy as in the first article (DUBUS 3/98) I present here two more 24GHz modules. The availability of beam lead diodes with good performance at 24GHz and it's difficult manipulation, along with the variable characteristics of the conventional encapsulated diodes, lead to the design of other forms of converters. In the present article I present a single diode mixer and an PHEMT mixer. Both modules can use the common design for the mechanics as described earlier.

Introduction

Balanced mixers using 2 diodes /1,2/ will certainly require a little bit more power than single device mixer. Also good balancing is desirable for good operation and therefore diodes are required to be as matched as possible. The performance of the rat-race mixers at 24GHz, using SMD packaged devices as the BAT15 may be not as good as we would like. Conversion losses of 8 to 10 dB can be obtained, but without much tuning effort figures like 15dB are most probable.
These difficulties encouraged me to try a single diode mixer design and a PHEMT mixer design, to take advantage of recent devices. Both modules share the same configuration the mixing element changes from one design to the other.
The PHEMT mixer resulted in a RX only mixer but with largely improved specifications comparing to any other types of mixers I've tried so far.

Single diode mixer.

The local oscillator doubler section remains unchanged from the previous design /2/, and it is expected to deliver as much as 10dBm at 24GHz to the input of the mixer. The mixer combines the RF and LO signals in a ring coupler that provides also the RF/LO isolation.
The ring coupler design can be found in some detail in the literature /3,4/ and will not be described here.
Several diodes from SIEMENS and NEC were tested and the results were in general 2 dB better than the balanced design. One of the best encapsulated devices in this configuration was the BAT15 in plastic package. While the best results, 7 dB conversion loss, were obtained from a single BAT30 in beam lead package.

Tuning the mixer for best performance is not too difficult, however the ring coupler has a sharp tuning point that is obtained by placing a small stub in the lower right corner of the ring. This adjust must be done before any other optimizations otherwise the diode would not receive enough LO power.

PHEMT RX Mixer.

The design using an PHEMT device is in all respects identical to the one using a single diode but uses a PHEMT transistor as the mixing element. Additionally this circuit has to include the transistor bias elements.
Several transistors were tested, and most of them preformed excellent. However the lowest noise figure devices were not the best for this application, as my test showed. The best device tested was the NE42484 in which I could obtain the impressive figures of 3dB conversion gain and 4dB noise figure (as far as I could measure).

Tuning is some how similar to the single diode mixer design. There is also to adjust the gate bias that is somehow critical to set. As the device is being used as a mixer, drain voltages and currents don't match the recommended values for the linear operation so experimenting is necessary to find the right values for gate voltage and for the drain resistor.

Construction

All PCBs are made of Rogers RT5780 10mils. After etched 1.5mm holes are opened at the grounding positions. Then solder them to a 0.8mm thick cooper sheet cut to fit inside the milled box. Some filing may be necessary for them to fit correctly. After some cleaning, to remove the solder flux they are ready to be populated. The modules can be placed in and changed as many times as necessary. Assembly of all components should be made with the modules out of the aluminum box. The ground connection of the FET' s sources should be done at the exact position where the ceramic case ends (to make the connection as short as possible). Apply all general rules for GaAs FETs and SMD described in so many other articles.

Concluding remarks.

The two converters presented in this article make possible to reduce the amount of gain necessary on the RX chain, namely on the LNA. Also, the PHEMT design, can reduce significantly the impact of mixer noise figure in the overall system noise.
Single diode mixers as good as 7dB conversion loss are now easy to construct and PEMT mixer can have the impressive 3dB conversion gain and 4dB NF that even enable it to be used as the first element in the simple transverter setups, or RX only stations.
Hardcopies of the PCB's at 4:1 scale and diagrams can be found at my web page: http://escriba.cfn.ist.utl.pt/cupido
Thanks to all that helped with info and components.

/1/ - 24GHz RatRace mixer - Erich Zimermann HB9MIN - DUBUS 2/93
/2/ - 24GHz Modules – Luis Cupido CT1DMK - DUBUS 4/98
/3/ - Microstrip circuit design - - Artech House .
/4/ - Microwave engeneering using micristrip circuits - E.H.Fooks - Prentice Hall