

Packaged chipsets for Next Generation X Band Phased Array Radar

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Abstract:

The performance of packaged Core chip, design architecture along with 12W packaged PA and its performance for the next Generation X band TRM would be presented. The challenges in designing these respective Packages and challenges & advantages in integrating these packaged parts for a TRM Module will also be discussed briefly.

Introduction:

The change in X band Radar requirement become inevitable since the evolution of the semiconductor technology. The concept of AESA has changed the approach towards the TRM based solutions instead the TWTA concept which has been there for a longer time. The advancement of Antenna technology has made the element and array size smaller which in turn become even more challenging in terms of making the smaller and compact size TRM to match. So the evolution towards making the multichip module to integrate many functions became important. We at Macom committed to doing this Multichip Module by integrating Phase Shifter, Attenuator, Medium power Amplifier and LNA in to a single package. The Module itself is a TRM with +23dBm Transmit power & 26dB receive Gain. This module has an excellent NF of 1.7dB typical which eliminates the requirement of LNA's if the gain by itself is sufficient for the system. The built in SPI controller & Tx/Rx

Controller makes this multichip module easy to control.

As the power level requirement has gone higher per TRM, Macom introduces the Power Amplifiers in the Power ranges of 5W, 10W, 12W & 15W also in the packages. These amplifiers are built in a fully molded QFN packages.

Not to forget the limiting portion of TRM which is very important to protect this integrated chip which is the backbone of the TRM has been served by our high power Shunt Diodes in a very small package size.

This paper gives the details of our Multichip Module, PA, LNA & High power Shunt diodes. We also discuss about possible line ups in X band for the various power levels.

Keeping high volume in mind and ease of production in a SMT assembly Macom introduces these parts in packages also.

Generic 4W & 10W TRM Architecture with Macom Packaged PA & Multichip Module:

10W TRM MODULE USING CORE CHIP

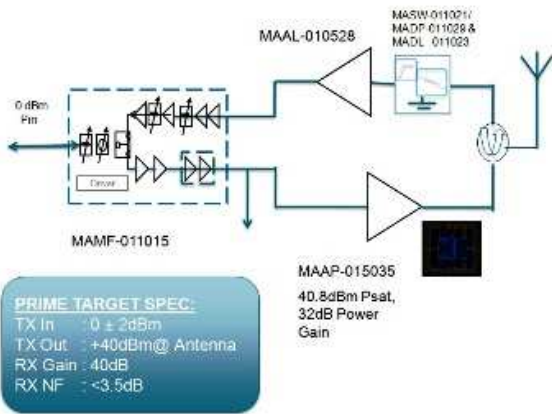


Fig 1

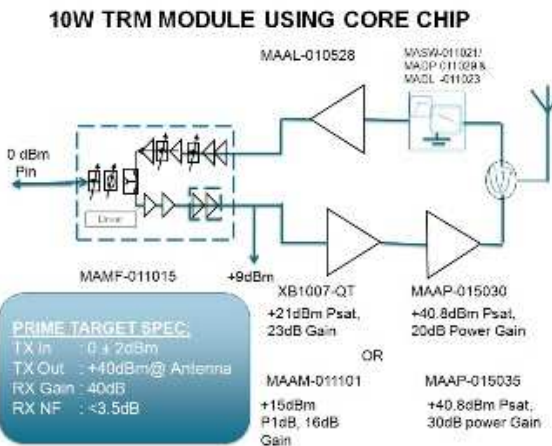


Fig2

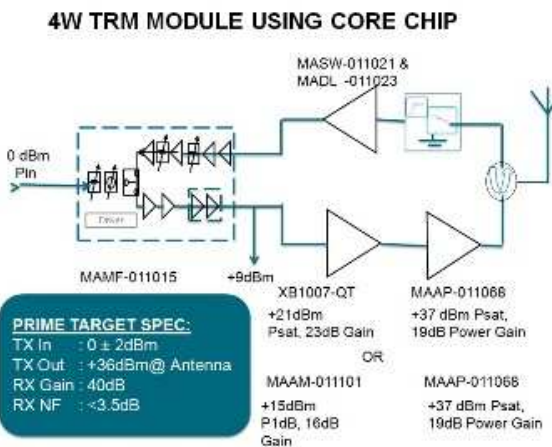


Fig 3

When you look into the above three architecture using our Multichip Module, based on the Gain & Power output of three available Power Amplifiers Macom can present TRM modules in the range of 4W & 10W.

Individual Performances

a) Multichip Module : Functional Schematic

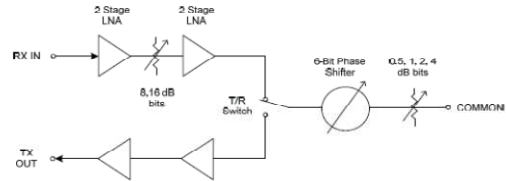


Fig 4:

As it is evident from the above Fig 4, the multichip module itself is an TRM by itself with Tx power of +23dBm & 26dB Rx gain with 1.7dB NF. This multichip module has the integrated 6 bit Phase shifter, 6 bit Attenuator, Tx/Rx Switch, medium power amplifier and LNA. This module had the built in controller chip. The attenuator is structured such a way that the common leg will have 4 bits starting with LSB of 0.5dB, 1dB, 2dB & 4dB to be utilized for minor power correction/adjustment in Tx path. The next highest bits of 8dB and MSB 16dB are exclusively for RX path, so that the RX path can utilize the complete 31.5dB attenuation range for gain tapering, while TX can have max of 7.5dB of attenuation with resolution of 0.5dB.

The IC utilizes Macom Tech's advanced 0.25um pHEMT process which has been optimized for Low Noise, Power Amplifier and Control & passive components. This makes very unique and it allows us to integrate all these function in a single chip.

This unique process allows us to design this Multichip with very less power consumption.

This Module includes the built in Serial to Parallel control chip to control the 6 Bit phase shifter & Attenuators.

This chip comes with very small 7 x 7 mm PQFN package.

The typical specification of this chip is as below

Frequency	: 8-11 GHz
Tx Gain	: 9dB
Tx Psat	: +23dBm
Rx Gain	: 26dB
NF	: 1.7dB

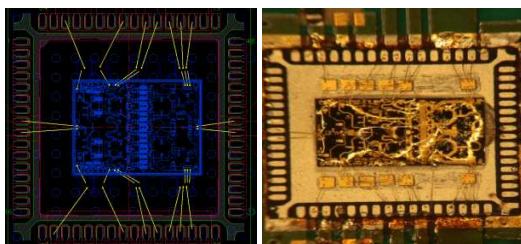
b) Power Amplifiers

Macom have four Pulsed Power Amplifiers in X band with different Gain & Power Output that can be used externally with the multichip module where high power is required. The brief specs of those Power amplifiers are as below

- (i) MAAP-011068: 5W Peak, 19dB Gain in 5mm PQFN package
- (ii) MAAP-015030: 12W Peak, 19dB Gain in 7 x 7 mm fully molded QFN package.
- (iii) MAAP-015035: 12W Peak, 32dB Gain in 8 x 8 mm fully molded QFN package.
- (iv) MAAP-015036: 15W Peak, 19dB Gain in 8 x 8 mm fully molded QFN package.

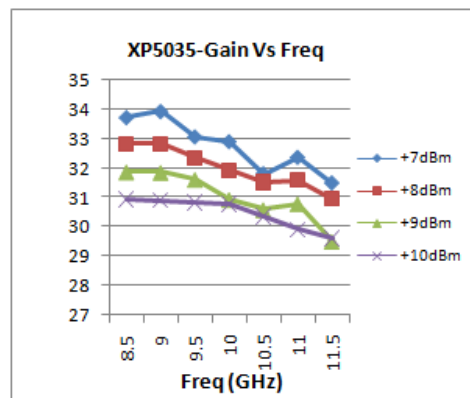
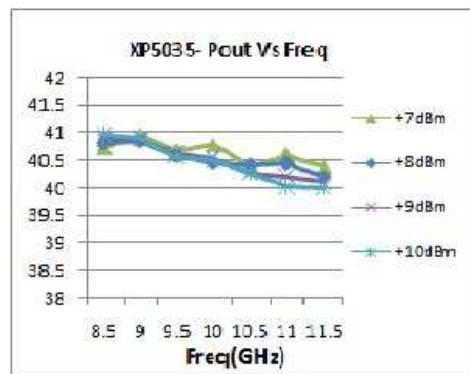
In this paper I would prefer to consider the high gain 12W PA to be used with the Multichip Module for the 10W transmit power. The performance detail of this PA is discussed as below.

MAAP-015035-DIE:



This is one of the PA's from our high efficiency PA family. This uses 0.25um pHEMT power process. This part is available in 8 x 8 mm 64 lead fully molded QFN package. The efficiency of this PA is as high as 40% with 30dB gain with 12W Pulsed power. This PA is recommended for the Pulsed application only. We recommend 25% duty cycle with 200uS pulse as the Max condition with 8V drain. There are two ways of biasing this Power Amplifier. One is with the built in On Chip Bias circuit which can be accessed with -5V Vgg and second one is Direct Gate biasing with -0.9V applied to the gate. The Typical Drain current is about 3A.

Typical Performance Graphs:



Considering the Fig 1 architecture of the TRM, with 0dBm as the input Power to the common leg of the Multichip Module (MAMF-011015) during the Tx mode with 9dB Tx Gain combined with 32dB gain from the PA(MAAP-015035) we could easily achieve 10W transmit power.

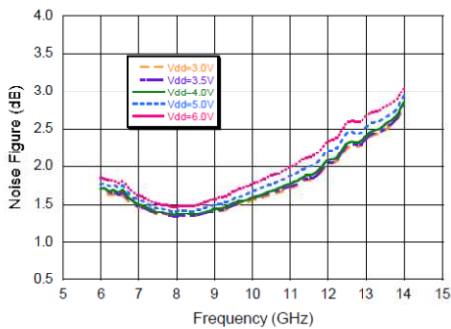
c) LNA :

MAAL-010528 is 50 Ohm I/O matched LNA covering X band with 20dB Gain, 1.7dB Noise figure. This pHEMT GaAs MMIC uses our 0.25um Low Noise Process. The system which requires very high gain in RX can consider this part. This LNA is a self biased LNA gives the optimum performance +3.3V/ 60mA current. At this +3.3V it has the lowest NF (1.5-1.7dB across 9-10 GHz with typical OIP3 of +26dBm.

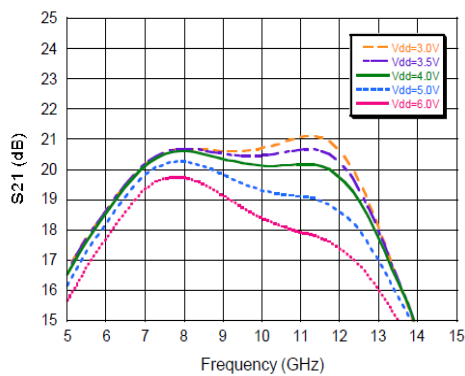
This device is available in 3 x 3 mm PQFN package

Typical performance Graphs:

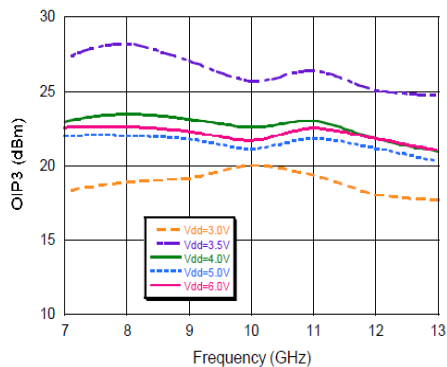
Noise Figure vs. Supply Voltage



Small-Signal Gain vs. Supply Voltage

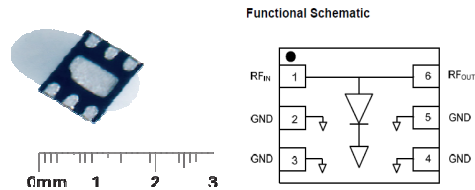


Output IP3 vs. Supply Voltage



d) Shunt PIN Diodes for Limiting :

The MACOM Shunt PIN Diode Series is designed for customers who need a versatile, low cost, ultra-small Shunt PIN diode element. Unlike the competition, MACOM's small, 1.5 X 1.2 mm plastic package reduces board space while enabling broadband performance comparable to chip-scale devices. Typical applications include high power switching through 6GHz with incident power up to 100W in case switching application & 10W power handling with +15dBm flat leakage in Limiting applications. Boasting excellent performance, low cost and easy implementation, the Shunt PIN Diode series offers a winning combination for customers looking for high-power diode solutions.



PIN Diodes:

Features:

- 3 Terminal LPF Broadband Shunt Structure
- 50 MHz - 12 GHz Broadband Frequency
- >100 W Peak Power Handling
- < 0.1 dB Shunt Insertion Loss
- > 25 dB Shunt Isolation
- < 20°C/W Thermal Resistance
- Lead-Free 1.5 x 1.2 mm 6-lead DFN Package
- RoHS* Compliant and 260oC Reflow

Limiter Diodes:

Features::

- 3 Terminal LPF Broadband Shunt Structure
- 10 MHz - 6 GHz Broadband Frequency
- 2.5 W Peak and CW Power Handling
- < 0.5 dB Shunt Insertion Loss
- < + 15 dBm Flat Leakage Power
- Lead-Free 1.5 x 1.2 mm 6-lead TDFN Package
- RoHS* Compliant and 260oC Reflow Compatible

Conclusion:

High performing and innovative MMIC in space saving plastic enables radar system designers to take full advantage of our Multichip module integration technology and achieve new levels of power efficiency while reducing system size and weight significantly. Utilizing sophisticated packaging and thermal management techniques to maximize design efficiency and component reliability enables designers to overcome challenging development hurdles and pioneer a new generation of high-performance, rugged radar systems. By making use of existing SMT technology capacity and best commercial practices we are also able to reduce the size, weight and cost of integrated “Plug-and-play” modular power solutions. These scalable and highly manufacturable modules, when used in a “True SMT” assembly and combined with additional RF SMT components to form complete TRM’s in AESA RADAR systems, will lead the way towards a truly modular RF solution for future AESA RADAR and multi-function systems.

In summary, the ability to offer a full SMT solution using our MMIC combines the best of advanced military power technologies and high-volume commercial manufacturing expertise. With this combination it is possible to break through the current boundaries of SWaP and realize a new level of performance not only in TRM’s but in the overall capability of future RADAR systems.

Acknowledgement:

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References:

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- [2] G. van der Bent, A. P. de Hek, A. Bessemoulin, “Low-Cost High-Efficient 10-Watt X-band High-Power Amplifier”, 2009 IEEE COMCAS.

Author Biography:

Akilan Krishnan is Field Applications Engineering Manager at M/A-COM Tech India, and has over 11 years experience in RF applications and technical sales..