

High Power GaAs MMIC Chipsets for 18 to 32 GHz Frequency Band Applications

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ABSTRACT

Recent commercial wireless applications such as Point to Point radio links, LMDS (Local Multipoint Distribution Service), LMCS (Local multi-point Communications Service) and Commercial K-Band Satellite based services have spurred significant activity in development of mmWave power amplifiers. These applications lie in the frequency range of 18 to 42GHz with possible future extensions to 60GHz. These systems employ digital modulation schemes for which highly linear mmWave power amplifiers are essential. This paper presents an overview of some chipsets consisting of High Power amplifiers covering the frequency range of 18 to 32GHz. Preferred solutions to a low cost subsystem vary from one subsystem manufacturer to another as it involves assembly and test capabilities in addition to component costs. The overall direction appears to be toward multi-chip module assemblies. Here, both chip and packaged level component options are considered.

SUMMARY

The transmitter section in a radio, such as a Point to Point and LMDS radio, requires the integration of several chips such as pre-driver, driver and output stages with desirable functions such as of on-chip power detection. The data modulation schemes are mostly digital, such as QPSK and QAM, which demand very stringent linearity specifications at system level to ensure the quality of the signal. This translates to the need for developing higher output power modules, providing for increased power consumption, more complex MMIC chip assemblies .etc. The most important frequency bands of the point to point and LMDS radio links applications are 18, 23, 26, 29, 31 and 38 GHz.

To achieve the high power level required by the mmWave radio link applications, a 0.25 μ m Power pHEMT technology has been used in the MMICs development [1]. To cover most of the frequency bands involved, we developed an 18 to 32GHz broadband driver amplifier, FMM5804. The MMIC has 18dB of gain, 23 dBm of output power and is fully matched [2]. The photograph of the MMIC is shown in Figure 1. Good return loss and broadband stability make this amplifier easy to integrate in a multi-chip environment.

A broadband MMIC analog attenuator covering 20 to 40 GHz frequency bandwidth and with a dynamic range of 20 dB, has also been designed, to be used at the input of the broadband driver.

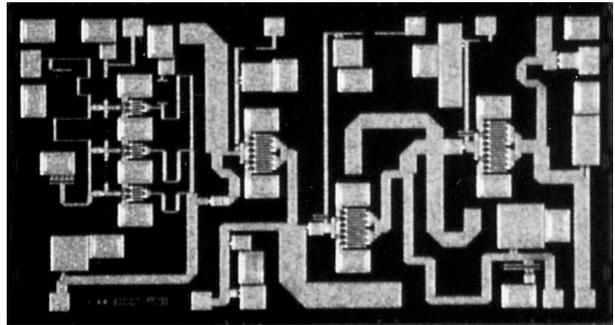


Figure 1– FMM5804 18-32GHz Broadband MMIC Amplifier. Chip size: 2.65 x 1.45 mm

A 17 to 20 GHz 1 Watt amplifier with 21 dB gain, FMM5805 (Fig.2) has been developed. The power and gain performance of this MMIC are shown in Fig. 3. Its 3rd order intermodulation performance IM3 is -38dBc @Pout=20dBm. FMM5804 driver and FMM5805 PA constitute a chipset well suited for a typical 18GHz radio link application.

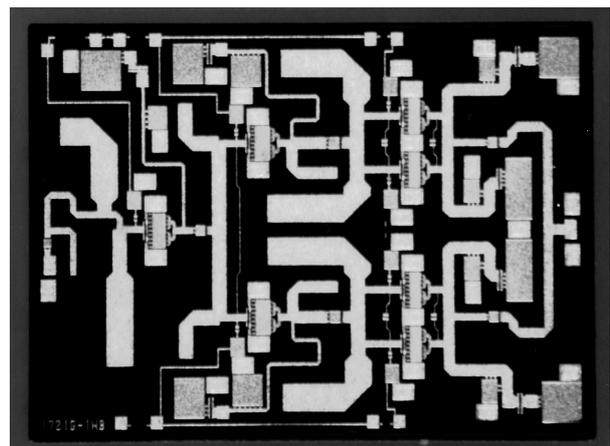


Fig 2 – FMM5805, 1W, 17-20GHz MMIC PA MMIC
Chip Size: 3.56mm x 2.66mm

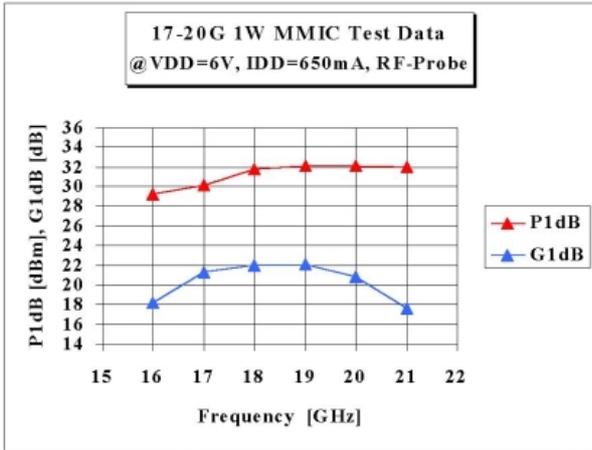


Figure 3 – FMM5805 1W 17-20GHz MMIC Power Amplifier Performance

Improving the linearity of the power amplifiers while maintaining the required output power level is a challenging task that can be achieved at the process level or/and at the circuit design level. In order to improve the linearity of the output stage, IM3 load pull has been carried out on some samples of Power pHEMT chips at 18 GHz using active load pull technique[3]. The load pull contours of IM3 are shown on Figure 4.

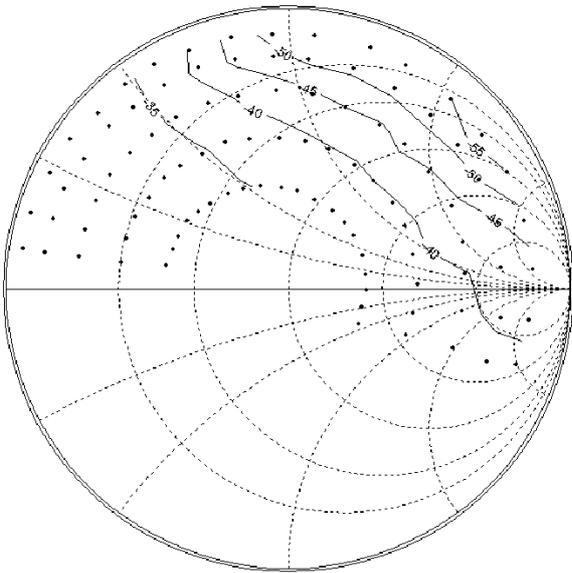


Figure 4 – IM3 Load Pull Contours of Power pHEMT at 18 GHz

Using this information a compromise between linearity and power output can be achieved and a design of a 24 to 27 GHz, 1 Watt MMIC Power Amplifier with 15 dB of gain, has been developed. The layout of this chip is shown in Figure 5.

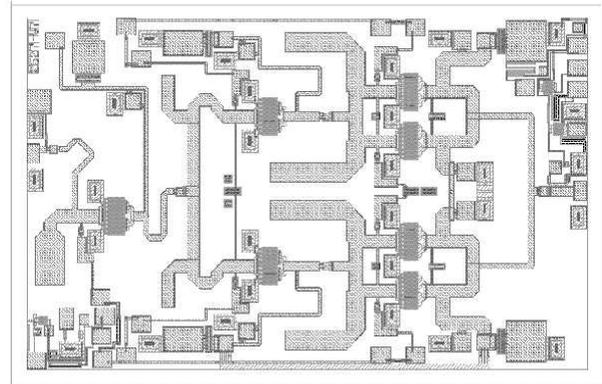


Figure 5 – 1W 24-27 GHz MMIC
Chip size: 3.6 x 2.3 mm

Power and linearity performance are shown in Figure 6. The IM3 is better than -40 dBc @Pout=20dBm all over the frequency bandwidth. An output power detector has been integrated in the chip to allow the power detection and the output power control by means of external analog variable attenuator. Besides the power detector, a biased reference diode is also placed on the MMIC chip. This facilitates temperature compensation by means of external differential amp circuits.

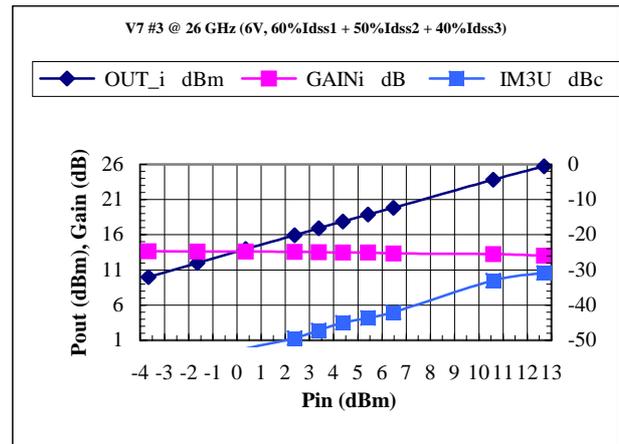


Figure 6 – 1W 24-27 GHz MMIC Power amplifier performance

Using the same configuration a 1 Watt 27 to 32 GHz MMIC Power amplifier, FMM5803 with 13 dB of linear gain, suitable for LMDS applications, has been also developed (pictures, performance not reported).

With FMM5804, FMM5803 and FMM5807 constitute an excellent choice of chips for 26 GHz radio links, LMDS applications and 30 GHz ground stations for commercial satellite uplinks.

To achieve the required system linearity, it becomes necessary to combine several high power amplifiers. One way to achieve this is through board level power

combiners, realized on ceramic or laminate substrates. Often results in loss in performance and also adds significantly to cost and size. To lower the costs, highest possible integration several 1 Watt sub-circuit MMICs is desirable. To meet this challenge, a 2W MMIC power amplifier with 14 dB of gain has been realized in a single chip of $3.6 \times 3.8 \text{ mm}^2$. The photograph of such MMIC is reported in Figure 7 and the power and gain performance are reported in Figure 8.

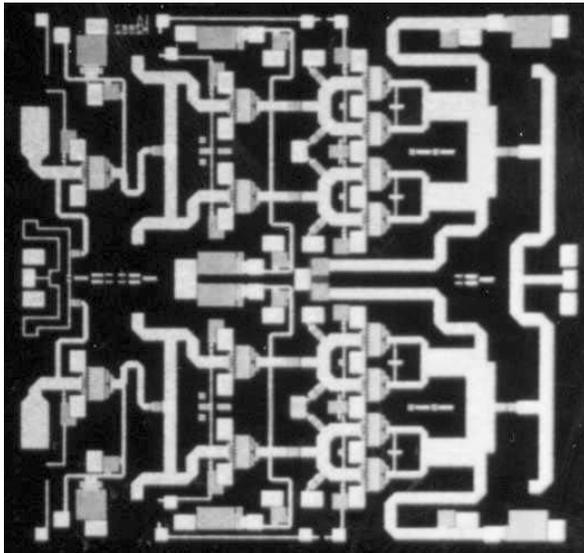


Figure 7 – 2W 24-26 GHz MMIC
Chip size: 3.6 x 3.8 mm

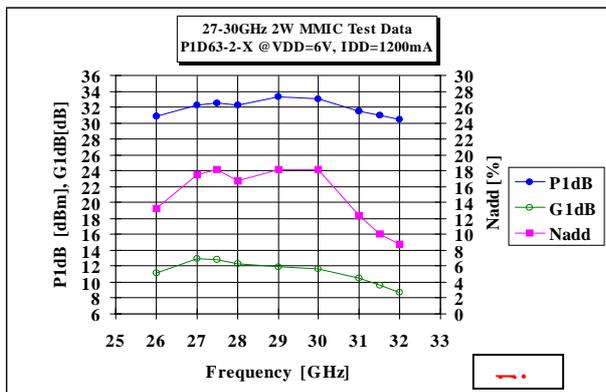


Figure 8 – 2W 24-26 GHz MMIC Power Amplifier Performance

In order to realize a compact, high gain, high power module for 26 GHz radio link application, the 2 Watt MMIC power amplifier shown above has been assembled together with the driver FMM5804 in a low-cost metal ceramic package. An overall gain of 30dB and an output power at 1 dB of compression point of 33.5dBm in the band from 23 to 26 GHz has been achieved. In Figure 9 the internal view of the packaged

module is shown.

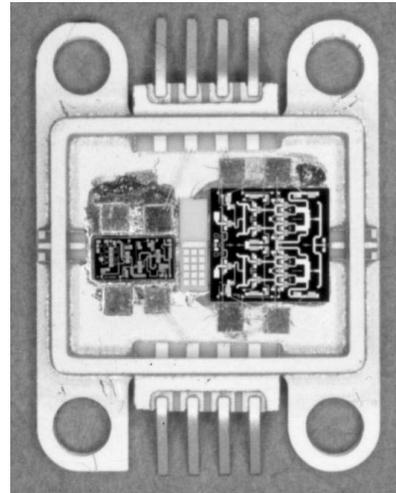


Figure 9 – Internal view of the packaged MMIC module (driver + output stage)

CONCLUSIONS

We presented an overview of some chipsets consisting of High Power amplifiers covering the frequency range of 18 to 32GHz. Both chip and packaged level solutions are proposed to overcome problems such as assembly and cost, which are particularly important in multi-chip module assemblies. High importance has been given in the achievement of the best linearity by means of active load pull technique.

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