EUROPEAN MMIC ACTIVITIES

John MAGARSHACK

THOMSON COMPOSANTS MICROONDES

ABSTRACT

A brief review of the development programmes involving MMIC's in Europe supported by the EEC and military administrations will be given. Then a glance at a European outlook on civil applications leads to examples from four leading European Manufacturers of MMIC's namely, PLESSEY, TELEFUNKEN, PHILIPS and THOMSON-CSF. These show how systems people are now exploiting MMIC's in new types of applications.

INTRODUCTION

It would for many reasons be a gross understatement to say that there are a lot of things happening in Europe these days. This applies not only to the political and economic scenes but is as appropriate for the technical development programmes. The perspective of economic union is profoundly changing attitudes of government planning and industrial policies. At the same time, indeed fostered by radical changes further east, there is a distinct redistribution of market trends in general for military and civil applications. For emerging technologies such as MMIC's it is of vital importance to assess the markets in 5-10 years time. Not only will the needs change but the new applications made possible by monolithically integrating microwaves must be defined and developed. Europe is a unique terrain for the development of such applications. Amongst new civil markets which will require quantities greater than a million per year there will be for instance satellites (DBS, V-sat, GPS) communications (mobile telephone) and transport and domestic applications (badges for identification, automatic payment, etc.).

In support of the industrial effort in these and military applications, European and government agencies are financing joint international industrial development on a considerable scale. The CEE Esprit and the IEPG (*) have important MMIC programmes. The applications and specifically European approach to organizing their development will be described in more detail during the talk.

The Industrial activities are illustrated with contributions from four leading groups in Europe namely PHILIPS, PLESSEY, TELEFUNKEN and THOMSON.

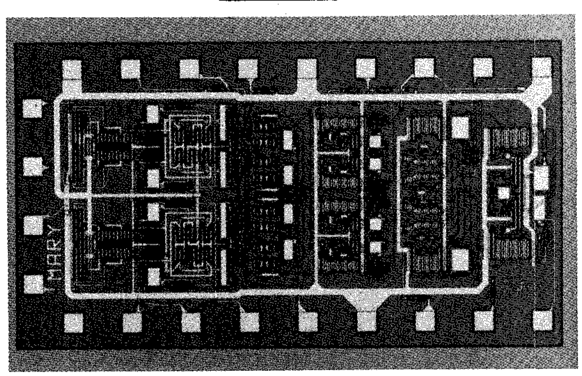
PHILIPS - LEP

PHILIPS have interests above all in civil applications and have made a speciality in fairly complex functions with balanced amplifier techniques (1). Four examples are given including a wide band Hemt amplifier which they were the first to publish (2).

Amongst MESFET MMIC's, 2 circuits illustrate the complexity of the MMIC. They include 50 to 100 transistors each :

. A 0.1 to 4.5 quadrature phase shifter

Figure 1

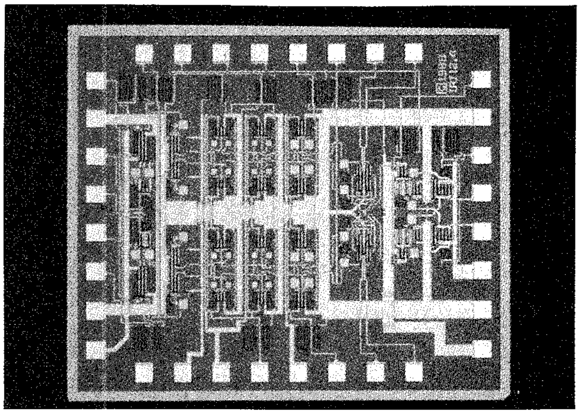


(*)A European NATO organization

90CH2869-6/89/0000-0085$01.00

. A S-band QPSK modulator shown in :

Figure 2

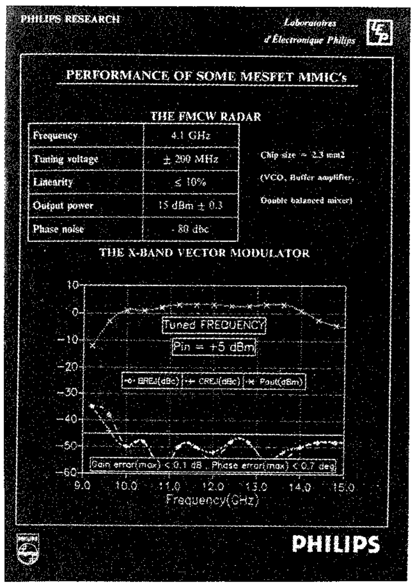


Both were designed in collaboration with TRT.

The first circuit exhibits at least 30 dB of image rejection over all the band. The fabrication yield was 61%. The second is the S-band QPSK modulator. Carrier and band rejection were better than 45 dB, corresponding to a phase error 0.8°, and a gain error less than 0.12 dB has been measured. The modulator has been successfully tested as a 16 QAM modulator in a radio link with no error correcting system. These circuits were fabricated at the PHILIPS Microwave Foundry.

Other complex circuits have been designed and fabricated. In particular, a FMCW radar (designed by TRT now a subsidiary of THOMSON-CSF) and an X-band vector modulator. The results are presented in Figure 3.

Figure 3



The second family of circuits uses Hemt devices including pseudomorphic structures.

The results obtained for Hemt MMIC's are 2.3 dB of noise figure with 12 dB of associated gain at 15 GHz using a two-stage reactive matched amplifier and 6 dB gain from 2 to 42 GHz using a cascode distributed amplifier.

Figure 4 presents the performances of the low noise Ku-band amplifier and of the distributed amplifier.

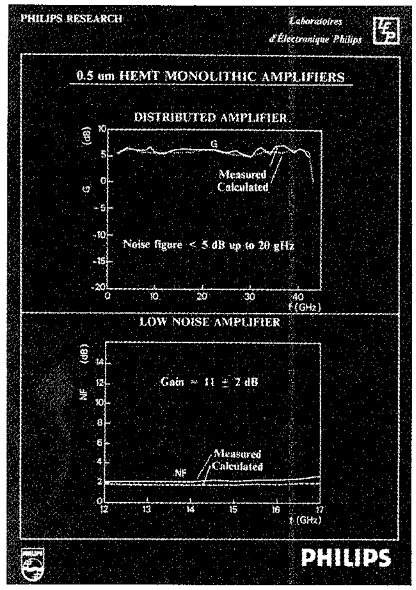


Figure 4

PLESSEY

PLESSEY has had the longest experience in MMIC's in Europe (and the world) and are now covering civil and military applications.

To illustrate the PLESSEY MMIC activities there are two examples of interesting developments now underway.

The first is a Multifunction MMIC for phased array applications shown in Figure 5.

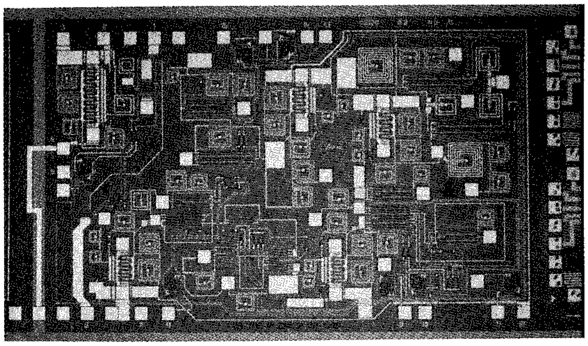


Figure 5

This is a three-port device designed for operation over the 5-6 GHz band. The block diagram is shown in Figure 6.

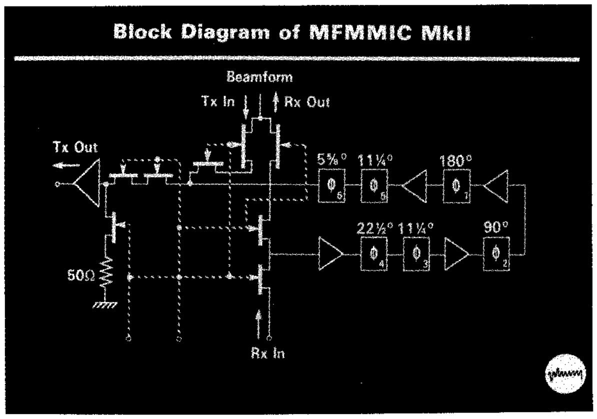


Figure 6

It utilises an on chip switching network so that a driver amplifier can be switched in during the Tx mode. The chip contains both low noise and medium power amplification (120 mW), a 6 bit switch filter phase shifter and SPDT Tx/Rx routing switches. It makes extensive use of stacked spiral inductors (only possible on the PLESSEY multi-dielectric process). Chip size is 10.7 mm2. Use is made of selective ion implantation to optimize performance for both switching and amplifying MESFETs on the same substrate. It is RF on wafer compatible.

The second example shows mounting chips with Flip Chip MMICs. This concept uses broad MMICs and low cost external matching circuitry to "tailor" the performance to specific needs. The MMICs are connected to the microstrip matching networks using a solder bump technology compatible with the PLESSEY GaAs Foundry process.

The chip photograph, Figure 7, is a broad band S and C band receiver circuit. The mixer is double balanced diode ring (gate-source diodes).

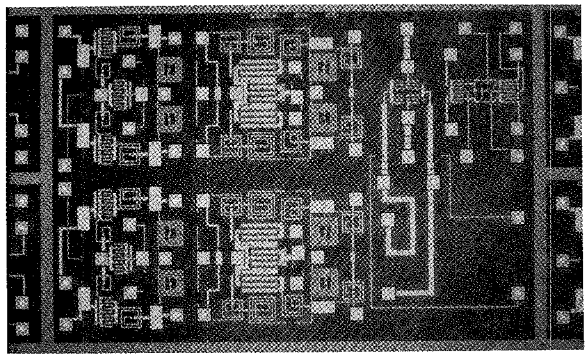


Figure 7

To demonstrate its operation two ceramic designs (12x12mm), one at 3 GHz and the other at 6 GHz, were produced. Both used the same MMIC chip.

Typical performance for both receivers is 3 dB N.F. and 20 dB conversion gain.

The ceramic design is overly complicated because we want to access all the bias points of the circuitry for diagnostic purposes.

One can see the chip photograph with the circuit configured as in Figure 7.

Figure 8 is the ceramic layout for the 3 GHz circuit showing the solder bond connections (54 in total).

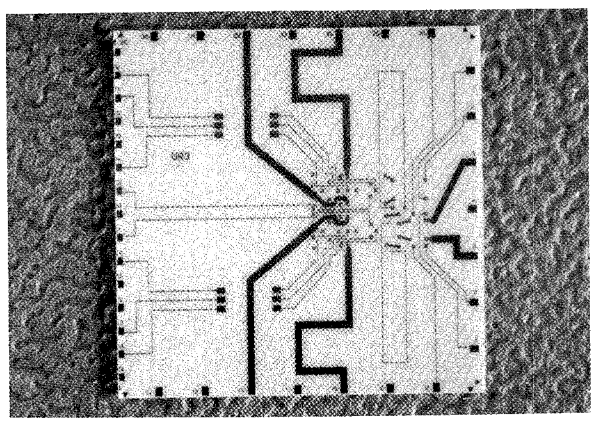


Figure 8

Finally Figure 9 shows the chip flipped into place.

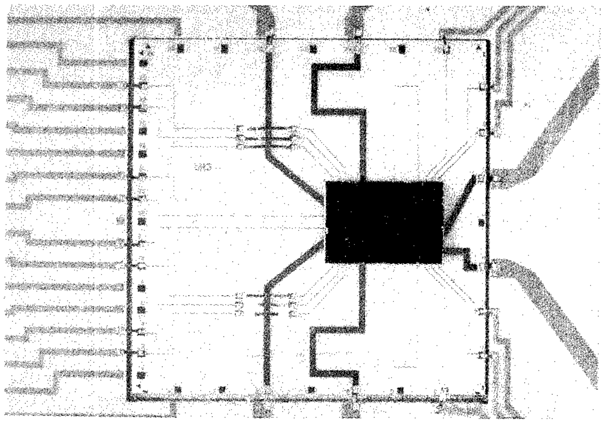


Figure 9

TELEFUNKEN ELECTRONIC GmbH

TELEFUNKEN has a wide experience in mm-wave subassemblies. They are working on monolithic I.C.'s at 30, 60 and 94 GHz together with THOMSON in an IEPG programme.

A good example of this work is the 60 GHz receiver (4) (5) illustrated in Figure 10.

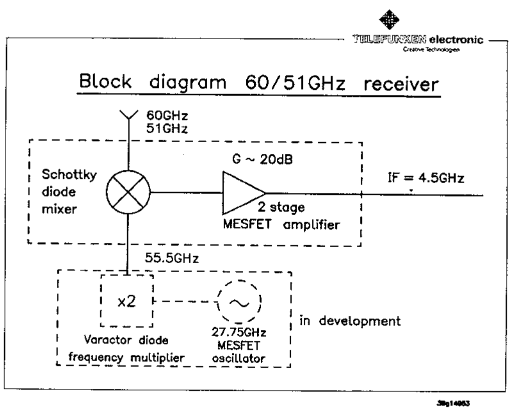


Figure 10

This shows the block diagram where the 60 GHz input is detected by a diode with an L.O. at 27,7 GHz multiplied by 2. There is an IF amplifier at 4,5 GHz integrated with the diode. The technology is illustrated in Figure 11.

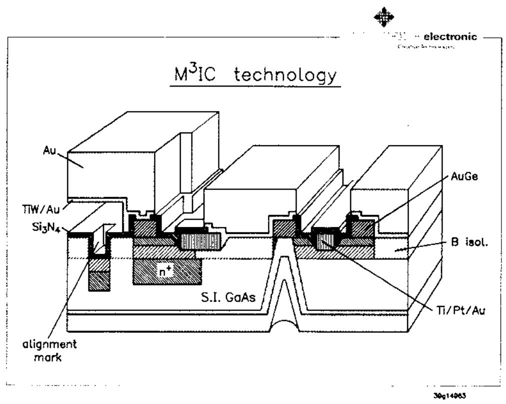


Figure 11

It is original in that it uses deep implanted n+ wells underneath an epi MBE grown active layer used for the diode and the transistor. In the latter case there is no n+ buried layer but there can be via holes for source grounding. The results from the circuit are given in Figure 12.

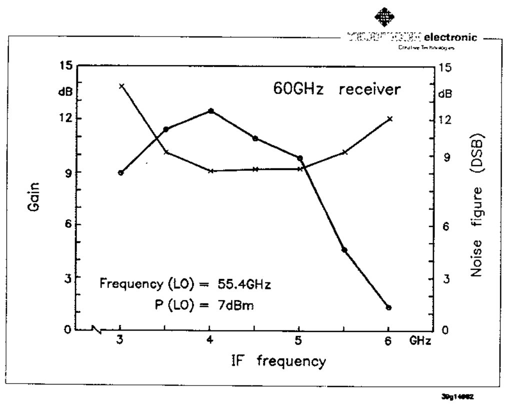


Figure 12

One can see a maximum conversion gain of 13 dB with a corresponding noise figure of 8 dB.

THOMSON-CSF

THOMSON's prime thrust in MMIC's has been to install a foundry for use by equipment manufacturer designers. The accent then for five years has been on well characterizing and stabilizing their technology (6) and it is now established on the commercial market. They have also a large research group in new materials and I.C.'s.

An illustration of their activities is seen in Figure 13 which shows the MMIC functions mounted in a direct demodulation receiver in the 6 to 8.5 GHz range (8).

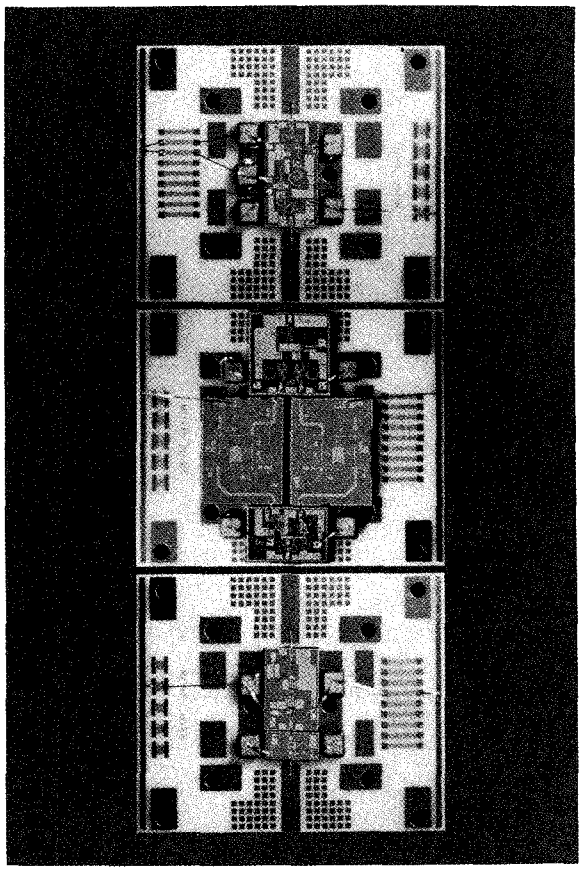


Figure 13

It uses a preamplifier, balanced mixer, dielectric resonator local oscillator as shown in Figure 14.

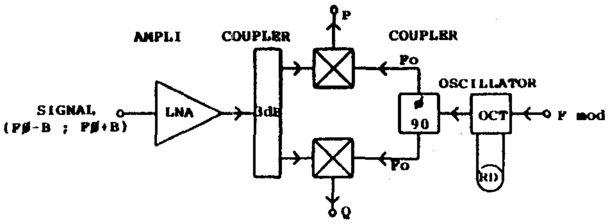


Figure 14

DIAGRAM OF H.F. C-BAND RECEIVER (THOMSON)

This receiver was made with ALCATEL designers in standard foundry technology and it illustrates the techniques used at THOMSON COMPOSANTS MICROONDES not only for the MMIC 0.5 µ family but also for a mounting chip on carrier technique which is standard and modular and has been developed for fast and cheap design, test and mounting.

A more advanced project made in conjunction with TEG in the mm-wave MMIC IEPG project, is the Hemt 60 GHz preamplifier and oscillator. It uses 0.25 µ e-beam technology (7).

CONCLUSIONS AND ACKNOWLEDGEMENTS

In conclusion the MMIC scene in Europe is very active. It is however evolving very rapidly due to the many recent events both in industry and on the national/international level. New markets are emerging such as DBS, mobile radio, etc. which have particular significance in Europe. These are very interesting times.

I would like to acknowledge the very active contributions to this paper of Jim TURNER (PLESSEY), Patrice GAMAND and Vlad PAUKER (PHILIPS - LEP), Alex COLQHOUN (TELEFUNKEN) and Christian RUMELHARD (THOMSON).

I also wish to acknowledge the kind permission from G. PAPAGEORGIOU to cite ESPRIT programmes, and from M. BONFILS (DRET) for military programmes.

REFERENCES

(1) A 10-14 GHz linear MMIC vector modulator with less than 0.1 dB and 0.8° amplitude and phase error.
F.L.M. van den BOGAART, R. PYNDIAH.
IEEE Microwave and Millimeter Wave Monolithic Circuits Symposium, June 1990.

(2) 2 to 42 GHz flat gain monolithic Hemt distributed amplifiers.
P. GAMAND, A. DESWARTE, J.C. MEUNIER, M. WOLNY, P. CHAMBERY.
10th GaAs I.C. Symposium, November 1988.

(3) "S and C band GaAs Multifunction MMIC's for Phased Array Radar".
A. LANE et al.
GaAs I.C. Symposium, October 1989, p. 259.

(4) "A Monolithic 60 GHz Diode Mixer in FET Compatible Technology.
B. ADELSECK et al.
Proceedings 1989. IEEE MMIC Symposium, p. 91.

(5) "A Fully Monolithic Integrated 60 GHz Receiver".
A. COLQHOUN et al.
GaAs I.C. Symposium, October 1989, p. 185.

(6) "Optimum Design and Realization of MMIC Power Amplifiers".
G. MONTORIAL et al.
19th European Microwave Conference, September 1989, p. 451.

(7) "60 GHz HEMT MMIC Amplifier and Oscillator".
D. DELAGEBEAUDEUF et al.
To be published in Electronic Letters.

(8) "GaAs Monolithic Balanced Mixer for C Band Direct Demodulation Receiver".
I. TELLIEZ et al.
19th European Microwave Symposium, 1989, p. 731.