ART1-VA/26-01-94

MODERN RADAR and EW SYSTEMS Call for the large scale use of GaAs MIC and MMIC

Vincenzo ALLEVA - Giuseppe PINTO

ELETTRONICA S.p.A. - Via Tiburtina Valeria, Km 13700 ROMA

Abstract

A modern ESM - ECM SYSTEM is an electronic warfare system constructed by assembling millimetric and microwave subsystems that meet very stringent electrical and mechanical characteristics.
The subsystem specifications warrant the use of monolithic circuits to meet the requirements.
In the proposed paper we will show electrical schematics, block diagrams, and photos of subsystem applications. In these assemblies, GaAs devices, in MIC or MMIC form, are used on a large scale.

Introduction

The new generation of ESM-ECM for avionic Systems, presents very tight electrical specifications that have to meet requirements of low power dissipation, limited weight and size.
Furthermore, the reliability and screening in the whole temperature and frequency range are also important, so particular care has to be taken on the choice and utilization of the active devices.
In this contest, a modern system is built by assembling different units such as Antenna Array, Down converters, Preselector and BITE.
These units are essentially composed of millimetric and microwave assemblies.
The present paper shows some integrations used in modern ESM-ECM Systems, highlighting the use of GaAs applications because the previously mentioned requirements can only be obtained using a large scale integration of GaAs components, either in MIC and MMIC configuration.

Assemblies and subsystems design

A. Generality

The design of assemblies for new RADAR and EW systems is the result of many years spent in the design of elementary circuits (in monolithic or hybrid configurations) and in technological improvements.
In fact, to satisfy very complex electrical specification in limited weight and size, the designer needs electrical building blocks and the technology able to integrate elementary multifunctional circuits.
Then, when multifunctions are obtained, particular attention has to be taken in the design of the integrations. At this point electromagnetic considerations, such as isolation among circuits, coupling, and interferences of V.S.W.R. become important for the achievement of the full compliance of the specifications.

B. Monolitics and hybrid circuits

The first step in the design of a supercomponent is the design of the basic circuits in MIC and MMIC configurations.
During the past years ELETTRONICA S.p.A. was fully involved in the development of MMIC [1, 2, 3], and at present the most utilized components are travelling wave amplifiers, feedback amplifiers, power amplifiers, switches, fast tunable filters etc.....
Fig 1 shows a typical monolithic SPDT layout designed in ELETTRONICA and realized in the ALENIA foundry.
The design in MIC technology is also important, especially in the millimetric wave frequency range.

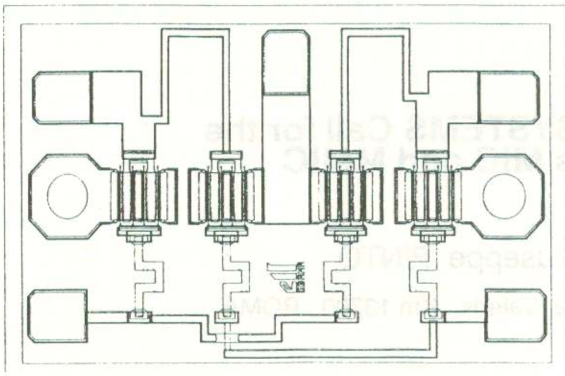

Fig. 1 : Monolithic SPDT

Examples are balanced power amplifiers, low noise amplifiers and in the millimetric range active mixer, amplifiers etc.....

Fig. 2 shows the photo of an active mixer in the millimetric frequency range. It down-converts 32 ÷ 38 GHz down to 2 ÷ 8 GHz with very low convertion loss (2dB) and a noise figure of 9 dB with an L.O. power of 10 dBm at 30 GHz.

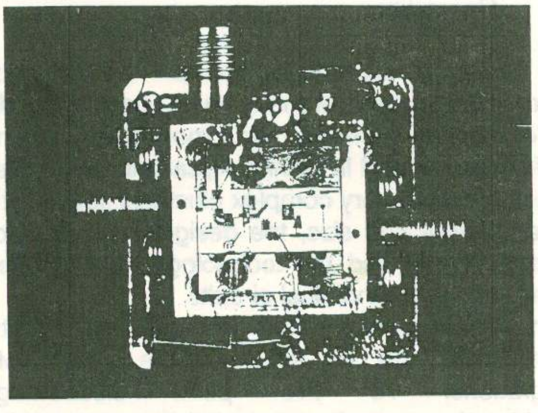

Fig. 2 : Millimetric MIXER

Fig. 3 shows the design of a millimetric two stages low noise amplifier built on a 7x14 mm carrier. The amplifier presents a noise figure of 5 dB with an associated gain of 10 dB over the whole 32-38 GHz frequency range.

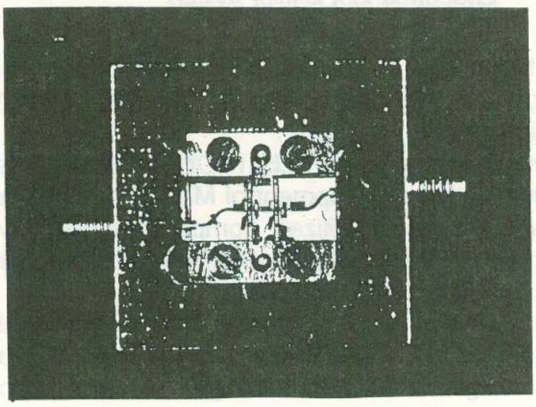

Fig. 3 : Millimetric LNA

C. Ibrido di monolitici (Monolitics hybrid)

The second step is the integration of several functions on a single and small circuit.

We previously spoke about the need of having multifunctions integrated in a single carrier of small size (7 x 14 mm) in order to meet the global specifications in limited size and cost.

It is easy to demonstrate the integration cost is directly proportional to the number of the stages (carrier plus circuit).The number of the stages heavily affects the electrical performances of the supercomponent and the system reliability. Then the components integration level has to be increased in order to reduce the stages number.

From this point of view, to exploit MIC and MMIC technologies has drawbacks: the former presents a high quantity of active and passive components connected by too many wires and needs complex tuning; the latter technique presents high losses in the GaAs, larger dimensions and lower yelds.

The two techniques, in these cases, are too expensive and have a reduced realiability.

The solution of this problem is to use both the technologies (MMIC and MIC) to obtain a circuit called "ibrido di monolitici" (monolithics hybrid). It is based on the integration of some monolithics circuits mounted on the same dielectrical substrate which support passive components (filters, dividers, etc...), and some time it also contains driver circuits. Fig. 4 shows the implementation of a power stage obtained using 4 monolitic power travelling wave amplifiers, balanced between two couplers.

The output power is 27 dBm in the 6÷18 frequency range.

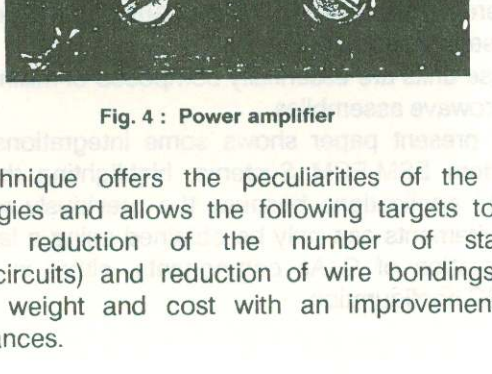

Fig. 4 : Power amplifier

This technique offers the peculiarities of the two technologies and allows the following targets to be reached: reduction of the number of stages (carrier/circuits) and reduction of wire bondings, of size, of weight and cost with an improvement of performances.

D. Integration and supercomponents

The final step for a modern microwave systems designer is to use the previously mentioned technologies and techniques in order to achieve complex and more sophisticated performances.
It is very important to study the geometries and the mechanical packaging of the integration. Problems of multipath interferences, or a non-perfect isolation may destroy the assemblies performance.
Furthemore a thermomechanical design is necessary in order to meet the requirements of power dissipations and reliability.

E. Examples of supercomponents

In this paragraph we present some assemblies obtained by means of the previously described technique.
Fig. 5 shows the block diagram of a Tx/Rx module, and Fig. 6 is the picture of its implementation.

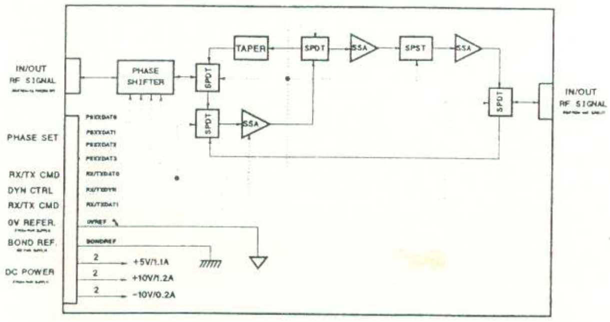

Fig. 5 : Tx/RX block diagram

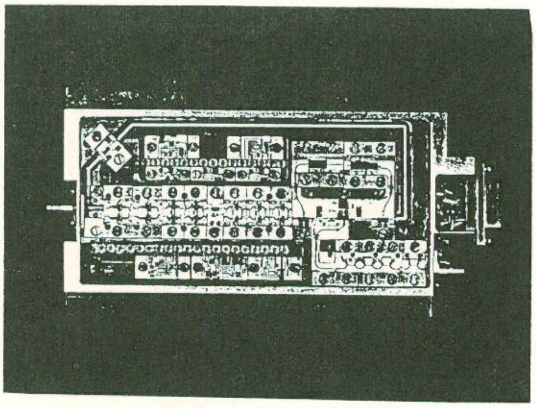

Fig. 6 : TX/RX module

This component is the basic building block of a supercomponent used in a phased array system.
The main functional requirements are: transmitted signal amplification (20 dB), 4 bit signal phase shifting, transitted signal amplitude modulation, fast Tx/Rx path switching (50 nsec), array pattern side lobe control, 20 dB received signal dynamic control and output power of 1 W min. up to 18 GHz
An other typical application where the GaAs is used on large scale is shown in Fig. 7.

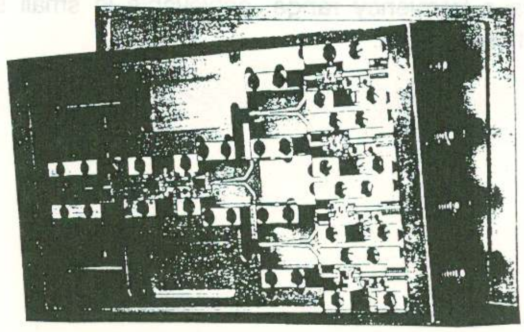

Fig. 7 : L.O. distributor

The picture represents an L.O. distributor. The signal coming from an oscillator is filtered, amplified (20 dB), divided by four and finally amplified (20 dB).
The output level of 15 dBm, drives four mixers.
The assembly works up to 20 GHz.
The third example of integration is the "heart" of a preselector assembly.
The Fig. 8 shows a dual channel high speed electronically tunable band pass filter. The component divides the 6 ÷ 18 GHz band into four sub-bands. Each sub-band is filtered by a dedicated combline filter which uses MeSFETs, as variable capacitors.
Eight feedback monolitic amplifiers serve as buffers between two cells of filters.

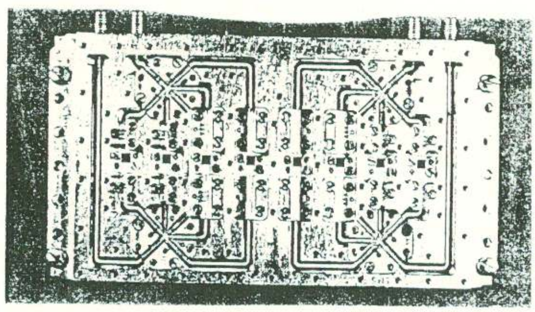

Fig. 8 : Fast tunable filter

Conclusion

Owing to the high number of MIC and MMIC, and the very stringent characteristics, a modern ESM-ECM SYSTEM is a prime example of large scale integration of GaAs devices.

To-day it is possible to show that a careful use of the MIC and MMIC techniques makes very complicated systems, requiring high quality and reliability supercomponents operating in the millimetric and microwave frequency range, achievable in small size and with low weight.

References

[1] G. Bianchi, G. Pinto, "DC ÷ 18 GHz GaAs MMIC SPST and SPDT", Military Microwaves '92.

[2] G. Bianchi, G. Pinto, "ELECTRONICALLY TUNABLE BANDPASS FILTER", GaAs '90, Gallium Arsenide Applications, Symposium in April 1990.

[3] G. Bianchi, G. Pinto, C. Giuliani, "MMIC 12 ÷ 13 GHz VOLTAGE CONTROLLED PHASE SHIFTER" ESA ESTEC WORKSHOP, March 14-15-16 th 1990.