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GaAs Power Devices for RADIO-LINK and Space Applications

G.P. Donzelli

Alcatel Telecom

Vimercate - Italy

Abstract:

This paper describes the development status of GaAs power devices in Alcatel Telecom for radiolinks and space applications.
In particular it will describe 30 W C-band low distortion high power Mesfet for high capacity digital Radiolinks and 10 W C-band power modules developed for phase array radar space applications in the frame of ENVISAT 1 project.
Recent development of power modules for K-band radio applications will also be presented.

Introduction

From year to year the needs in telecommunication systems never stop increasing both in the civilian and space applications. To support this growth, radiocommunication manufacturers have to design, develop and provide an increasing number of medium and high power transmitters in various frequency bands.

In the Radio Links system (1,2,3) specially for high capacity Plesiosynchronous Data Hierarchy, 140 Mbits, or Synchronous Data Hierarchy, 51/155 Mbits long haul equipments, the typical output power needed has to be 30 Watt from 2 to 11 GHz, while for Urbans Links (K-band) typical output power is in the range of few watts. Amplifier from 100 Watt up to 400 Watt are developed by defense systems suppliers used in troposcatter network at 2 or 5 GHz for strategic links.
For satellite communications, both earth and space segment, a wide range of transmitted power according to the data rate and the frequency band is required. High power amplifiers up to 500 Watt are used for international gateways and LEOs systems such as GLOBALSTAR and for phase array antennas where the key component are the SSPA's (solid state power amplifiers).

Microwave Radio Links

Design and development of microwave power transistors closely follow the evolution of the new digital radio transmission equipments, with the objective to provide them with low cost, high linearity, high efficiency key components.
In fact, the existing strong competition in the market of radio equipment, in term of prices and performances, prompts the manufactures worldwide towards the introduction of ever more sophisticated technologies, among which the exploitation of microwave power devices plays a most significant role.
MESFET technology is already in production since early '80 both in analog and digital applications. In particular MESFET based commercial devices (either discrete FETs or MMICs) are being used in all power microwave radiolinks functions up to 23 GHz.
P-HEMT technology is getting off the laboratories as the candidate for very low-noise, high gain applications and very high frequency domain (from 15 GHz to 90 GHz); some products are already in production (mainly low-noise), and power products are close to production standard.
30 W C-Band power FET's are needed as final stage of 80 W power amplifiers for earths station and high capacity digital links.
8 Watt GaAs chip has been designed and manufactured with optimized channel doping profile (4,5). This power chip has 19 mm gate width and 0,5 micron gate length.
To improve thermal resistance the chip is thinned down to 30 μm with plated up heat-sink of 30 μm gold (fig.1). Four of these chips were combined with input & output matching networks achieving 30W output power with PAE more than 35% and I.P. (Intercept Point) greater than 56 dBm at 5 GHz. Thermal resistance lower than 1.2 C°/W were obtained to insure safe channel temperatures.
Fig. (2a, 2b) show a photograph of the device and its typical RF performances.
PHemt technology process were developed to obtain 1 W output power at K-band.
The device structure is based on a double delta doped heterostructure with a stop etch layer and 0.5 μm gate length to assure high yield and reproducible process (6).
The device exhibits output power of 0.4 W/mm at 20 GHz. Typical performances are shown in fig (3) this structure will be used to design and manufacture 1 Watt devices for the Urban Radio Links transmitters.

Space applications.

The introduction of phased array Radar techniques employing active T/R Modules in quantities of some hundreds to a few thousands per antenna is attractive for the users due to the high systems resolution and efficiency, mobility and reliability in comparison to tube transmitters.
In the frame of ENVISAT 1 programme (launch date July 1999), Alcatel Italia has developed and manufactured C-band SSPA to be used in T/R modules of ASAR instrument (Advanced Synthetic Aperture Radar). This instrument is a high-resolution wide swath imaging radar that can be used for global land and ocean manitoring and surveillance.
The active antenna is made up of 5 panels regrouping a total of 20 tiles. The main active part are transmit/receive (T/R) modules. Each tile contained 16 T/R modules, (2 for each TR module) that means a total of 640 SSPA.
Typical main features of the ASAR are shown in table (1).

In the manufacturing of TX/RX modules for phased array radar, the most important objective are costs, weight and size reduction therefore multichip module technique is an ideal technique.
Fig. (4a, 4b) show the layout and the photograph of the SSPA.
Such a module (2x1 cm^2) exhibits 20 dB gain and 10W output power, with a typical power added efficiency of 35% at 5.3 GHz.
It is a two stage amplifier where the driver section has a single ended configuration and use 6mm wide Fet, while the output power stage is balanced type and employs two 12 mm wide Fet. In order to minimize the module size and weight (3.9 grams) the input and the interstange networks were made on high dielectric constant (Er=38) substrates.

Conclusion

In this paper we have shown the status of GaAs power devices developed in Alcatel Italia for final industrial applications in high capacity, high linearity Radio Links transmitter (C-K band) and space C-Band phase array radars.

References:

1.- M. Pagani, C. Bassani, A. Panzeri, L. Scopelliti "Integrated modules for SDH microwave radio" Proc. of 5th International Workshop on GaAs in Telecommunications, Rome, Italy, April 1995.

2.- B. Davide M. Pagani, A. Panzeri "Modular, Low Cost, High efficiency, C BAND POWER Amplifier, for SDH Radio "Proc. of 5th European Conference on Fixed Radio Systems and Networks" Bologna, Italy, May 1996.

3.- M. Pagani, M. Remonti, S. Velati, A. Panzeri "GaAS MMIC for cost effective insertion in digital Radio Link transceiver" Proc. of 5th GaAs '97, European Galluim Arsenide Applications Symposium, Bologna, Italy, Sept. 1997.

4.- E.M. Bastida, P. Antolini, A. Castelli, G.P. Donzelli, B. Gabbrielli, C. Longari, F. Rasà, C.L. Scopelliti" High effinciency and power ion implanted MESFET devices "Proc. 24th European Microwave Conference, Cannes France Sept.1994

5.- A. Castelli, F. Rasà and C.L. Scopelliti "High-power and high-efficiency ion-implanted GaAs MESFET with buried p-layer" Proc. GaAs Applications Symposium '94., Torino, Italy, April 1994.

6.- A. Brinciotti, G. Di Maio, G. Ravasi, S. Bianchi. C.L. Scopelliti, A. Castelli "PHEMT device for microwave power applications based on a double delta dopedw heterostrutture with a stop atch layer" Proc. of GaAs '97, European Gallium Arsenide Applications Symposium. Bologna, Italy, Sept. 1997.

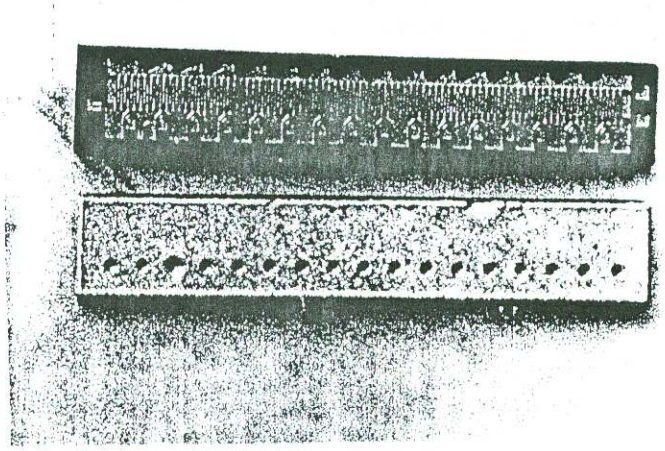

Fig. 1 - 8 W power chip with VIA HOLES (0.6 mm x 3.3 mm)

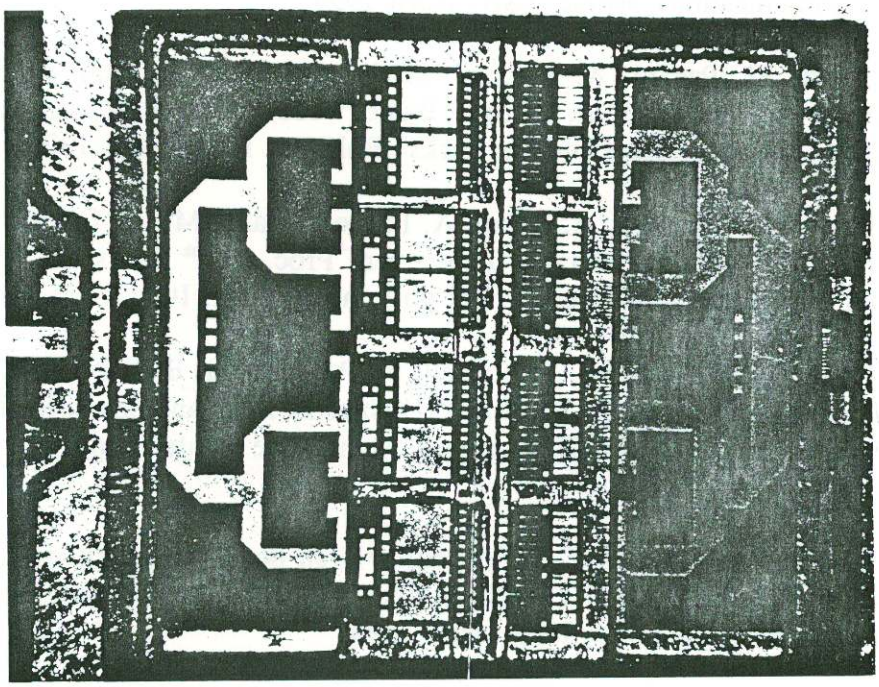

Fig. 2a - 30 W C-band power MESFET

Characteristics	Symbol	Test conditions		Device			Unit
				1	2	3	
Output power at 1db compression point	P1db	Vds=10V Ids=.6Idss	f=5.9 Ghz	44.5	44.6	44.2	dBm
			f=6.15 Ghz	44.5	44.6	44	
			f=6.4 Ghz	44.2	44.6	44.1	
Linear power gain	Glp	Vds=10V Ids=7.2A	f=5.9 Ghz	8.6	9	8.9	db
			f=6.15 Ghz	8.7	8.9	9	
			f=6.4 Ghz	8.5	8.7	8.9	
Power added efficiency	ηadd	Vds=10V Pout=P1db	f=5.9 Ghz	33.3	35.4	33.2	%
			f=6.15 Ghz	34.4	35.8	32.6	
			f=6.4 Ghz	32	35.5	33.9	
Drain current at 1db compression point	Id(RF)	Vds=10V	f=5.9 Ghz	7	6.8	6.6	A
			f=6.15 Ghz	6.8	6.7	6.5	
			f=6.4 Ghz	6.7	6.7	6.3	
Third order intermodulation distortion products	IM3	Vds=10V Ids=7.2A Pout=33dBm S.C.L	f=5.9 Ghz	-46	-46	-45	dBc
			f=6.15 Ghz	-46	-46	-45	
			f=6.4 Ghz	-46	-46	-45	

Fig. 2b - Typical microwave performances of 30 W device

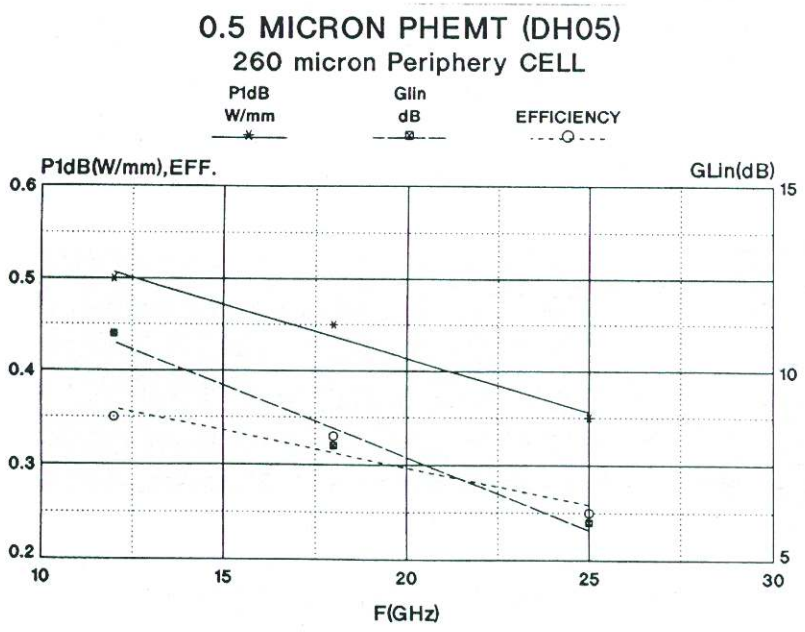

Fig. 3 - P-Hemt RF performances

❑Frequency:	C-band:	5.331 GHz
❑Resolution:		30 x 30 m
❑Antenna Size:		10 x 1.2 m
❑Peak Radiated Power:		1500 W
❑Average Radiated Power:		97 W
❑Elevation Beam Steering:		± 13°
❑Number of T/R Modules:		320
❑Number of Tiles:		20
❑Dual Polarization:		HH-VV

Table 1 - ASAR FEATURES

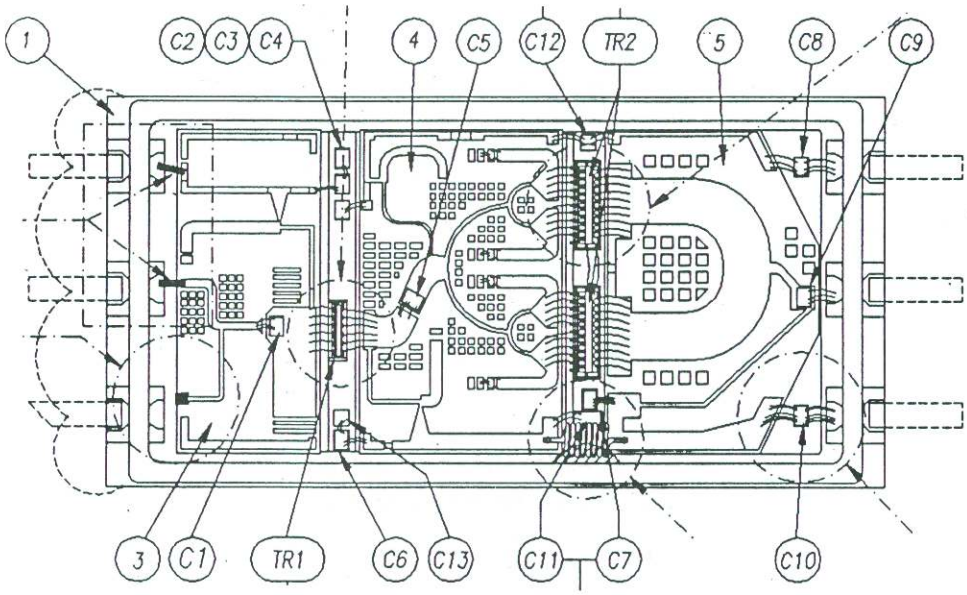

Fig. 4a - SSPA layout

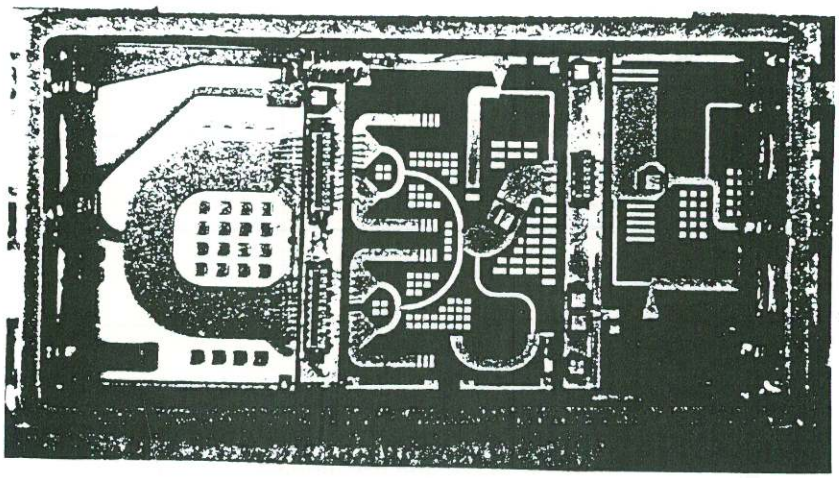

Fig 4b - 10 W SSPA photograph (2 x 1 cm^2)