C / KU -BAND PULSED TRANSMITTERS FOR POSEIDON 2 ALTIMETER

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***Abstract* — Solid State Transmitters (Tx) have been used in radar application for many years. The main advantages of the pulsed Tx are the followings:**

- Low distortion of amplitude and phase during the pulse.

- High reproducibility of identical pulses.

- High quality of output spectrum: low harmonic contents and reduced delay time.

In this paper we present the design and the measured results of 30W C-band Transmitter and 8W Ku band Transmitter used for the Poseidon 2 Altimeter. (Jason satellite).

I. INTRODUCTION

In modern radar systems, the power transmitter of a satellite equipment requires not only high efficiency Transmitter in order to reduce the power consumption and the dissipated power on the satellite, but also a high linearity, and high quality of the output RF spectral signal.

These equipments are the essential parts of an advanced radar altimeter (Poseidon Instrument) that are integrated inside the Jason satellite [1,2]. The satellite will be launched at the beginning of 2001.

This instrument with the dual-frequency C/Ku band measures the height of the sea winds with the accuracy better than 1cm and also detects the rain events.

The Jason satellite will carry many sensitive instruments such as the triple-band radiometer operating over the frequency range from 1GHz to 40GHz. Consequently, the extremely stringent required out-of-band gain, out-of-band output power, and Inter Pulse Noise Power density demand a very high quality output power spectrum on the Transmitters.

In this paper, we describe the design and the performances of the C/Ku band transmitters that can achieve these stringent requirements.

II. TRANSMITTERS DESIGN

C-band Transmitter:

The C-band transmitter is made of two elementary boxes with a connecting harness: a dedicated Pulsed Electronic Power Conditioner (Pulsed EPC) and a RF chain.

The Transmitter provides more than 53dB of gain, 30W-output power, with an associated PAE greater than 25%.

The main function of the Pulsed EPC is to convert the primary power input into pulsed secondary output voltage for supplying the Tx RF-part. The Pulsed EPC is managing the incoming pulses and the TTC interfaces with the satellite bus.

The RF chain consists of the following modules:

- A Pass band filter at the chirp frequency (725-1075MHz).
- A double balanced mixer to convert the chirp frequency into the transmitting frequency (5125-5475 MHz).
- A dedicated filter to suppress the image frequency and the unwanted mixing products of the mixer.
- Two MMIC attenuation and gain blocks for compensating the gain variation over the required temperature range.
- A medium level amplifier with 25dB of gain, output power higher than 32dBm, and with the associated PAE greater than 35%.

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- A power divider by 4, and four power modules: each power module (C-band HPA): provides 39.5dBm of output power at 2dB of gain compression with the PAE greater than 40%. This amplifier is an in-house self-content Hybrid-module, using one 4.8mm HFET power chip device followed by two times 9.6mm HFET power chip devices in parallel.

- A power combiner by 4 with low losses in microstrip.

- An output isolator with the associated power load providing the equipment with a good RF in-band matching and a protection from any short circuit at the output port.

The block diagram of the pulsed C-band transmitter is shown in the figure 1.

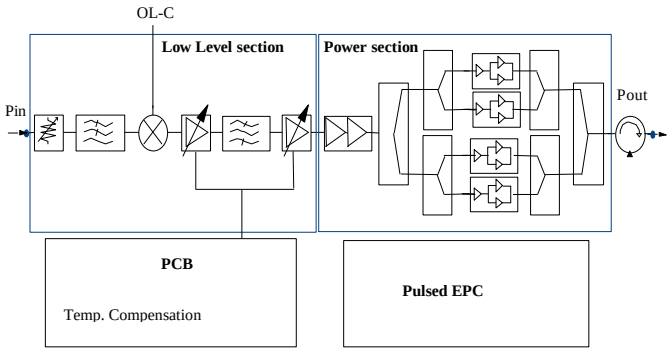

Fig. 1: C-band Transmitter Schematic Diagram

Ku-band Transmitter:

The Ku-band transmitter is made of two elementary boxes with a connecting harness: a dedicated Pulsed Electronic Power Conditioner (Pulsed EPC) and a RF chain.

The Transmitter provides more than 40dB of gain, 8W-output power, with an associated PAE greater than 15%.

The RF chain consists of the following modules:

- A Pass band filter at the chirp frequency, a double balanced MMIC mixer to convert the chirp frequency into the transmitting frequency (13.4-13.75 GHz), a dedicated filter, two MMIC attenuation and gain blocks, two medium level amplifiers.

- A power module (Ku-band HPA): providing 37dBm of output power at 2dB of gain compression with the PAE greater than 27%. This amplifier is an in-house self-content Hybrid-module, using one 4.8mm HFET power chip device followed by two times 4.8mm HFET power chip devices in parallel.

- A power divider by 2, and two power modules, and a power combiner by 2

An output waveguide isolator with the associated power load providing the equipment with a good RF in-band matching and a protection from any short circuit at the output port.

The block diagram of the pulsed Ku-band transmitter is shown in the figure 2.

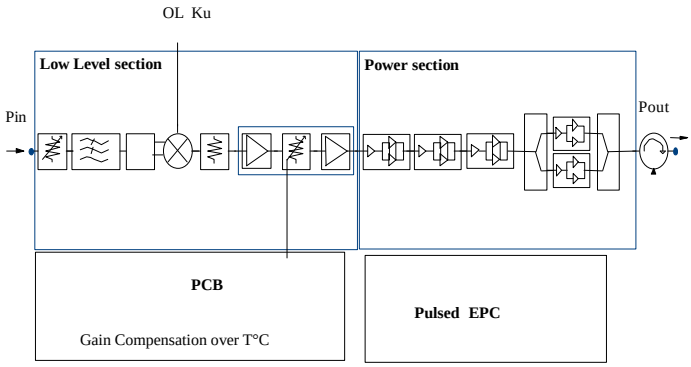

Fig. 2: Ku-band Transmitter Schematic

III. Experimental Results

Hybrid Power Amplifiers (HPA):

The power amplifiers have been designed and manufactured by Alcatel using the microwave hybrid technology and the power chip devices [3,4]. Figure 3 shows the simplified schematic of these two-stage amplifiers.

To avoid imbalance operation, each couple of HFET is connected by gate and drain stabilizing resistors. To obtain the optimum power performance, a load pull simulation was performed with in-house model using Libra simulator [5]. The two stages at C-band are designed on a high dielectric substrate with low insertion losses, in order to reduce the output section losses and optimize the matching network.

The RF and DC decoupling as well as the bias circuits are included in the Hybrid-Power Amplifier to make it a self-content module without the need of outside circuitry.

The measured power performance of the C-band HPA is shown in the figure 4.

The output power is 39.5dBm at 2dB of gain compression with a linear gain of 22dB and the associated PAE greater than 40%.

The measured output power, gain, and the power added efficiency of the Ku-band HPA is plotted in the figure 5. The output power is higher than 37dBm at 2dB of gain compression with a linear gain of 10dB and the associated PAE greater than 27%.

There is a good correlation between the simulation and the measured results. This has been achieved by using a comprehensive and extensive methodology developed by Alcatel [3,4,5].

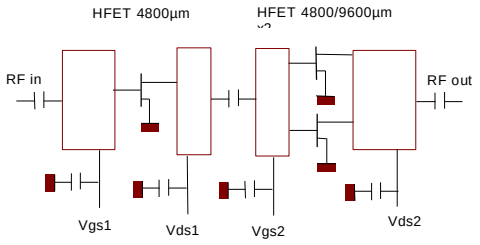

Fig. 3: Simplified schematic of the HPA

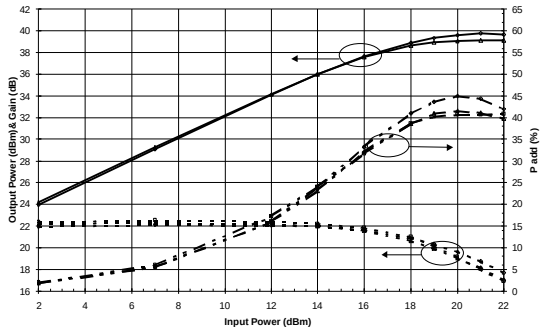

Fig. 4: Measured results of C-band HPA
(Between 5.125-5.475GHz)

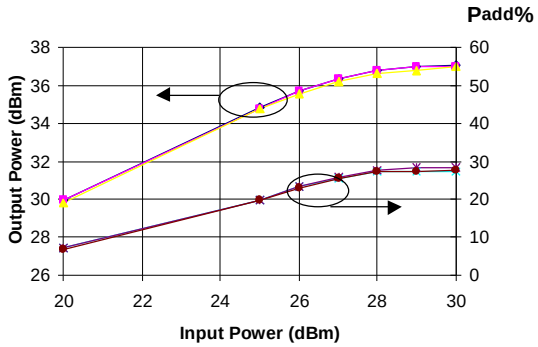

Fig. 5: Measured results of Ku band HPA
(Between 13.4-13.75GHz)

C-Band Transmitter:

The measured time domain response of the output signal of the C-band Transmitter is given in figure 6. The output power is 45.2dBm, while the amplitude distortion during 110µs-pulsed signal is less than 0.1dB.

The main critical parameter for the Altimeter is to get a low delay time.

The measured time delay variation over the operating frequency range is 0.9 nano-seconds as is shown in the figure 7.

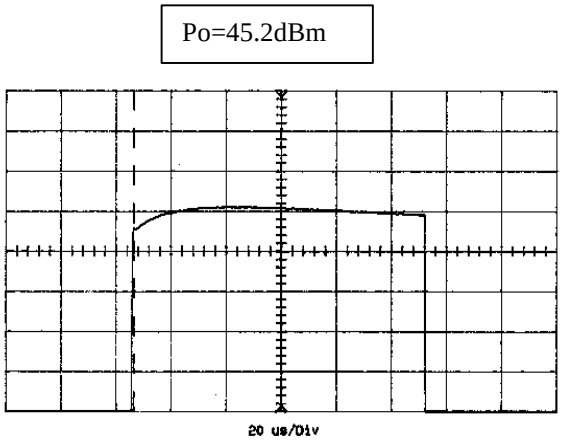

Fig. 6: Measured time domain response of C/Tx
(@F=5.3GHz)

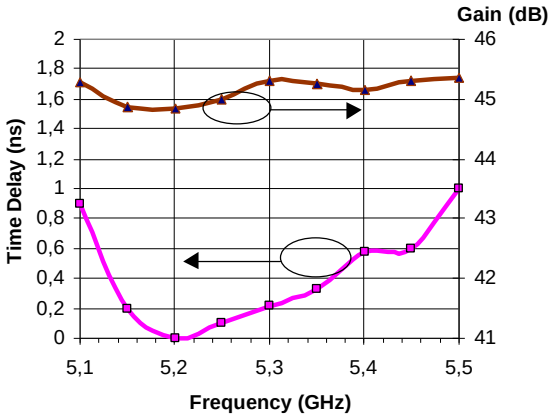

Figure 7: Measured relative time delay and gain of the C/Tx

Ku-Band Transmitter:

The measured pulsed output signal of the Ku-band Transmitter is shown in figure 8. The output power is 39.5dBm, while the amplitude distortion during 110µs-pulsed signal is less than 0.15dB.

The measured absolute value of the time delay is 10.1 nano-seconds. The time delay variation over the operating frequency range is 0.7 nano-seconds as is shown in the figure 9.

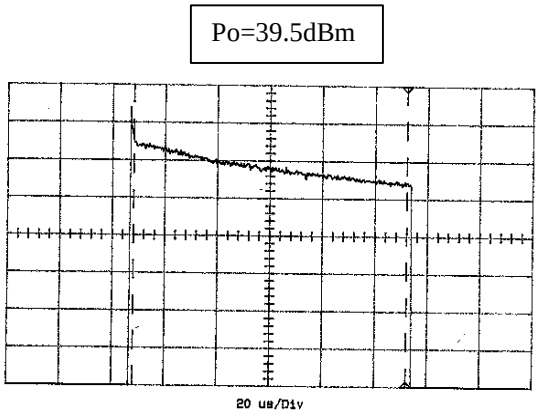

Fig. 8: Measured time response of Ku/Tx (@F=13.6GHz)

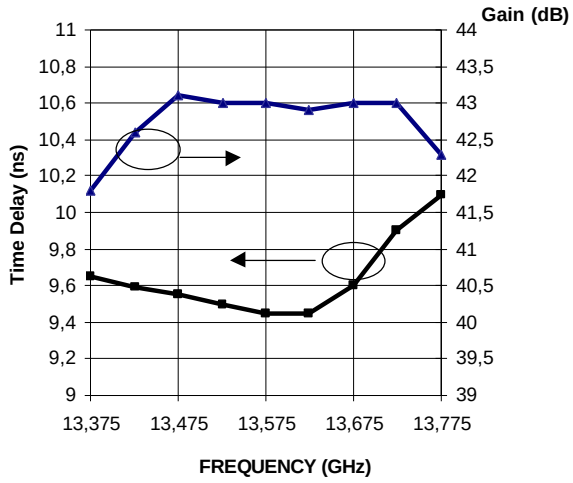

Fig. 9: Measured time delay and gain of the C/Tx

The output power and power consumption of the C-band and Ku-band transmitters for the 110 µs-pulse duration and two configurations of 4Ku/1C and 6Ku/1C are given in the table 1:

Table 1: The measured performances of the C/Ku band Transmitters.

Config.	Duty Cycle (%)		Po (dBm)		Pc (W)	
	Ku-Tx	C-Tx	Ku-Tx	C-Tx	Ku-Tx	C-Tx
4Ku/1C	18.1	4.5	39.5	45.2	14.2	9.2
6Ku/1C	19.4	3.2	39.5	45.2	14.9	6.9

The measured harmonic contents of the transmitters are less than –40dBc, with the out-of-band signal levels at the 18.3GHz, 23.8GHz and 34GHz less than –174dBm.

IV. Conclusion

We have developed and manufactured 30W C-band Transmitter and 8W Ku-band Transmitter to be integrated in the Poseidon Altimeter for measuring the height of the waves over the oceans.

This instrument is on the board of Jason satellite with many other sensitive experimental instruments, which requires a very high quality output power spectrum.

In conclusion, low distortion of the pulsed waveforms; high linearity, small size and weight of the Transmitters make the technology ideal for many satellite radar applications.

Acknowledgement

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