ALCATEL TELEMETRY TRANSMITTER AND BEACON TRANSMITTER (NEW GENERATION)

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SCOPE

Presentation for ITC 98 of Alcatel Espace last studies and developments regarding TTC Products This document lays on 3 parts:

- a technical point of view
- a technology/design description
- a synthesis showing main performance and results

KEY WORDS

Telemetry Transmitter, Beacon Transmitter, Modulation, Phase Locked Loop, Synthesizer

1. INTRODUCTION

Among the Alcatel pilot products, we find without any doubt, TTC equipment.
One can say that regarding C/ Ku/Ku+ TC&R Receivers and Telemetry Ttransmitters or Beacons Transmitters, Alcatel is now leader in the world.
And Alcatel could not imagine to be absent today.
We will present here what may be the reason of Alcatel success:

- Up to date signal processing techniques (a large study team have been working on the most modern techniques for several years and we will try here to summarize its work).
- Design resulting from a long experience allowing high rate production, low cost with still high performances.

2. TECHNICAL POINT OF VIEW

2.1 TRANSMITTER GENERAL ARCHITECTURE.

Figure 1 shows a standard Ku Band Telemetry Transmitter block diagram

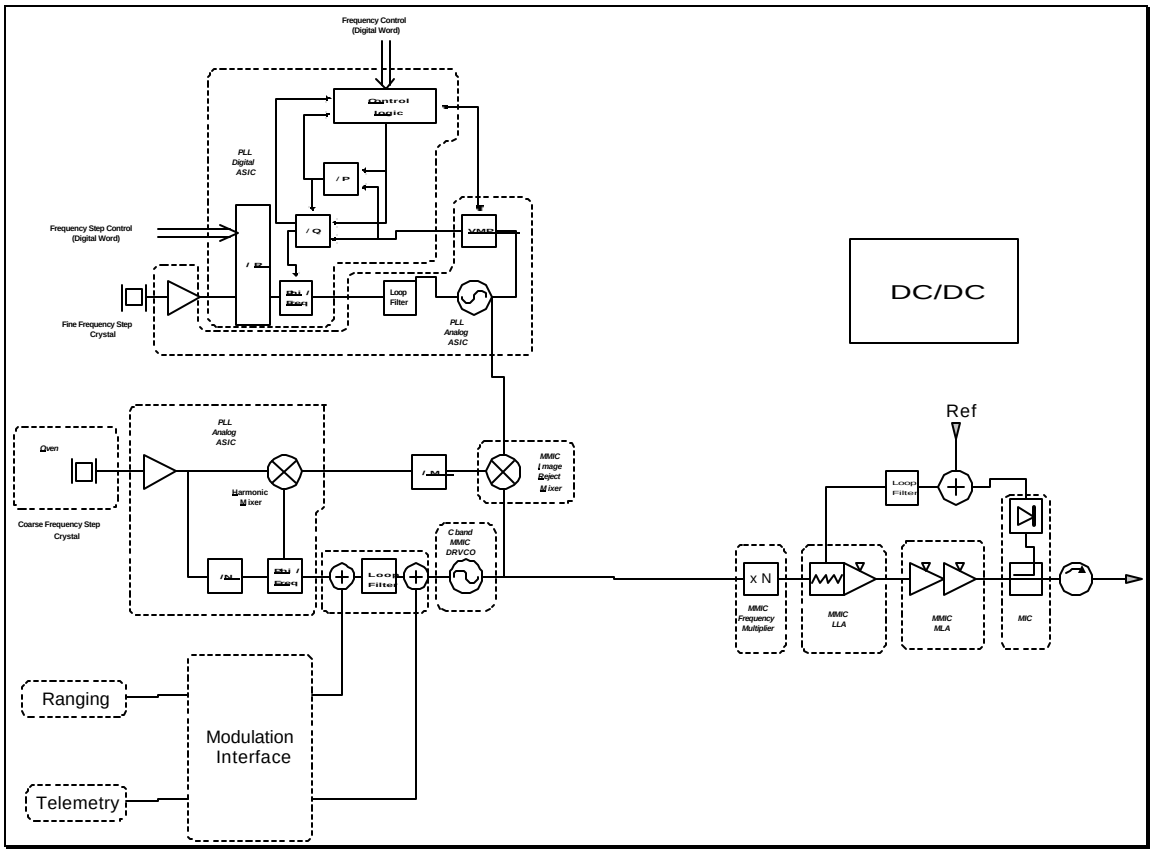

Figure 1 : Standard Ku band Transmitter Block Diagram

A Telemetry Transmitter can be divided into three main functions.

- Signal generation and amplification up to the specified output level.
- Interfacing with spacecraft, signal processing and carrier modulation.
- Telecommand and telemetries managing.

A Beacon Transmitter usually do not include any carrier modulation, so the dedicated functions are not implemented within the unit.

2.1.1 SIGNAL GENERATION.

This bloc consist of a C band Dielectric Resonator Voltage Controlled Oscillator with a very high Quality factor in order to keep modulation index constant with an excellent phase noise.
The output of the C band DRVCO is locked on a Crystal Oscillator Reference by means of a Phase Locked Loop in order to meet the frequency stability requirement. This PLL uses a frequency transposition in order to:

- Minimize Crystal procurement costs and schedule
- Offer to the customer the possibility to generate two different frequencies.
- Offer the possibility of a very late final frequency choice.

It is followed by a Frequency Multiplier (if needed) to reach the nominal output frequency
Then, Power Amplification achieves the required output level. In order to meet the output power stability requirement, an Automatic Level Control loop is implemented. This loop detects the output level and corrects it by varying a Voltage Controlled Attenuator.

2.1.2 INTERFACE AND CARRIER MODULATION

The interface function is in charge of interfacing with the TC&R Receiver for the Ranging tones and with the SCU for the TM subcarriers.
The modulation function is basically implemented within the DRVCO by means of a Varactor Diode coupled to the DR, for classical transmitters but also within the PLL for very low Ranging tones frequencies .
It also manages the Ranging and Telemetry channels by switching them On or Off, according to the received telecommands.

2.1.3 TELECOMMAND AND TELEMETRIES MANAGING

This bloc includes

- All the telecommands interfaces.
- The associated telemetries.
- The internal switching interfaces.

2.2. FREQUENCY GENERATION PRINCIPLES.

The basic idea is to generate one frequency among a very large quantity of possible frequencies while minimizing the number of crystals to purchase, which are usually the main schedule issue.
The output frequency range is coarsely cut up into 10 MHz (in C band) or 40 MHz (in Ku Band) sub bands. From this first coarse cutting up come the main loop crystal frequencies
Then, every subband is finely cut up into 125 or 500 kHz.
The number of crystals is reduced to 60 instead of about 1000 for a single frequency generation method.
The synthesizer is composed of a main loop, principally made of analog ASIC and GaAs MMIC modules, and of a transposition loop made of analog and digital ASICs, according to the block diagram in Figure 2

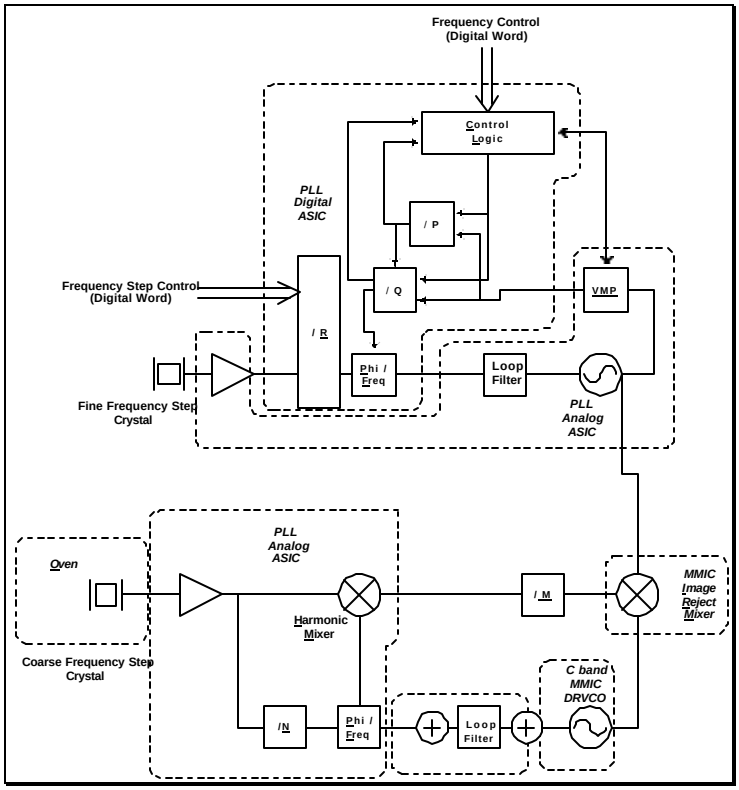

Figure 2 : Frequency Generation Principle

Main Loop architecture.

This loop is composed of an Ovenized Crystal, a PLL analog ASIC, a microwave frequency divider and two GaAs MMICs.
M and **N** in the main loop are fixed modulus dividers. As previously explained, the coarse frequency is mainly set by crystal frequency and harmonic selection in the Harmonic Mixer of the main loop. A Phase/Frequency Comparator controls this loop.

At power up, the frequency acquisition characteristics of such a comparator, helps the loop to lock whatever the initial conditions are. The VCO is a low cost GaAs MMIC associated to a Dielectric Resonator coupled to a microstrip transmission line to form a C band VCDRO. The Image Rejection Mixer is a low cost GaAs MMIC that reduces the image mixer product and the LO signals in order to drive the microwave divider M properly. For MMIC manufacturing reasons, only the IF coupler is made of discrete capacitors and inductors.
For phase noise purpose, the loop bandwidth is set to about 5 kHz.
For stability reasons, the crystal is mounted in an oven that keeps crystal temperature constant.
The transposition loop, is mainly build up with an analog and a digital ASIC. The PLL analog ASIC includes the frequency generation, the loop filter, a 50 MHz Oscillator and a Variable Modulus Prescaler. The PLL digital ASIC includes two programmable counters P and Q , a Control Logic that controls the V.M.P. and the counters P and Q. A digital Phase/Frequency Comparator controls the transposition loop. As for the main loop, the frequency characteristics of this comparator always locks the loop in any case.

2.3 MODULATION PRINCIPLE.

The Phase Modulation process takes place in two different places of the frequency generation circuit. The main modulation input is located at DRVCO side. But as previously explained, the loop bandwidth being close to 5 kHz for phase noise reasons, low frequency minor tones are very perturbed by large loop bandwidth. To bypass this problem a second modulation input is located just after the phase comparator, according to the block diagram in Figure 3.

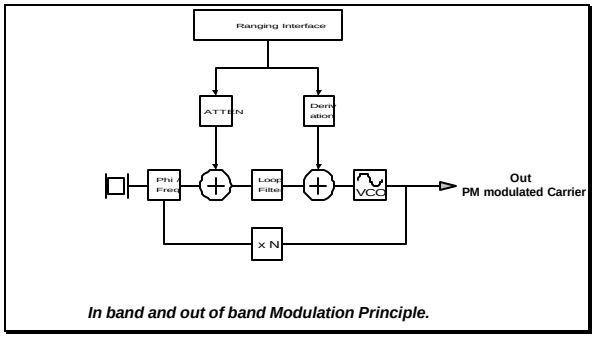

Figure 3: In band and out of band phase modulation principle

This modulation principle allows the use of low cost space qualified parts while keeping modulation performances and spectral purity

Typical plot of modulation index versus modulation frequency is given in Figure 4 , and a plot of typical SSB Phase Noise in Figure 5 .

Transmitter main performances

	C-band	Ku-band
Frequency range	3.4/4.2Ghz	10.7/12.75Ghz
Output power range		
High	up to 26 dBm	up to 27 dBm
Low	from 6 to 10 dBm	up to 6 to 10 dBm
Output power stability	<1 dBpp (all conditions)	<1 dBpp (all conditions)
Integrated Phase Noise	<3°rms	<5°rms
Output frequency stability	±4.8 ppm (all conditions)	±4.8 ppm(all conditions)
Power consumption	<13W	<13W
Reliability	700fits at 45°C	700fits at 45°C
Weight	<1.3kg	<1.3kg
Size	152mm x 200mm x 66mm	152mm x 200mm x 66mm
Qualif. Temp. range	-20/+65°C	-20/+65°C

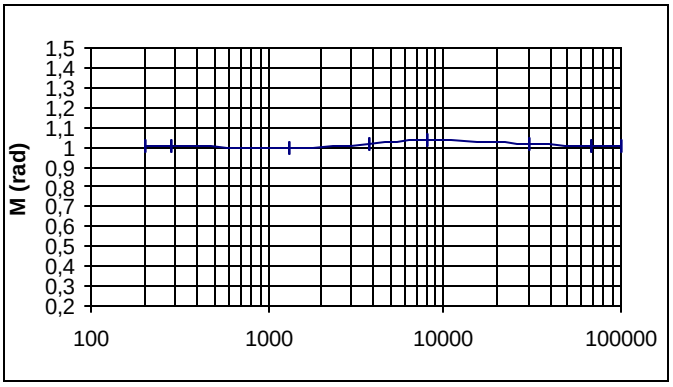

Figure 4 Modulation index vs frequency

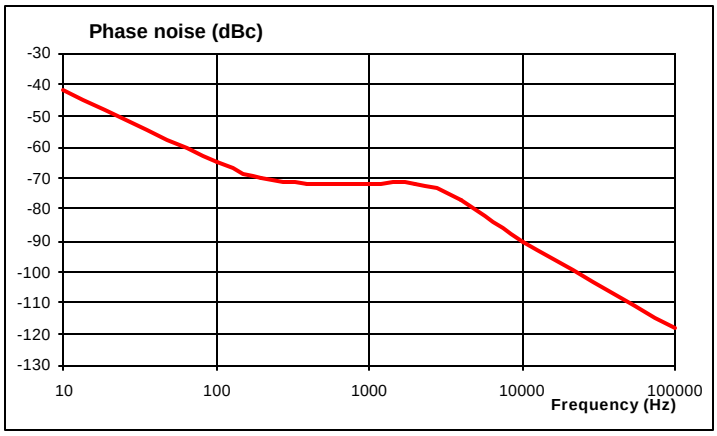

Figure 5 SSB Phase Noise at 12 GHz

3. TECHNOLOGY & INDUSTRIALIZATION

3.1 MODULARITY/INTERCHANGEABILITY

The philosophy of the Transmitter and architecture lays on modularity The Figure 6 illustrates the transmitter mechanical breakdown, and Figure 7 is a picture of our regular Telemetry Transmitter.

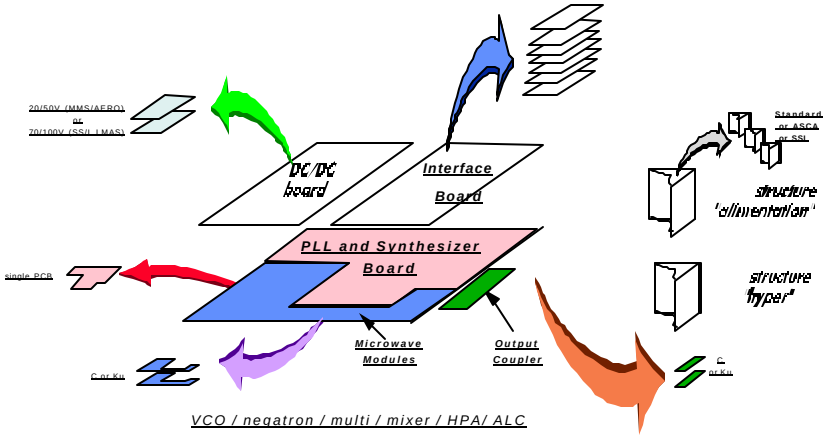

Figure 6 : Modular architecture of the Transmitter

This modularity allows us to make a Beacon Transmitter without any other new development, just by removing from the Interface Board the unnecessary parts.

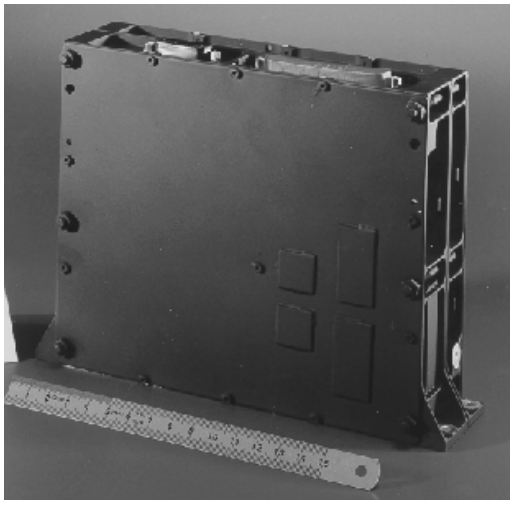

Figure 7 Ku band PM Transmitter

3.2 TECHNOLOGIES USED

We definitely wanted to be competitive on cost, interchangeability was not the only way of research.
We have to develop very integrated modules allowing minimum tuning.
For that reason, we developed specific modules as the following :

3.2.1 MMIC

We use MMIC in the RF sections. These GaAs MMICs dies and their specific microwave packaging up to 18 GHz were designed by ALCATEL ESPACE for standard TTC and Telecom applications. Typical Ft is about 30 GHz. We especially take care of packaging because it was an major issue for technical performances and cost effectiveness. Figure 8 shows the MMIC micropackage arrangement inside the telemetry transmitter.

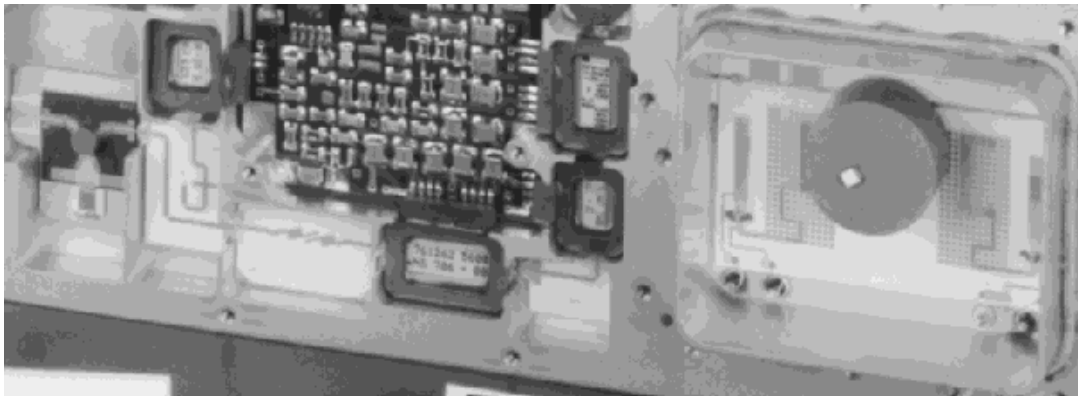

Figure 8: MMIC in RF section of the Telemetry Transmitter

3.2.2 ANALOG & DIGITAL ASICS

We use an analog ASIC at frequencies up to 200 MHz and for LO synthesizer, as shown in Figure 9. These ASICs were developed by ALCATEL ESPACE in space qualified standard cell gate arrays for general purpose applications. Typical Ft of this technology is 9 GHz for the faster circuit. The present limitation for frequency performances is the packaging and the PCB assembly process. Digital ASIC are used for Synthesizer logic control. These ASICs were designed by ALCATEL ESPACE in a space qualified technology. These functions are used in ALCATEL ESPACE TT&C Receivers and Transmitters and also in Telecom products

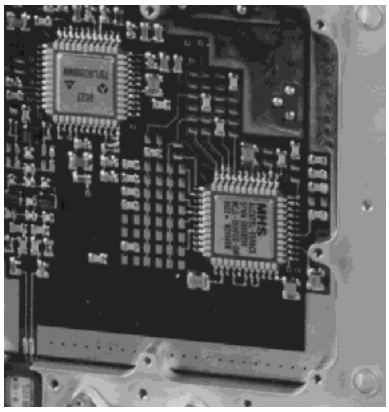

Figure 9: Telemetry Transmitter Synthesizer ASICs

4. CONCLUSION

4.1 BACKGROUND

Thanks to the presented techniques and technologies , we managed to propose « on the shelf equipments » (and « basic bricks ») which allows very short delivery schedule: around 7 months.
Just regarding the presented generation, we supplied already 50 sets of transceivers (more than 50% of world commercial market)
We have to add to this number the 120 command receivers and 120 telemetry transmitters produced for Globalstar (Low Earth Orbit satellite constellation) using the same techniques.

4.2 FUTURE

Thanks to our high level of experience regarding command receiver and telemetry transmitters design and production (more than half of the world today's market),we are today to develop Skybridge Constellation TT&C units (more than 160 units).
We keep still working on the future units (higher integration, lower costs and schedule, up to Ka band and new standards ...).

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