



[SSC13-I-8] X Band Downlink for CubeSat : From Concept to Prototype
| **Gwenael Guillois, Thomas Dehaene, Tristan Sarrazin (Syrlinks)**
Eric Peragin (CNES)

> X Band Downlink for CubeSat : Introduction and Concept

- CubeSat or NanoSat are considered for new type of missions for earth observation, astronomy or space spectrum survey missions
 - → Large amount of data so much higher data rate telemetry solutions are required
 - → So trend is to move from UHF/S to **X-band**
- 1st system analysis made by CNES & Syrlinks in 2011/2012 :
 - Leading to a presentation “X Band downlink for CubeSat made by E. Peragin in August 2012 at 26th Annual AIAA/USU Conference on Small Satellite, Logan (USA)
 - Upto 1.5-2 GBytes can be downloaded by pass with a 2W RF output power, a small 0dBi patch antenna on board, and 5 m antenna at the ground station

> X Band Downlink for CubeSat : “From concept to prototype”

- Key specifications

Item	Typical value
Frequency band	8025 to 8400 MHz
RF Output power	2 W typical tunable from 30 to 33 dBm (with an option up to 34 dBm)
Waveform (modulation, coding & filtering)	OQPSK / convolutional coding 7 ½ / 6 th order Butterworth
Data rate (user)	Programmable from 3 to 50 Mbps
Implementation losses	< 1 dB @ BER = 10 ⁻⁹
Data & clock input format	LVDS
Input DC voltage	8 to 32 V (no galvanic isolation)
Power consumption	~ 10 W for +33 dBm RF
Volume	< 10 x 10 x 3.0 cm ³
Weight	~ 300 g
Operating temperature	-40 to +50°C
Life time	2 to 5 years (depend upon qualification tests)
Radiation tolerance	5 to 10 kRad (depend upon qualification tests)

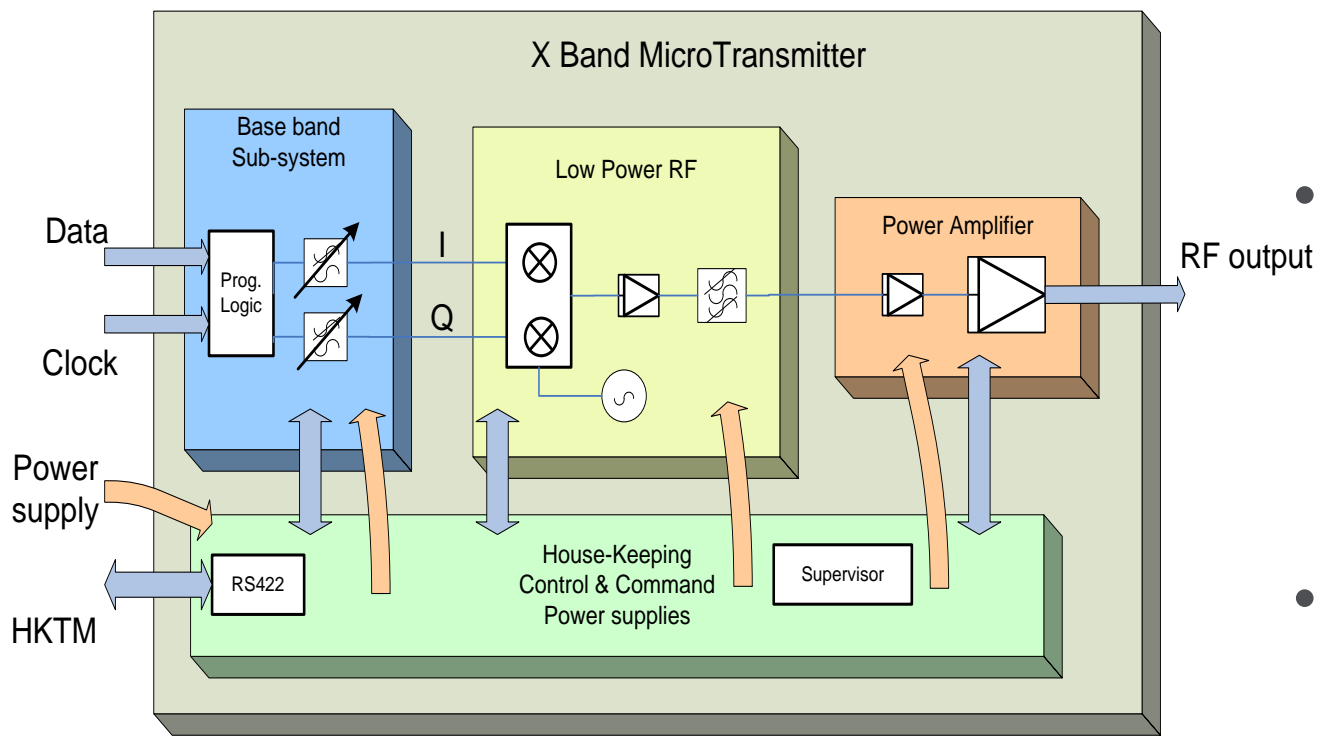
- 1st prototype developed by Syrlinks in 2012/2013



- All key functions (BB+RF) except power management are integrated in this prototype

> X Band Downlink for CubeSat : Transmitter architecture

- BB sub-System :
 - Input digital data are encoded, mapped and filtered
 - Tunable filter (upto 50 Mbps)
- RF sub-system :
 - Homodyne up-converter
 - Synthesizer (TCXO, X band VCO, PLL IC and prescaler)
 - RF filter
- Power Amplifier sub-system
 - Driver + Power stage : up to 34 dBm at the RF output.
- Control/command Sub-system
- Power sub-system (*not included in the proto*)

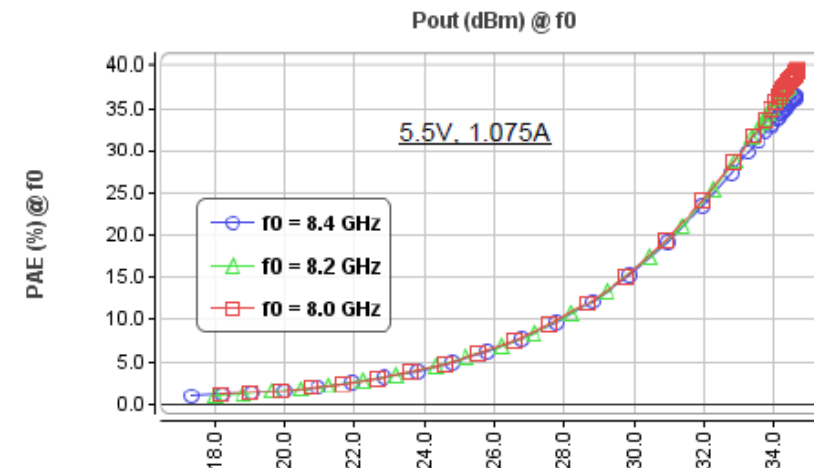
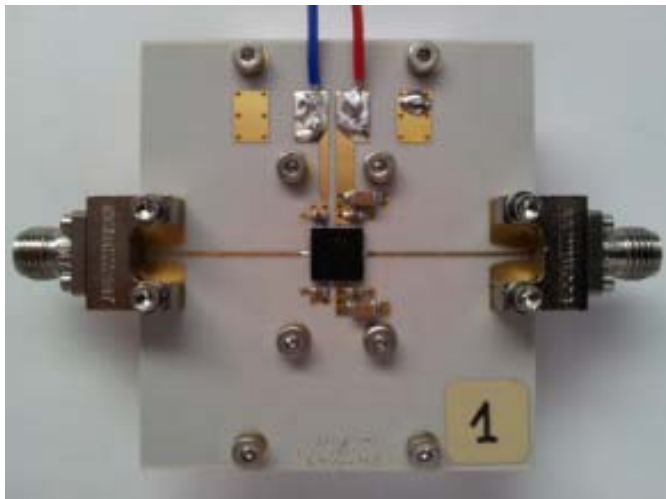


> X Band Downlink for CubeSat : Component selection and Qualification

- COTS components are used :
 - Some components are based on the heritage of X band PROBA-V transmitter (ESA mission launched on May 2013), but others are new.
 - Each COTS components choice is justified.
 - > Components technology is described and reliability data from manufacturer are provided.
 - > Some specific qualification tests are made on some key selected components (Destructive Part Analysis (DPA), burn-in, cumulated-dose radiation test, heavy ions radiation test, ...).
- Qualification of equipment :
 - Some “aggravated tests” will be done (temperature cycles, life tests, on/off cycles, mechanical trials, vacuum tests, radiation tests, ...).
 - More severe conditions levels might be then applied to stress the equipment in some cases up to destruction.
 - This principle was successfully applied on 2 of our products :
 - > **Myriad TTC transceivers in S band:** 44 transceivers delivered to CNES, EADS Astrium and Thales Alenia Space
 - > **Proba V X band transmitters:** 2 FM delivered to ESA with GaAs RF amplifier and 1 FM delivered with GaN RF amplifier) + other FM under manufacturing (Europe and North America)

> X Band Downlink for CubeSat : Power amplifier Sub-System

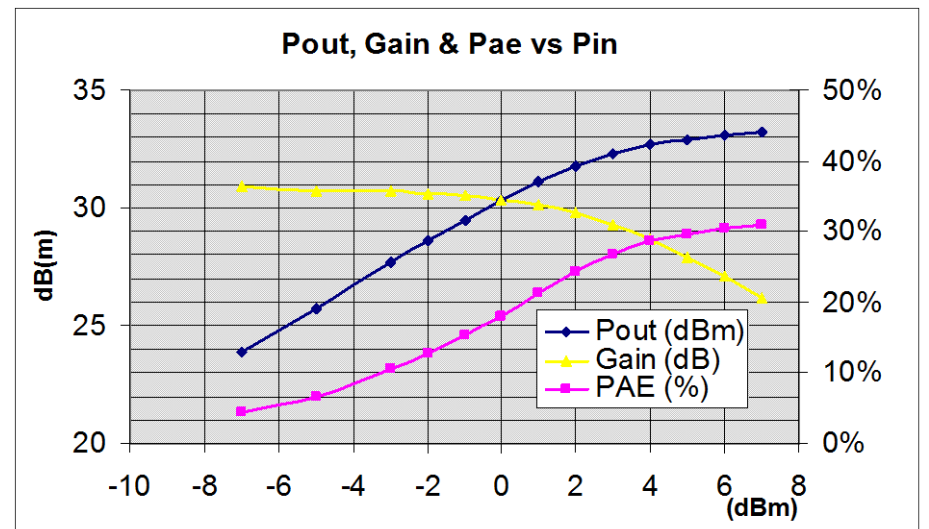
- This is a key function with more than $\frac{3}{4}$ of the total consumption of the transmitter
- A specific study was made on a load-pull test bench to optimize the efficiency (allowing to reach between 35/40% PAE for 34dBm)



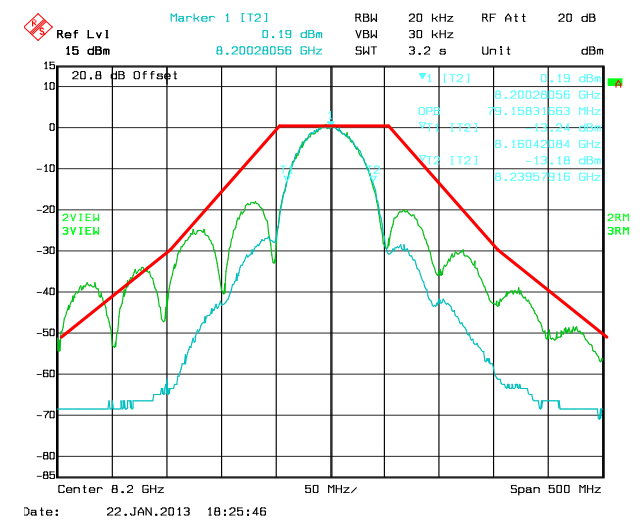
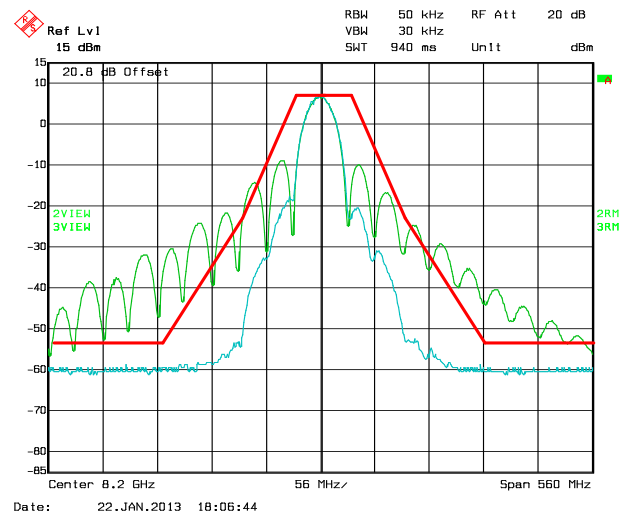
Optimized input and output matching circuits were designed for the power stage RF transistor

> X Band Downlink for CubeSat : Measurement Results on Prototype

- RF chain characteristics @ 8200 MHz



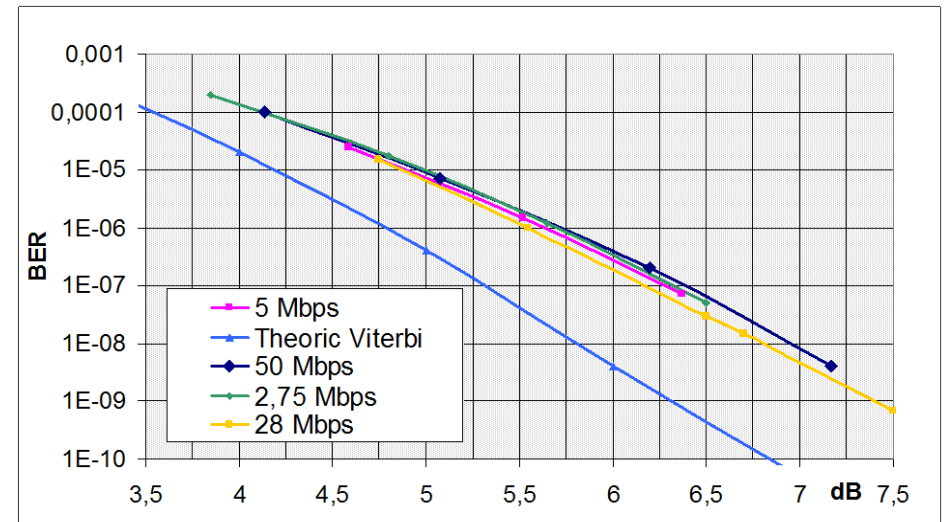
- Emitted spectrum (with and without filtering) @ 28 Mbps & @ 50 Mbps



> X Band Downlink for CubeSat : Measurement Results on Prototype

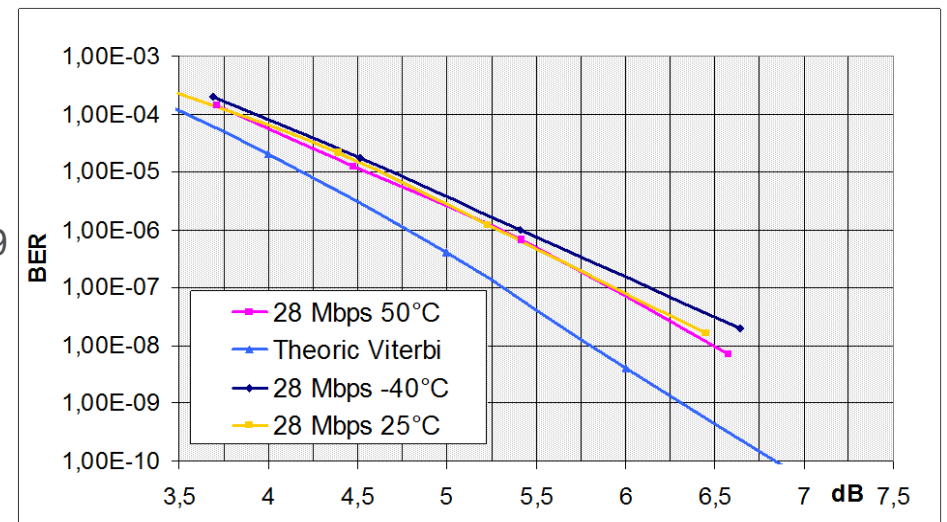
- OQPSK Modulation with Convolutional coding (7; 1/2)

- BER vs Eb/N0
 - for some data rates



- In temperature from -40°C to $+50^{\circ}\text{C}$

- Implementation losses : 0,8to1dB @10⁻⁹
 - Including “receiver losses”



> X Band Downlink for CubeSat : Main conclusions

- This prototype confirms the feasibility of X band transmitter for CubeSat
- The prototype presents very interesting performances which are very closed to those of usual X band modulators for bigger satellites.
- With a total DC consumption of 10W (for 2W RF output power), a volume of 0.3U and a mass of 300g, this transmitter allows to download telemetry to ground stations at data rate between 3 to 50 Mbps with less than 1 dB system transmission losses.
- The transmitter can be operated in fixed or variable bit rate in flight.
 - The VBR would allow to “roughly” doubling the damping capacity
 - But this operating mode requires a flexible data rate mass memory solution and some adaptations on ground station receiver

> X Band Downlink for CubeSat : Next steps

- EQM development on-going
- Thanks to PROBA-V qualification campaign and specific pre evaluation tests, risk of product qualification is low.
- Flight models should be available in Q3 2014
- C band version of this MicroTransmitter would be easily achievable (interest for specific missions as AIS, ...)

Thanks for your attention

Gwénaél GUILLOIS – gwenael.guillois@syrlinks.com

Visit us on booth 101