Wave
Advanced Technology Applications

IMT
Ingegneria Marketing Tecnologia

L'impegno Italiano nel settore dei CubeSat: tecnologie e missioni future

Ka Transmitter for CubeSAT New Space Missions (SDR KaT)

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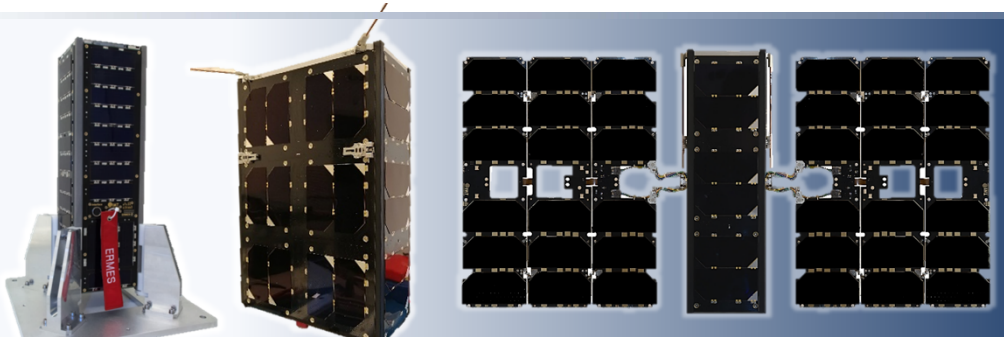
S. Arena, T. Cavanna (**Wave srl**)

02-04 Luglio 2024



IMT Srl

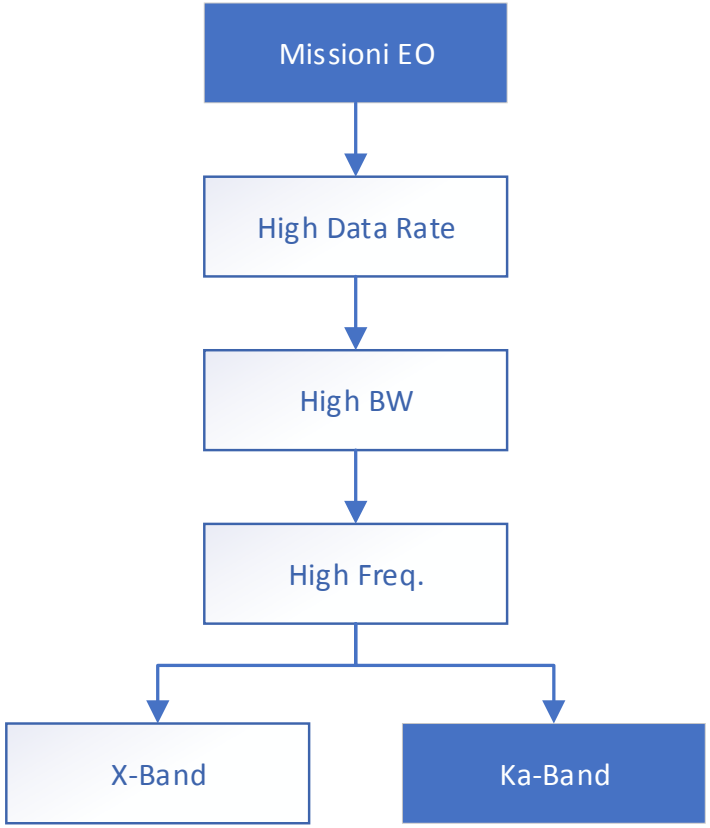
Since 1991:

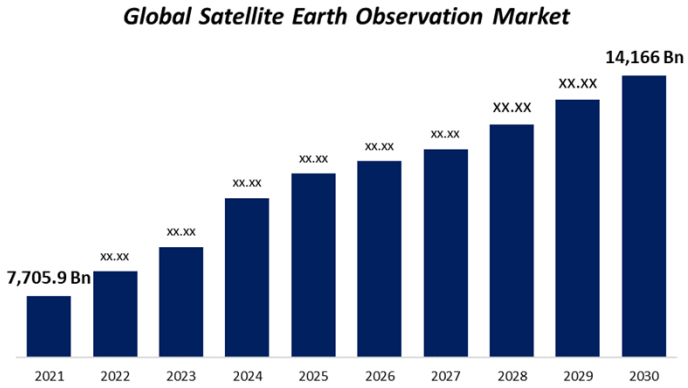
System Engineering: design and development of Nano/Microsatellites and relevant On-board Units for Space applications.

Parts Engineering: Characterization and Testing of EEE components.

IoT Solutions: design and development of IoT Solutions for Smart Cities, Environmental, Infrastructure and Agriculture monitoring.

Ka-Band Downlink



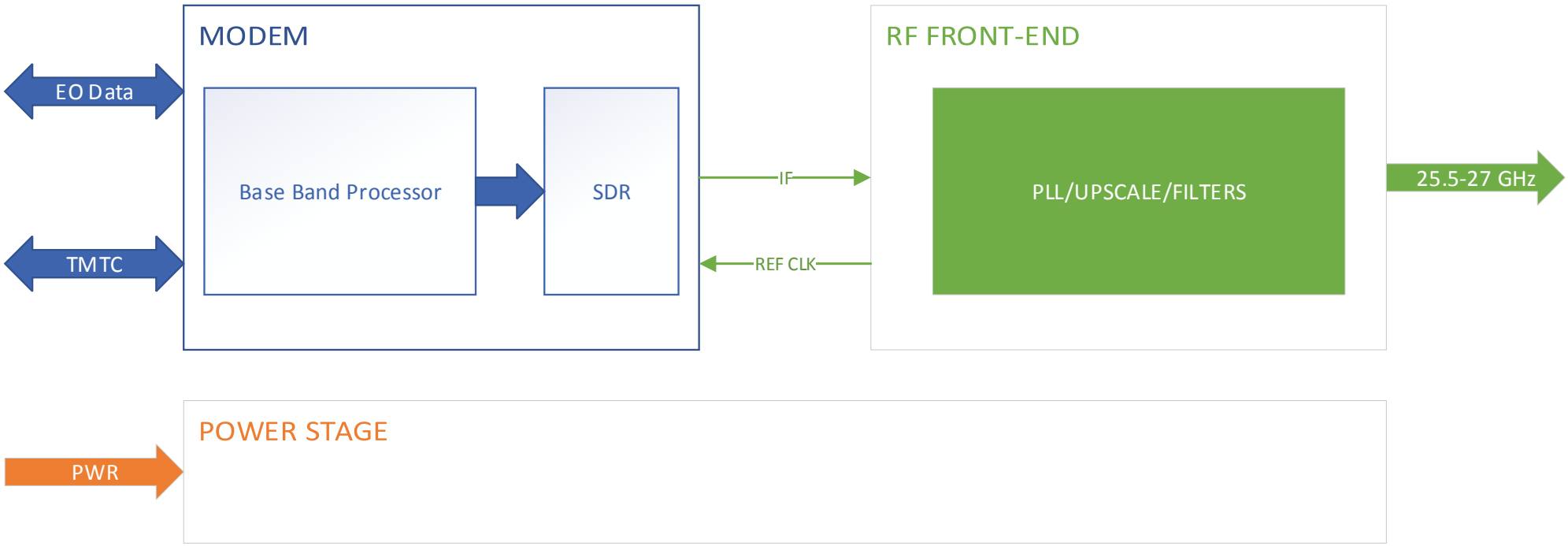


Satellite Earth Observation Market Size, Share and Forecast to 2030 (sphericalinsights.com)

ECC REPORT 115

"Almost all earth observation spacecraft are using the frequency band 8 025-8 400 MHz for transmitting their payload data to ground stations."

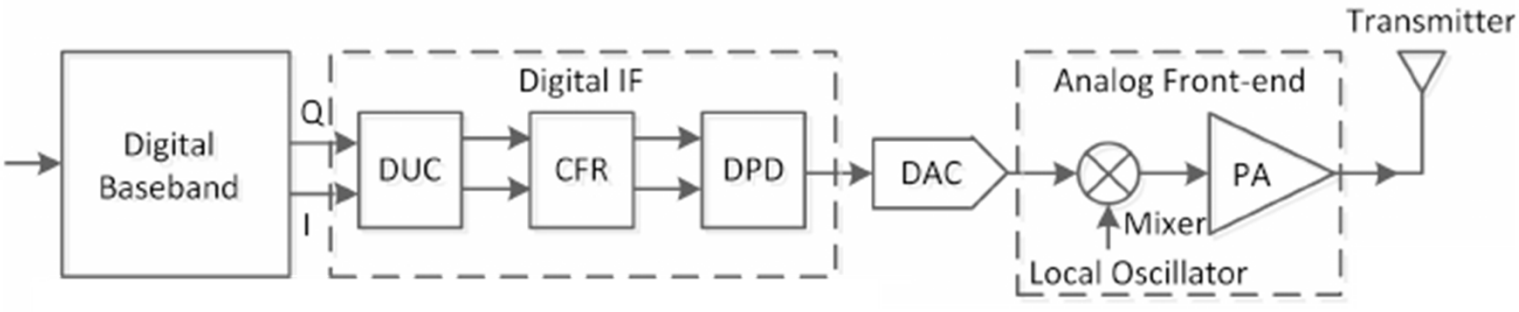
Architecture



Preliminary design

Software Defined Radio

"Software-defined radio (SDR) is a radio communication system where components that conventionally have been implemented in analog hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a computer or embedded system."[1]

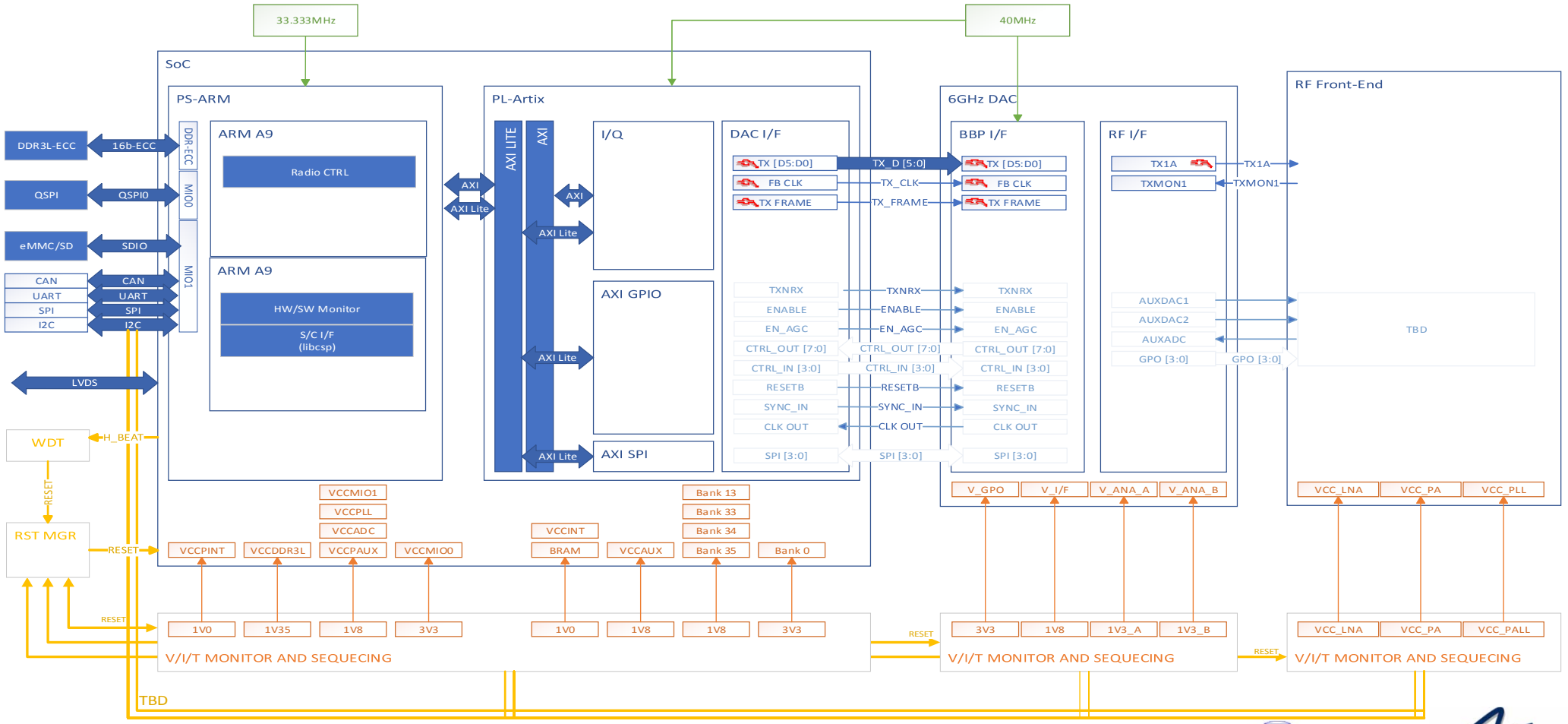


[1] Markus Dillinger; Kambiz Madani; Nancy Alonistioti (2003). Software Defined Radio: Architectures, Systems and Functions. Wiley & Sons. p. xxxiii. ISBN 0-470-85164-3.

Enhancements

- Watchdog
- Golden Image
- SW EDAC (Hamming)
- DDR ECC
- RT/RH Components
- LCL

Preliminary Design



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Performances (TBC)

Frequency Range	25.5 GHz to 27 GHz
Bandwidth	up to 56MHz
Output Power	25-30 dBm
EIRP	50 dBm
Modulation Schemes	QPSK , 8PSK, 16 APSK, 32 APSK, 64 APSK
Coding Schemes	Convolutional, Reed-Solomon, Turbo and LDPC
Oscillator	TCXO
Input Data Rate	>100Mbps
Input Type	CAN (TMTC / Low Speed) LVDS or Custom (DATA / High Speed)
Symbol Rate	50Msps
On board Memory	>4GB
Supply Voltage	12V-36V
Power Consumption	≤8W Idle ≤15W Transmission
Volume	≤0.5U (w/o antenna)
Mass	≤0.6kg (w/o antenna) ≤1.2kg (with antenna)
Operational temperature	-20ºC to 60 ºC

Wave Srl

Since 2005:

RF and Microwave: MMIC and Module design for defense, space and telecom applications.

From UHF up to W band design experience.

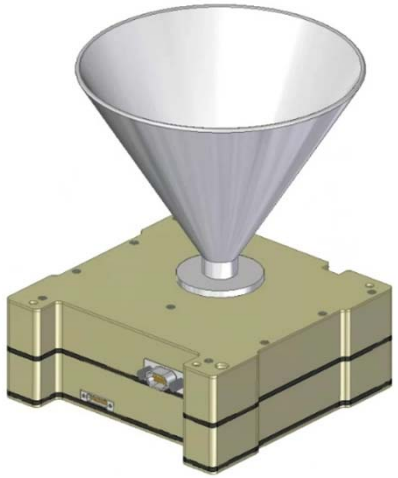
RF Constrains from Cubesat Platform

Due to Limited on-board power: only 8-10W are available for the Ka Upconverter and Power Amplifier.

Platform Stability: Ka band pointing losses could easily reach around 4-5dB due to misalignment with the ground station antenna.

Ka band variable attenuation sources such as clouds, oxygen, water vapor could lead to several dBs of signal attenuation at the receiver level.

Limited space: due to the cubesat form factor 10 x 10cm is the available space for TX lineup modules, including the Ka band frequency synthesizer section.



Typical EIRP: a target of around +50dBm.

All those constrains guide towards a compact Ka payload with an high gain directive antenna (more than 20dBi at Ka frequencies).

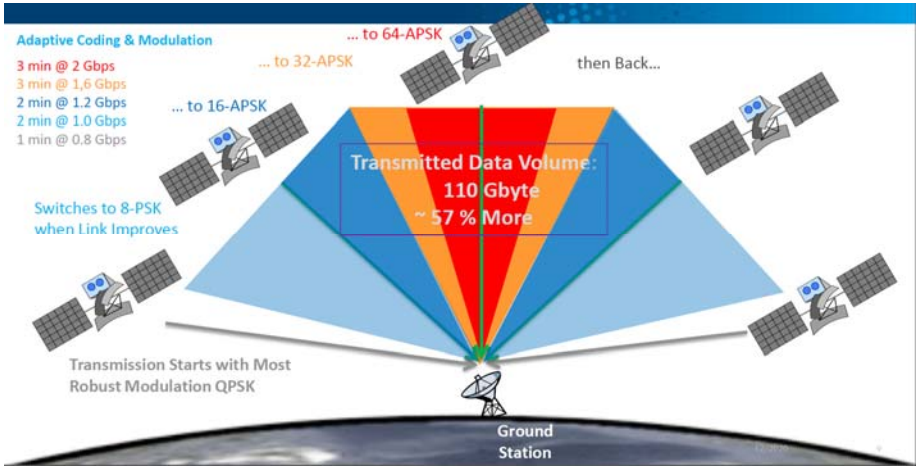
Power Amplifier (PA) Requirements

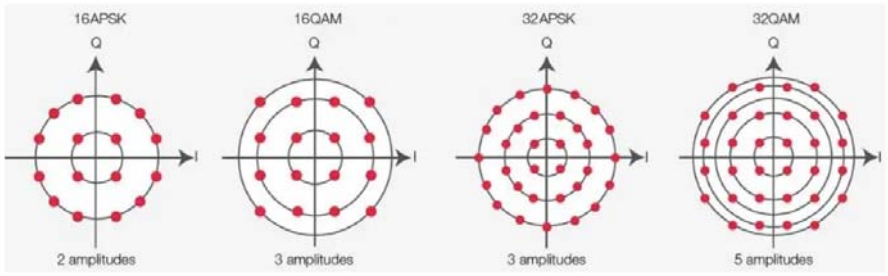
SDR enabled Adaptive modulation schemes permit to optimize link speed and overcome Ka band variable attenuation respect to link budget, but require output power flexibility.

SQPSK, PSK and APSK modulations (with lower PAPR) are more tolerant to PA non linearities than QAM enabling quasi-saturation or saturation working conditions and consequently more efficient transmitters.

Limited COTS options are available for 25.5-27GHz PA selection. European or USA solutions exhibit efficiencies between 15% and 22%.

To match power consumption constraints, limited available COTS components and required output power, Digital Predistortion can be a potential solution.





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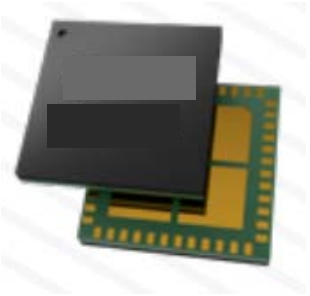
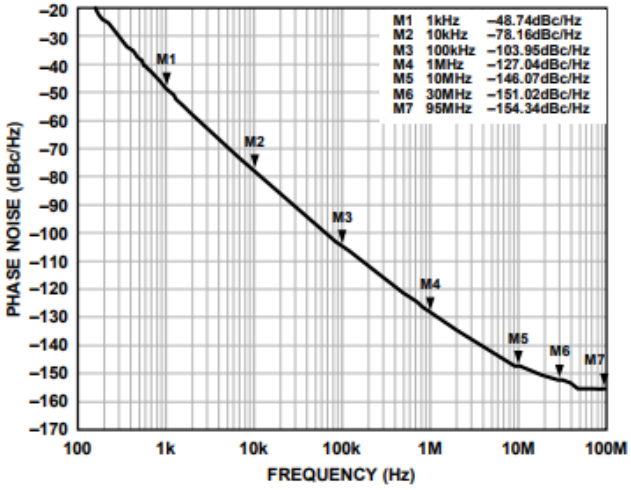
Frequency Synthesizer

Thanks to the SDR output RF frequency range the Ka Upconverter can be based on a single frequency conversion architecture.
Frequency Agility is obtained at SDR level, fixed frequency Ka synthesizer is an hypothesis.
Hybrid module approach to frequency synthesis, such as DRO, are quite big respect to the available space for the synthesizer which shares the 10x10cm footprint with all the other payload RF and DC elements.



Frequency synthesis between 20GHz and 30GHz can be realized with synthesizer chipset, a low cost and low space alternatives to a classic hybrid approach.
High data-rate spectral purity are achievable with the new synthesizer chipsets.



CUBESAT application will require a dedicated environmental screening for synthesizer chipset without space heritage.

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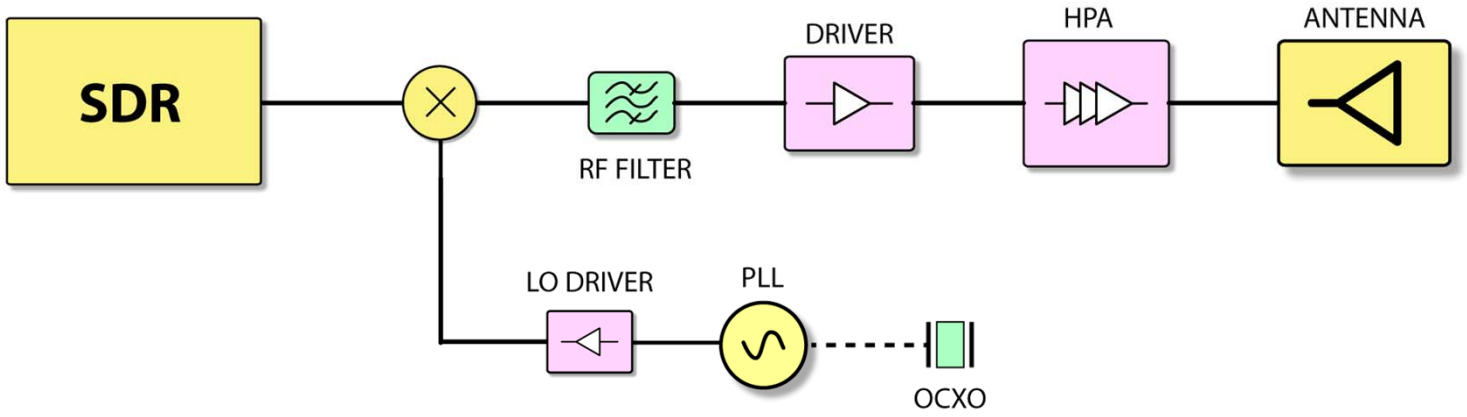
Architecture

The simpler the architecture the best it can match the space constraints of the CUBESAT architecture.

Technological challenge:

- Heat dissipation of the PA. Metal-backed RF PCB solution used in the C-DST TX project will be the baseline for this system.



Conclusions

IMT Srl & Wave Srl are developing a Ka Transmitter for Cubesat missions like Earth Observation or TLC.

The Effort of both is focused on:

- Performances: to meet link requirements with the best efficiency
- Reliability in Space: to meet LEO space requirements

CUBESAT Technological requirements:

- Low Power: power availability on platform and heat dissipation
- Small Dimensions: space availability on platform and losses reduction due to long RF paths at high frequencies

Roadmap

- Project started
- 20 Months of development
- Expected Q1 2026

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SDR KaT
Software Defined Radio
Ka Transmitter

"L'impegno italiano nel settore dei CubeSat: tecnologie e missioni future" 2° ed.
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