GAUSS T&C RADIOS FOR MICROSATELLITES

4th IAA Conference on University Satellite Missions and CubeSat Workshop

G.A.U.S.S. Srl – IAA-AAS-CU-17-09-10
GAUSS was established as a Laboratory of the School of Aerospace Engineering in La Sapienza Rome University. The purpose was to involve directly the students in the design and the manufacturing of University Microsatellites.

GAUSS built its satellites using Radios that make use of COTS electronics.
- SpaceQuest. Ltd Radios
- AstroDev Radios

GAUSS wanted to create its own radio since the first satellite it launched in 2000.
GAUSS Srl has gained a strong experience commanding satellites in space (UniSat-5, UniSat-6, TuPOD) for several years.

It took Two years and Four hardware iterations to arrive to the final product.

AX25 not recommended for uplink.
Available Radios

- **GAUSS Radio UHF 2W**
  - Up to 33dBm with more than 50% efficiency
  - Possibility to feed it with a single 3.3V line

- **GAUSS Radio UHF 5W**
  - Up to 37dBm with 45% efficiency
  - 3.3V and 12V input voltage

- Radio UHF Ground Dongle
- Why two radios? PA sweet point
GAUSS T&C Radios for Microsatellites  GAUSS Srl - IAA-AAS-CU-17-09-10
GAUSS Radio UHF 2W
GAUSS Radio UHF 5W
Radio Characteristics

- UHF Band;
- Rx and Tx (Half-duplex);
- Uplink/Downlink frequencies, modulations and protocols can be different;
- Off the shelf industrial grade / automotive components;
- Operating temperature range -40°C to +110°C;
- Integrated TNC, radio can be interfaced using KISS;
- Data-rate: 300bps to 100kbps;
- Sensitivity: -122dBm @1.2kbps, -119dBm @9.6kbps, -109dBm @50kbps;
- Configurable output power and frequencies in orbit;
- SMA or MMCX Connector;
- Firmware can be updated while in orbit.
Radio RF Connectivity

- **Supported protocols:**
  - **AX.25** supported. Not recommended for satellite uplink
  - **FEC** Viterbi k4 supported.
  - **RAW** mode supported. Radio behaves as an analog front-end.

- **Supported modulations:**
  - FSK/MSK/GFSK/GMSK

- **Will be supported via firmware upgrade:**
  - FEC Viterbi k7 and Reed-Solomon will be soon supported.
  - 4FSK/4GFSK
  - Up to 250kbps of speeds
  - AES data encryption (128 and 256 bit keys)
Radio Hardware Connectivity

- Radio is connected through a 20 pin connector
- Radio supports:
  - UART
  - I2C
  - SPI
  - CAN
Radio Firmware

- Firmware is duplicated on the MCU for redundancy.
- Same firmware for all the GAUSS T&C Radios.
- A bootloader checks the integrity of the firmware every time the radio boots.
- Radio configuration is duplicated on its flash memory. Its integrity is checked every time a read is attempted.
- Radio firmware can be upgraded on flight:
  - From onboard commands;
  - Directly from the ground station. This feature can be enabled-disabled on flight in order to minimize security risks;
  - Firmware size is around 40kB
GAUSS PCB For testing

GAUSS T&C Radios for Microsatellites

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GAUSS PC104 Dual Radio
Radio UHF Ground Dongle
It replicates the same hardware as the GAUSS radios, it shares all its capabilities and firmware.

Initially designed for an easy interface of your satellite in the laboratory without the need of complex hardware attached to your computer.

Maximum output power of 15dBm. It has a digital pin to drive a possible external power amplifier. With an external amplifier this dongle could become your own ground station for Uplink and Downlink.

USB Drivers are multiplatform (Windows, Linux, MacOS)

When attached to the computer, a dual UART will appear:
- Radio command
- TNC UART
GAUSS Radio Computer Software

- Multiplatform (Linux, Windows, MacOS)
- Easy interface to command or configure the radio
- It supports “Hamlib rgctl” in order to automatically correct the Doppler using orbital propagators
- It allows direct firmware upgrades
GAUSS Future on radios

- GAUSS 2W VHF Version.
- Firmware updates for improving performance and adding capabilities:
  - FEC Vit-RS, 250kbps, 4FSK, AES
- SDR Blocks compatible with GAUSS radios.
- GAUSS S-Band for payload downlink.
Thank you

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