

Group of Astrodynamics for the Use of Space Systems

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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 experience commanding Satellites

- GAUSS SrI 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





GAUSS Radio Architecture





Radio Characteristics

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- 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 frontend.
- 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





- □ 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



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GAUSS PC104 Dual Radio





Radio UHF Ground Dongle



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Radio UHF Ground Dongle

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- 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

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- 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 Radio Computer Software

💰 GAUSS MiniGround USB Dongl	e — 🗌	×					
Connect to the radio on startup							
Radio Tlm Refresh interval (ms):	100			GAUSS Ground Don	gle		<
RSSI calibration correction (dB):	-120			File TCP OAKT Kadio	нер		_
Telemetry UART				425	200 01		
UART name:	COM4			Tx: 455	. 590 . 04	・ ビ ロ Z 19200bps 15dBr	
UART speed:	19200				400.00	9 H7 2GFSK Kiss C	in .
Start Telemetry TCP bridge or	n startup					• 192000ps RAW	
Telemetry TCP Port:	2024						
Telemetry TCP Port emulation:	Hamlib rigctl 🗸 🗸			Receiving, -139dBm		Tx: 0, Rx: 0, E-Tx: 0, E-Rx: 0, T: 27.	9C
		-		Disconnect Radio		Log Top Kiss	
Data UART							
😭 GAUSS MiniGround USB Dor	igle Settings		– 🗆 🗙				
General Interfaces Transiers	ion Reception AV 25 5	EC Reason					
and a little faces frammisss	Ion Reception AX.25	EC Dealon					
GAUSS Radio type:	GAUSS Radio Dongle						
Firmware version:	0.32		Radio Dongle Log				– 🗆 X
Hardware revision:	UHF MSP ver 1.1		2011/12/00 10:13:27:012.	Senar port, complaisconnected.			^
Serial number:	0		2017/12/06 18:15:27.028:	Dongle Data UART found	ed 57600 bauds		
Packet minimum distance (ms):			2017/12/06 18:15:27.411: 2017/12/06 18:15:27.427:	Serial port 'COM3'disconnected. Serial port 'COM4' connected with spe	ed '19200' bauds		
Radio reception mode:	RAW	oreamble	2017/12/06 18:15:27.637: 2017/12/06 18:15:28 760:	Dongle TLM UART found			
Allow remote configuration access?			2017/12/06 18:15:29.882: Serial port 'COM4'disconnected.				
Master Password:			2017/12/06 18:15:29.885: Search of UAR1s traished with the tollowing results: Telemetry UAR1 tound at: COM4, Data UAR1 tound at: COM3 2017/12/06 18:15:35.496: It was not possible to save the configuration to file 'GroundDongleControl.conf'				
			2017/12/06 18:16:04.196: Serial port 'COM4' CTL connected with speed '19200' bauds 2017/12/06 18:16:05.142: TLM UART is on correct COM Port				
Frequency Factory Calibration:			2017/12/06 18:16:05.190: Radio Firmware: 0.32 2017/12/06 18:16:05 190: Radio Firmware: 0.32				
- Transmission Frequency Calibration (Hz):			2017/12/06-16:05:253: hardware comiguration souce with size: 199, Senarhumber, 0, Hardware revision number, 2, is hight hardware; hase 2017/12/06-18:16:05:398: outputBufferStatus 1500				
- Reception Frequency Calibration (Hz):			2017/12/06 18:16:05:462: uart1imSpeed 1 2017/12/06 18:16:05:509: uartDataSpeed 3				
			2017/12/06 18:16:05.606: 2017/12/06 18:16:10.624	Got new configuration struct with size	: 49224		
			2017/12/06 18:16:11.041:	txFreq 435400000			
			2017/12/06 18:16:11.359: 2017/12/06 18:16:11.888:	txFreq 434400000 txFreq 435400000			
			2017/12/06 18:16:13:502:	txFreq 435399000			
			2017/12/06 18:16:15.437:	txFreq 435398010			
			2017/12/06 18:16:15.659: 2017/12/06 18:16:15 915:	txFreq 435398020 txFreq 435398030			
			2017/12/06 18:16:16.380:	txFreq 435398040			~
			<				>
		Reload	Send				
Send Test Packet		Flash	Close				

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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.



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Thank you

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