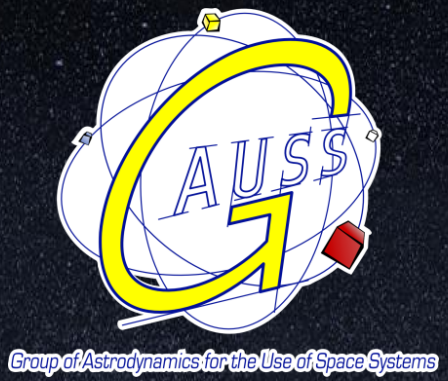

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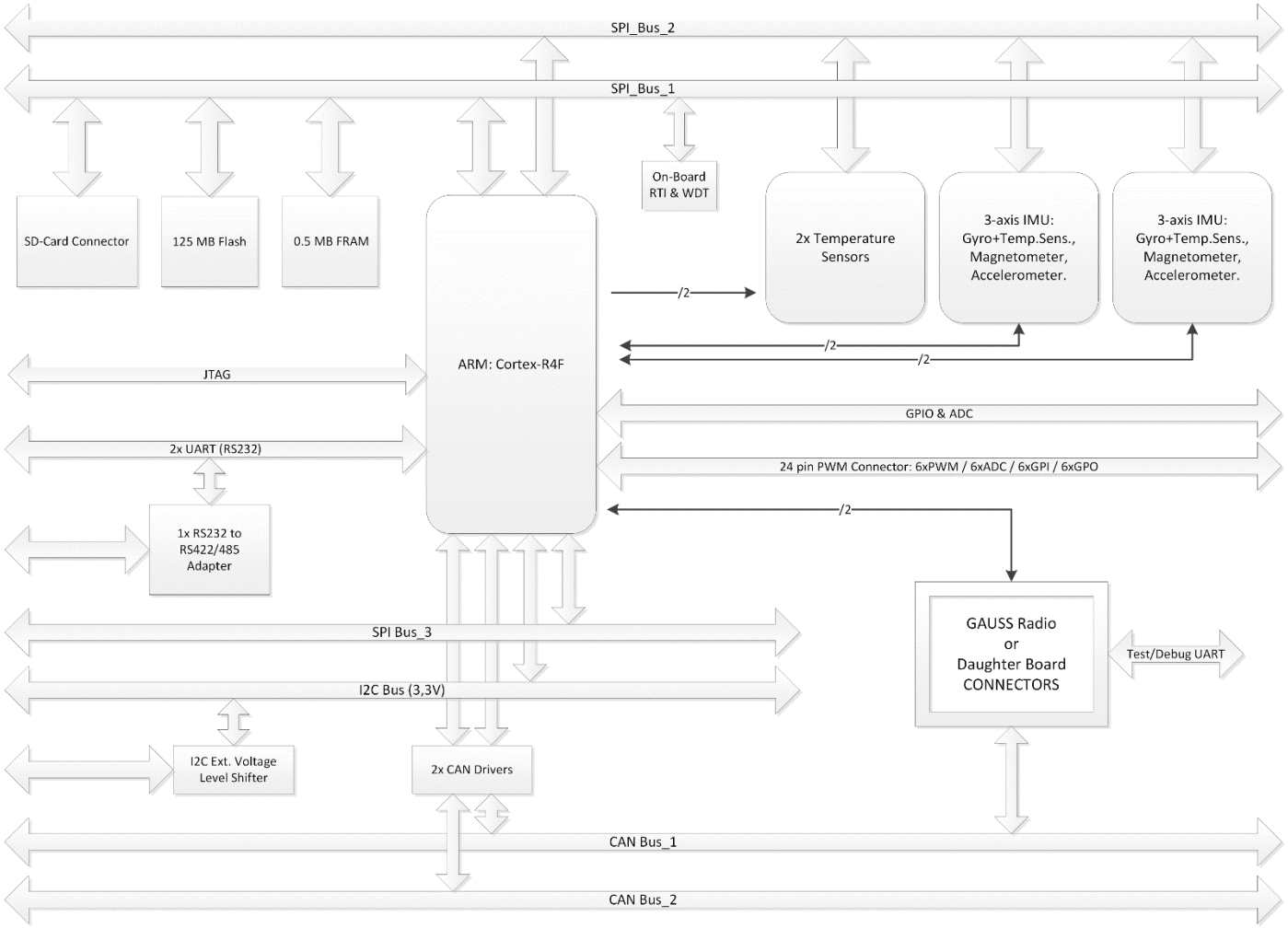
HERCULES: A RELIABLE OBC SAVING SPACE ON YOUR CUBESAT

G.A.U.S.S. Srl – IAA-AAS-CU-17-09-11

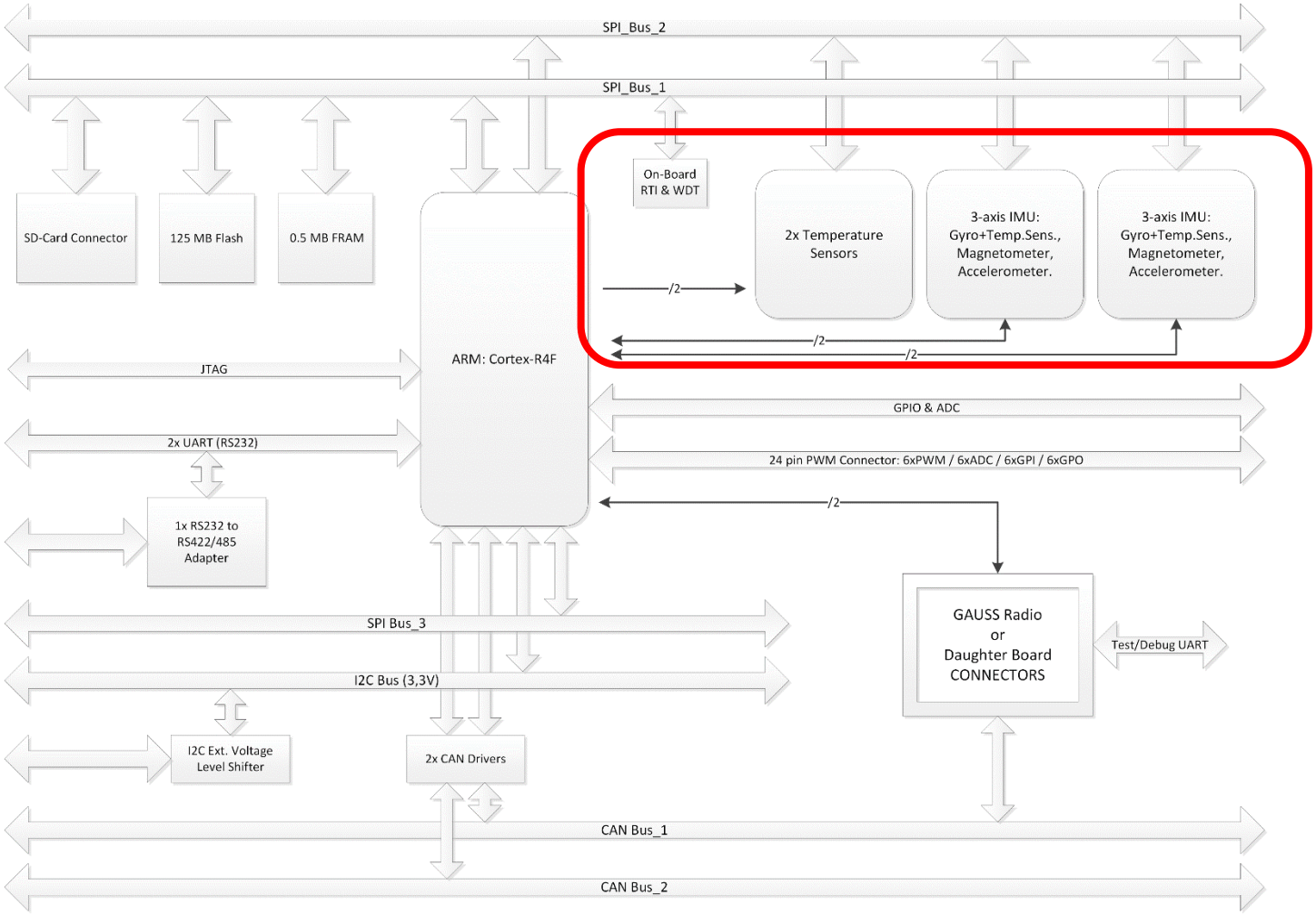
ABACUS OBC vs Hercules OBC

- **ABACUS OBC**
  - MSP430 (up to 25MHz)
  - FPGA 500K Gates (up to 100MHz)
  - Flight heritage:
    - 5 satellites
    - Already gained more than 3 years of continuous operation
- **Hercules OBC**
  - ARM (up to 220MHz) for Safety & Critical applications
  - Reliable design
  - Offers compact solution for small satellites
  - Usable as Payload Computer

Hercules OBC Blocks System



On Board Sensors

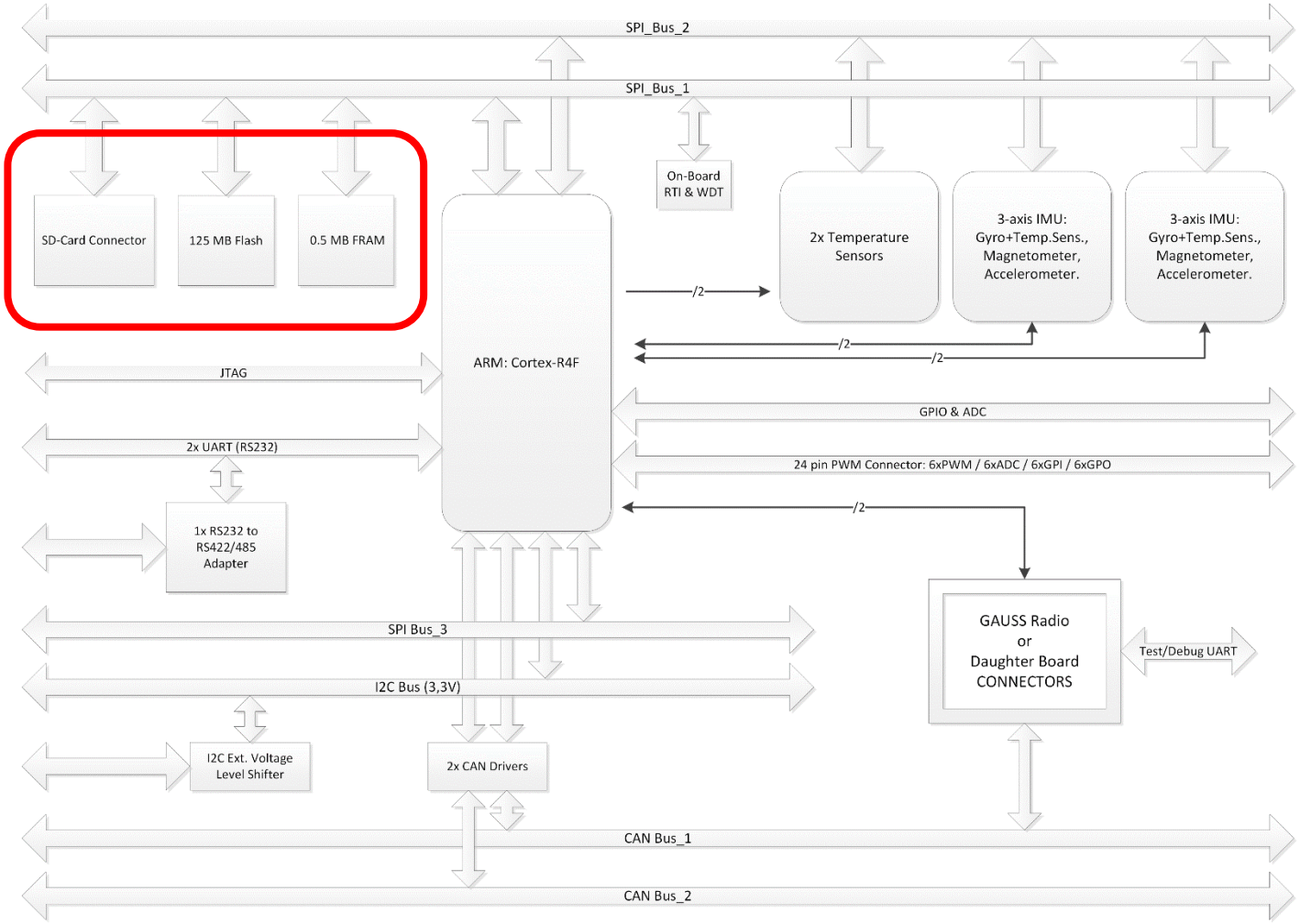


On Board Sensors

- All sensors connected on dedicate SPI bus
- 2 x complete 9 DoF IMU
  - Redundancy
  - Noise reduction
  - General features:

Acc Full Scale	±16 [g]
Acc Max Resolution	16 [bit]
Mag Full Scale	±4800 [µT]
Mag Max Resolution	16 [bit]
Gyro Full Scale	±2000 [°/s]
Gyro Max Resolution	16 [bit]
Gyro Noise Spectral Density	0.01 [°/s/√Hz]

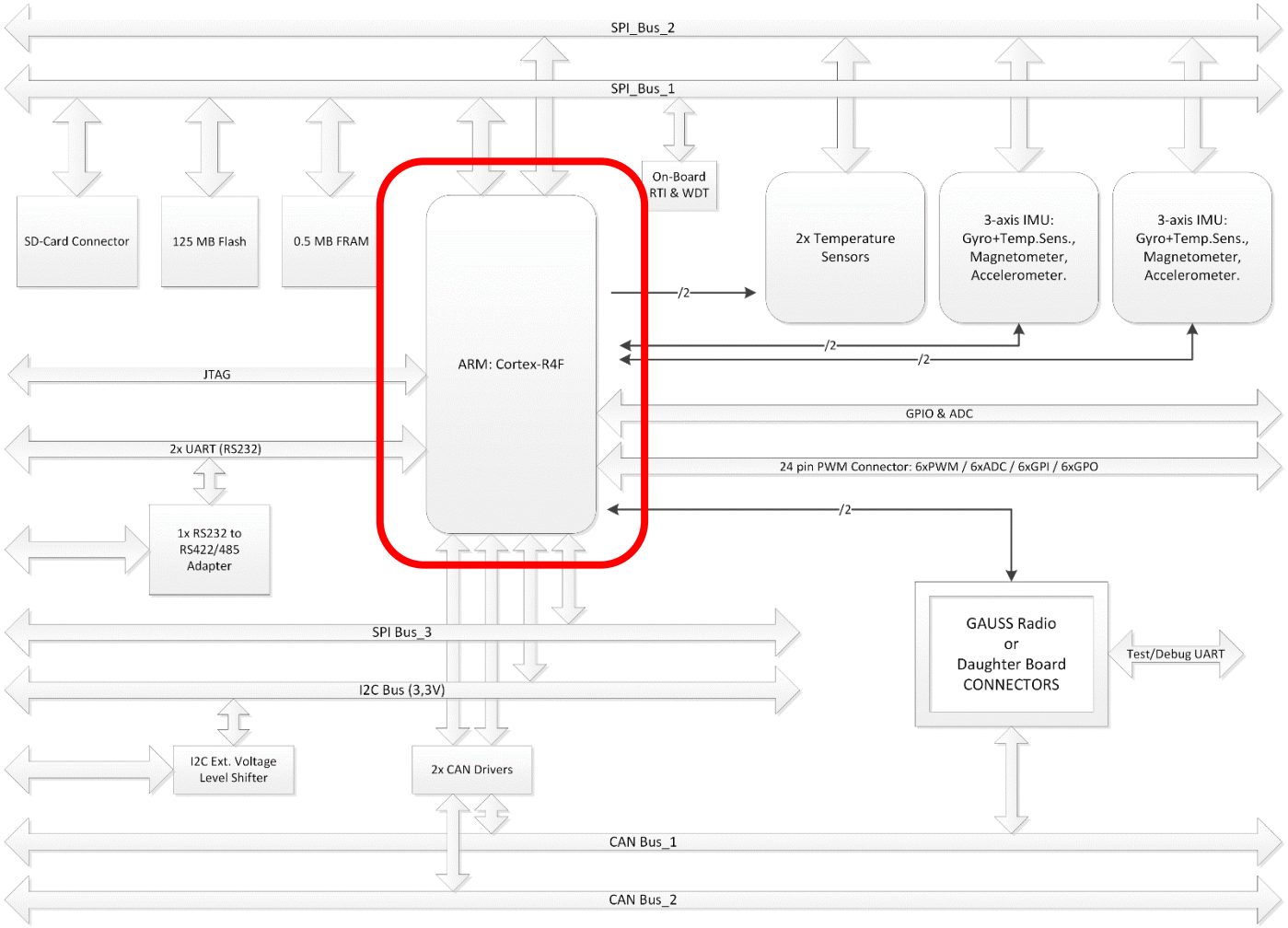
On Board Memory Mass Storage



On Board Memory Mass Storage

- All memories connected to a separate SPI bus
- Ferroelectric Ram (FRAM) non volatile memory
  - Radiation and Electric Field Tolerant
  - Data retention of more than 10 years @ 85°C
  - R/W cycles greater than Flash memory (10^{14} vs 10^{6})
  - Faster than Flash memory
  - Usable for critical data or recovery system data
  - Capacity 0.5 MB
- Flash Memory
  - On board memory mass storage
  - Capacity 125 MB
- SD Card socket connector

Hercules CPU core

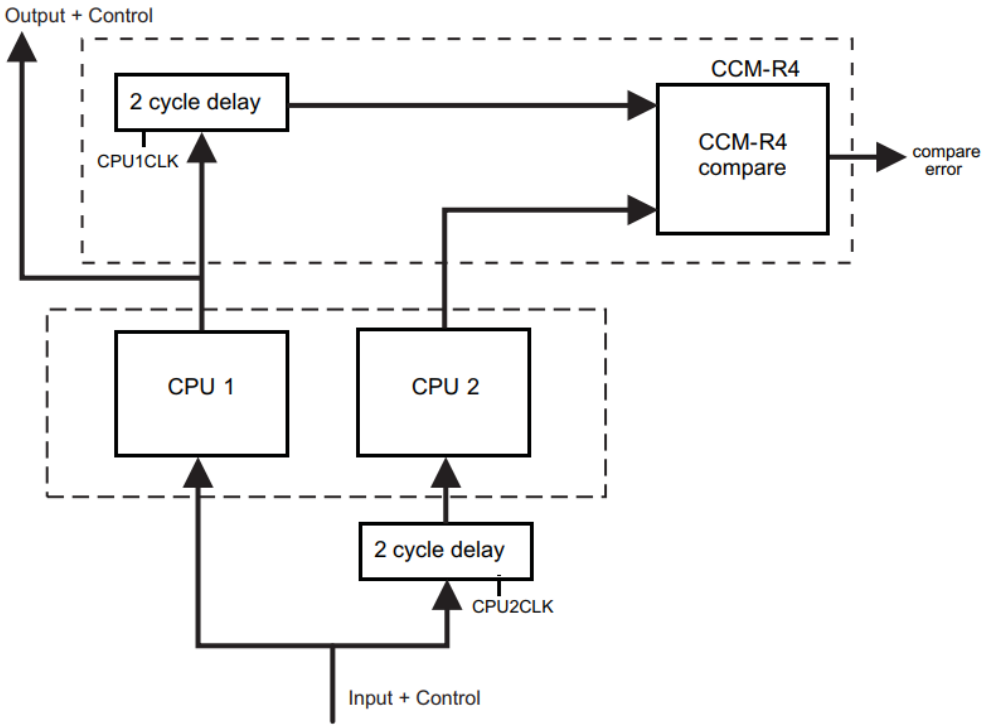


CPU & Safety Features

- 32 bit RISC Floating Point CPU
  - 1.66 DMIPS/MHz, up to 220MHz
- Designed for Safety-Critical applications (“Hercules” family CPUs of Texas Instruments)
- Dual ARM Cortex-R4F CPUs running in lockstep:
  - CPUs perform same operation, than compare the results for each clock cycle
  - in case of fault it can enter in a defined safe mode (safe island approach)

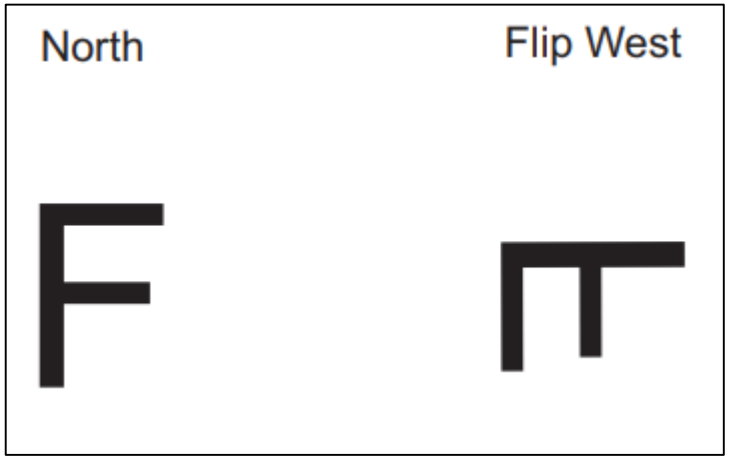
CPU & Safety Features

- Common mode impact protections:
  - Signals of the CPUs to be compared delayed by 2 clock cycles



CPU & Safety Features

- CPUs have a different physical placement on the chip and a dedicated guard ring for each CPU



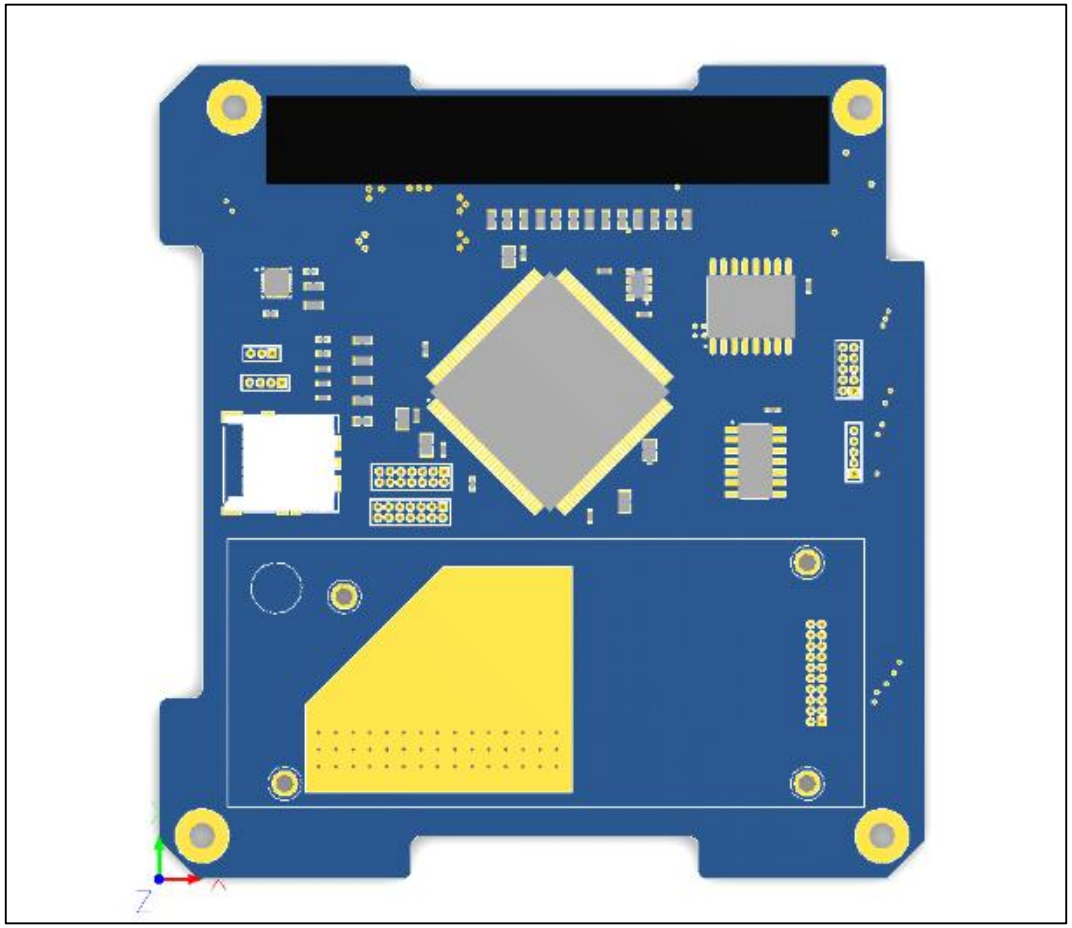
CPU1 = "north" orientation CPU2 = "flip west" orientation

CPU & Safety Features

- Other safety features:
  - Integrated Flash and RAMs all with ECC
  - Built-In Self-Test (BIST) for CPU and on-chip RAMs
  - Cyclic Redundancy Checker module (CRC)
  - Parity diagnostics on all peripheral memories
  - Analog and digital loopback to test for shorts on I/O
  - etc…

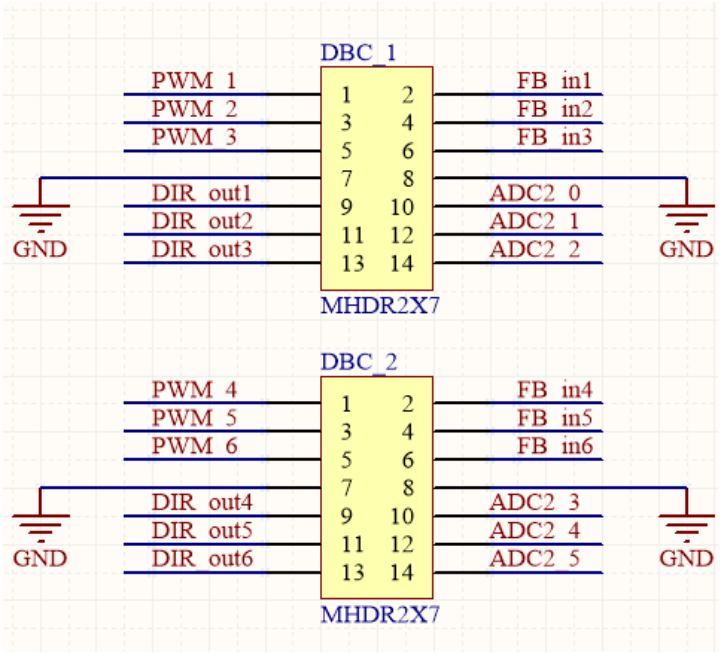
Currently studied by Airbus-DS and ESA

Hercules OBC (render)



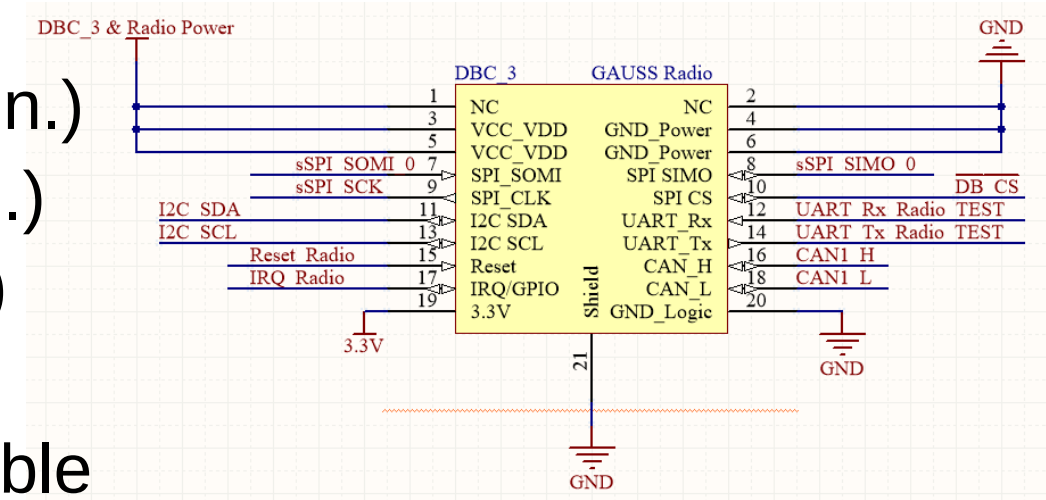
Daughter Board Connectors

- Connector for a Customer Daughter Board
  - 18 pins usable as GPIO
  - 6 ADC Input
- May be used for motors & coils control
  - 6 PWM Output
  - 6 Direction Output
  - 6 Feedback input
  - 6 ADC for current measurement
- Digital Pins are reported also on H1/H2 connector

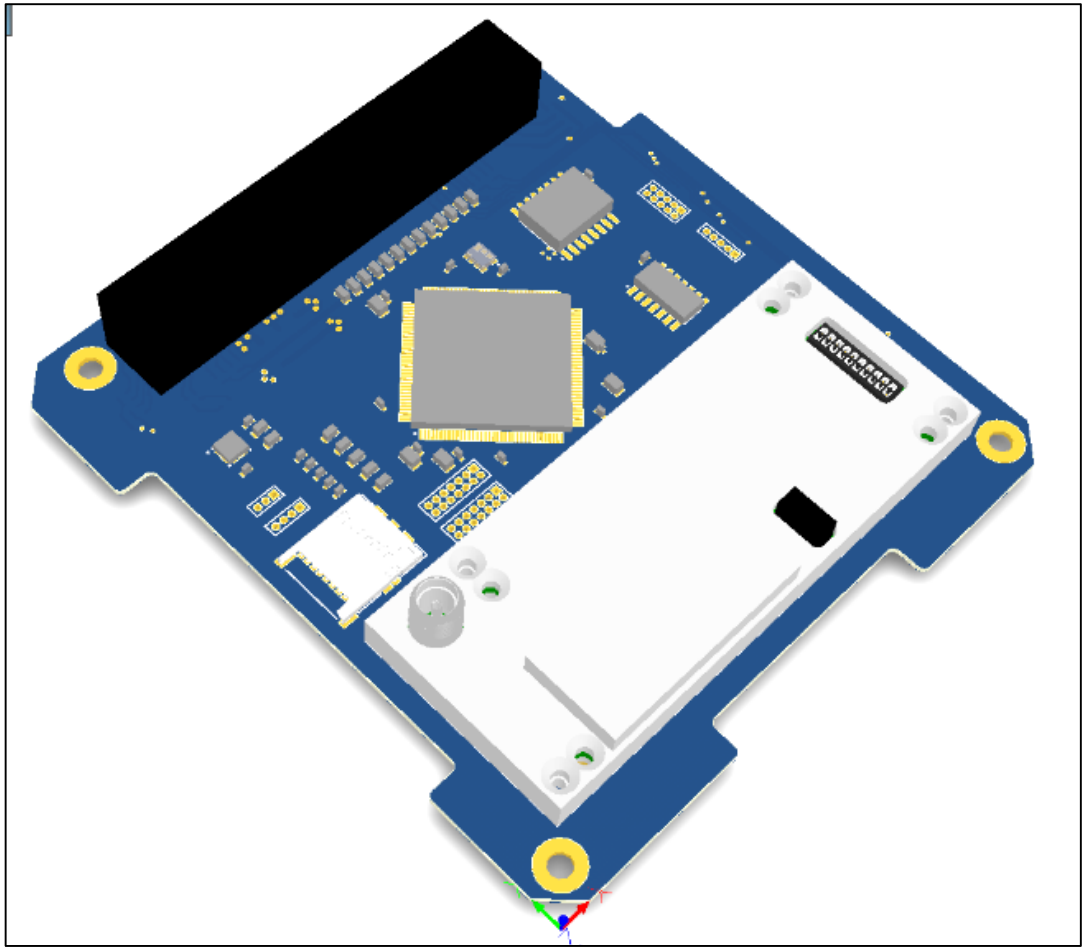


Daughter Board & Radio connector

- Connector GAUSS Radio Compatible
  - 1x CAN (H1/H2 conn.)
  - 1x I2C (H1/H2 conn.)
  - 1x SPI bus (shared)
  - 3x GPIO
  - Power pins (selectable source)
  - Direct Radio TEST UART Connection

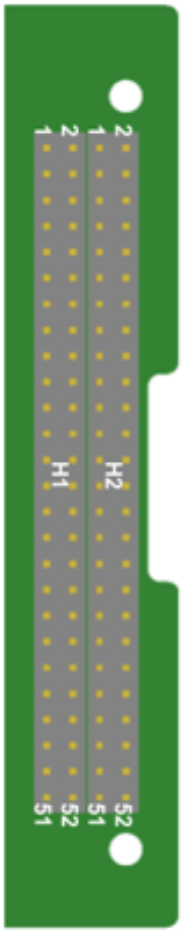


GAUSS OBC & Radio: 2 in 1 System



CubeSat Connector (H1/H2)

- Digital Bus available
  - 2x CAN 2.0B
  - 2x RS232 (configurable as slave)
  - 1x RS422/485 adapter (from one RS232)
  - 1x I2C (+ a shifted voltage connector)
  - 1x SPI
- Other pins
  - 10x ADC Channels
  - Several GPIOs
  - MCU specific features (N2HET, PWM, etc.)
- Selectable Power source pins

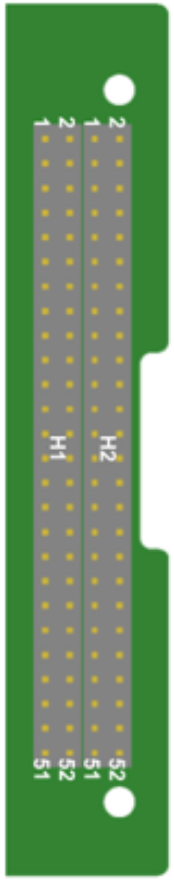


Reconfigurable Connector (H1/H2)

H1 Connector			
Description	Pin #	Pin #	Description
CAN1_L	1	2	GPIO / NC
CAN1_H	3	4	GPIO / NC
GPIO / NC	5	6	GPIO / NC
GPIO / NC	7	8	GPIO / NC
GPIO / NC	9	10	GPIO / NC
GPIO / NC	11	12	ADC / NC
ADC / NC	13	14	ADC / NC
ADC / NC	15	16	ADC / NC
UART2_b_TX / RX	17	18	UART2_a_TX / RX
UART2_d_TX / RX	19	20	UART2_c_TX / RX
SPI_SCK / GPIO	21	22	SPI_SDI_SOMI / GPIO
SPI_SDO_MOSI / GPIO	23	24	SPI_CS0 / NC
SPI_CS1 / GPIO	25	26	SPI_CS2 / GPIO
SPI_EN / CS3 / GPIO	27	28	
	29	30	
	31	32	
	33	34	WDT_INT / NC
	35	36	
	37	38	
UART1_a_RX / TX	39	40	UART1_b_TX / RX
I2C_SDA	41	42	
I2C_SCL	43	44	
GPIO / NC	45	46	GPIO / NC
VCC_1 Power	47	48	VCC_4 Power
VCC_2 Power	49	50	VCC_5 Power
VCC_3 Power	51	52	VCC_6 Power

NC = Not Connected

	Mandatory
	Selectable



H2 Connector			
Description	Pin #	Pin #	Description
CAN2_L / NC	1	2	
CAN2_H / NC	3	4	
	5	6	GPIO / NC / Test LED
ADC / NC	7	8	ADC / NC
ADC / NC	9	10	ADC / NC
ADC / NC	11	12	GPIO / NC
GPIO / NC	13	14	GPIO / NC
GPIO / NC	15	16	GPIO / NC
GPIO / NC	17	18	GPIO / NC
GPIO / NC	19	20	GPIO / NC
	21	22	
12V / NC	23	24	12V / NC
5V / NC	25	26	5V / NC
3.3V / NC	27	28	3.3V / NC
GND	29	30	GND
A_GND	31	32	GND
	33	34	
	35	36	
	37	38	
	39	40	
	41	42	
	43	44	
	45	46	
	47	48	
	49	50	
	51	52	

NC = Not Connected

	Mandatory
	Selectable

Other features

- PC/104 CubeSat form factor compatible
- Powered using 3.3V or 5V and from different configurable pins
- Off the shelf industrial/automotive grades components
- Operating temperature range -40°C to +85°C

Conclusion

- OBC Hercules
  - Based on a Safety-Critical application designed processor
  - Radiation tolerant FRAM memory
  - Complete 9DoF redundant IMU
  - Versatile CubeSat connector & Daughter connectors
  - Possibility to create a compact system for small satellites including the GAUSS Radio on the same board

Thank you

- **G.A.U.S.S. S.r.l.:**
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