



Galileo Avionica

**Contribution to  
DC/DC Converter Technology  
Round Table**

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A Finmeccanica Company

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- Galileo Avionica DC/DC converters Portfolio (1/8)
  - DC/DC Converters for S/C Electrical Power Systems: Main Bus Regulation
    - Battery Charge Regulators (BCRs)
      - SEPIC conversion topology, in order to fit with all Power System Configuration
      - Output Charge Current up to 7A per module (@Vbattery up to 38V)
      - Conversion efficiency > 91%
    - Battery Discharge Regulators (BDRs)
      - Push-Pull or Buck conversion topology in order to fit with all Power System Configuration
      - Output Power up to 300W per module (2 modules are allocated on a single PCB)
      - Conversion efficiency in the range from 93% to 96.5%
    - Solar Array Power Regulators
      - High power step-down converters for Solar Array MPP regulation
      - Output Power up to 420W per module (2 modules are allocated on a single PCB)
      - Conversion efficiency > 91%
    - Heritage and Flight experience

SOHO PCU

ARTEMIS PCU

SICRAL MRU

ATLANTIC BIRD MRU

RADARSAT-2 PCU

COSMO SkyMed PCU

ATV PCDU

SICRAL 1 B MRU

- Galileo Avionica DC/DC converters portfolio (2/8)
  - DC/DC Converters for S/C Electrical Power Systems: Payloads Supply
    - Power units, featuring power conditioning and distribution to payloads (galvanic insulation when required)
    - Modular design based on a number of DC/DC converter modules
      - Input voltage range from 28V to 120V, both regulated and unregulated
      - Typical output power for each converter module: 300W
      - Overall unit output power up to 7700W
      - Resonant push-pull conversion topology, zero current, zero voltage switching
      - Power protection and distribution features available
    - Heritage and flight experience
      - ISS MPLM power distribution box (PDB)
      - METOP payload module power control unit (PLM PCU)
      - COSMO SkyMed central power supply unit (CPSU)
      - COSMO SkyMed SAR antenna power supply (SAPS)

- Galileo Avionica DC/DC converters portfolio (3/8)
  - EPCs for RF Equipment: Solid State Power Amplifier (SSPA)
    - Multiple output (+9V, +/- 5V) DC/DC converters with galvanic isolation
      - Different power sizes (55W to 180W)
      - Capability to interface both regulated and unregulated power busses
      - Optimum output power quality: max output ripple < 10mvpp, in all operative conditions (including CS)
      - Sequential power application/removal
      - Main output voltage external control capability
      - Conversion efficiency greater than 85% (90% for regulated power bus)
    - Heritage and flight experience
      - ARTEMIS S-band FSPA
      - SICRAL SHF SSPA
      - ATV S-band SSPA
      - GSTB-V2 SSPA (pre-development)
      - GSTB-V2 SSPA
      - GALILEO IOV SSPA (under development)

- Galileo Avionica DC/DC converters Portfolio (4/8)
  - EPCs for RF Equipment: UHF Solid State Power Amplifier (USPA)
    - Multiple output (+29V, +10V, - 5V) DC/DC converters with galvanic isolation
      - 360W Output Power
      - Optimum Output Power Quality: max output ripple < 20mVpp, in all operative conditions (including CS)
      - Main output voltage external control capability
      - Conversion efficiency greater than 90% (with Bus Voltage = 42Vreg)
    - Heritage and Flight experience
      - SICRAL USPA
      - SKYNET 5 LPA (manufacturing in progress)

- Galileo Avionica DC/DC converters Portfolio (5/8)
  - EPCs for RF Equipment: Travelling Wave Tube Amplifier (TWTA)
    - High Voltage EPC with galvanic isolation
      - Wide electrical output power range (up to 300W) and output voltages (up to 20KV)
      - Capability to interface both Regulated and Unregulated Power Busses
      - Fits different TWT types from various manufacturers
      - Grid pulse modulation (switch-on time < 200ns for 3KV Grid Voltage)
      - Capability to supply Channel Amplifiers and/or Linearizers
      - Conversion efficiency up to 95% for Regulated Power Bus
    - Heritage and Flight experience
      - CASSINI TWTA
      - ENVISAT TWTA
      - HOT BIRD 5 TWTA
      - SICRAL TWTA
      - GSTB-V2 EPC for TWTA (manufacturing in progress)
      - SICRAL 1 B TWTA (under development)
      - CLOUD PROFILING RADAR EPC (under development)

- Galileo Avionica DC/DC converters Portfolio (6/8)
  - EPCs for RF Equipment: Frequency Generator and Other RF Units
    - Low power, multiple output DC/DC converters with galvanic isolation.
      - Various Output Voltages: +/-15V, +/-12V, +/- 5V, ...
      - Capability to interface both Regulated and Unregulated Power Busses
      - Optimum Output Power quality for minimum interferences with RF signal
      - Limited dimensions for allocation in small sized payloads
    - Heritage and Flight experience.
      - CASSINI Frequency Generator Chirped Up-Converter
      - ENVISAT Frequency Generator and Conversion Unit
      - SICRAL:
        - QPSK Modulator
        - SHF Downconverter
        - VHF/UHF Tunable Synthesizer
        - X-band Frequency Agile Source
      - EUROSKEYWAY Frequency & Master Clock Generator Unit
      - COSMO SkyMed:
        - X-Band Tx/Rx Drive Unit
        - Power Supply Unit for Tile T/R modules
      - Galileo GSTB-V2:
        - Atomic Clock (Passive Hydrogen Maser)
        - Frequency Generation and Upconversion Unit



- Galileo Avionica DC/DC converters Portfolio (7/8)
  - Power Control Units for Electric Propulsion Subsystems
    - Power Units, including a number of low voltage and high voltage DC/DC converters, featuring all the functions required to supply and operate a complete Electric Propulsion Subsystem (Thruster and Neutralizer)
    - Thruster supply voltage up to 9KV
    - Beam current control at 12 bit resolution (0.5uA step)
    - Capability to control and supply different types of neutralizer
  - Heritage and Flight experience
    - ARTEMIS RIT-10 Power Control Unit (PCU)
    - SMART 2 FEEP Power Control Unit (PCU)
    - MICROSCOPE Power Processing and Control Unit (PPCU) (under development)

- Galileo Avionica DC/DC converters Portfolio (8/8)
  - Motor Drivers and Controllers for Automation and Robotics
    - Biphas full-bridge configuration for AC brushless motors
    - Accurate motor current regulation for minimum motor torque ripple
    - Motors speed and position closed loop control
    - Management of complex failure cases with fail-safe approach
  - Heritage and Flight experience
    - EUROPA Controller Hardware (under development)

- DC/DC Converters Design & Development (1/3)
  - General Considerations
    - DCDC converters are assumed to be standard modules, but:
      - DC/DC converters main requirements (input/output I/F, physical layout) are very often application dependant, being usually fitted to the requirements of the host unit
      - Particularly, the auxiliary functions (TLCs, TLMs, protections) have variable requirements, even in very similar applications
      - Some of the most important EEE parts in DC/DC converter modules are single source (high procurement cost and very long delivery time)
    - It results that:
      - Even if the DC/DC converter function is a standard function of any space electronic equipment, the relevant tailoring to a specific programme is not a trivial issue and can require an important part of the overall available resources (which cannot be devoted to other important developments)

- DC/DC Converters Design & Development (2/3)
  - Galileo Avionica Design Approach
    - Electrical design
      - Power Section
        - » specifically adapted for each application
        - » conversion topology selected basing on consolidated experience
          - low power                      ⇒                      Flyback
          - medium power                ⇒                      Forward
          - high power                    ⇒                      Push-Pull, Bridge, Buck
        - » Input/Output filters designed to meet applicable requirements
      - Control Section
        - » Standard control IC's for generic applications (1845, 1846, 1806)
        - » Custom developed Hybrid circuit, when economically viable
      - Auxiliary Functions (TLCs, TLMs, protections, synchronization, etc)
        - » Standard basic circuits, customized and adapted to the applicable requirements
    - Mechanical design
      - Module dimensions and layout adapted for each application
      - Standard solutions for main issues (heavy parts fixation, thermal design of power devices)

- DC/DC Converters Design & Development (3/3)
  - Galileo Avionica Parts Procurement Approach
    - Passive Parts
      - Galileo Avionica have set up internal stocks of passive parts thanks to an important effort in standardization and types reduction
    - Active Parts
      - Due to high unit cost and variable quality levels requirements, active parts are procured according to specific programmes needs
      - some high recurring active parts (diodes, small signal transistors) are available as internal stock
    - Hybrid Circuits
      - Hybrids Circuits are procured by lots large enough to compensate for the high non recurring procurement cost
      - Galileo Avionica has set-up and successfully applied a procurement approach based on
        - » Manufacturing and test of Flight Hybrid circuits following ESA PSS-01-608 "Generic specification for hybrid microcircuits"
        - » Selection of Add-On components following ESA PSS-01-60.
        - » Add-On components evaluation following MIL-PRF-38534 para. C 3.6 "alternate integrated circuit die (ICD) evaluation"

- Working Areas for Improvements in Costs & Schedule
  - Requirements Standardization
    - Significant improvements can be achieved in development time and cost by requirements standardization:
      - Input and Output ranges definition (Input Voltage, Output Voltages, Output Power)
      - Standard EMC requirements both for Conducted Emissions and for Conducted Susceptibility
      - TLCs, TLMs, protections, synchronization, etc
  - EEE Parts Selection and Standardization
    - Rad-Hardened Power Mosfet issue shall be improved as soon as possible: single supplier condition is no more tolerable in terms of lead time, ITAR restrictions, parts availability and costs
    - Parts standardization is of fundamental importance for effective cooperation with parts manufacturer and availability of specific data (radiation data, temperature and life drifts)
    - Use of COTS to be investigated

- **Conclusions**
  - Galileo Avionica is one of the most important European manufacturer of DC/DC converters for Space application. Their DC/DC converters portfolio covers most of the needs of a modern SpaceCraft.
  - The DC/DC Converters Design and Development approach presently applied by Galileo Avionica is the result of a continuous attempt to reduce schedule and costs.  
It has insured some important improvements, but much can be done further.
  - Agency role is crucial in the support of a standardization activity, in terms of requirements, design solutions and EEE parts selection.  
Requirements standardization could insure important improvements in DC/DC converter technical performances, cost, delivery time.  
Agency support towards a European capability for power FETs production is highly recommended.
  - Use of Hybrid Circuits is an important chance but requires very high non recurring costs.  
Any possible solution leading to limitation of Hybrid Circuits non recurring costs, without affecting the final device reliability, should be proposed by the interested manufacturers and carefully considered by the Agency and the Main Prime Contactors.
  - Galileo Avionica is ready to cooperate with any partner, Agency or Prime, in order to identify and carry-on valuable activities on the discussed issue.