Equipment with CAN-TM/TC Interface for Flexible Payloads on modern Telecom Satellites

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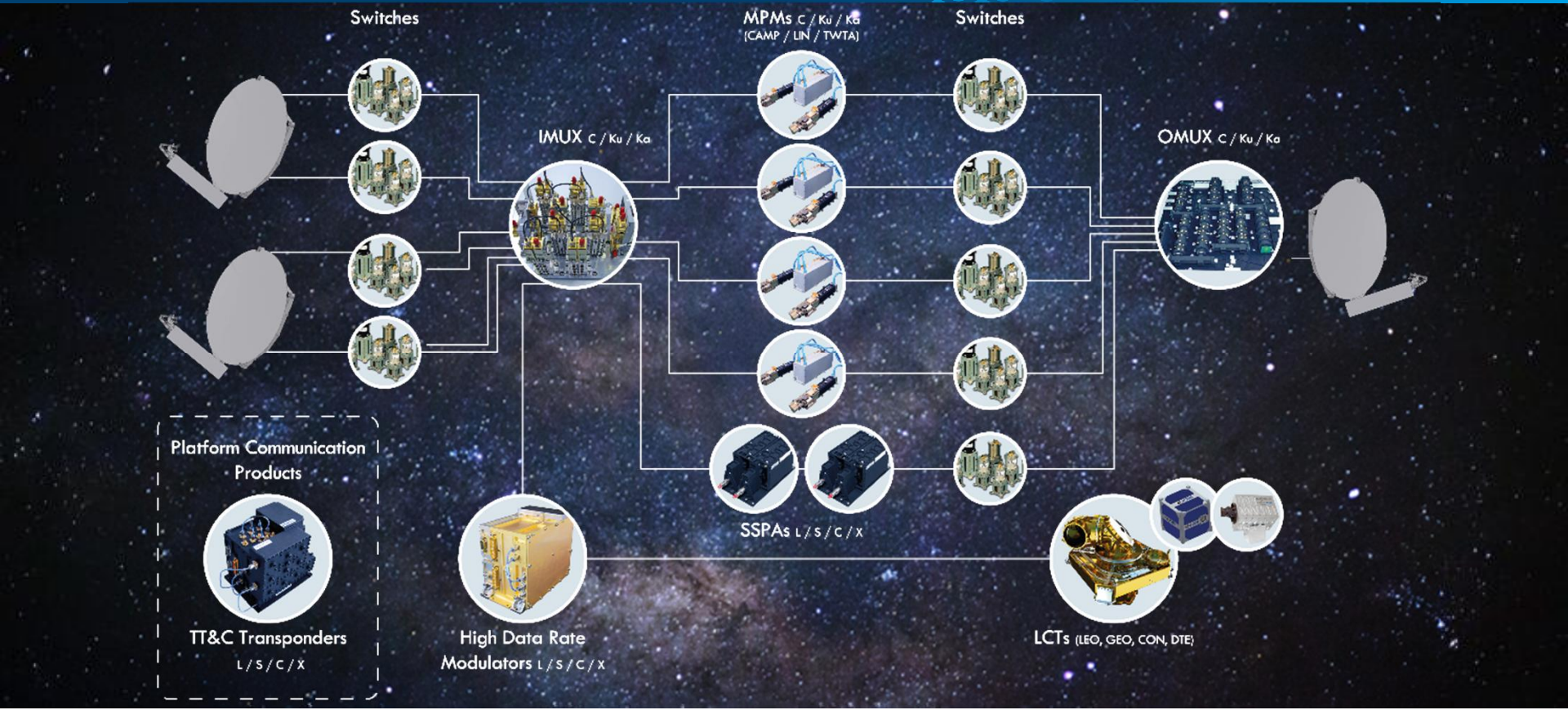
TESAT SPACECOM - PRODUCTS



CAN for High Power Amplifier TM/TC

Amplifier Products: MPMs, TWTAs and SSPAs

- RF amplifiers based on TWT and GaN power semiconductors are broadly used in satcom payloads.
- RF signal conditioning, i.e. small signal amplification and pre-distortion, is provided by LCAMPs associated to individual high power amplifier stages.
- Amplifiers are supplied by electronic power conditioner (EPC) that connects the units to the main bus power supply.
- Interfaces:
  - Main bus (MB) – trend towards 100 Volt.
  - Low power RF: SMA or SMA-K
    High Power RF: Rectangular Waveguide / TNC
  - Mechanical and thermal interface – limited number of options.
  - TM/TC – large variety of options, impact on equipment design ➔ non-recurring cost driver

DUAL TWTA

X-Band SSPA

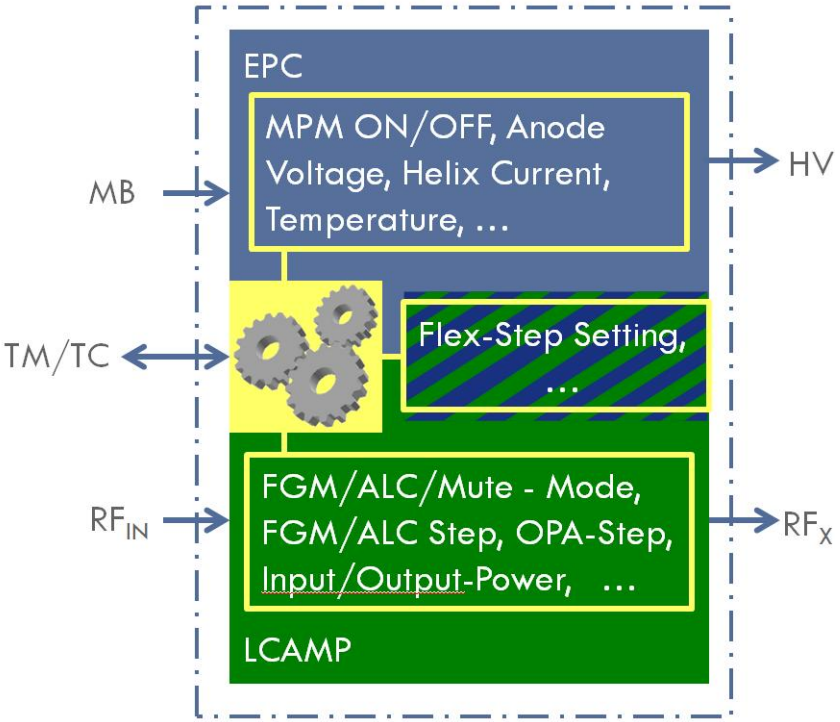
170W Ka-Band Dual MPM

TM/TC Functions – Example Microwave Power Module (MPM)

- Set of TM/TC-functions is limited and independent of platform and customers
- TM/TC to each of the MPMs (EPC/ LCAMPs) by
  - Pulse commands
  - Bi-level / analog TM
  - Proprietary serial interfaces

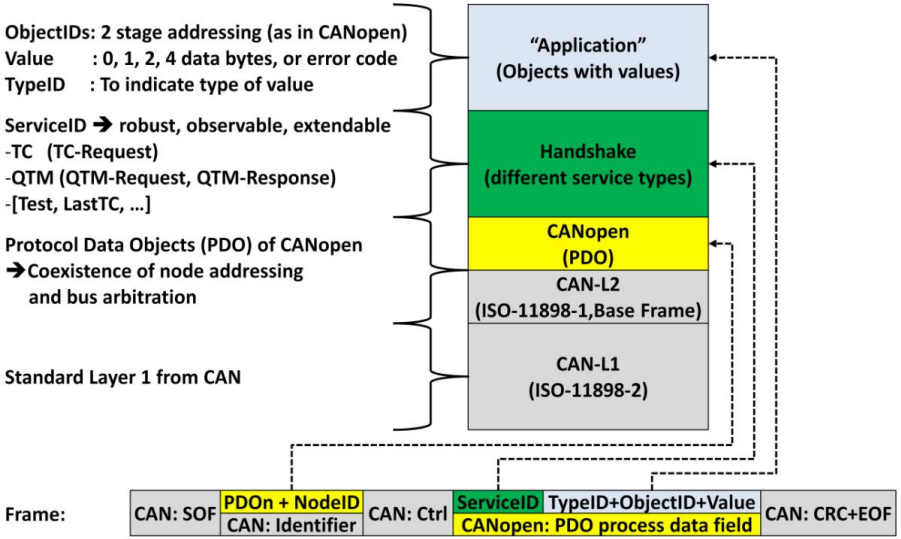
- Defined by platform manufacturer, implemented by equipment manufacturer.
- Large variety of protocols - equipment standardization is limited.

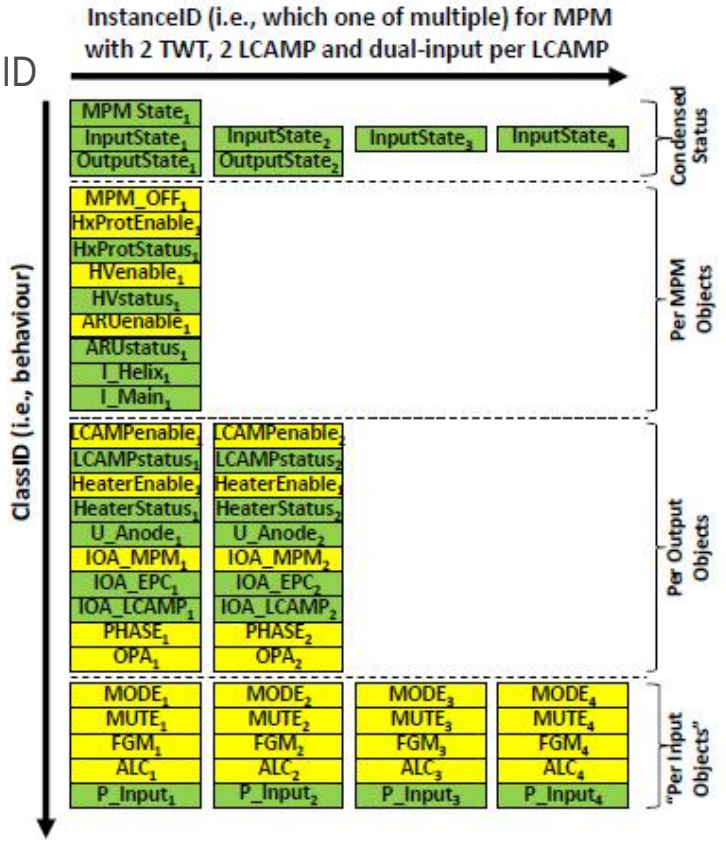
- CAN TM/TC interface has been developed and can be provided to all customers



CAN Frame Mapping – Example for MPM TM/TC

- TM/TC objects have been organized in instances and classes
- Corresponding Object ID is made from Class ID and Instance ID
- PDO process data is build from various IDs (object, type, and service) and the data to be transferred
- Same logic applies for other Tesat products





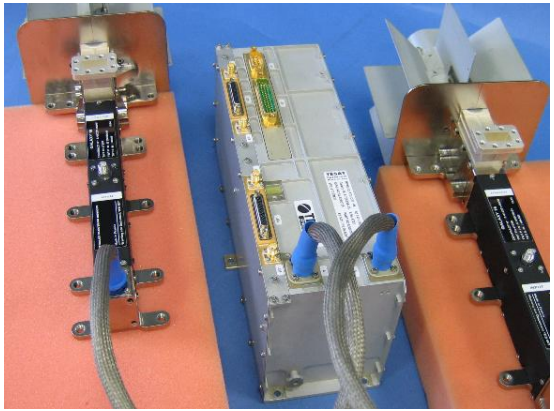
CAN IP - ASIC/FPGA Implementation details

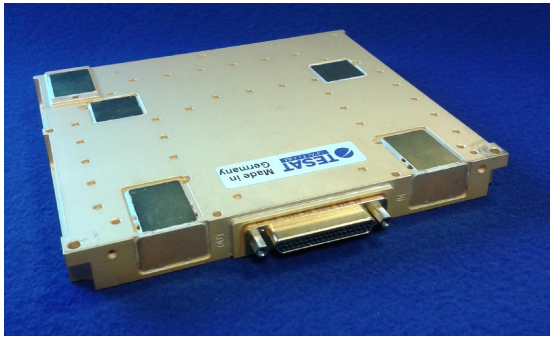
- CAN core IP: IniCAN
  - Industrial proven (CAN 2.0B, ISO 11898-1)
  - In use @Tesat since 2007
  - Typical implementation size: 4% of RTAX2000 FPGA

- CAN TM/TC interface including redundancy selection and CANopen protocol layer is Tesat internal IP
  - Adaption to needs of Tesat equipment as bus slave:
    - Subset of minimal CANopen implementation according to §9 in ECSS-E-ST-50-15C.
    - Master/slave relationship between bus master and node, i.e. slave node only transmits data if requested by the master.
    - Slave node enters operational mode directly after power-on.
    - Selective bus access architecture either per heartbeat or edge detection mechanism.
  - First version created in 2013
  - Typical implementation size (including IniCAN): 10% of RTAX2000

CAN FOR HIGH POWER AMPLIFIERS - STATUS

- Core components for amplifier products:
  - Integrated ISO transceiver - pin allocation of available components is similar and parts are expected to be interchangeable when accounting for 8/10-lead footprint.
  - LCAMP control ASIC LARS2 fully qualified available on stock for further MPM/SSPA projects
- MPM projects with CAN TM/TC I/F have been delivered to be used on European satellite platforms.
  Additional programmes are currently running.
- Dedicated CAN test units with flight representative interface circuit are available to support CAN bus system tests w/o the need for further RF equipment.

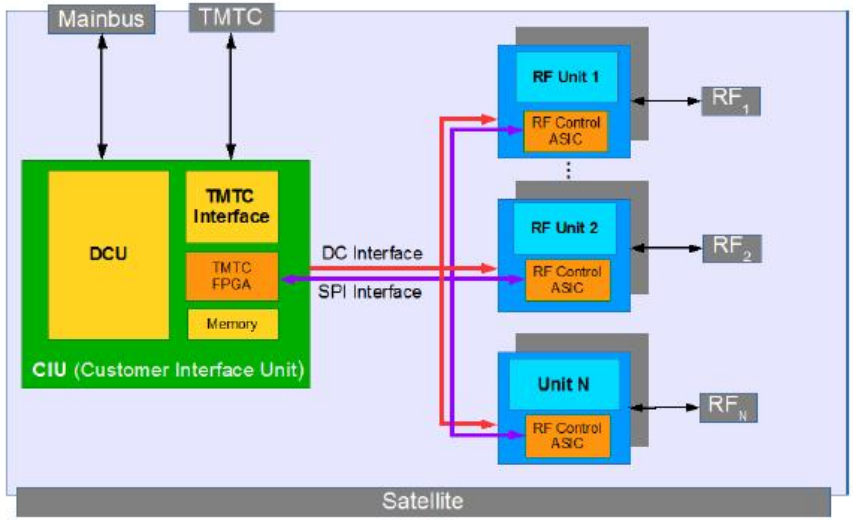




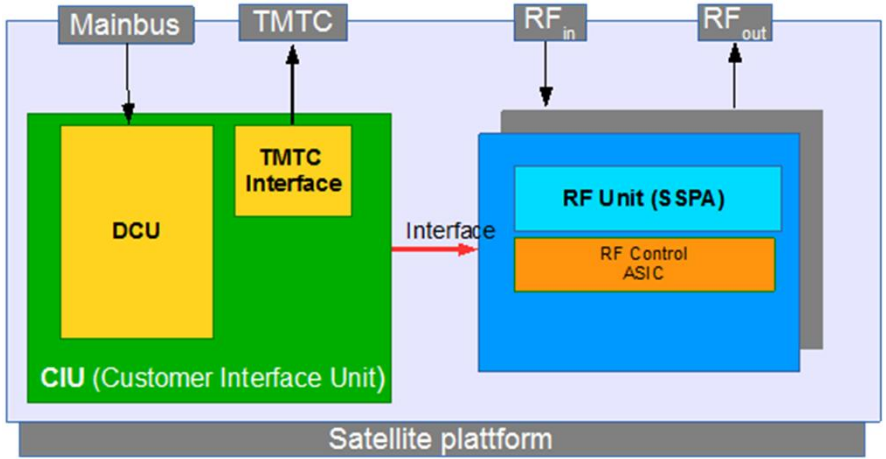
RF Amplifiers for Flexible payloads

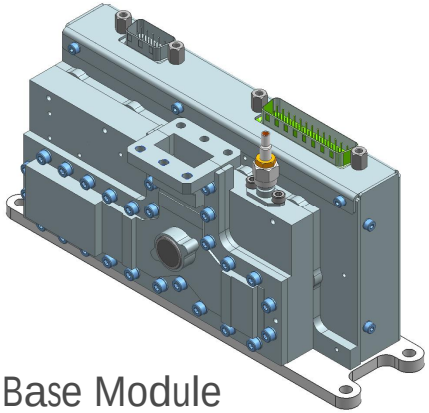
HDI Product Platform Concept

- To provide various types of equipment for future flexible payloads Tesat created HDI generic product platform concept for LEO an GEO consisting of CIU and various functional blocks
- Customer Interface Unit
  - Standardized power supply (DCU) and SPI Control Interface between CIU and functional blocks
  - TM/TC Interface to satellite bus CAN/SOCAN as standard, customer specific upon request
- Large variety of functional blocks:
  - SSPAs and Low Noise Amplifiers
  - Modulator Section
  - Frequency Synthesiser
  - Up/Down converter and Receivers
  - Bandpass Filters, Isolators, MEMs

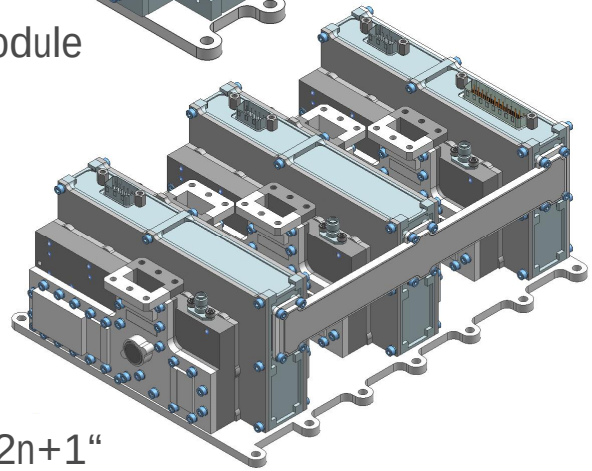


- Scalable stand-alone SSPA design
  - SSPA #1 and CIU base module
  - Further pairs of SSPAs with individual DCU and common TM/TC interface





HDI SSPA Base Module

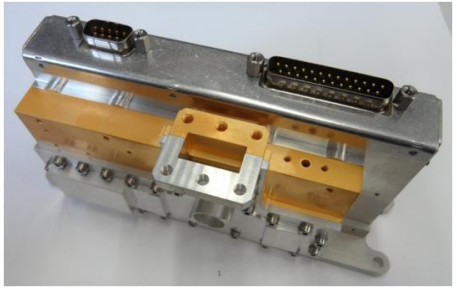


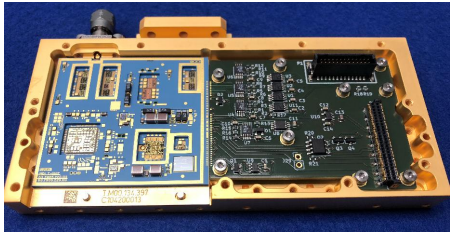
HDI Multipack SSPA „N=2n+1“

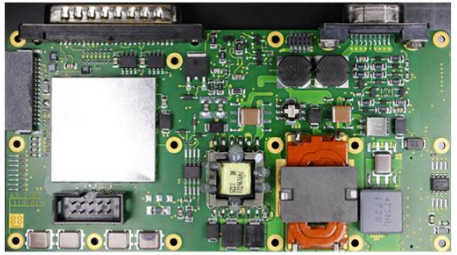
HDI Products – Ku-Band SSPA Prototype

- Compact Ku-Band SSPA for Geo-Satellites
- Design, manufacturing & test ongoing
  - Key elements in RF section (transition, isolator) as well as new DC converter unit have been tested successfully.
  - RF multilayer substrate equipped with UMS high power MMIC amplifier based on GH25 GaN technology.
- Application: amplifier for new payloads architectures

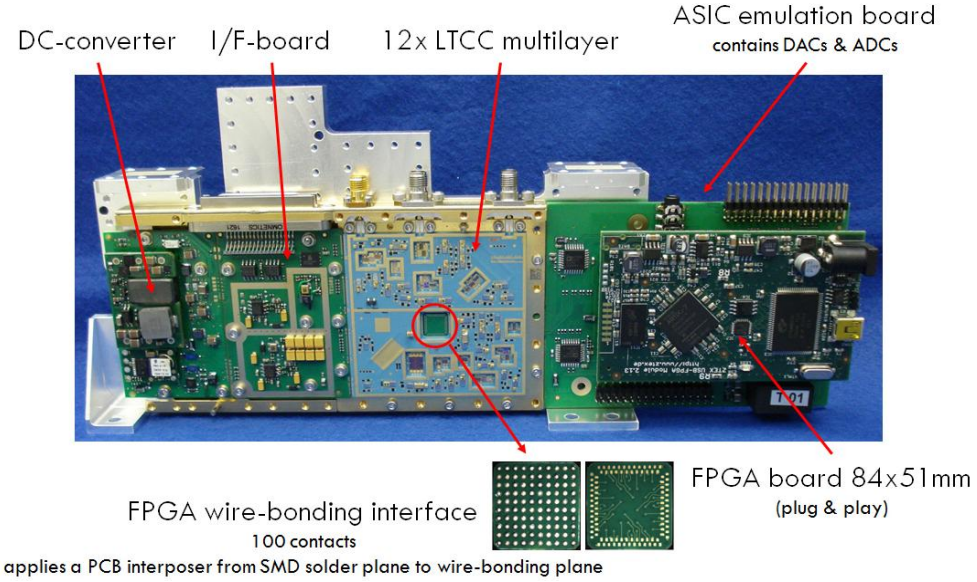
Parameter	Value	Remarks
Operating Frequency	10.7 GHz – 12.75 GHz	
Nominal RF Output Power	15W ... 25W	Depending upon thermal conditions & requirements
RF Input Power	-35dBm ... -10dBm	In FGM or ALC mode
Main Bus Interface	50V ... 100V	Various options available
DC power	50W	@ NOP 15W RF
TM/TC Interface	ON/OFF: High-level / Bi-level Other TM/TC: CAN serial I/F	CANopen / SOCAN - according to platform requirements
Size	164mmx56mmx81mm	
Mass	750 g	

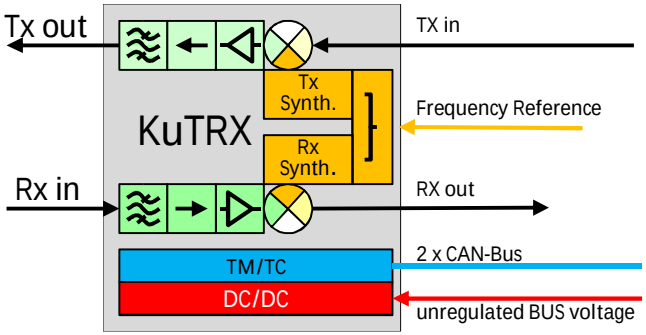






- Highly integrated TRX module:
  - Ku-Band SSPA and converter from Ka- to Ku-Band – downlink
  - Ku-Band LNA and converter from Ku- to K-Band – uplink
  - Transmit-receive I/O filter & isolator, frequency synthesizers





- Mixed signal control ASIC emulated for demonstrator by FPGA board
- CAN TM/TC functions:
  - gain setting
  - power monitoring
  - synthesizer control
  - memory up/download

HEINRICH HERTZ TELECOM MISSION

Heinrich Hertz Mission - H2Sat

- German Heinrich Hertz or H2Sat aims to explore and test new communications technologies in space at a technical and scientific level
- Development performed on behalf of the space agency of the German Aerospace Center (DLR) using funding provided by the German Federal Ministry of Economics and Technology (BMWi) with the participation of the Federal Ministry of Defence (BMVg).
- Mission will offer universities, research institutes and industry a platform for conducting numerous scientific/technical experiments.
- Mission objectives:
  - Scientific/technical verification of hardware and software and scientific experiments in the area of communications.
  - Preparations/testing of pre-operational satcom services for German (public-sector) users.
- Heinrich Hertz is planned to be launched in 2021

HEINRICH HERTZ

DLR Deutsches Zentrum für Luft- und Raumfahrt

Gefördert durch:

Bundesministerium für Wirtschaft und Technologie

aufgrund eines Beschlusses des Deutschen Bundestages

Unter Beteiligung:

Bundesministerium der Verteidigung

HEINRICH HERTZ MISSION - H2SAT

- Tesat is responsible for design and manufacturing of the scientific payload.
- Moreover, various types of innovative payload equipment are developed provided to the payload by Tesat.
- Corresponding in-orbit tests have been defined and will be carried throughout the mission, i.e. access to the provided equipment / technology will be given when the satellite is in orbit.

- Tesat equipment for scientific payload:
  - Flexible power amplifiers
    FPM 300W Ku Band / FPM 250W Ka Band
  - Flexible Filters
    FlexINET, FlexOMUX
  - CAN subsystem with Payload Interface Unit

HEINRICH HERTZ

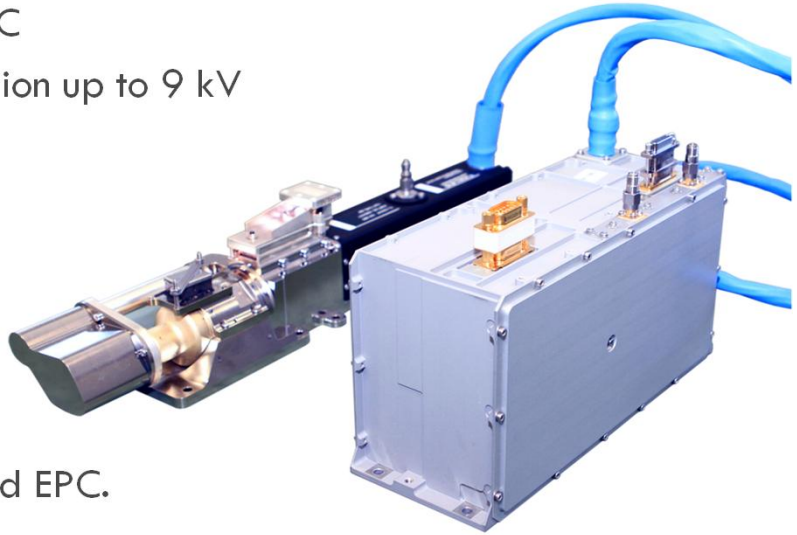
DLR Deutsches Zentrum für Luft- und Raumfahrt

Gefördert durch:
Bundesministerium für Wirtschaft und Technologie
aufgrund eines Beschlusses des Deutschen Bundestages

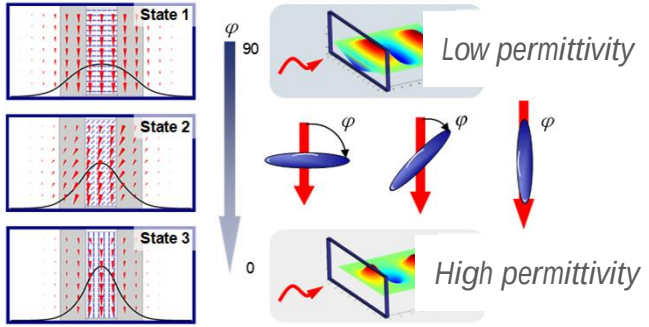
Unter Beteiligung:
Bundesministerium der Verteidigung

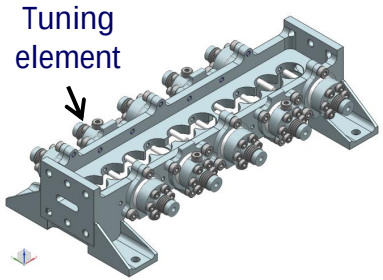
300W Ku Band FPM

- The FPM is the latest generation of Tesat's microwave amplifiers for satcom applications.
- FPM 300W Ku Band successfully qualified with support of an ESA Artes C&G program
- Key parameters:
  - Configurable output-power until -3 dB via CAN TC
  - TWT 5 collector design with high voltage generation up to 9 kV
  - I/F PCB with analog TM/TC and CAN Interface
    - Beside TM/TC during the mission CAN bus is used for programming purposes during manufacturing process.
    - CAN bus has also been selected for internal communication between subunits, i.e. LCAMP and EPC.

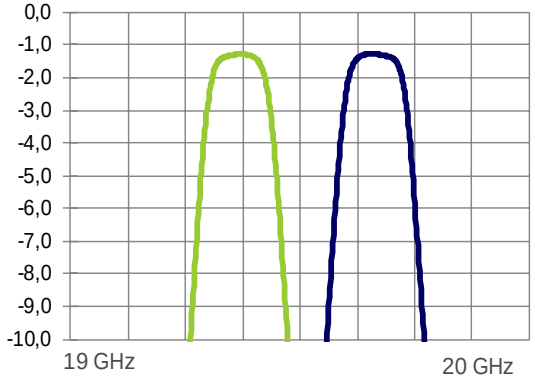


- Technology background
  - Permittivity of liquid-crystal (LC) depends on crystal orientation
  - Crystal orientation can be manipulated by external electric field – as known from LC displays
  - Static control voltage – very low power consumption
- Liquid-crystal loaded tuning element is the key component in tunable filter unit
- By adjusting tuning voltages bandpass center frequency can be changed as shown for Ka-band filter example



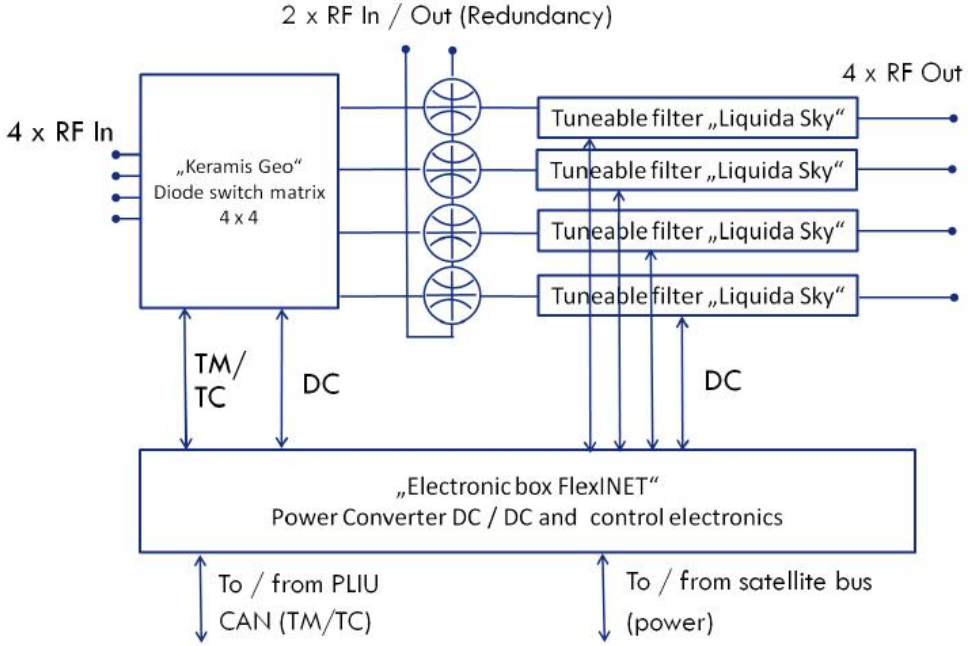


Tunable filter unit

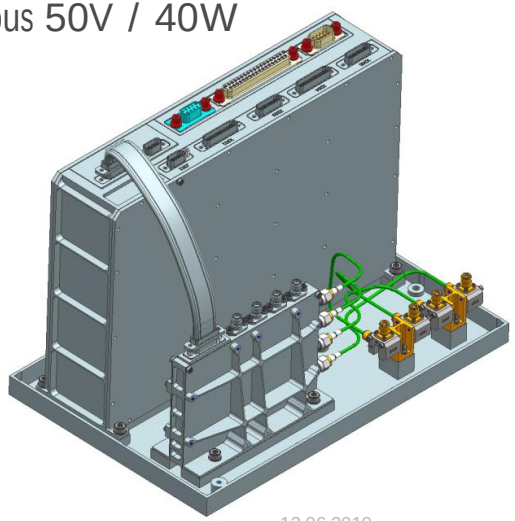


Tuning range of filter

- FlexINET building blocks:
  - LC tunable filters
  - 4x4 diode switch matrix
  - Coax RF switches
  - E-box

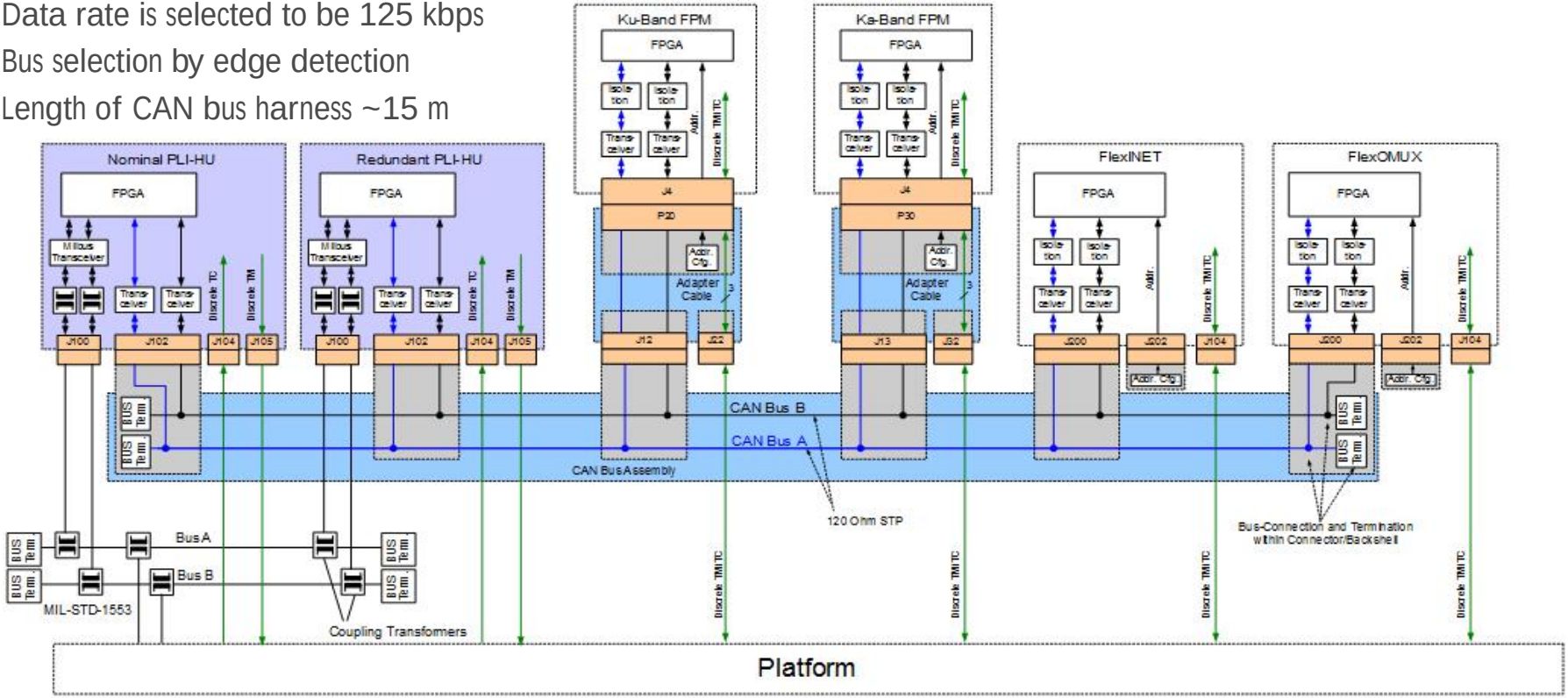


- E-box FlexINET:
  - DC/DC and control unit for FlexINET tunable filters and 4x4 diode switch matrix
  - 50+ output voltages for filter tuning (!)
  - CAN Bus TM/TC - protocol framework similar to other Tesat payload products
  - Main bus 50V / 40W



CAN System Heinrich Hertz Satellite

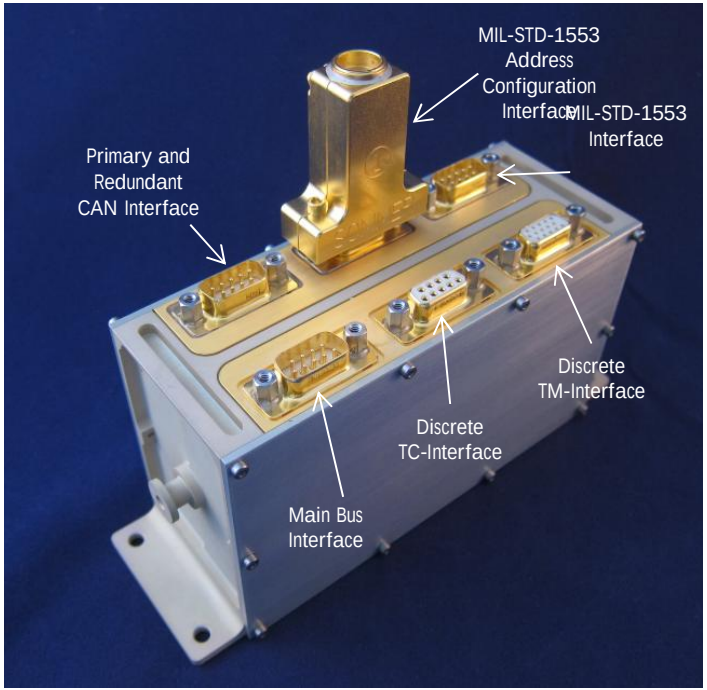
- CAN I/F based on CANopen protocol for Tesat equipment
- Data rate is selected to be 125 kbps
- Bus selection by edge detection
- Length of CAN bus harness ~15 m



Payload Interface Hardware Unit (PLI-HU)

- Main Function of PLI-HU - bridge between the platform MIL-STD-1553 bus and the payload CAN bus.
- PLI-HU provides an acyclic TM/TC I/F via MIL-STD-1553 bus
  - Telecommand forwarding from MIL-STD-1553 to CAN
  - Telemetry forwarding from CAN to MIL-STD-1553
- Periodic, autonomous acquisition of telemetry from CAN bus: Telemetry is stored in PLI-HU internal non-volatile shared memory, which is accessible via MIL-STD-1553 Bus.
- Can be provided for various platforms w/o existing CAN I/F

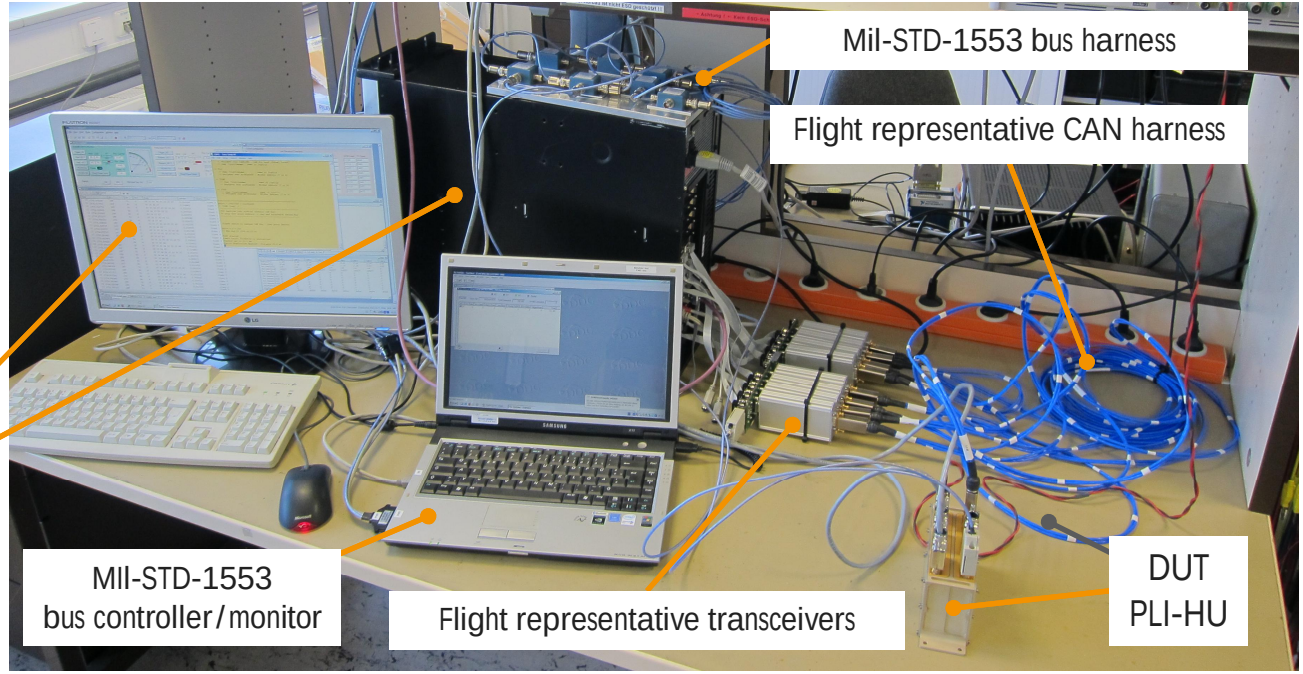
Parameter	Value
Housekeeping TM/TC Interface	MIL-STD-1553
Payload Interface	CAN-Bus
Bus voltage	50 V
Power consumption	1.8 W typ.
Dimensions	168 x 58 x 86 mm³
Mass	0.7 kg
In-orbit lifetime	15 years
Development status	EQM



Payload Interface Hardware Unit

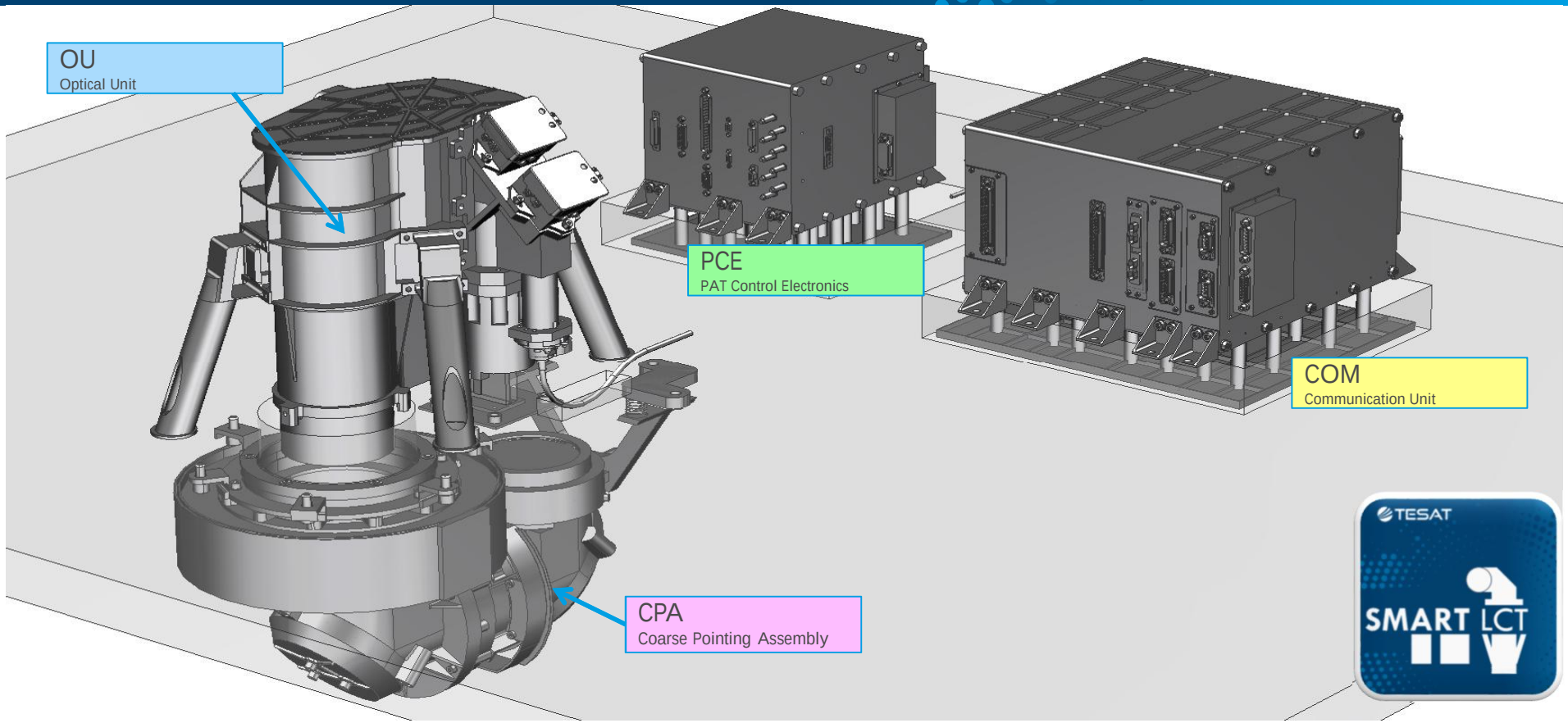
PLI-HU Test – Test Bed

- Functional test and performance evaluation with dedicated test bed in development lab: simulation of 8 CAN bus nodes in the shown test setup
- Mil bus environment avaialable / proven from other interface test campaigns
- CANoe development and test software to drive flight representative transceivers



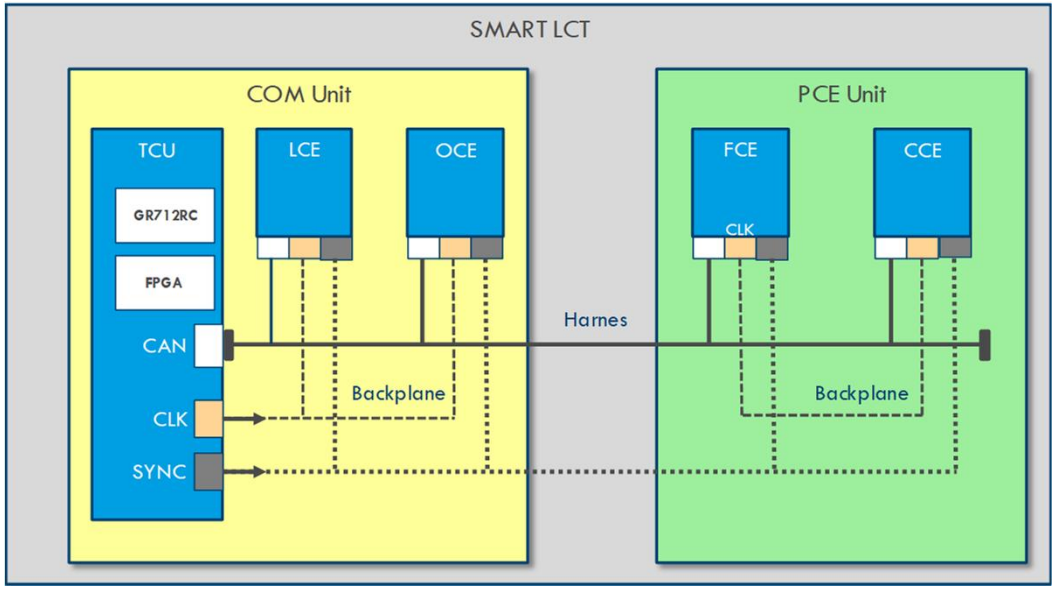
SMART LCT – NEW LASER COMMUNICATION TERMINAL

SMART LCT - New Laser Communication Terminal



SMART LCT - CAN BUS TOPOLOGY

- CAN bus used as LCT internal bus to control, supervise and monitor LCT Units
- LCT Sub-Units interconnected via CAN bus running at 1MBit/s
- Two different Units COM and PCE
  - COM Sub-Units: TCU, LCE and OCE
  - PCE Sub-Units: FCE, CCE

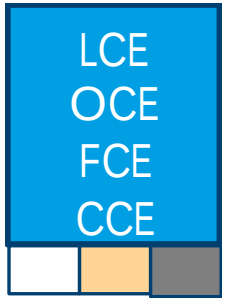


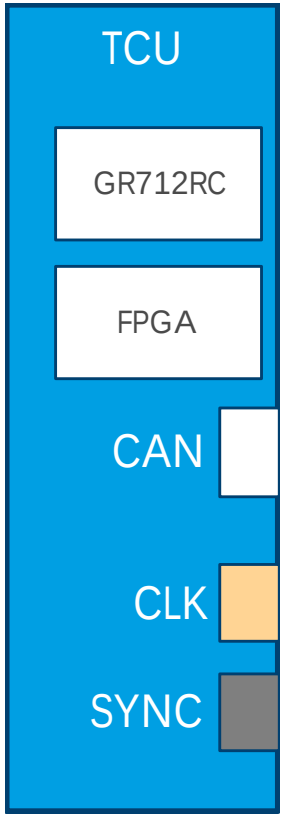
- Local CAN buses in COM and PCE via Backplane
- Distributed CLK Signal (40MHz) from TCU/FCE (cost optimized, no extra oscillator required)
- SYNC Signal (10Hz) provided by TCU to other LCT units for synchronized TM data acquisition

SMART LCT – CAN RELATED HARDWARE

- Terminal Control Unit (TCU)
  - LCT Control Unit – powered by software
  - TCU implements CAN interface to LCT internal units
  - TCU based on SoC GR712RC from Cobham Gaisler
  - One CAN Interface used in current design - Two CAN Interfaces possible, e.g. to replace MIL-STD-1553B interface for S/C TM/TC
  - SOCAN IP-Core, compatible to Philips SJA1000
  - Radiation tolerant CAN transceiver INTERSIL ISL 72026SEH
  - Protocol is subset of CANopen – similar to other Tesat products
  - Master/Slave approach - TCU acts as master and LCT units as slave

- LCT Units
  - Four LCT Units configured, controlled and supervised by TCU over CAN
  - Control Electronics of LCT Units FPGA based (Microsemi ProASIC3)
  - CAN IP Core: IniCAN from INICORE INC used for LCT Units
  - Current design supports 1MBit/s

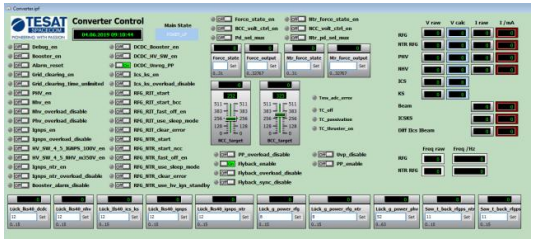




Other Products – Electric Propulsion

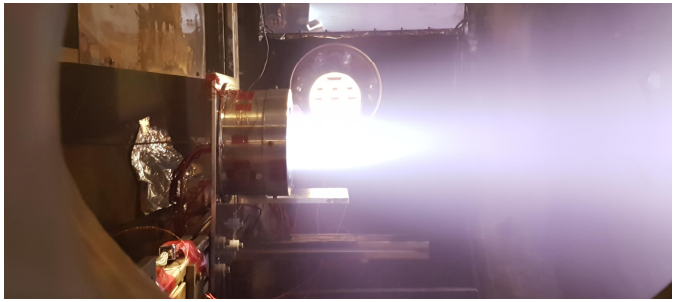
- Thruster control unit (TCU)
  - TCU includes all electrical support functions for Electric Propulsion (EP) system
    - Grid supplies
    - RF supplies
    - Pressure and temperature control loops
    - Autonomous operating and sequencing

New space TCU



Control panel for CAN I/F

- Serial TCU CAN Interface
  - customer telemetry and configuration selection
  - debugging, tuning and test functions
    - individual output power switching
    - monitoring of internal signals
    - digital tuning and configuration



Thruster coupling test with Tesat TCU

SUMMARY – CAN @ TESAT 2019

» MPMs for telecom payloads with CAN TM/TC have been delivered to a number of flight projects. Thanks to the close exchange between all partners, especially with Airbus TLS, the ramp up went really smooth and very quickly.

» A CAN network with various different types of equipment will be demonstrated and investigated on the Heinrich Hertz Mission.
Corresponding results are regarded to be useful for future system planning

» CAN has been baselined for various new kinds of equipment since it allows for flexible use and customer / platform independent interface definition.
This independency is key for minimizing development effort for new equipment where TM/TC is typically not the core functionality

THANK YOU FOR YOUR ATTENTION!

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