TESAT SPACECOM

PIONEERING WITH PASSION

CAN @ Tesat – CAN in Telecom Payload Products

ESA Workshop CAN in Space, June 16th 2017

Outline

» Tesat‘s Product Portfolio

» CAN implementation details in Tesat‘s products

» CAN development status and outlook on future projects

TESAT'S PRODUCT PORTFOLIO

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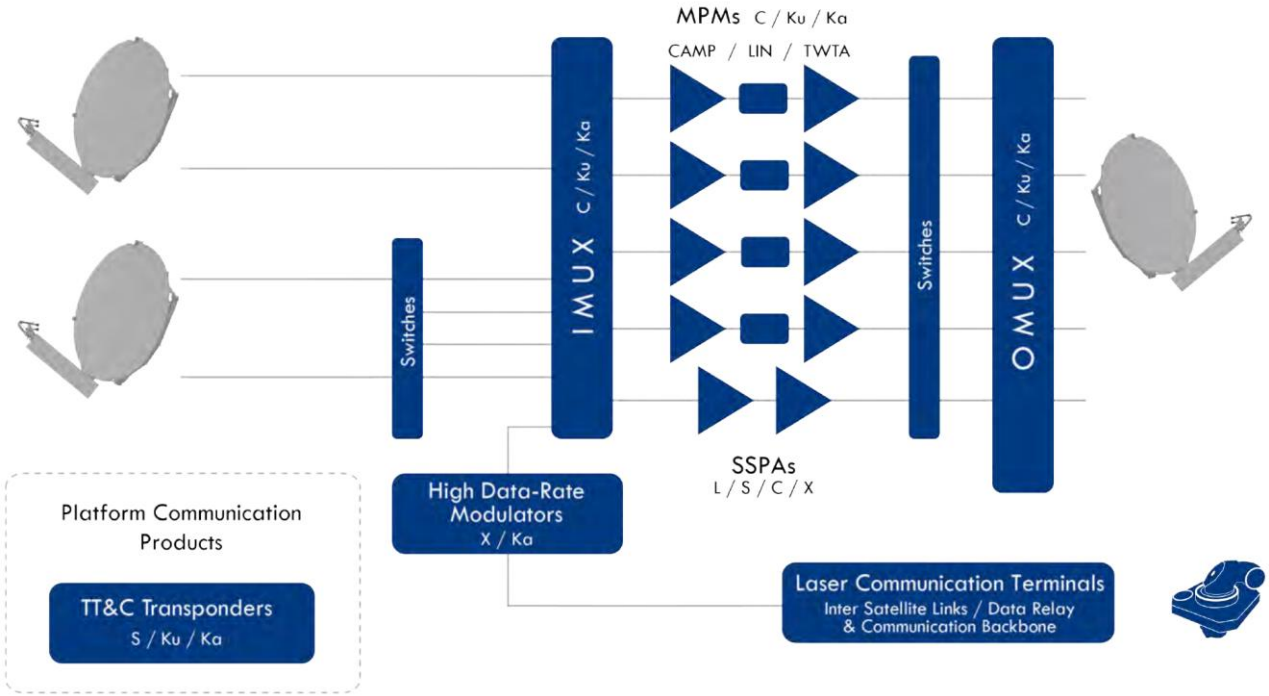
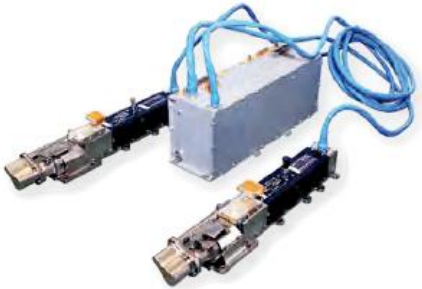
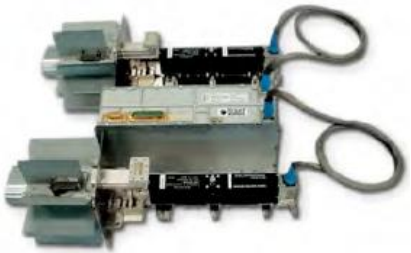


Amplifier Products: MPMs, TWTAs and SSPAs

- RF amplifiers based on TWT are still broadly used in satcom payloads.
- RF power and predistortion is provided by LCAMPs associated to individual tubes.
- TWT and LCAMP supplied by electronic power conditioner (EPC) - connects the units to the main bus power supply.
- Similar arrangement in SSPAs, assembled from solid-state based amplifier stage and DC converter unit.
- Equipment control typically by individual TM/TC interface.



170W Ka-Band Dual MPM



DUAL TWTA

X-Band SSPA

TESAT PRODUCTS: PASSIVE, DATALINK AND LASER

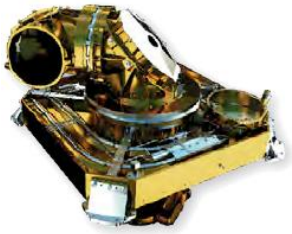
- Innovative filter concepts and high performance waveguide switches to support the customer in providing best satellite performance.
- Fully digital modulator for Gigabit per second range and universal TTC transponder product family for S-, Ku-, and Ka-Band.
- Worldwide unique laser communication terminals: Commercial breakthrough with EDRS.
- Housekeeping functions for all types of equipment are required today or will be of interest in the future.

Switches

OMUX

Ka-Band QPSK Modulator

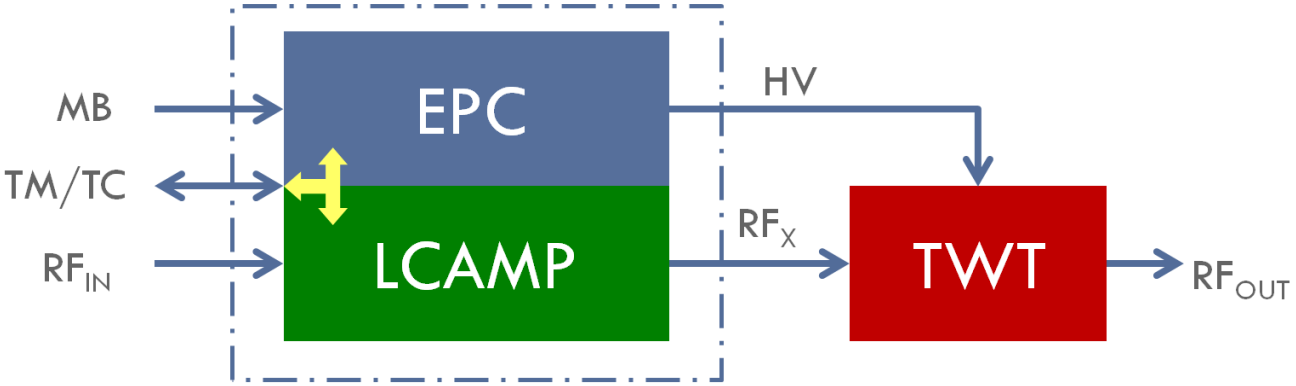
S-Band TTC Transponder



Design Model of a Laser Terminal

CAN implementation details in Tesat's products

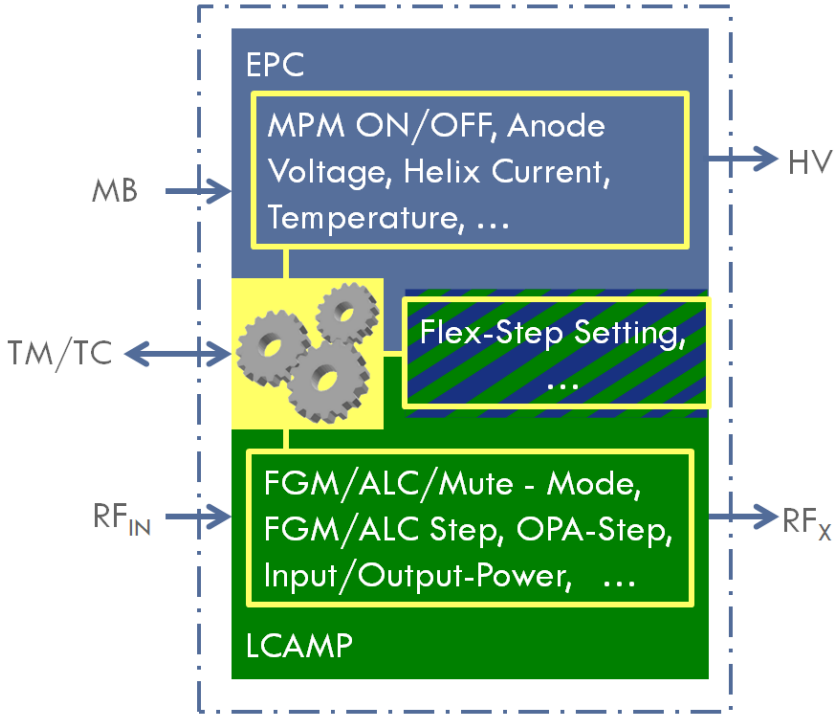
Amplifier Interfaces: Microwave Power Module (MPM)



- Main bus (MB) – Trend towards 100 Volt.
- RF_{IN} and RF_X – Low power, SMA or SMA-K for Ka-Band.
- HV – Limited number of high voltage supply configurations.
- Mechanical and thermal interface – limited number of options.
- TM/TC – Large variety of options, impact on equipment design.

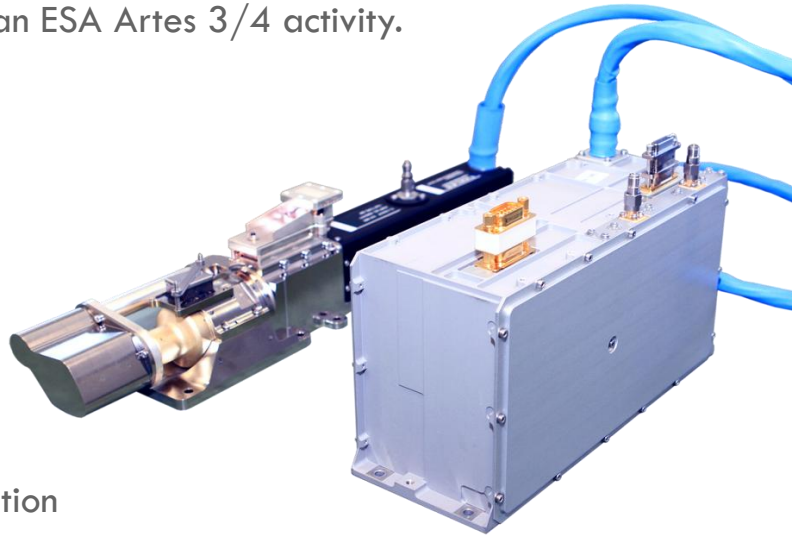
TM/TC Functions: Microwave Power Module (MPM)

- Set of TM/TC-functions is limited.
- 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.



FLEXIBLE PROGRAMMABLE MPM – EQM

- The FPM is the latest generation of Tesat's microwave amplifiers for satcom applications.
- First unit successfully qualified in 2016 in the frame of an ESA Artes 3/4 activity.
- Key parameters:
  - Configurable output-power until -3 dB via CAN
  - TWT 5 collector design for improved efficiency
  - I/F PCB with analog TM/TC and CAN Interface with discrete isolated transceiver
    - Interface standardization is a key parameter to reduce cost and improve project schedule.
    - CAN bus has been selected for internal communication between subunits.
    - CAN bus is used for programming purposes during manufacturing process.



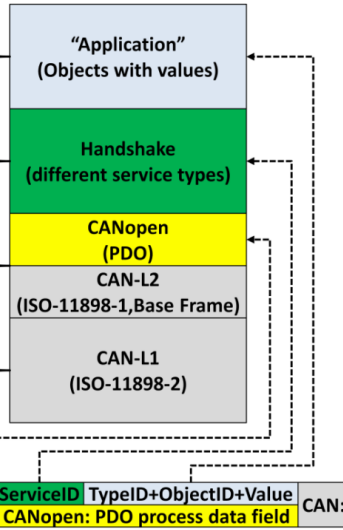
Frame Mapping

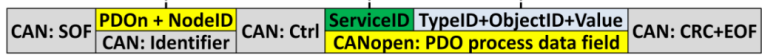
ObjectIDs: 2 stage addressing (as in CANopen)
Value : 0, 1, 2, 4 data bytes, or error code
TypeID : To indicate type of value

ServiceID ➔ robust, observable, extendable
-TC (TC-Request)
-QTM (QTM-Request, QTM-Response)
-[Test, LastTC, …]

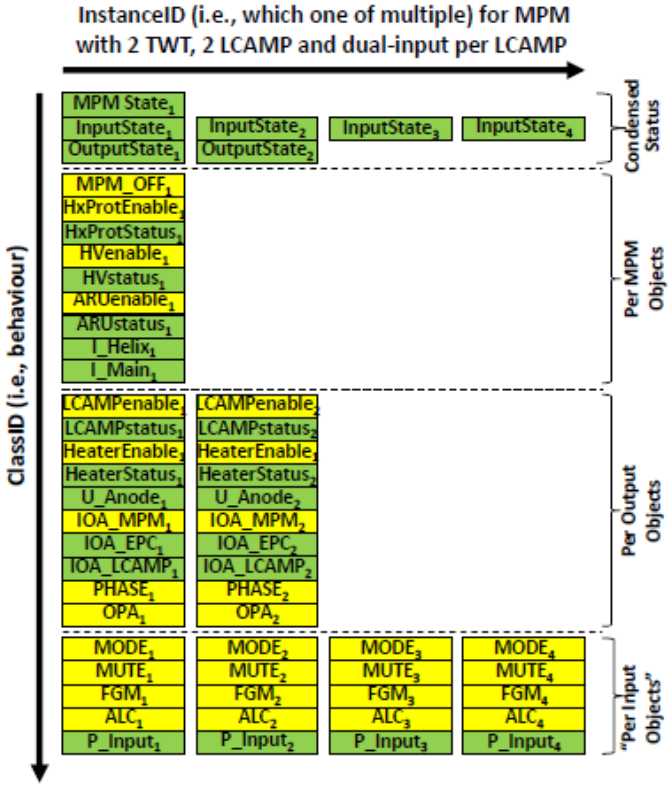
Protocol Data Objects (PDO) of CANopen
➔Coexistence of node addressing and bus arbitration

Standard Layer 1 from CAN



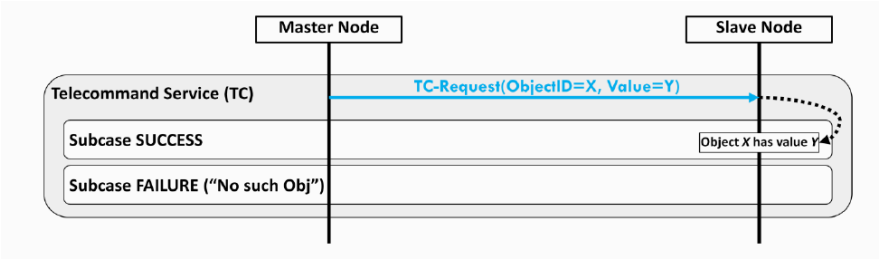


Object ID = Class ID + Instance ID

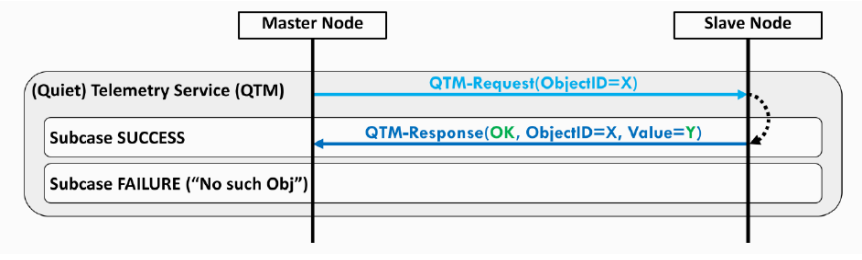


Standardized Handshake

- Multi-Master vs. Master-Slave concept
  - Slave node only transmits data if requested by the master
  - To keep it simple, MPMs are assumed to be operated as slaves on the bus
  - MPMs may also be used in a Multi-Master environment



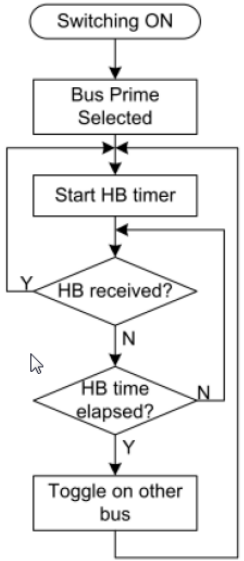
Handshake for telecommand



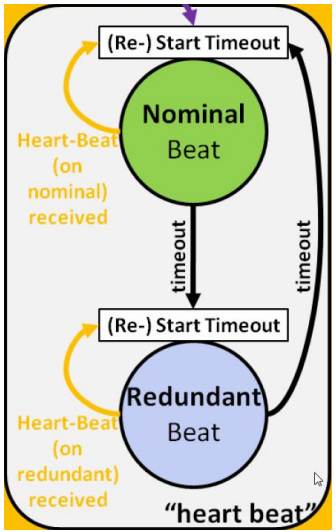
Handshake for telemetry

Redundancy Management: Bus Selection Heart Beat

- Master sends periodically a broadcast CAN message including the Heart Beat protocol
- The master (Heart Beat producer) is responsible for issuing the heartbeat frame within the specified time.



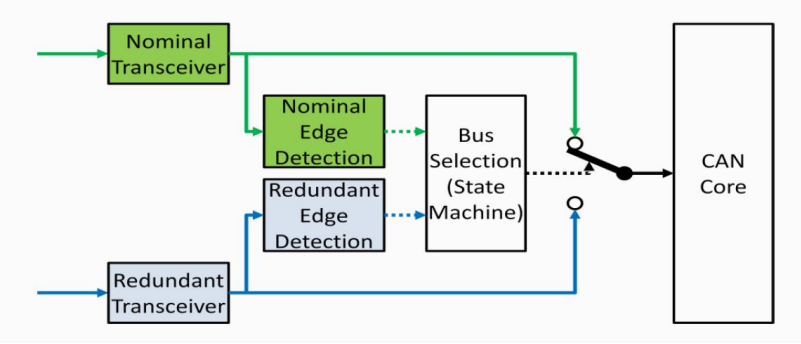
Heart Beat Bus selection process



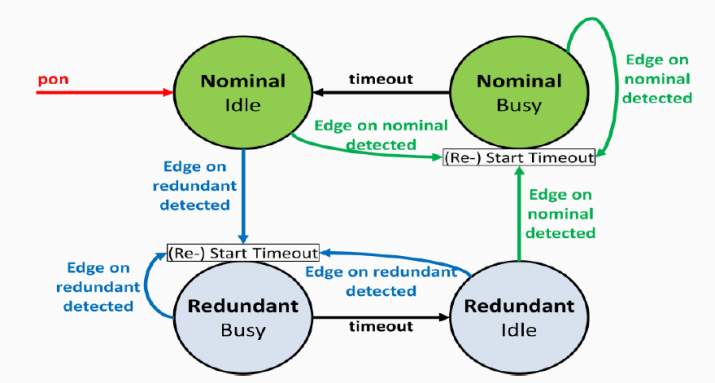
State machine Heart Beat

Redundancy Management: Bus Selection Edge Detection

» Structure of CAN front-end for slave nodes

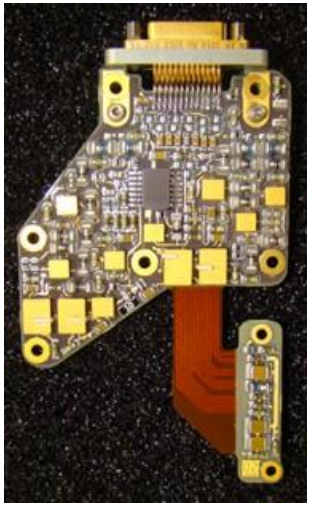


» State machine for automatic bus selection in slave nodes



I/F Board

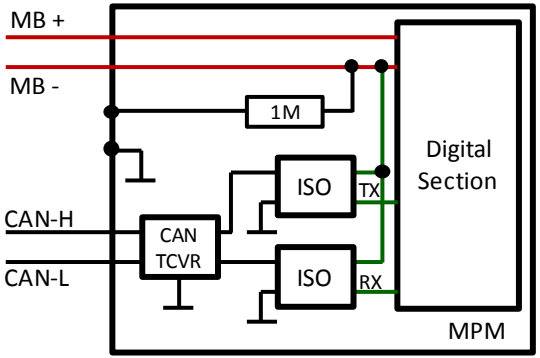
- Implementation of a “discrete” isolated transceiver, due to non qualified radiation hardened integrated transceivers at the time of development
  - Maximum data rate: 125 kbps
  - Limited electrical performance
  - Standard parts, no export issues
  - “on stock”
  - MDM connector
  - Double Isolation requirements
  - 7 bit hardware address (Node ID), configurable at connector / harness level

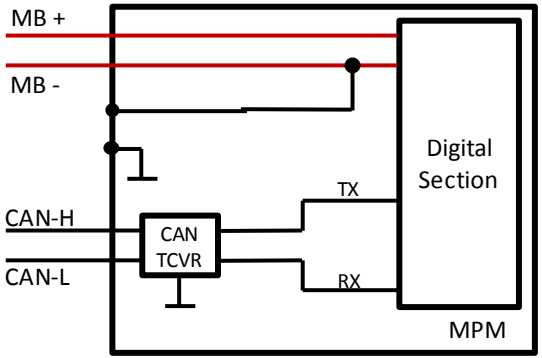


Data Rate and Grounding Constraints

- Depending upon platform requirements the main bus return (MB-) might be isolated or connected to chassis ground.

- Grounding constraints may require the use of optocouplers for galvanic isolation in the Rx/Tx section. Performance of optocouplers limits the maximum bus speed.
- Current CAN bus implementation supports 50, 125, 250, and 500 kbps
  - 250 kbps might become standard for equipment w/o need for galvanic isolation
  - 125 kbps feasible with optocouplers and limited network size, 50 kbps as fallback
  - 1Mbps not supported in current implementation.

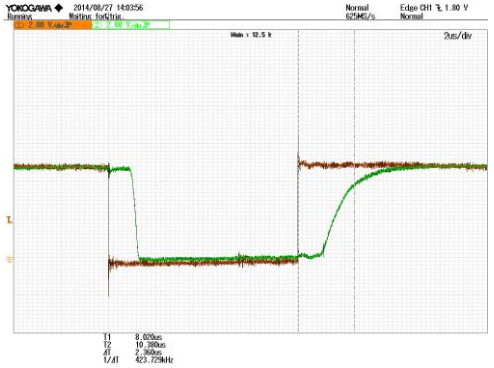




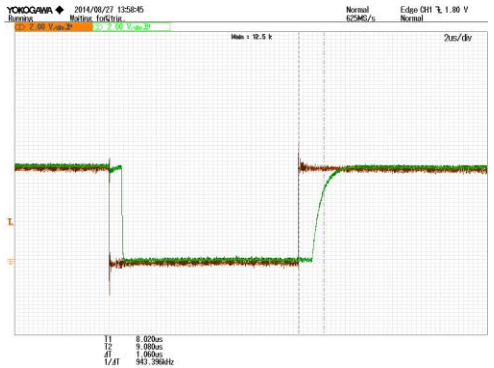
Galvanic Isolation

- Optocoupler for galvanic isolation
  - Limitation of bitrate
- Experimental measurement:
  - Signal from Tx to Rx:

    Latency reduction from 2,36 µs to 1,06 µs (including quantization time, electrical propagation delay)
- Options:
  - transformer principle, e.g. iCoupler
  - avoid galvanic isolation for serial interface!



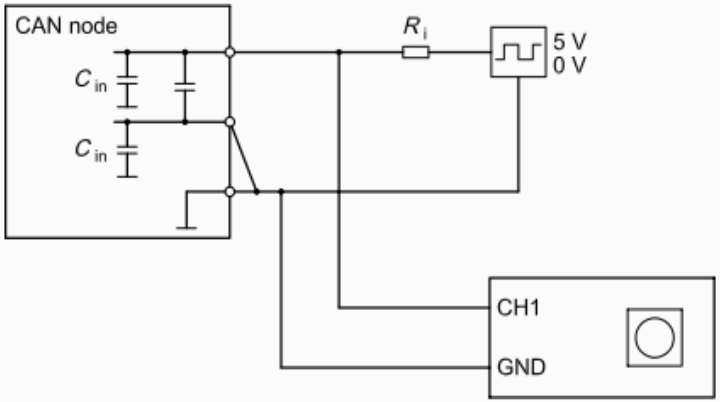
Delay with Isolink Optocoupler OLS300

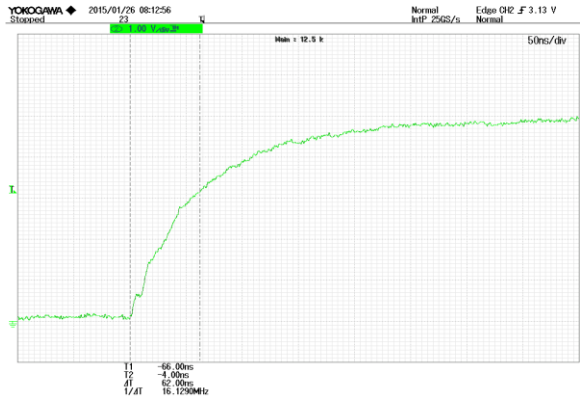


Delay with Isolink Optocoupler OLS500

Conformance Test

- Executed conformance test to ISO11898-2 includes the following considerations:
  - Dominant/recessive input threshold of CAN node
  - Internal resistance of CAN_L and CAN_H
  - Internal differential resistor
  - Measurement of the internal delay time
  - Input capacity





$$C_{in} = \frac{\tau}{R_i} = 62\ pF$$

Integrated Transceiver

- Current standard in Tesat's LCAMP design is based on integrated transceivers and supports data rates up to 500 kbps with LARS2 ASIC

- 250 kbps and 500 kbps are currently asked for by TESATs customers

- A dedicated CAN test unit has been developed and manufactured to support CAN bus system tests w/o the need of further RF equipment.

CAN DEVELOPMENT STATUS AND OUTLOOK ON FUTURE PROJECTS

SOC Feedback

» SOC discussion regarding ESCC-E-ST-50-15C

9.1 COB-ID assignment

a. The address(es) of the master(s) shall have the highest priority(ies).

b. Slave node address ID(6).. ID(0) assigned to each node shall conform to clause 10 of this document.

NOTE NODE-ID 0 is used to broadcast all nodes in the network. It does not use it.

» According to Table 9-13 of ECSS Node-ID 0 is reserved for broadcasting NMT, SYNC and TIME STAMP objects.

» For PDO broadcast Tesat's CAN Bus implementation utilizes Node-ID 127.

SOC Feedback

» SOC discussion regarding ESCC-E-ST-50-15C

9.4.6.1 Module control services

a. Autonomous operations of slave nodes shall not be used.

NOTE This implies that the use of remote node start, stop, enter pre-operational, reset and reset communication services is forbidden.

» Tesat slave nodes with CAN interface currently enter operational state automatically after unit is switched on via separate TC.

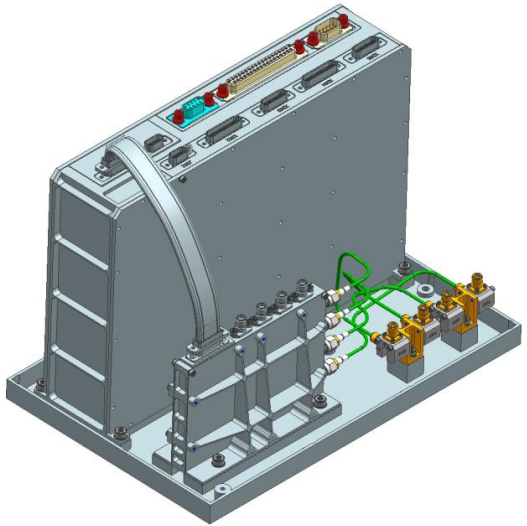
» Compliant to the above note (no use of remote node start, stop, enter pre-operational, reset and reset communication services).

» Not compliant to the requirement? Maybe misinterpretation of the term “autonomous operations”.

Future Projects

- Regular MPM projects indicate strong interest – from European and non-European satellite manufacturers
- Laser Communication Terminal – for internal communication between subunits

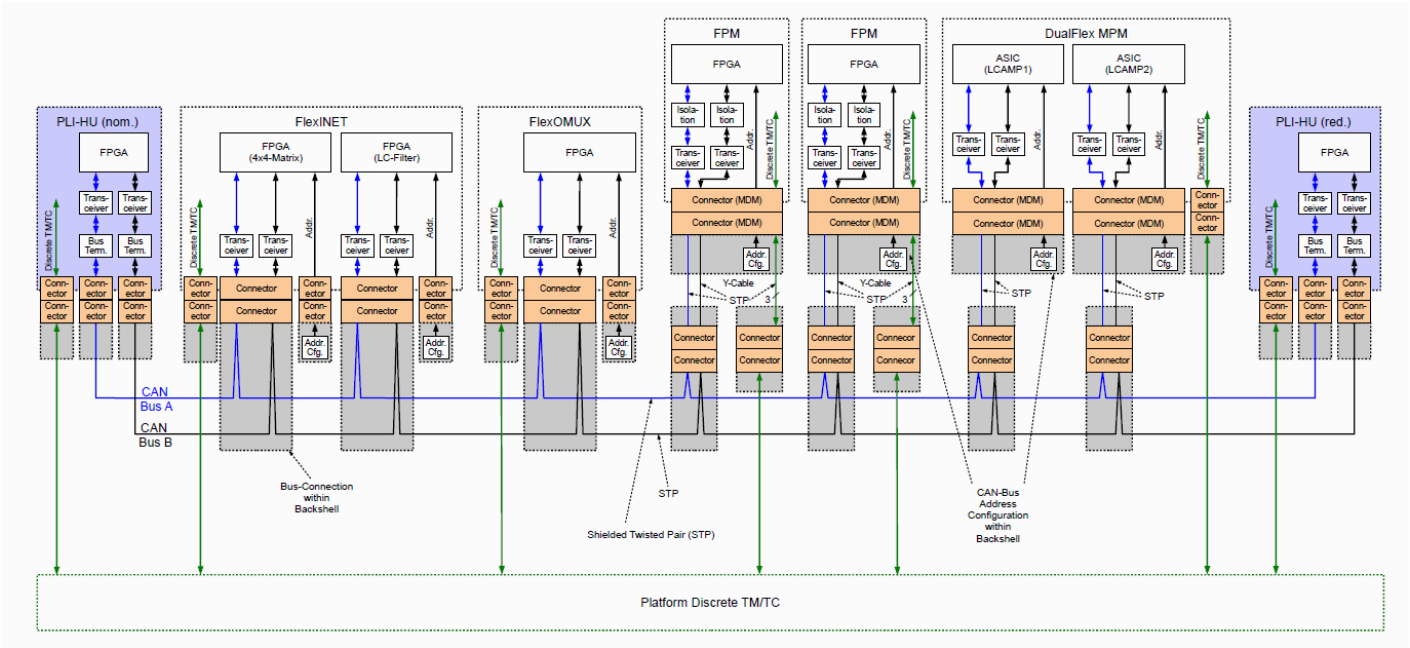
- Heinrich Hertz Satellite (H2Sat) – Proposed equipment for scientific payload:
  - Flexible Programmable MPM
  - Dual Flex MPM
  - FlexINET, FlexOMUX
    - TM/TC interface with CAN bus implemented according to ECSS standard.
    - Protocol framework similar to other Tesat payload products (e.g. MPM) → only functional adaptation required.
  - PLIU



FlexINET Control Unit

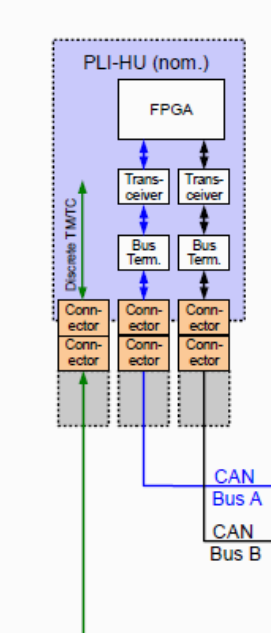
FUTURE PROJECTS

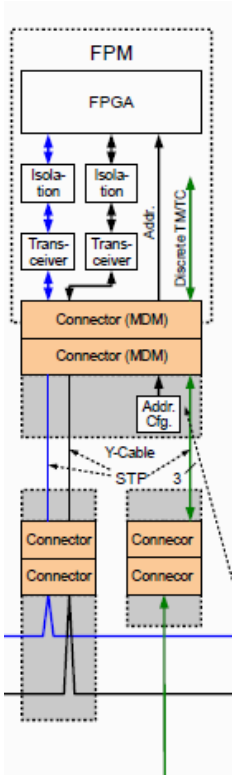
» CAN System Heinrich Hertz Satellite



Future Projects

- System Heinrich Hertz Satellite
  - CANopen protocol
  - 125 kbps data rate
  - Bus selection through edge detection
  - Discrete TM/TC interface
    - TC switch on/off the device
    - TM on/off status



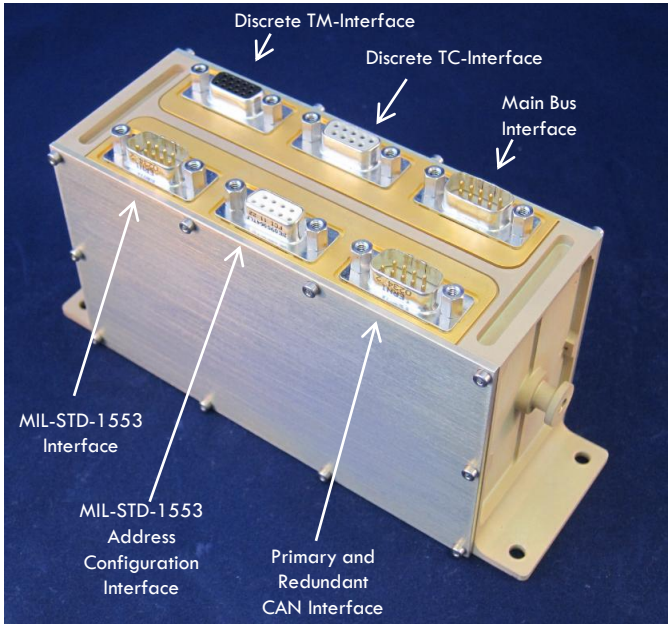


Payload Interface Hardware Unit (PLI-HU)

Main Function of PLI-HU:

- Builds a bridge between the platform MIL-STD-1553 bus and the payload CAN bus.
- Providing an acyclic TM/TC interface via MIL-STD-1553 Bus (Telecommand forwarding from MIL-STD-1553 Bus to CAN Bus. Telemetry forwarding from CAN Bus to MIL-STD-1553 Bus)
- 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).

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	Prototype



PLI-HU Prototype

THANK YOU FOR YOUR ATTENTION

Christoph Schieber
Development Engineer Power Supply
+49 7191 930-2699
Christoph.Schieber@tesat.de

Tesat-Spacecom GmbH & Co. KG
Gerberstraße 49
71522 Backnang
www.tesat.de