GEO Dual Mode PPU & LEO HEMPT PPU

EPIC Workshop 2017

Madrid 24-25 Oct

ThalesAlenia Space

a Thales / Leonardo company

25-10-2017

Ref. = LP-PPU-PPT-17027-01-00

Ref. Model = 83230347-DOC-TAS-EN-005

Presentation Plan

Thales Alenia Space in Belgium, previously named "ETCA" was created in 1963,

- 54 years' experience in power supplies for space applications
- Electric Propulsion activities since 1996

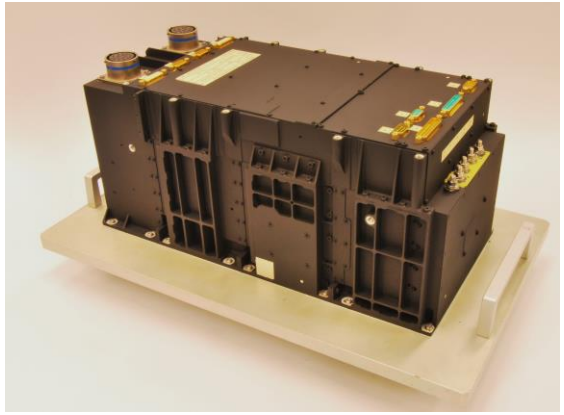
Outline

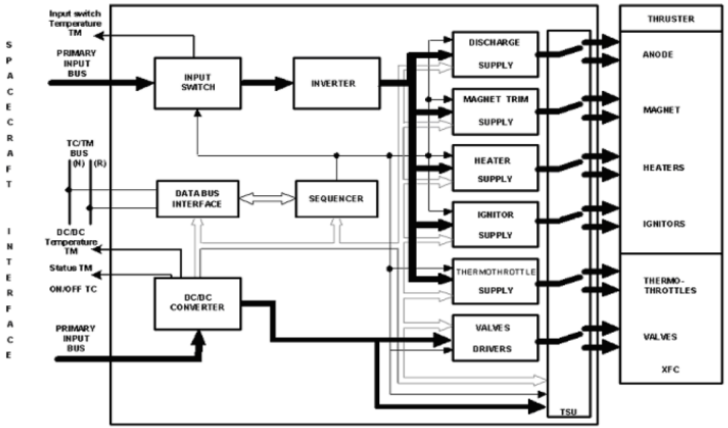
- **Background:**
  - PPU Mk1 & PPU Mk2
  - PPU Mk3
- **GEO Dual Mode PPU**
  - Activities
  - Heritage
  - Definition
- **LEO HEMPT PPU**
  - Activities
  - Heritage
  - Definition

PPU Mk1: Product Overview

Power Processing Unit Mk1

Mass	10.9 kg
Dimensions	390x190x186 mm3
P anode	**1 500 W**
Input power bus	**50V** or 100V
Efficiency at nominal conditions	91.6% (50V) 92.4% (100V)
Reliability for one PPU + TSU	2996 fits
Operating up to pressure of	200 mPa
TC/TM plug-in module	Mil-Std-1553 OBDH-RS485 (RUBI) ML16/DS16
Thrusters	SPT-100 PPS1350-G





- **Flight Heritage** since September 2003
  - **Smart-1** reached the Moon, 4 958 hrs operation
  - **12 telecom satellites** in flight with 2 PPU Mk1
  - **39 800 hrs** cumulated flight operation
- **35 PPU Mk1 FM's** delivered to
  - ADS, ESA, IAI, OHB, Safran, TAS-F

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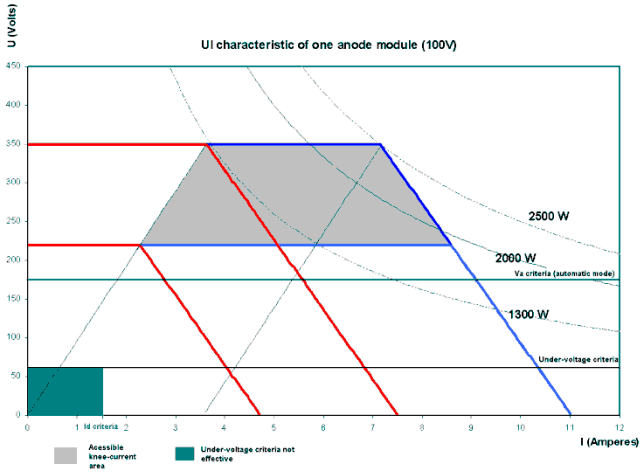
PPU Mk2: Product Overview

Power Processing Unit Mk2

Mass	11.8 kg
Dimensions	390x190x190 mm3
P anode	**2 500 W**
Input power bus	**100V**
Efficiency at nominal conditions	95%
Reliability for one PPU + TSU	1700 fits
Operating up to pressure of	1 Pa
TC/TM plug-in module	Mil-Std-1553
Thrusters	SPT-100 PPS1350-G PPS1350-E

- **Qualified** since July 2014
- PPU Mk2 EQM successfully coupled with
  - SPT-100; PPS1350 at 1.5 kW and 2.5 kW
- **10 PPU Mk2 FM's** ordered by 2 Customers



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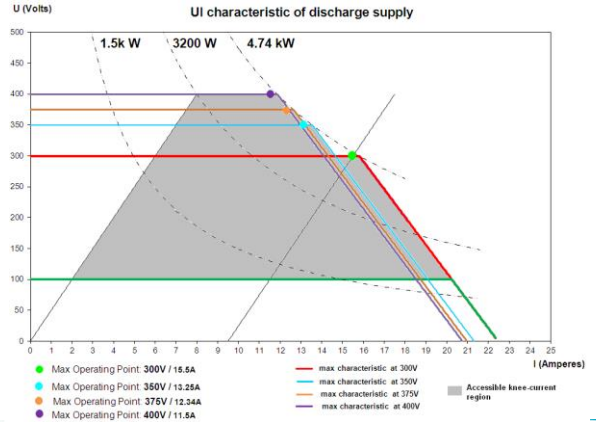
PPU Mk3 Description: Product Overview

Power Processing Unit Mk3

Mass	18.6 kg
Dimensions	390x315x263 mm3
P anode	**4 740 W**
Input power bus	**100V**
Efficiency at nominal conditions	95%
Reliability for one PPU + TSU	2300 fits
Operating up to pressure of	1 Pa
TC/TM	Mil-Std-1553
Thrusters single cathode	SPT140-D PPS-5000 Variant for XR-5 PFCV



- **Qualified** since March 2016
- PPU Mk3 DM/EQM successfully coupled with SPT140-D, PPS-5000, XR-5
- **25 PPU Mk3 FM's** have been **ordered** by three European Primes
- **9 PPU Mk3 FM's** are already **delivered**
- **3 PPU Mk3 FM's** are **in-flight** since June 2017, on the first European satellite performing Electrical Orbit Raising

PPU Mk3 Development : Timeline

Study phase

Design &
Development phase

DM manufacturing & test

EQM MF & qualification

FM manufacturing

2013 | 2014 | 2015 | 2016 | 2017

RR | PDR | CDR | QR | FM1

Coupled tests
Anode supply / SPT140-D
at Fakel facilities

Coupled tests
DM / SPT140-D
at Aerospazio

Coupled tests
DM / PPS-5000
at CNRS

Coupled tests
DM / XR-5
at QinetiQ

Coupled tests
EQM/ SPT140-D
at Aerospazio

Coupled tests
EQM/ PPS-5000
at CNRS

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GEO Dual Mode PPU (1/2)

In the frame of the H2020 CHEOPS project (GA 730135), TAS-B leads the task 3.3: Dual Mode PPU

- Task 3.3 is part of the WP3 - **HET Dual Mode System for GEO/NAV**
- Sub-task 3.3.1: PPU specification
  - PPU Co-engineering with thruster manufacturer. PPU Architecture study & specification
- Sub-task 3.3.2: Dual Mode PPU design
  - PPU Pre-Project design, definition,
  - Anode supply, HIMT supplies, Reconfiguration switching design & justification for PDR
  - Preliminary Design Review
- Sub-task 3.3.3: Dual Mode Breadboard MAIT and coupling test with thruster
  - Breadboard manufacturing & test
  - Breadboard test bench implementation
  - PPU Coupled test (with thruster and FMS) preparation, on-site participation, test report

TAS-B is involved in the following WP's:

- WP1 - Coordination, dissemination & exploitation
- WP2 - Strategies for value creation and cost reduction

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GEO Dual Mode PPU (2/2)

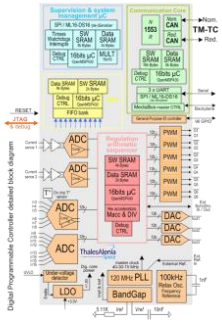
Heritage PPU Mk3 & CHVPS

- Single 5kW anode supply
  - Configurable to deliver 500V or 1kV or 2kV
  - 100V Regulated bus
  - Innovative electrical topology
  - Digital Control
- Demonstrator tested in 2016

GEO Dual Mode PPU Definition

- Anode Module
  - Output voltage range: 250V-800V
  - Output power range : 3 kW - 7 kW
  - Configurable in parallel or in series with reconfiguration switches
- Cathode Module
  - Heater supply
  - Ignitor supply
  - FCU supplies with regulation loop for the discharge current
- Key technologies
  - Use of GaN transistors
  - Competitive High Power / High Voltage planar transformer
  - Use of TAS-B Digital Processor Controller (µcontroller dedicated to space applications)

Digital Controller Architecture



Features :

- 3x µc cores
- 4x 13bits 1Msps ADCs
- 3x 12bits DACs
- 6x PWM controllers
- 1553, UART & CAN
- Built-in osc., PLL, Vref & digital supply converter
- Radiation hardened
- No US export constraint

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LEO HEMPT PPU (1/2)

In the frame of the H2020 HEMPT-NG project (GA 730020), TAS-B leads the WP5: LEO-PPU

- Task 5.1 WP Management
- Task 5.2 LEO-PPU Definition
  - To define the low-cost LEO-PPU based on a thruster/PPU interface optimized with the thruster manufacturer
    → SRR held 22 June 2017
- Task 5.3 LEO-PPU Design
  - To design LEO-PPU, including the interface to non-regulated power bus, the power supplies for the thruster, the regulation loop and the PPU sequencing.
  - Preliminary Design Review
- Task 5.4 LEO-PPU Breadboard Manufacturing and Test
- Task 5.5 LEO-PPU Breadboard coupling test with thruster

TAS-B is involved in the following WP's:

- WP1 - Management and Dissemination
- WP2 - Spacecraft System Studies, Business Cases & Exploitation

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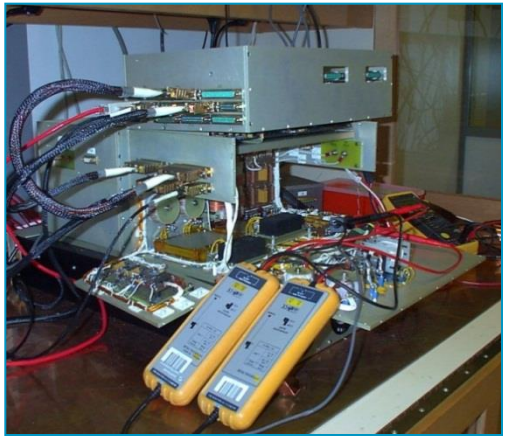
LEO HEMPT PPU (2/2)

Heritage

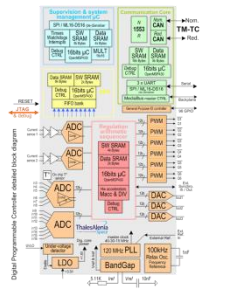
- 2 PHVC modules of 2.5kW connected in series, commandable up to 2kV / 4.7kW
- 100V Regulated bus
- Demonstrator successfully coupled with
  - RIT-22: 900V-2kV in Giessen
  - RIT-22: 500 hrs life-test
  - HEMPT-3050: 500V-1kV in Ulm



LEO HEMPT PPU Definition

- Anode Module
  - Output voltage range: 400V-800V
  - Maximum output power: 700W
  - two supplies configurable in parallel or in series with reconfiguration switches
- Neutralizer Module
  - Heater supply
  - Keeper supply
  - EPG-limiter (clamping of the floating ground of the thruster)
  - FCU valve driver (isolation, thruster, neutralizer) with regulation loop for the discharge current
- Key technologies
  - Use of GaN transistors
  - Competitive planar transformer
  - Use of TAS-B Digital Processor Controller (µcontroller dedicated to space applications)

Digital Controller Architecture



Features :
- 3x µc cores
- 4x 13bits 1Msps ADCs
- 3x 12bits DACs
- 6x PWM controllers
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Conclusion

- Based on strong heritage from PPU Mk1 and from PPU Mk2 , TAS-B has designed, developed and qualified the competitive **PPU Mk3** product dedicated to **5kW HET** and 100V satellite platforms.
  - Short time to market: KO in 2013, **QR** in **March 2016**
  - Coupling tests with **PPS-5000**, **SPT140-D** and **XR-5** thrusters.
  - **25** PPU Mk3 FM's **ordered**,
  - **9** PPU Mk3 FM's **delivered**,
  - **3** PPU Mk3 FM's **in-flight**

- Thanks to the H2020 EPIC, TAS-B is designing and developing two PPU competitive products:
  - In the frame of CHEOPS, **Dual Mode HET PPU** for GEO/NAV applications,
  - In the frame of HEMPT-NG, **HEMPT PPU** for LEO applications

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730135 & 730020.

GEO Dual Mode PPU & LEO HEMPT PPU

Thank you for your attention

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