Essential TeleMetry (ETM) support ASIC

DUTH/SRL - SPACE ASICS

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Rationale & Goals

What is currently available?

Essential Telemetry Encoding and Telecommand Decoding capability already exists (SCTMTC ASIC)

What is missing

Essential Telemetry Acquisition functionality to complement the SCTMTC does not exist $\Rightarrow$ ETM ASIC

Essential means that it can operate without the need of a S/C computer

Potential benefit

In addition ETM can be used as a Remote Telemetry component that interfaces to the S/C Main Computer

Functionalities

ETM autonomously performs the following tasks on power up:

- Sequential scanning and sampling of discrete Analog and Digital inputs
- Convert the Analog inputs to digital values
- Format the sampled data into Space Packets
- Output the sampled formatted data either on the CAN or the PacketWire interface

Applications

- Essential telemetry support in S/C
- Remote Terminal Unit in space data acquisition systems
- Housekeeping in space instrumentation

ETM Configurations

Stand Alone (STD)

ETM ASIC connected through PacketWire interface to one SCTMTC ASIC's Virtual Channel for data transfer.

Cascaded Daisy Chain (CSC/DC)

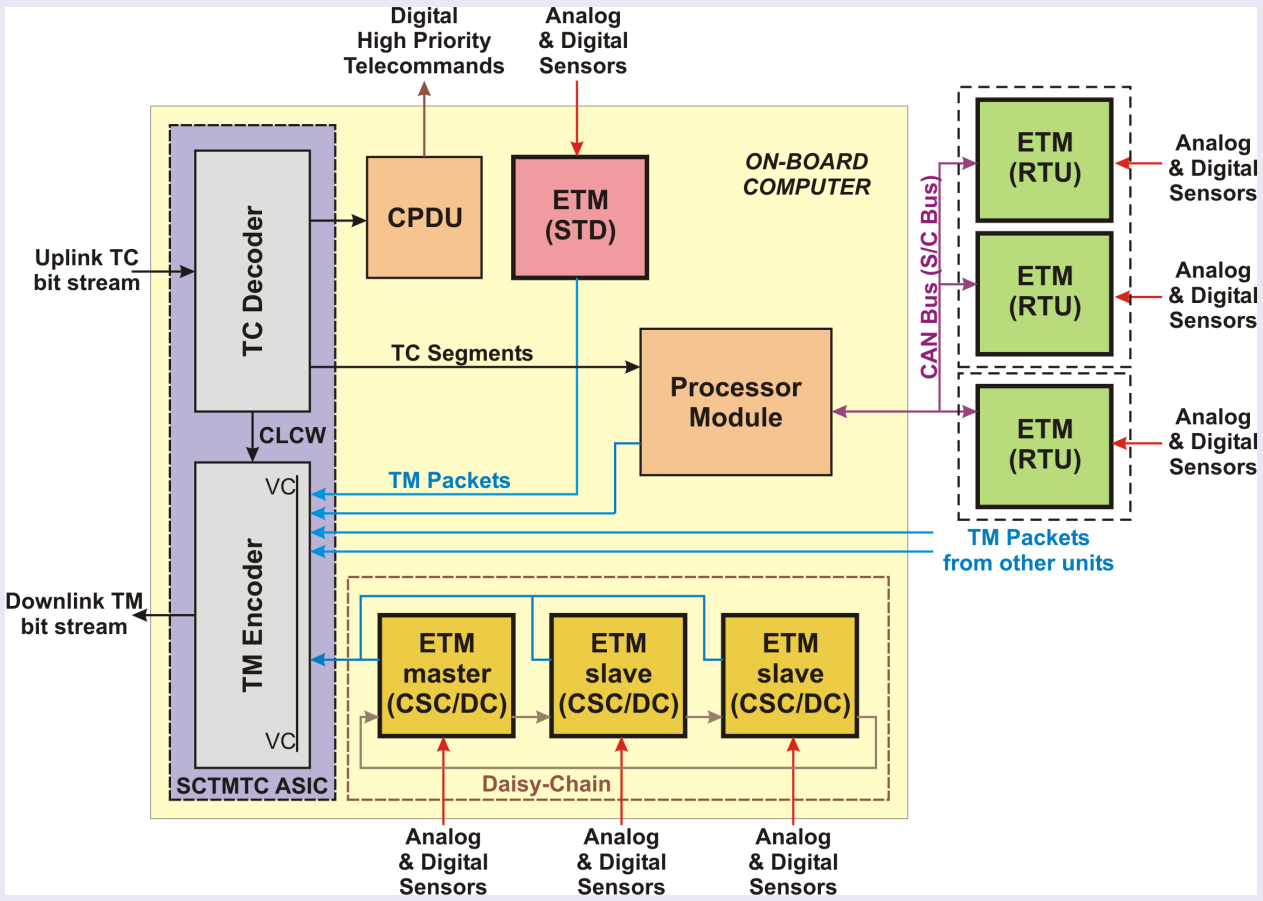
ETM ASICs are connected in a Daisy Chain scheme through PacketWire interface to one SCTMTC ASIC's Virtual Channel for data transfer. One ETM is configured as Master and the rest as Slaves.

Remote Terminal Unit (RTU)

ETM(s) are connected to a Processor Module through CAN interface.

ETM System Context

ETM System Configurations

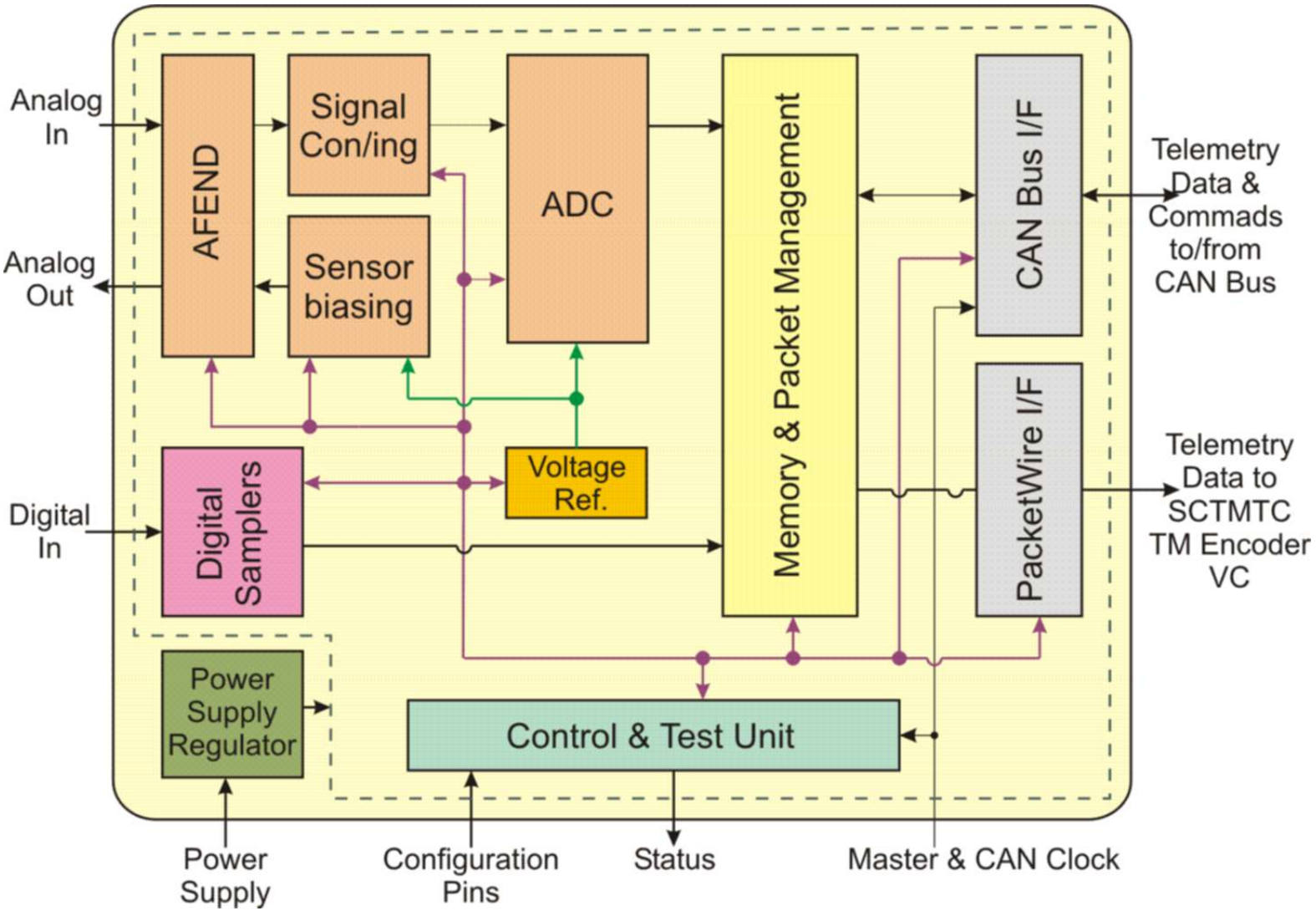


STD and CSC/DC

- Settings are set through hard pins
- No μP is required
- CAN is off
- PW is on

RTU

- Settings are set either through hard pins or through the CAN IF
- μP is required
- CAN is on
- PacketWire is off


Analog In
Analog Out
Digital In
AFEND
Signal Con/ing
Sensor biasing
ADC
Voltage Ref.
Digital Samplers
Memory & Packet Management
CAN Bus I/F
PacketWire I/F
Telemetry Data & Commads to/from CAN Bus
Telemetry Data to SCTMTC TM Encoder VC
Power Supply Regulator
Control & Test Unit
Power Supply
Configuration Pins
Status
Master & CAN Clock

Key Features

Analog Section

- 12 bit Successive Approximation ADC
- An Analog Front end Mux along with
  - a Sensor Bias unit
  - a Signal Conditioning unit
- Built in Voltage Reference
- Internal Voltage Regulator
- Digital Sampler unit

Digital Section

- A Memory & Packet Generation unit
- A PacketWire IF
- A CAN IF
- A Control and Test unit

Key Design Characteristics

- Over 200000 transistors
- 65% is digital
- 35% is analog
- ETM is mixed signal
- Full custom layout
- Fully transferable design
- Die size 5x5mm in iHP SiGe 0.25μm process
- AZ ADC
- Beyond the rails sampling capabilities
- Substrate isolation between analog and digital

Modes of Operation

Analog Channels

- 32 analog input channels, split into four groups (4, 4, 8, 16) activated by means of dedicated pins
- Each one of the 4 Analog input channels groups can be independently configured for:
  - Voltage measurements (single-ended or differential)
  - Temperature measurements with passive sensors (PRTs, NTCs)
  - Digital signal measurements (in this configuration the 12 bit ADC is configured for 1 bit measurements)

Digital Channels

16 digital input channels configurable as differential or single-ended

Sampling Frequencies and Packet Collection

- Various sampling frequencies supported (20mHz-4KHz)
- Sampled data organized into Space Packet Format, according to Space Packet Protocol, CCSDS Blue Book, CCSDS 133.0-B-1

Communication IFs

CAN IF

- CAN (CAN Controller + CANopen) + Large Data Unit Transfer (LDUT) Protocol
- Non-redundant interface, compliant with the mandatory as well as some optional requirements specified in Recommendations for CAN Bus in Spacecraft Onboard Applications, ECSS-E-50-xx Draft 2.1, May 2005
- Baud Rates supported: 1Mbps, 500 Kbps, 250 Kbps and 125 Kbps

PacketWire IF

- Serial synchronous communication interface for the Space Packets transmission at 16Mbps
- Compliant with the SCTMTC ASIC's Virtual Channels PacketWire Interface

Normal/Event Mode

Ways to reduce packet generation

Multiple ETMs can generate too much data for a telemetry device. In some cases it is wanted. However, in some cases some intelligence is required to decide when to send the data.

Normal Samples **acquired** and **transmitted continuously** (in each scan sequence period)

Event Samples are **acquired continuously** (in each scan sequence period) **but transmitted only:**

1. when any of the discrete Digital inputs has changed compared with its previously sampled value or
2. every 65536 Scan Sequences

EM Validation Status

Tests already performed

- IDDQ, SAF, Functional tests completed successfully
- Good analog and digital performance
- TID Tests completed up to >500KRad (1MRad next week). No signs of degradation yet.
- Initial temperature tests indicate good behavior in the -55 to +125°C range

Tests pending

- SEE Testing. Goal is to reach LET values of 120 MeVcm2/mg
- Full temperature testing
- Power supply testing

Key Challenges

Mixed signal development

- Inserting a 12 bit ADC along with a CAN IF on the same die can be challenging.
- Special design was needed so as to have a functioning chip.

On chip voltage reference

- Voltage references are generally hard to design so as to be rad hard.
- Optimization on a large number of factors is required.

Accomplishments

Low Power

- <20mW at 16MHz in RTU mode.
- <16mW at 16MHz in STD or CSC/DC modes.

Low noise in the analog portion

- ADC noise floor increases 0.2 LSB when CAN IF is used instead of PacketWire IF (RTU mode).
- 0.1LSB/MHz after 16MHz when PacketWire IF is used (STD and CSC/DC).

RadHard

- Sub 10ppm Voltage Reference after 400KRad.
- Less than 1LSB INL after 400KRad. No missing codes. Auto-Zeroing takes care of any TID induced errors.
- Fully functional CAN/CANopen module after 400KRad.

Future Work

FM production

FM submission is expected in Q2/Q3 2010
Minor design modifications will be required

Expansion of ETM with new functionalities

- High and low side current sensing
- Expansion of the ADC to 14 bits
- PWM and DAC for control capabilities