Essential TeleMetery (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 ⇒ 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
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 $\mu$P is required
- CAN is off
- PW is on

RTU
- Settings are set either through hard pins or through the CAN IF
- $\mu$P is required
- CAN is on
- PacketWire is off
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 0.25\(\mu\)m 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
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 radiation 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.
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