ADVANCED ELECTRONIC SOLUTIONS | **AVIATION SERVICES** | **COMMUNICATIONS AND CONNECTIVITY** | **MISSION SYSTEMS**

# Rad-Hard Microcontroller For Space Applications

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AMICSA 2016

- Microcontroller for embedded space applications:
  - European Space Agency activity
  - Mixed Analog and Digital ASIC
  - Prototypes available Q2 2017

- Cobham Gaisler has developed digital HW/SW platform

- IMEC provides analog functionality

- GR716 – LEON3FT Microcontroller
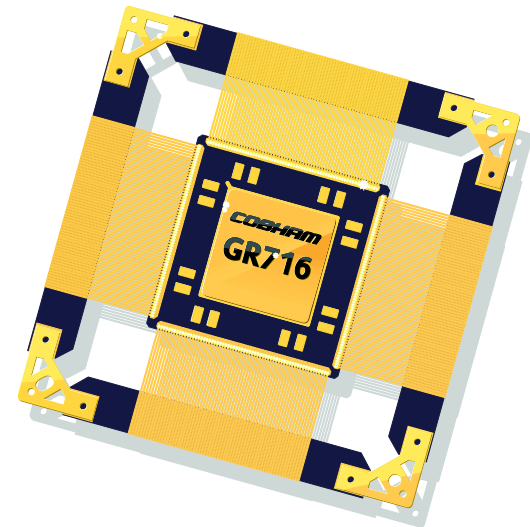
- Contents
  - Background
  - Microcontroller features
    - Features Overview
    - Digital functions and interface
    - Analog functions and interface
  - Special features
    - LEONREX
    - Interrupt improvements
    - DMA controllers
    - Configuration
  - Applications
  - Conclusions

Background

- ESA funded activity "Microcontroller for embedded space applications"

- The objective is to develop a standalone microcontroller suitable for sensor and control applications in space.

- The microcontroller should have good real-time performance and have system level functions to minimize the use of external components

- ESA compiled HW requirements
    - Functional
    - Performance
   - Quality

GR716 – LEON3FT Microcontroller

Feature overview

- Fault-tolerant LEON3 Processor, 32 register windows, 192 KiB EDAC protected tightly coupled memory and support for reduced instruction set

- System frequency up-to 50 MHz and SpaceWire frequency up-to 100Mhz

- 64 Mixed CMOS General purpose inputs and outputs

- Integrated LVDS for SpaceWire and "SPI for Space"

- On-chip ADC, Temperature Sensor, Brown-Out detection, DAC, Oscillator, PLL and support for single 3.3V supply

- Expected to withstand 300krad(Si) and is single event latch-up immune for linear energy transfer values above 118 MeVcm2/mg.

- Reduces mass, space, power and cost due to high level of integration

GR716 – LEON3FT Microcontroller

Digital Function Overview

- LEON3FT - Fault-tolerant SPARC V8 processor
- Memory protection units
- Non-intrusive advanced on-chip debug support unit
- 8-bit external PROM/SRAM interface with EDAC BCH protection
- Boot from external SPI or I2C memory protected by EDAC and dual memory redundancy
- SpaceWire interface with time distribution support
- MIL-STD-1553B interface
- CAN 2.0B controller interface
- PacketWire with CRC acceleration support
- Programmable PWM interface
- UARTs, SPI, I2C, GPIO, Timers with Watchdog, Interrupt controller, Status registers, JTAG debug, etc.
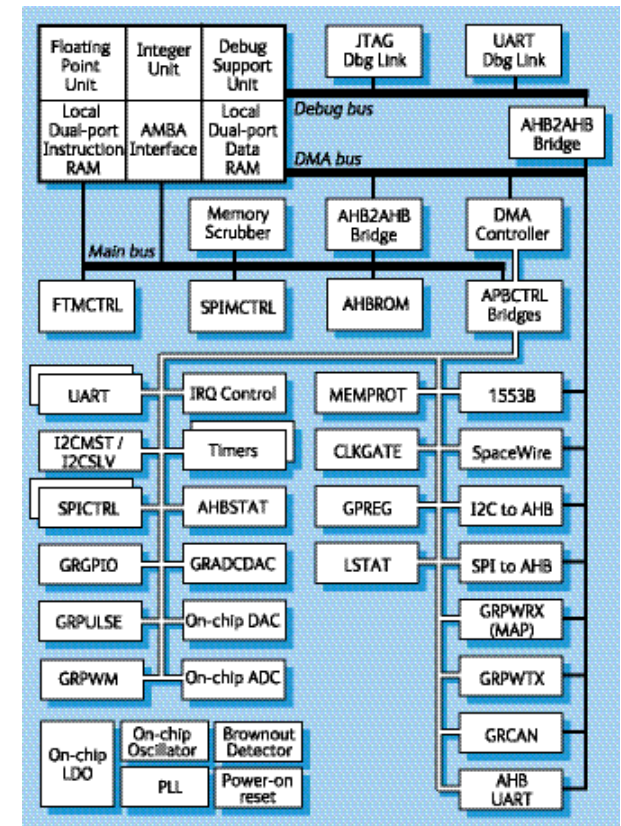
Analog Function Overview

- Mixed General purpose inputs and outputs
  - Programmable internal pullup/pulldown
- Power On Reset
- Brown Out Detection
  - Programmable level detection
- Analog to Digital Converter
  - 12bits @ 200Ksps, 4 channel differential or 8 channel single ended
  - Pre-amplifier (0dB, 6dB or 12dB)
  - Digital Oversampling support (4 bits)
- Digital to Analog converter
  - 12bits @ 3Msps
  - 4 channels
- On-chip regulator for 3.3V single supply
- LVDS Driver and Transmitter
- Integrated PLL
- Temperature sensor
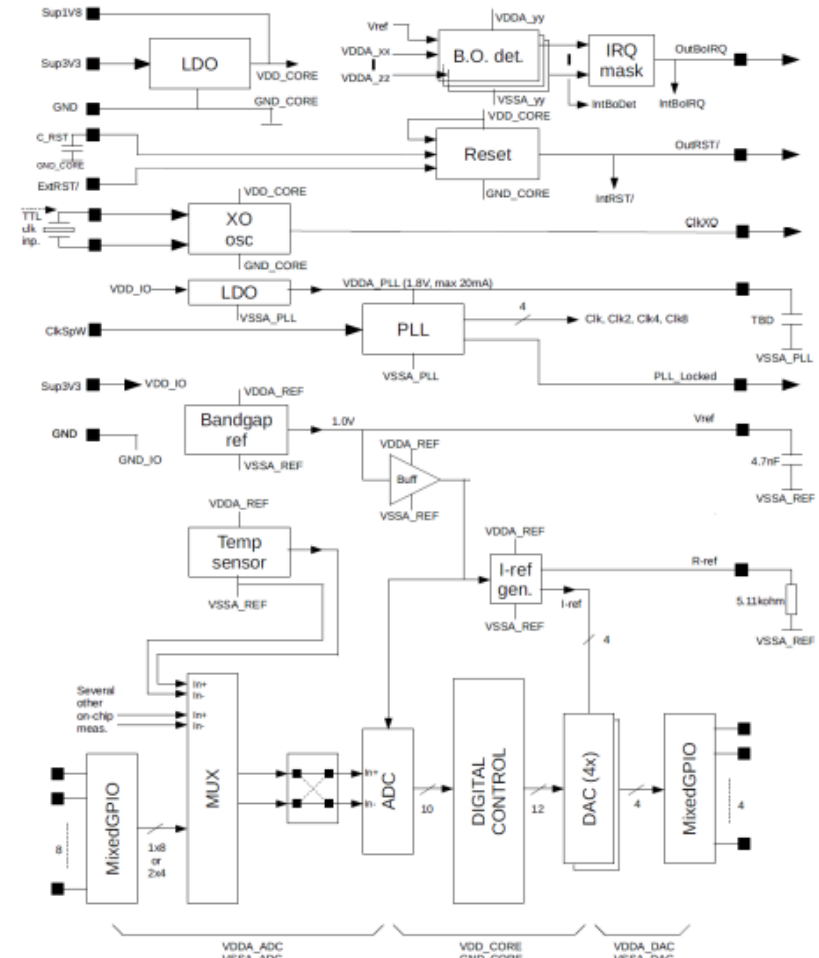
- LEONREX

  - LEON-REX is an in-house development to extend the LEON processor with an reduced instruction set

  - Purpose is to improve code density to allow fitting more instructions into local RAM

  - Designed to allow "retro-fitting" into LEON3FT pipelines with only minor speed/area penalty

  - Allows gradual transition where existing SW environment can be used to unmodified and converted piece by piece to use new instruction set.

  - Assembler, compiler and debugger support

Special Function Overview

- Programmable DMA transfers through stand-alone DMA controller
  - Respond to interrupts
  - Polling register
  - Loop support
  - Respond to combination of interrupt and register polling

- Programmable DMA user scenarios
  - Offload processor
  - Autonomous transfers from/to ADC/DAC without CPU intervention
    - Low noise sampling
  - Autonomous transfers between:
    - UART to UART
    - SPI to SPI
    - I2C to I2C
    - Any interface to/from memory or vice versa

GR716 – LEON3FT Microcontroller

Special Function Overview

- Programmable IO functionality:
  - Select function per pin

  - 64 Pins dedicated to user functionality

  - 12 of 64 have mixed analog and digital capability

  - LVDS for SPW or SPI for Space

  - Programmable pullup/pulldown

  - LVDS transmitter and receivers for SpaceWire and "SPI for Space"

- Non programmable pins:
  - 4 pins for dedicated SPI ROM
  - Debug interface

GR716 – LEON3FT Microcontroller

Special Function Overview
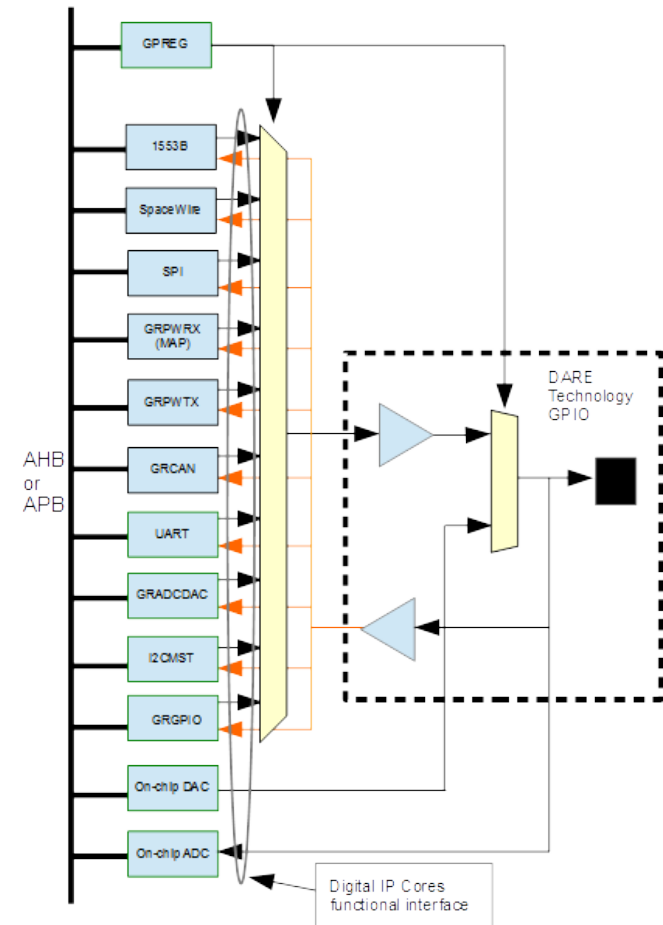
- Boot and configuration
  - Remote access support:
    - SpaceWire
    - SPI for Space
    - UART
    - I2C

  - Boot from external memory
    - PROM-, SRAM-, MRAM-, SPI- or I2C-memory
    - Dual memory redundancy
    - BCH EDAC protection
    - Checksum protection of application software

  - Internal boot ROM:
    - Setup and configure the device from cold or warm reset
    - System self-tests (CPU, register windows and local instruction and data memory)
    - Assembles Boot Report
    - Sets up C run-time environment

GR716 – LEON3FT Microcontroller

Real-time support and features

- Real-time support and features

  - Single cycle instruction and deterministic program execution

  - Interrupt time-stamping

  - Predictable and low latency interrupt support

  - Atomic operations to local data memory and peripherals
    - OR, AND, XOR and Set&Clear

  - Non-intrusive debug support

  - Digital architecture with dual port data memory to separate DMA transfers from processor transfers

- Debug capabilities

  - Debugging is non-intrusive

  - Plug-n-play and full GRMON2 support

  - Trace bus activity on multiple busses

  - Remote debug without software support via SpaceWire, UART, SPI

  - The LEON3 Statistics Unit (performance counters) is used to count processor events, in order to create performance statistics for various software applications

- Minimum application Requirements:
  - 3.3V supply
  - Frequency resonator in the range of 5Mhz to 25Mhz.
  - De-coupling capacitor
  - Reference resistor

- Minimum application Enables
  - System clock and reset
  - Remote access to GR716 via SpaceWire, SPI, UART and I2C
  - Access to all functions

Summary
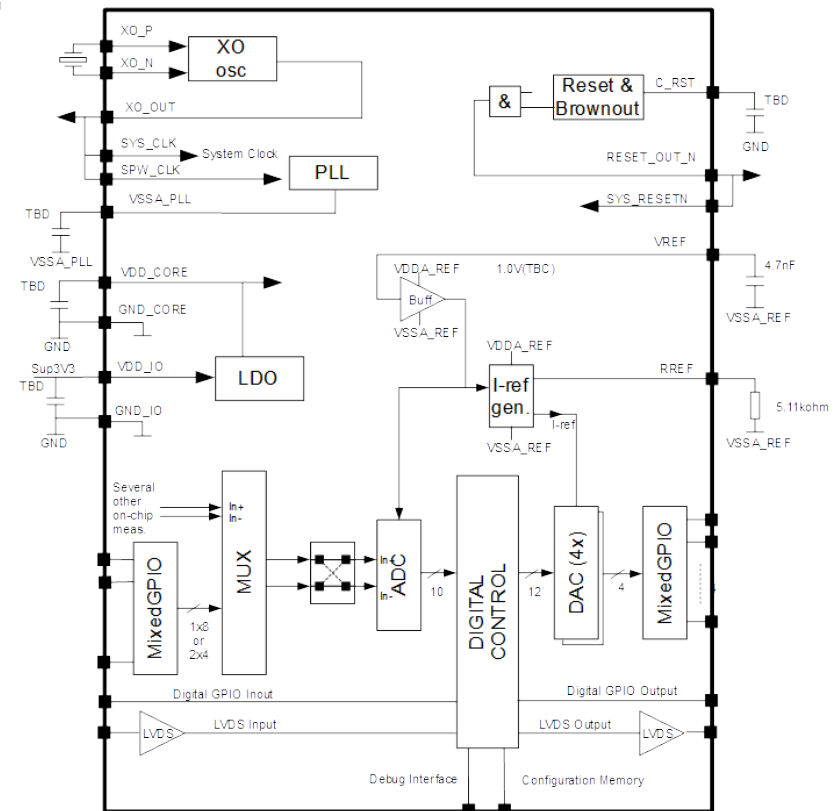
- GR716 offers great flexibility and supports many different communication standards

- System level functions integrated

- GR716 requires very few external components

- Cobham Gaisler will provide a uC software environment tailored for the GR716

- Prototypes in Q2 2017

Thank you for listening!

For questions contact: info@gaisler.com