Rad-Hard Microcontroller For Space Applications

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Introduction

• 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
Presentation agenda

- 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.
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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
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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
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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
• 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
• 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
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Debug Capabilities

• 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
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Microcontroller 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