# GRCANFD: CAN-FD Controller with DMA Engine and AHB or AXI Interface

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Presenter Joaquín España Navarro
Cobham Gaisler
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# Overview

- GRLIB CAN 2.0 IP cores
- GRCANFD
- CAN-FD transceivers
- Software drivers and simulators
- Conclusions

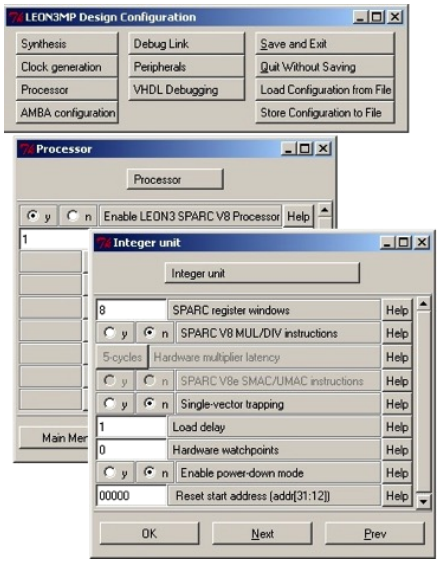
# 01

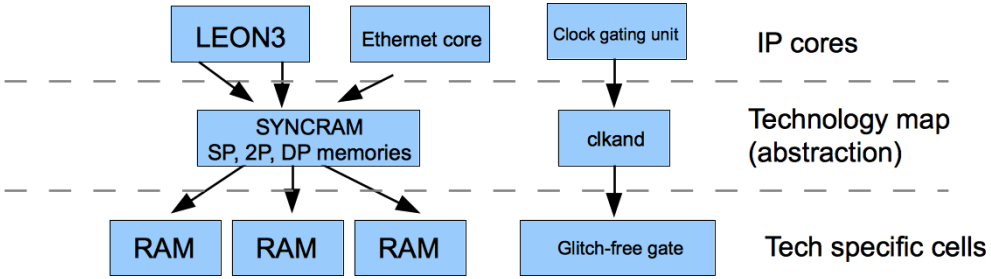
# GRLIB CAN 2.0 IP cores

# GRLIB CAN 2.0 IP cores

## GRLIB

- GRLIB is a complete design environment
  - Processors, Peripherals, Memory controllers
- AMBA on-chip bus with plug&play
- Fault-tolerant and standard versions
- Support for tools and prototyping boards
- Portability between technologies
  - IP cores instantiate abstractions, which then map to an element in the target technology
- Template designs
  - Cobham XC6S – 7-series, Xilinx and Microsemi boards



# GRLIB CAN 2.0 IP cores

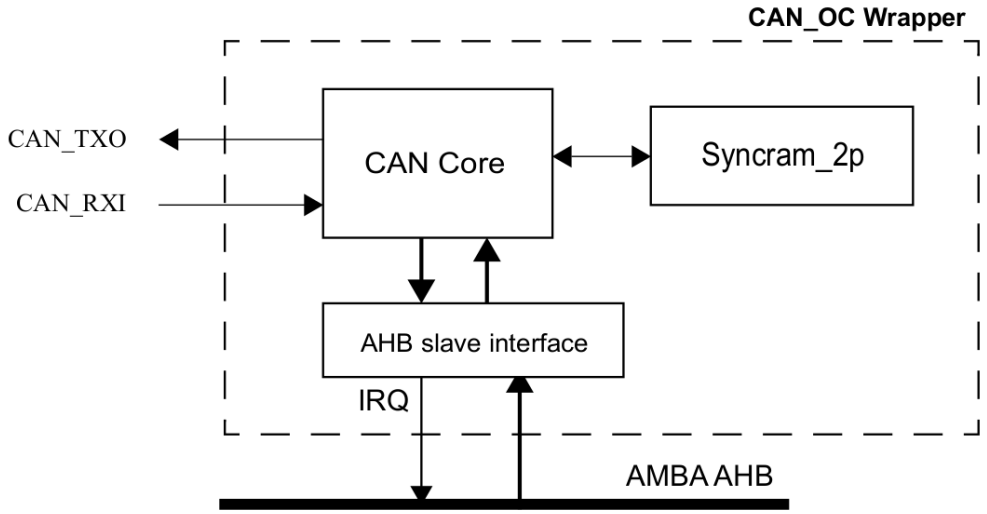
## CAN IPs overview

- CAN has increasingly been used in space applications to replace conventional spacecraft bus architectures
  - Reduces the amount of wires and connectors
  - Flexibility when adding new nodes to the network
  - Low power consumption
  - Arbitration and error detection built into the protocol
- GRLIB has traditionally offered CAN 2.0 IP cores
  - CAN_OC
  - GRCAN
  - GRHCAN (only for use within ESA projects)

# GRLIB CAN 2.0 IP cores

## CAN_OC

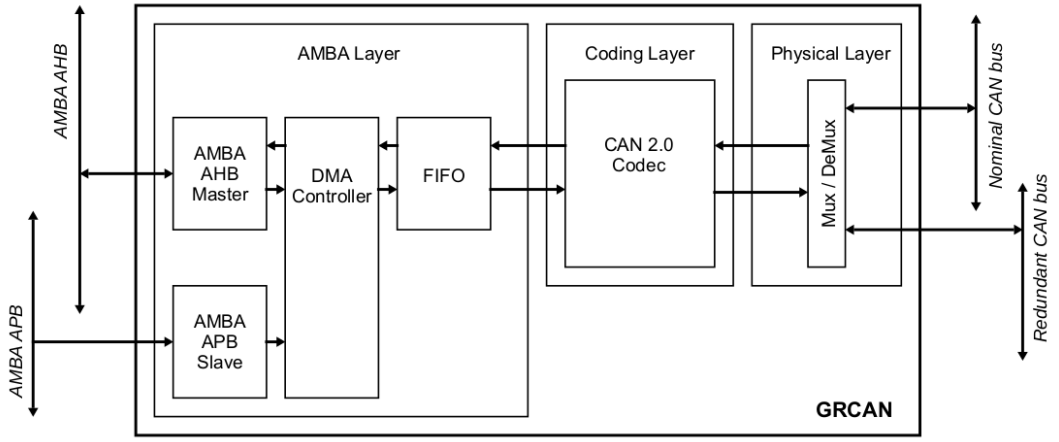
- CAN_OC is a GRLIB wrapper for the CAN controller from Opencores
- Compatible with CAN 2.0 (both base and extended formats)
- AMBA AHB slave interface for accessing the CAN core registers
- Present in GR712
- CAN_OC is a legacy IP and therefore is not recommended for new designs



# GRLIB CAN 2.0 IP cores

## GRCAN

- GRCAN also uses the CAN controller from Opencores
- Compatible with CAN 2.0 (base and extended formats)
- It adds DMA engine to autonomously fetch and store frames from/to memory external to the IP through an AMBA AHB master interface
- AMBA APB slave interface for configuration registers
- Present in GR740 and GR716
- GRCAN is a legacy IP and therefore is not recommended for new designs

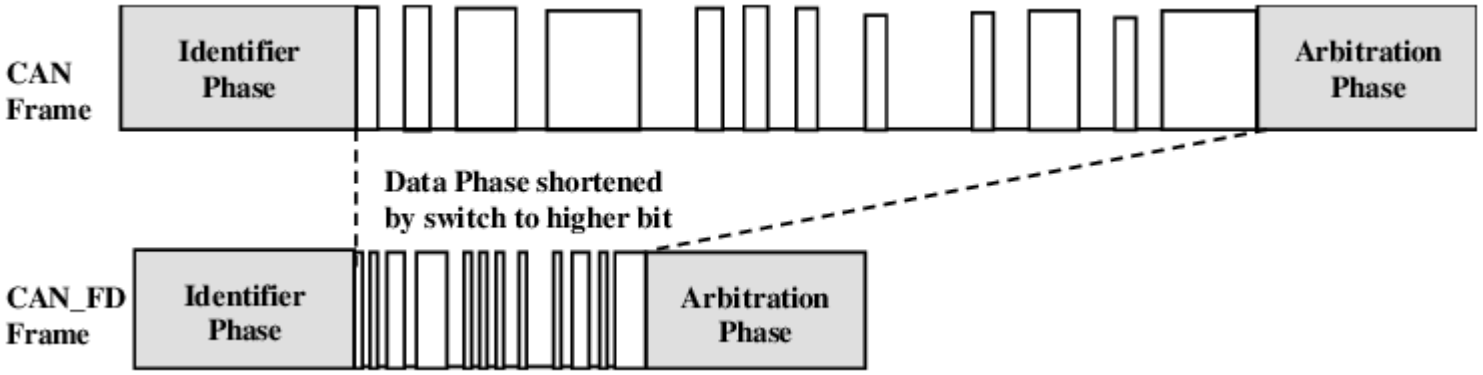


# 02
# GRCANFD

# GRCANFD

## Rationale

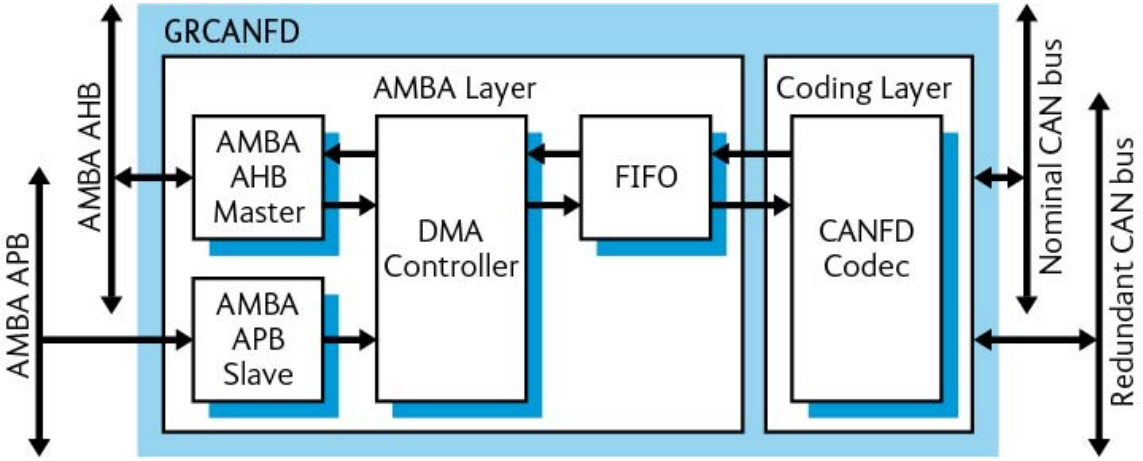
- CAN-FD introduced in 2012 to meet the requirements of higher bandwidth in modern applications
  - Maximum payload of 64 bytes
  - Optional bit-rate switch (typ. up to 8 Mbit/s)
  - CAN and CAN-FD nodes can still coexist in the same network
- New GRLIB IP to offer the benefits of the FD extension to the space industry: GRCANFD



# GRCANFD

## Overview

- Completely developed in-house, including the internal CAN-FD controller
- It includes DMA engine to autonomously fetch and store frames through a generic bus master interface
  - Wrappers available for both AMBA AHB 2.0 and AXI4
- AMBA APB slave interface for configuration registers
- Planned to be included in the flight models of the GR716
- Recommended IP for new designs



# GRCANFD

## Coding layer

- The CAN-FD controller implements the functionality related to MAC and PL (PCS) sub-layers of the protocol
- Designed according to ISO 11898-1: 2015 (2nd edition)
- Main functionality:
  - Transmission, reception and acknowledgment of frames
  - Arbitration control
  - CRC calculation and verification
  - Error detection and signaling
  - Bit segments generation and synchronization
  - Transmitter delay compensation

# GRCANFD

## AMBA layer

- Configuration registers and interrupts generation
- DMA engine with separate TX and RX channels and a local FIFO (SRAM, 512 bytes)
- The TX channel fetches up to 2 frames from external memory and stores them into the FIFO. New frames are fetched as soon as the codec transmits a complete frame
- The RX channel filters and stores up to 2 frames received by the codec into the FIFO. The frames are then written to external memory and new frames can be locally stored
- External memory handled as circular buffers. Content management based on frame descriptors and pointers
- External memory located on-chip or external to the chip

# GRCANFD

## Key differences between GRCAN and GRCANFD

- GRCANFD designed to maintain backward compatibility with GRCAN to the maximum extent possible
- Classical frames represented by 1 descriptor of 16 bytes
- FD frames may require 1 – 5 descriptors
  - First descriptor: control & status bits, data (8 bytes)
  - Additional descriptors used depending on DLC
- New bits in the first descriptor (FDF and BRS)
- New registers for controlling CAN bit timing parameters (Nominal and Data Bit-Rate Configuration Registers)
- Transmitter Delay Compensation Register
- Baud-Rate Selection and Triple Sampling not supported

# GRCANFD

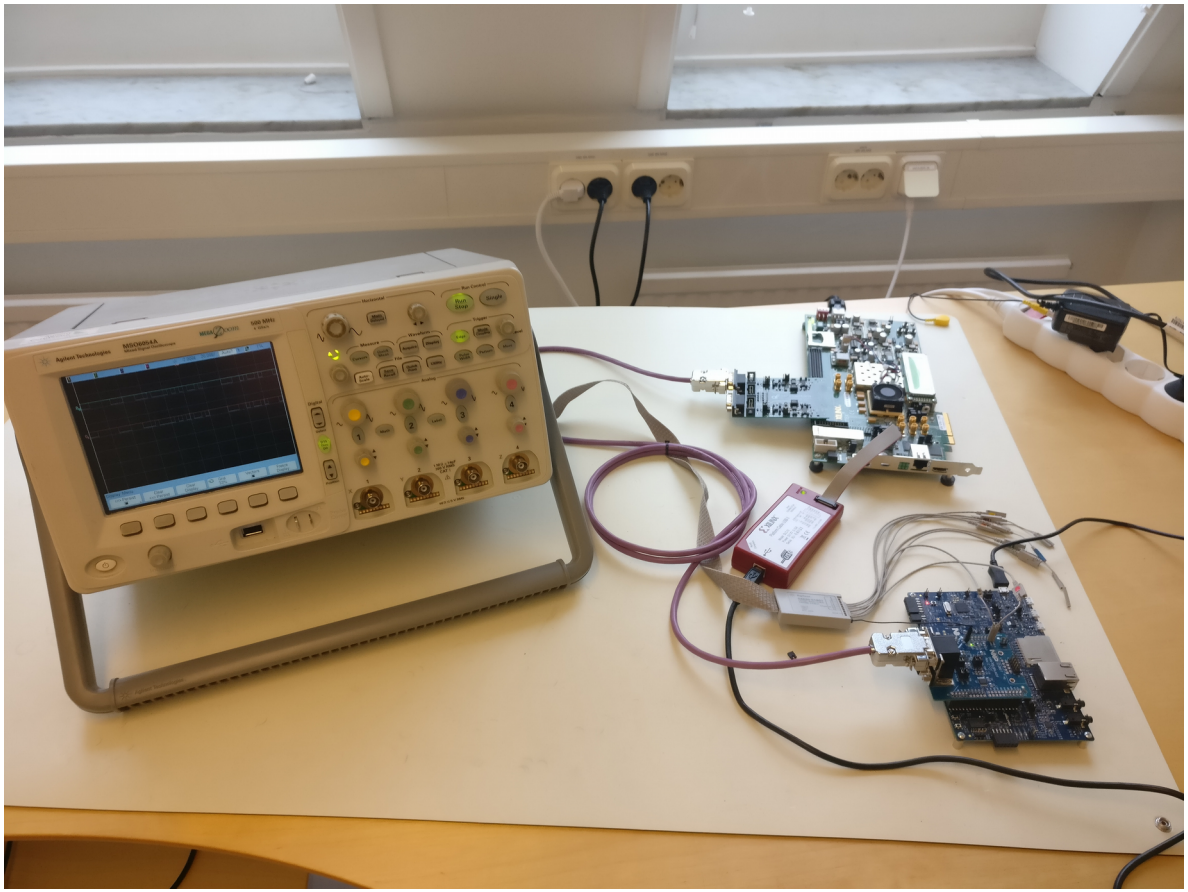
## Additional features

- CAN bus redundancy
- TX and RX channels controlled independently
- Frame acceptance filters
- TX and RX SYNC filters (interrupt generation)
- Single-shot mode
- Listen-only mode
- Transmitter delay compensation of up to 2 data bit-times
- Overload frame generation when RX FIFO is full

# GRCANFD

## Verification

- GRCANFD has been extensively tested in simulation and hardware against independent CAN-FD controllers



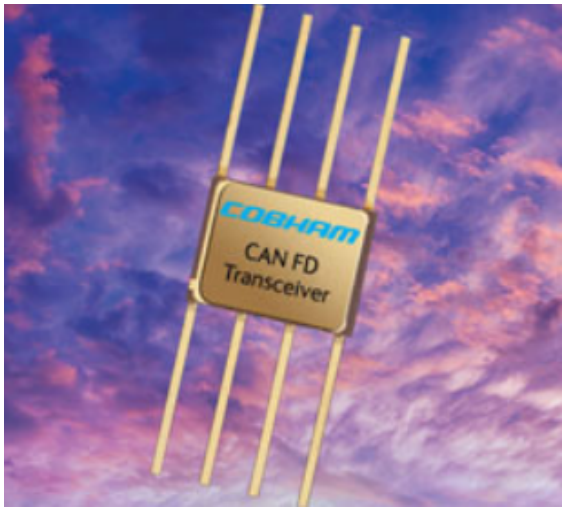
# 03

# CAN-FD transceivers

# CAN-FD transceivers

## UT64CAN333X series

- Cobham Semiconductor Solutions has introduced a series of CAN-FD transceivers implementing the Physical Layer of the standard: UT64CAN333X
- Compatible with ISO 11898-2 and ISO 11898-5 standards
- 10 kbps to 8 Mbps bit-rates
- QML V qualification completed
- Three transceiver options:
  - Low power sleep mode
  - Diagnostic loopback
  - Bus traffic monitoring and baud-rate adjustment



# 04

# Software Drivers and Simulators

# Software drivers and simulators

## Overview

- Software support:
  - GRCAN for Linux, RTEMS, VxWorks, Bare-metal
  - Upcoming support for GRCANFD
  - Support includes drivers and examples
- CAN & CAN-FD simulation:
  - TSIM2: CAN_OC
  - TSIM3: CAN_OC, GRCAN, GRCANFD

# 05
# Conclusions

# Conclusions

- GRLIB not just an IP library, but also a complete environment supporting the major EDA tools and technologies
- GRLIB has traditionally included CAN 2.0 IPs such as CAN_OC and GRCAN
- GRCANFD, Cobham Gaisler's latest CAN IP, implements the new features defined in the CAN standard: bit-rate switching, larger data payload, etc.
- CAN-FD transceivers available as prototypes, QML Q and QML V qualified components
- Software support includes drivers, examples and simulators

Thank you for listening!