Virtual ECUs for high performance transmissions

Presented by:
Ewaut Dewinter
Application software engineer
Contents

- Tremec and high performance DCTs
- Transmission controls and Application Software
- Simulation and testing philosophy
- Performant Simulation Environment
Tremec develops and produces high performance transmissions

**TREMEC key facts**
- Fully owned subsidiary of Kuo Group
- Focus on high torque/high requirements
- Leader in performance transmissions & transmission subsystems
- Active in performance Dual Clutch Transmission systems since 2003
- Active in Europe, USA, Mid & South America
- 1,650 employees
- 225 m$ turnover LTM 2017

**KUO key facts**
- Controlled by Senderos family
- Long term strategic holding company
- Activities in:
  - Consumer – food
  - Chemical – synthetic rubber & polystyrenes
  - Automotive – transmissions & aftermarket
- Active in 70 countries – HQ in Mexico City
- 20,000 employees
- 2.100m$ turnover LTM 2017
Tremec Belgium focuses on DCT hardware and software

TREMEC center of competence for development & production of performance DCT transmissions & subsystems

- Hardware development of DCTs in the 600 Nm – 1000 Nm range
- Development of Controls hardware and Controls software

Sales & program management office for North-American OEM’s

USA – Wixom MI

TREMEC center of competence for development & production of gear systems

Mexico – Querétaro
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Tremec has expertise in all disciplines needed for transmission control

**Electronics**
- TCU using multicore technology
- Design compatible with multiple transmission configurations

**Base software**
- AUTOSAR framework and Operating System
- Control and diagnostics of IO
- Communication with other ECUs

**Safety software**
- ISO 26262 compliance
- Safety goal monitoring

**Application software**
- High level functionality for drivability
- Mid level functionality for hydraulic and mechatronic control
- Model based algorithms
- Generic modules calibratable per application

**OBD**
- CARB 1968.2 compliance
- Electrical, Controller, Consistency and Performance Diagnostics
Application software makes the difference in DCT applications

- A DCT gearbox can handle a **wide range of shift feelings**
- A **brand specific car temperament** can be created just by changing software
- The same DCT gearbox can be used in different models
  - different calibrations are used to match driveline experience with type of car

Luxuriously Comfortable  Ferociously Sporty
Contents

 Tremec and high performance DCTs
 Transmission controls and Application Software
 Simulation and testing philosophy
 Performant Simulation Environment
Complete powertrain simulation aids both the Hardware & Software design

HW: Component design
SW: Control algorithm development

Detailed clutch model -> Simplified clutch model

Detailed valve model -> Simplified valve model

Engine + engine controller -> CAN communication

Vehicle Dynamics

Complete Vehicle
Different simulation models are used for different goals

Detailed dynamics
- Variable step solver
- Focus on correct behavior
- No focus on performance

Simplified dynamics
- Fixed step solver
- Focus on execution time
- Approach real behavior

\[ F_{\text{Flow}} = \int_{C.S.} (\rho v_x \cdot \vec{v} \cdot \vec{n}) dA = \frac{\rho \cos \theta}{C_D A(x)} \cdot Q^2 \]
Different simulation models are used for different goals

- **Detailed dynamics**
  - Variable step solver
  - Focus on correct behavior
  - No focus on performance

- **Simplified dynamics**
  - Fixed step solver
  - Focus on execution time
  - Approach real behavior

- **Verifying hardware design**
  - Developing dedicated controls application

- **Real-time testing of application on a real or virtual TCU**
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- Tremec and high performance DCTs
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Business case
Tremec targets high performance applications

Parallel development of all components (short time to market)
- SW development needs to start before HW is finalized
- Limited availability of test vehicles

OEMs want unique character and stand-out features
- Agile SW implementation and testing environment
- Confidence in new algorithms before vehicle testing
- Possibility to explore new concepts and variants

Tremec needs a performant simulation environment to reach the desired SW maturity
Performant Simulation Environment
Buildup of know-how and initial tools

2011
- Software testing in MiL environment
  - Test patterns applied to inputs
  - Testing of only one software module
- Out-dated HiL setup
  - No in-house knowledge of updating the configuration

2013
- Development of complete vehicle simulation
  - Detailed model of hydraulic and mechatronic transmission components
  - Simplified model of vehicle dynamics
  - Basic implementation of other vehicle controllers

2015
- Development of PiL setup
  - Processor in the Loop: TCU is connected to a simulated vehicle but without IO processing
  - Possibility to test full Application Software functionality and integration

2016

2017

Today
Performant Simulation Environment
PiL setup for full ASW testing

Development of PiL setup

2011
2013
2015
2016
2017
Today

ECU
Engine

TCU
DCT

BCU
Vehicle

Sensors/actuators

Simulated vehicle + controllers

Simulated Transmission IO sent via private CAN bus

Physical relation/interface
Performant Simulation Environment
Further steps towards SiL testing

- Implementation of QTronic Silver and TestWeaver
- Testing of new algorithms without TCU HW needs

Simulated vehicle + controllers

ECU → Engine

TCU → DCT

BCU → Vehicle

2011
2013
2015
2016
2017
Today
Virtual TCU enables flexible ASW testing

- Implementation of QTronic Silver and TestWeaver
- Full Application Software compiled into a virtual TCU

Buffer containing IO data

Buffer containing CAN data

Modules processing raw sensor data
Modules generating actuator targets

Modules processing raw CAN data
Modules generating CAN information

TCU Software

BSW
HAL
CAN
ASW

vTCU

TREMÉC

A kuo Group Company
Performant Simulation Environment
Extension of testing equipment with HiL

- Transition of PiL setup from Windows desktop to Real Time computer
- Development of HiL setup as an extension of PiL setup with hardware inputs and outputs

2011
2013
2015
2016
2017
Today

User interaction

Compile model
VehicleModel.dll

VeriStand – NI PXI chassis

TCU

XCP
Performant Simulation Environment
Extension of testing equipment with HiL

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2017
Today

User interaction

Compile model

VeriStand – NI PXI chassis

Solenoids DAQ IO

VehicleModel.dll

TCU

XCP

VehicleModel.dll

VehicleModel.dll

VehicleModel.dll
TestWeaver is used for regression testing and software release validation

### Weekly TestWeaver run
- Python scripts for regression
- Automatic script generation

### SW release TestWeaver run
- Regression test of diagnostic routines
- Release documentation

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Silver environment for complete ASW testing and algorithm validation

Performant Simulation Environment
Advantages of full virtual testing
Parallel development of all components (short time to market)

- SW can be developed and tested on new configurations implemented in the VehicleModel
- Silver environment available on each computer

OEMs want unique character and stand-out features

- Immediate testing of the algorithm behavior by the SW developer
- Validation of new algorithms before release to minimize downtime and debugging
- Flexible and modular simulation environment
Proof Of Concept for new projects and algorithms

E-motor

High performance Hybrid DCT
- Shadow shifting
- Flying starts
- Boosted driving

Interface definition

Test algorithms by sharing simulation files with OEM

Simulation model update

Successful testing on the first prototype vehicle
Tremec has developed State of the Art simulation and testing capabilities

Multiple methods for simulation to enable virtual SW development

- Modular simulation components that can be protected and shared
- Support for different testing methods and toolchains
Questions