

Engine Management: Control Software & Calibration

5 days

MOT/LOICOM-E

Overview

LEVEL

Expert

PURPOSE

This course provides a deeper knowledge on the development process of an engine control strategy.

LEARNING OBJECTIVES

Upon completion of the course, participants will be able to:

- transform a strategy, based on physical phenomena in the engine, into a control law that will be programmed in the computer,
- define, design, simulate, integrate and validate a control strategy in a V cycle development process,
- code and understand the constraints of coding in a real time environment,
- understand and apply the design of experiments,
- know the process to optimize parameters in order to meet the different customers' needs: cold engine starting, performances, consumption, driving pleasure, noise.

WAYS AND MEANS

This training is based on knowledge acquisition through practice. An engine control project is the basis for the learning. The learner is active during this training: he designs, realizes, tests, analyzes and validates himself the engine management system he has developed. Stages of active learning are:

- fully applied training with real world examples on Matlab work station.
- design and calibration of control strategies with Matlab-Simulink.
- engine model and torque structure design with Matlab-Simulink.
- engine management validation with an engine model: MIL.
- manual and automatic coding with Simulink (RTW) and C language.
- software integration in a computer.
- software validation with HIL test.
- validation and calibration on engine test bench.

At the end of the training, participants will own the models, calibration tools, control strategies and a digital computer they have developed.

PREREQUISITES

No prerequisites for this course.

Agenda

FUNCTIONS & STRUCTURE OF AN ENGINE MANAGEMENT SYSTEM

1 d

Introduction: why are there electronics in the engines.
General structure of gasoline and Diesel engine management systems.
Components: actuators, sensors, logic controllers.
Electronic system: power supply, webs, optical cables, multiplexing.
Software: structure, input/output processing, strategies, calibrations, evolutions.

Development methods: contributors, key-steps, V cycle, tools.

DEVELOPING A CONTROL LAW

3 d

Automatics basic knowledge: tuning the IPD (integral plus derivative) regulator.

Modeling a gasoline engine: system input and output, assessment of the inlet air volume, modeling the intake manifold, assessment of the manifold pressure, throttle gas flow calculation using Barré de Saint-Venant law, ignition advance efficiency, engine dynamics equation and speed calculation.

Control law development practical on Matlab workstation: designing an idle speed tuning on a gasoline engine. Design a torque structure.

Block diagram representation. Establishing the different sub-models: calculation of airflow, of the torque shown, of the speed. Introducing air/fuel ratio and speed measurement noises. Speed IPD regulation.

Exercises to use the created law: actions on the influences and tuning of the IPD regulation parameters. Observation of the speed signal obtained.

System identification. Real time embedded control. Design of actuators control like body throttle or EGR valve.

VALIDATION OF A CONTROL LAW

0.5 d

Validation steps are performed with Matlab-Simulink, on computer and engine test bench.

Validation steps: What are the reasons? What are the objectives? What kind of technologies and tools are used?

MIL - SIL validation: strategy functional validation with an engine modeling.

SIL validation: presentation of the approach, interests of this step, automatic code generation.

HIL validation: presentation of the approach, interests of this step, computer strategy integration after encoding, hardware test on a bench.

Functional validation with an engine, strategy test on engine bench. Comparison between simulation and measurements. Calibration methodology.

Transcription of a control law into a code that can be integrated into the Electronic Control Unit (ECU).

ECU programming and calibration. Automatic coding and manual coding.

Development tools: mock-up and fast prototyping of the engine control strategies.

Fixed point and floating point.

IMPLEMENTING A CONTROL LAW IN A CONTROL UNIT

0.75 d

Transcription of a control law into a code that can be integrated into the Electronic Control Unit (ECU).

ECU programming and calibration. Automatic coding and manual coding.

Development tools: mock-up and fast prototyping of the engine control strategies.

Fixed point and floating point.

DEVELOPMENT & CALIBRATION

0.5 d

The development and calibration work will be illustrated by real examples.

Different performances to be taken into account: basic tuning, performances, driving pleasure, cold engine operability, depollution/standards to meet, DPF regeneration, OBD and diagnostic.

Consideration of dispersions, the surrounding conditions, ageing. Choosing the operating points that represent the cycle. Impact of the different engine tuning parameters.

Example of the advance and EGR calibrations optimization on a constant low load point. Impact of water temperature on the development parameters.

Specific calibrations methodologies. Calibration tools development by the control strategy designer.

Calibration scheduling in order to reduce the cost of tuning.

Definition of DoE. Representative operating points. Optimization of calibration. Use of numerical models.