

# Automation of Integration Tests

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# Automation of Integration Tests

- Introduction
- Background
  - Controller Area Network (CAN)
  - Integration tests
  - Brake management
- Automating integration tests
  - Tools
- Test Program

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# Introduction

## Integration tests

- **Verifies that individual systems work together**
- **Verify CAN communication between truck's Electronic Control Units (ECU)**
- **Positive test round in lab allows testing in a real truck**

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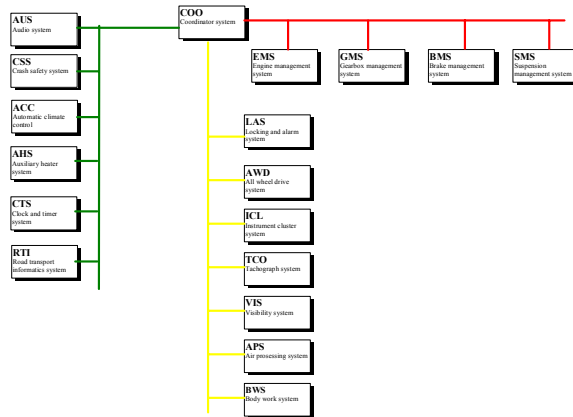
## Controller Area Network

- **Controller Area Network (CAN)**
- **Introduced in 1986 by Bosch**
- **Handles communication between Electronic Control Units (ECU)**
- **Used mostly by automotive industry**

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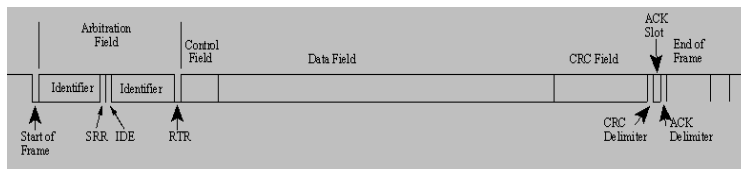
# Controller Area Network Scania



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# Controller Area Network Message frames

- **Data frame message**
  - 29 bit identifier (CAN 2.0B)
  - 8 bytes of information
  - **CAN specifications tell the distribution of information in the data field**



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## Controller Area Network Arbitration example

- ECU 1: 0
- ECU 2: 0
- ECU 3: 0
- Bus: 0

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## Controller Area Network Arbitration example

- ECU 1: 01
- ECU 2: 01
- ECU 3: 01
- Bus: 01

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## Controller Area Network Arbitration example

- ECU 1: 010
- ECU 2: 010
- ECU 3: 011
- Bus: 010

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## Controller Area Network Arbitration example

- ECU 1: 0101
- ECU 2: 0101
- ECU 3: 011
- Bus: 0101

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## Controller Area Network Arbitration example

- ECU 1: 01010
- ECU 2: 01011
- ECU 3: 011
- Bus: 01010

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## Controller Area Network Arbitration example

- ECU 1: 010100101.....
- ECU 2: 01011
- ECU 3: 011
- Bus: 010100101.....

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## Integration Tests



- **Integration Lab**
  - Two computers
  - ECUs
  - Instrument panel
  - Buttons, levers, etc.
  - Power supply
  - Instruments

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## Integration Tests

- **CAN communication**
- **Robustness of CAN**
- **User functions**
- **(Diagnostic tests)**

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## Integration Tests CAN communication

- **Messages sent as defined in CAN specification, for each ECU**
  - ID
  - Interval time
- **Gateway**
- **Busload during ignition on/off**

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## Integration Tests Robustness

- **Temporary short-circuit**
- **Temporary open-circuit**
- **Error frames on CAN-bus**
- **High message load**
- **Low/High voltage**

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# Integration Tests

## User functions

- **Hundreds of functions of various complexity and functionality.**
- **Prerequisites**
- **Stimuli**
- **Response**

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# Integration Tests

## User Functions - Brake management

- **ABS (Antilock Brake System)**
- **EBS (Electronic Brake System)**
- **Retarder**
- **Exhaust brake**
- **Other ECUs part of the brake functions:**
  - **EMS (Engine Management System)**
  - **COO (Coordinator)**
  - **ICL (Instrument Cluster)**
  - **GMS (Gearbox Management System)**

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# Integration Tests

## User Functions - Brake management

- Traction Control (TC)
  - Reduces wheel spinning due to high engine torque
  - Brake Control
  - Engine Control
- Antilock Wheelbrake Control
  - Prevents wheels from locking during braking

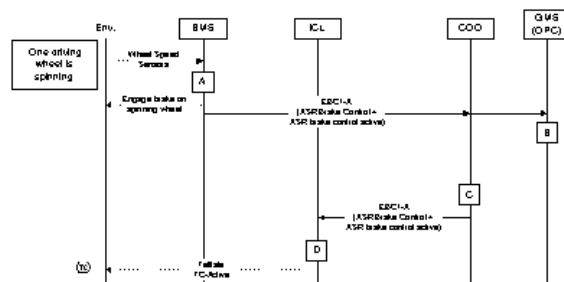
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# Integration Tests

## User Functions - MSC

- Message Sequence Chart
  - Function description concerning CAN
- Example: Traction control: Brake control



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# Automating Integration Tests

- Logging CAN traffic
- Disconnection of ECUs
- Stimuli generation
  - User functions
- Presentation of results

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# Automating Integration Tests

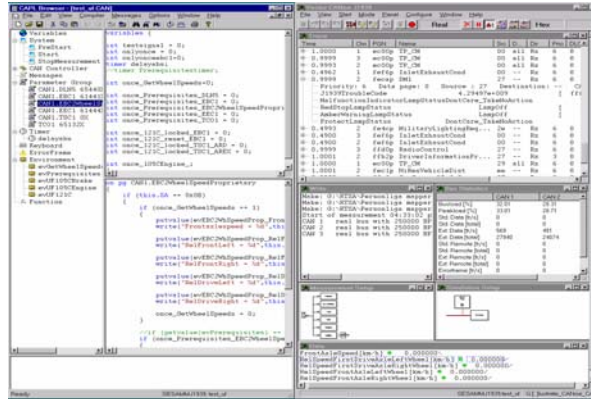
## Logging CAN - CANoe

- CAN open environment
- Logs traffic on CAN buses
- Windows
  - Trace
  - Statistics
  - Graphs...etc
- CAPL programs

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# Automating Integration Tests Logging CAN - environment



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# Automating Integration Tests Logging CAN - CAPL

- Similar to C
- Event driven
  - on start
  - on pg (parameter group, CAN message)
  - etc.
- Communication with other software
  - COM, CANLib
  - Environment variables

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## Automating Integration Tests Disconnection of ECUs

- Relays
  - Supply
  - Ground
  - CAN
- NI PCI-DIO-96
- NI LabVIEW
- Convert to DLL

## Automating Integration Tests Stimuli generation

- **Before: Manually using function generators and knobs and switches on instruments**
- **Stimuli needed for testing brake user functions**
  - Wheel speed signals to BMS
  - Tachograph speed to TCO
  - Engine speed to EMS

## Automating Integration Tests Stimuli generation - Tools

- **Function generators controllable from PC via GPIB interface**
- **PCI cards**
  - function generators
  - AO ports
  - Counter ports
- **dSPACE tools**

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## Automating Integration Tests Stimuli generation - dSPACE

- **dSPACE – Autobox**
- **Systems for developing or testing rapid mechatronic control systems**
  - Wheel speed signals
  - Engine speed signals
  - PWM signals
- **Signals controlled by implementing Simulink models into hardware, using Real Time Workshop (RTW)**

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## Automating Integration Tests Stimuli generation - dSPACE

- Controldesk
- Access libraries:
  - MLIB (Accessed with Matlab as COM-server)
  - CLIB (Requires a self written PC application)
  - RTPLib (Access through Python script)

## Automating Integration Tests Stimuli generation - dSPACE

- Testprogram calls Matlab function with requested “signal speed” as input
- Matlab function uses MLIB to access Simulink model, implemented in dSPACE hardware
- Verification of CAN signal with CANoe
  - Ex. EBC2Proprietary.FrontAxleSpeed = 20km/h

## **Automating Integration Tests Presentation of results**

- **Before: templates in MS Word**
- **Excel more convenient for automatic tests**
  - **Simple**
  - **Common tool at Scania**
  - **Operations may be performed in the template**
  - **Macros**

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## **Automating Integration Tests Main program**

- **User interface**
- **Able to communicate with other software**
- **Easy to expand in the future**

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# Automating Integration Tests

## Main program - Visual Basic

- Microsoft RAD tool
- High level language
- Most commands are written and compiled C/C++ code
- Interface with CANoe via CANLIB
- Calls DLLs
- Easy to communicate with Excel

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## Test Program

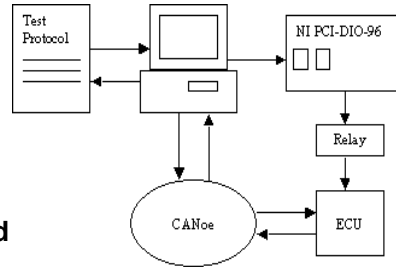
The screenshot shows a Windows-style application window titled "Integration Test Main Form". The main content area is titled "Integration Tests" and contains a tabbed interface with three tabs: "CAN-Com", "Robustness", and "User Functions". The "CAN-Com" tab is active and displays the "CAN-Communication" section. This section includes two large buttons labeled "RUN" and "STOP". Below these buttons are three input fields: "Current ECU", "CAN-Bus", and "Current Message". At the bottom of the section, there are two more input fields: "Rows to test" and "Notes".

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## Test Program CAN communication test

- Test “controlled” by Excel template
- Disconnects interfering ECUs
- Reads from CAN via CANoe and CAPL
- Response written to Excel template
- All results summarised in Excel



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## Test Program Robustness tests

- Example: Low Voltage test
  - Voltage is slowly reduced by sending a control signal to the power supplier using a LabVIEW DLL
  - Reads from CAN to find out at which voltage the communication stops and when it re-appears
  - Presents results in Excel template

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## Test Program User function tests

- **Stand-alone VB program**
  - No reading from Excel
- **Disconnects interfering ECUs**
- **Stimuli generation**
- **Reads from CAN**
- **Presents results in Excel**

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## Test Program User function tests



- **Excel user function test template...**

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# Test Program

- **Possible to create fully automatic integration tests**
  - Easy to expand with more tests
- **Automatic tests reduce required time consumption in integration lab**
- **Results need to be reviewed manually**

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# Future automation work

- **Add more tests to program**
- **Computer controlled buttons, levers etc**
- **Computerised instrument panel monitoring**
- **Link test cases with MSCs**
- **Automatic error report generation**

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## Automation of Integration Tests

# THE END

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