EV2106B01

- Main Microprocessor
  - SPC5606B
  - 64MHz
  - 1M Flash
  - 80K SRAM
  - Float Point Capability
- Sensor 5V Supply: 3 channels
- Inputs
  - 26 Analog Inputs
  - 11 Digital Inputs
  - 5 Speed Inputs
- Communication
  - 3CAN 2.0B (CANA, CANB, CANC)
  - CANA, CANB support wake-up function
- Software Watchdog
- Outputs
  - 8 Low side drivers (2 of which can be configured as PWM outputs)
  - 16 High side drivers (9 of which can be configured as PWM outputs)
- EEPROM Emulation
- 9-16V Operating Voltage
- OTP: 6K
- Environmental
  - Operating temperature: -40 °C to 85 °C
  - ISO16750 Compliant
  - ISO7637 Compliant
- Simulink Model Based Design

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Date	Version		Description
Jul. 2017	V 1.1		First release
Jul. 2017	V 1.2		
Sep. 2017	V 1.3		
Nov.2017	V 1.4		
June.2017	V 1.5		V310
July, 2020	V 1.6		
Aug, 2020	V1.7		Format
Apr, 2021	V1.8		Contact info & web name

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Chapter 1 General Information

1.1 Introduction

Vehicle Control Unit, or VCU, is the master controller for an electric or hybrid vehicle.

VCU receives the sensors and driver input signals, including pedal inputs, vehicle speed signals, and other inputs, manages the system energy, commands the driver demanded torque to powertrain, coordinates vehicle components, achieves fault diagnose and determines the overall vehicle drivability.

VCU plays a critical and supervisory role in the vehicle control network, or CAN bus-based network.

1.2 Features

- VCU is designed with ISO26262 function safety in mind and comes with a main chip and a monitor chip built-in, for safety monitoring.
- VCU comes with the basic software, or BSW, which supports all typical input / output drivers for vehicle controls.
- The BSW is encapsulated in the MATLAB/Simulink environment, and the user can develop the control system with 100% model-based-design methods.
- The VCU hardware is abstracted from the application software and relieves the controls engineer from the challenge of the microprocessor configuration and embedded real-time software.
- VCU comes with a CAN bus based reprogramming tool, which is supported by our boot loader that is pre-programmed into the microprocessor.
- VCU supports the CCP based calibration tools, like INCA, CANape, as well as EcoCAL, developed by Ecotron.

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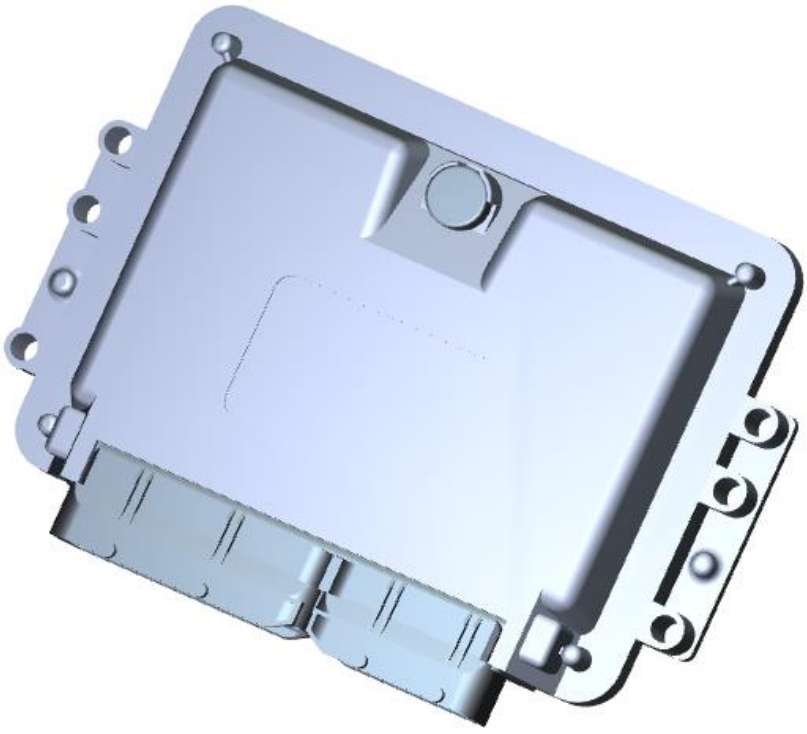
Chapter 2 Mechanical Installation

2.1 Mechanical Dimensions

The housing dimensions are 207 x 150 x 42 mm. The housing color is silver, made of die-cast aluminum.



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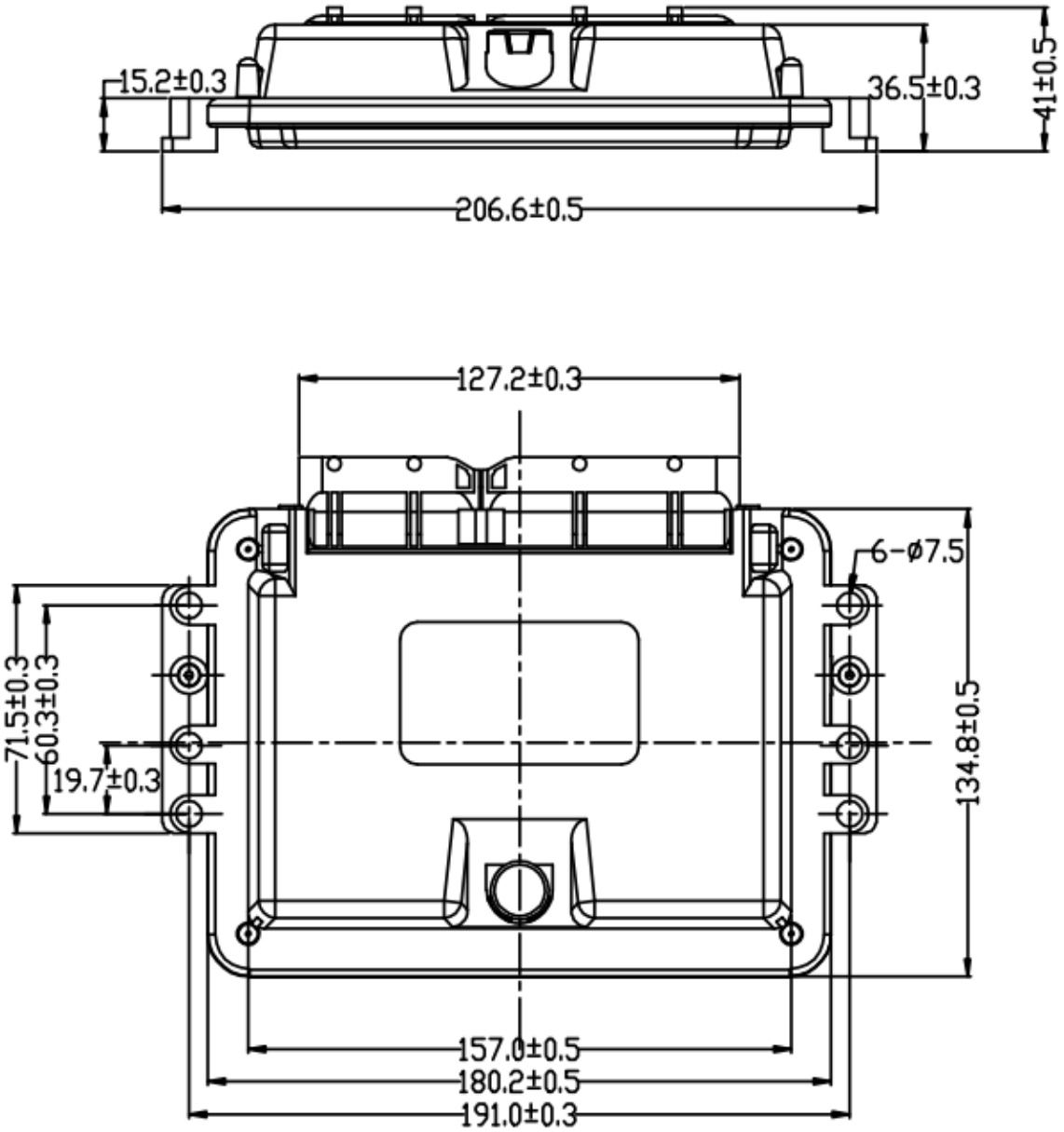

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2.2 Connectors

VCU uses the automotive industry rated, "Tyco" brand, connectors. The connector meets the auto safety requirements and has 121 pins total. The following table lists the connector models.

No.	Name	Type	Supplier
1	PCB needle	1746979-1	Tyco
2	81P sheath	1473244-1	Tyco
3	40P sheath	1473252-1	Tyco
4	Terminal	964282-2	Tyco
5	Terminal	968220-1	Tyco
6	MQS 81P LEVER(R) ASSY	1473247-1	Tyco
7	MQS 40P LEVER(L) ASSY	1473255-1	Tyco
8	MQS RETAINER HSG FOR 81P	368382-1	Tyco
9	MQS RETAINER HSG FOR 40P	368388-1	Tyco

2.3 Housing Parameters

- Housing size：207×150×36mm
- Materials：Die-casting aluminum
- Waterproof 121-pin connector
- Good rigidity
- Waterproof breathable vent, good heat dissipation

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Chapter 3 Hardware Parameters

3.1 Hardware Features

- Main microprocessor

  Freescale SPC5606B: 64MHz, Flash 1MB, SRAM 80K, float point capable
- Monitor microprocessor

  Freescale S9S08: automotive rated 8-bit low-cost microprocessor
- CAN bus: 3 channels, support CANA, CANB wake up
- Sensor 5V supply: 1 channel
- Analog inputs: 26 channels, 12-bit or 10bit, supporting both 0-5v inputs (16 channels) and 0-12v inputs (10 channels)
- Digital inputs: 11 channels, 6 channels active low and 5 channels active high
- Speed inputs: 5 channels
- Low-side driver: 8 channels, 1A current (4 channels) and 7A current (4 channels)
- High-side driver: 16 channels, 1.5A current for each channel

3.2 Specifications

Supply Voltage	DC 12V (9~16V)
Working Temperature	-40~85℃
Humidity	0~95%, no condensation
Storage Temperature	-40℃~85℃
Protection Level	IP67
Mechanical Shock	50g
Expected Life	10 years
Electric Performance	ISO16750, ISO7637 compliance
EMC	CISPR25
Dimensions	207×150×42mm

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Weight	≤600g

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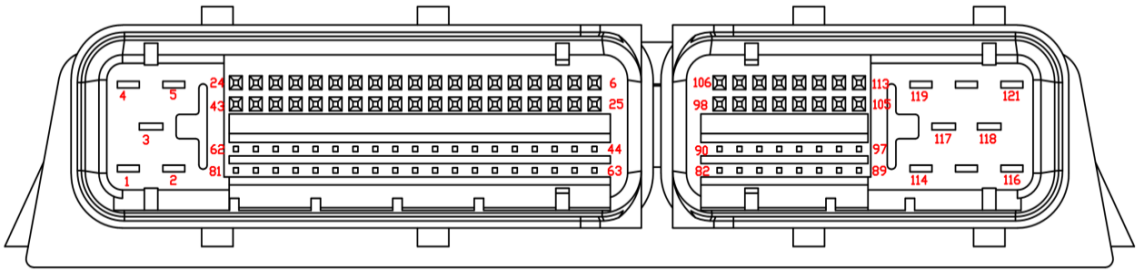
Chapter 4 Connector Pinouts

4.1 Connector View

The connector has two rows with 121 pins. The pin numbers are specified as below.



4.2 Pinout and Functions

Name	Pin #	Name	Description	Function (reference only)
5V2	51	5V supply 1		Sensor 5v supply
	41	5V supply 2		
	49	5V supply 3		
A00	15	Analog input0	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	Driver selected auto-mode
A01	34	Analog input1	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	Sensor signal
A02	16	Analog input2	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	Driver selected sport-mode
A03	35	Analog input3	0-5V, internal pull-up R_pull_up=100K AD Resolution=12bit	Sensor feedback signal
A04	17	Analog input4	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=10bit	Driver selected 4WD-mode

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A05	36	Analog input5	0-5V, internal pull-up R_pull_up=100K AD Resolution=12bit	
A06	18	Analog input6	0-5V, R_divider=453R R_pull_down=100K AD Resolution=12bit	Pedal sensor
A07	37	Analog input7	0-5V, R_divider=453R R_pull_down=100K AD Resolution=12bit	
A09	71	Analog input9	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	HVIL primary
A11	32	Analog input11	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=10bit	
A12	24	Analog input12	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	Brake pedal 1
A13	43	Analog input13	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	
A14	62	Analog input14	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	High voltage AC-CC
A15	81	Analog input15	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	High voltage DC-CC
A16	13	Analog input16	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	Driver selected EV-mode
A18	33	Analog input18	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	Regeneration disable Switch

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A22	19	Analog input22	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	Emergency stop switch
A24	20	Analog input24	0-5V, internal pull-up R_pull_up=1K AD Resolution=12bit	
A30	22	Analog input30	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	
A31	79	Analog input31	0-12V, active high R_divider=15K R_pull_down=6.8K AD Resolution=12bit	
A33	23	Analog input33	0-5V, internal pull-up R_pull_up=5.1K AD Resolution=12bit	Brake pedal 2,
A34	61	Analog input34	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	Front hood open signal
A36	72	Analog input36	0-12V, R_divider=15K R_pull_down=6.8K AD Resolution=12bit	HVIL secondary
A37	14	Analog input37	0-5V, internal pull-up R_pull_up=220K AD Resolution=12bit	Acceleration pedal 2
A39	12	Analog input39	0-5V, internal pull-up R_pull_up=220K AD Resolution=12bit	Acceleration pedal 1
BATT1	3	12V power	9-16V R_divider=15K R_pull_down=6.8K AD Resolution=12bit	12V battery 1
BATT1	1	12v power	9-16V R_divider=15K R_pull_down=6.8K AD Resolution=12bit	12V battery 2
CANA SHILD	21	CANA Shielded cable		

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CANAH	56	CANAH	CANA signal	Electric Drivetrain CAN high, 120R termination
CANAL	55	CANAL	CANA signal	Electric Drivetrain CAN low
CANB SHILD	77	CANB Shielded cable		
CANBH	57	CANBH	CANB signal	Powertrain CAN high
CANBL	76	CANBL	CANB signal	Powertrain CAN low
CANCH	54	CANCH	CANC signal	Data CAN high, 120R termination
CANCL	73	CANCL	CANC signal	Data CAN low
DI05	6	Digital input5	0-5V, low effective R_pull_up=2K	
DI06	25	Digital input6	0-5V, low effective R_pull_up=2K	
DI07	7	Digital input7	0-5V, low effective R_pull_up=2K	
DI08	8	Digital input8	0-5V, low effective R_pull_up=2K	
DI09	65	Digital input9	0-12V, high effective R_divider=15K R_pull_down=6.8K	
DI10	46	Digital input10	0-12V, high effective R_divider=15K R_pull_down=6.8K	
DI12	10	Digital input12	0-12V, high effective R_divider=15K R_pull_down=6.8K	
DI13	26	Digital input13	0-5V, low effective R_pull_up=1K	
DI14	27	Digital input14	0-5V, low effective R_pull_up=1K	
KEYON(DI)	67	Key switch input	0-12V, high effective R_divider=15K R_pull_down=10K	
	68			

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GND	2	Power ground		
GND	4	Power ground		
GND	5	Power ground		
GND	120	Power ground		
GND	121	Power ground		
GND	48	Signal ground		
GND	60	Signal ground		
GND	70	Signal ground		Acceleration pedal 1 ground
GND	74	Signal ground		Acceleration pedal 2 & brake pedal ground
GND	75	Signal ground		Sensor ground
HSO01	113	High-side drive 1	1A, Peak current1.5A	newly increased
HSO02	112	High-side drive 2	1A, Peak current1.5A	newly increased
HSO03	111	High-side drive 3	1A, Peak current1.5A	newly increased
HSO04	110	High-side drive 4	1A, Peak current1.5A	newly increased
HSO05	108	High-side driver 5	1A, Peak current1.5A	MCU enable
HSO06	100	High-side driver 6	1A, Peak current1.5A	BSG enable
HSO07	107	High-side driver 7	1A, Peak current1.5A	BMS enable
HSO08	99	High-side driver 8	1A, Peak current1.5A	DC/DC enable
HSO09	106	High-side driver 9	1A, Peak current1.5A	
HSO10	98	High-side driver 10	1A, Peak current1.5A	
HSO11	94	High-side driver 11	1A, Peak current1.5A	Water pump 1 (PWM)
HSO12	86	High-side driver 12	1A, Peak current1.5A	Water pump 2 (PWM)
HSO13	105	High-side driver 13	1A, Peak current1.5A	newly increased
HSO14	104	High-side driver 14	1A, Peak current1.5A	newly increased

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HSO15	103	High-side driver 15	1A, Peak current1.5A	newly increased
HSO16	102	High-side driver 16	1A, Peak current1.5A	newly increased
LSO01	95	Low-side dirver1	1A	
LSO02	109	Low-side dirver2	1A	4WD mode background lamp
LSO03	90	Low-side dirver3	1A	Auto mode background lamp
LSO04	101	Low-side dirver4	1A	Sport mode background lamp
LSO13	97	Low-side dirver13	7A	
LSO14	96	Low-side dirver14	7A	Start relay control
LSO15	118	Low-side dirver15	7A	newly increased
LSO16	89	Low-side dirver16	7A	
SPEED1	64	Frequency input1	Maximum frequency 1.5KHz	
SPEED2	47	Frequency input2	Maximum frequency 1.5KHz	
SPEED3	66	Frequency input3	Maximum frequency 1.5KHz	
SPEED4	11	Frequency input4	Maximum frequency 1.5KHz	
SPEED5	30	Frequency input5	Maximum frequency 1.5KHz	

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Chapter 5 Function Description

5.1 Power Management

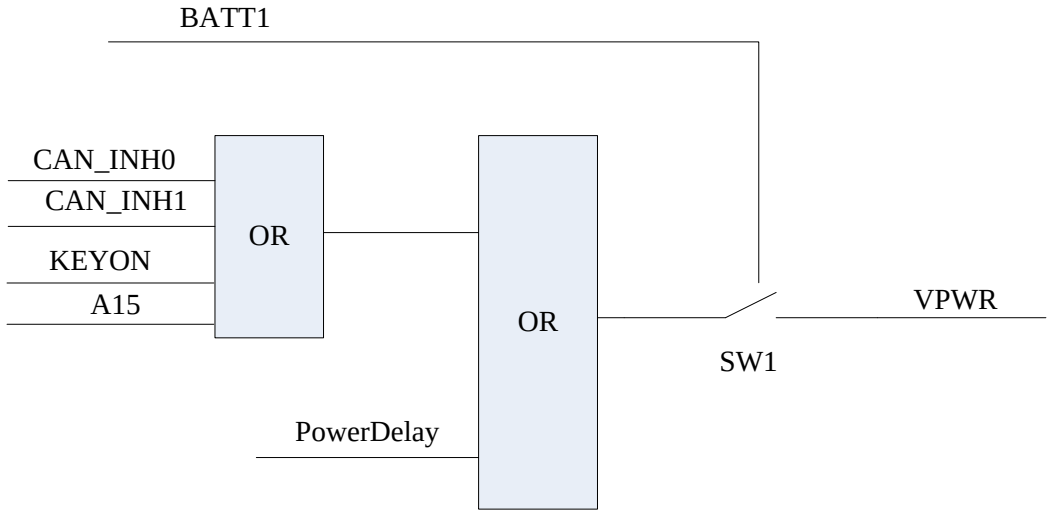
The power-down delay of VCU can be controlled by an internal circuit or a relay.

The "power-down delay" or "after-run" function, is often needed for control application, where the system needs to do some "housing keeping" jobs, after the user keys off the vehicle. For example, the controller will store the critical data into non-volatile memory, or NVM.

5.1.1 Internal Circuit Control

It is controlled by the internal switch "Power Delay", when the external level of CAN_INH0 from CANA, CAN_INH1 from CANB, KEYON, A15, and the internal Power Delay has a high level, the switch SW1 is turned on.

Specific implementation of software: If the external logic level is high, the level of Power Delay is controlled by the internal to high; while the external logic input is low, it will delay for a period of time to turn the level of Power Delay to low.



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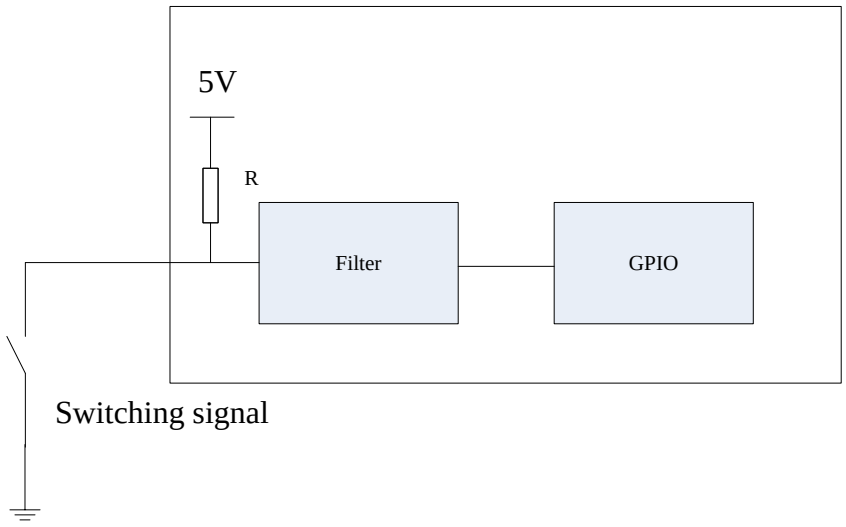
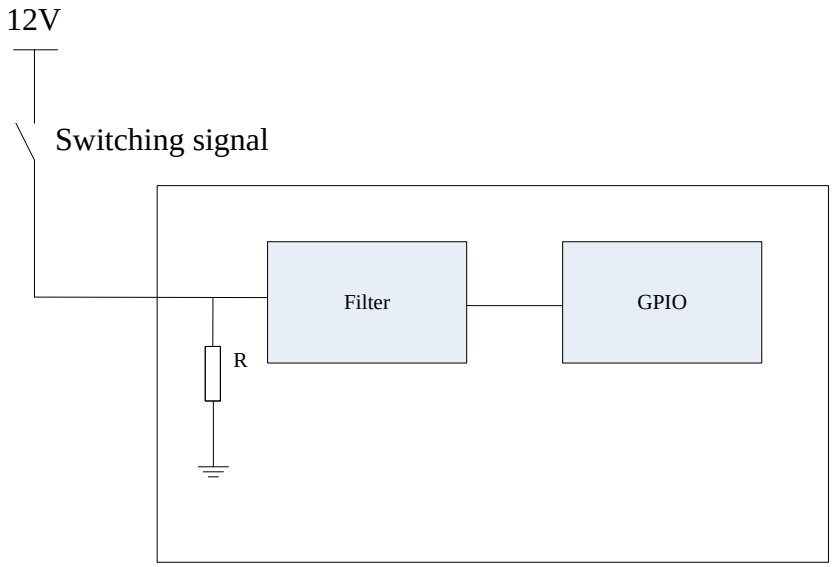
5.2 Switch Inputs

The digital input module has 11 channels. DI05-DI08 and DI13-DI14 is by default valid for low level input, and DI09, DI11, DI12, KEYON is by default valid for high level input.



Low level input valid



High level input valid

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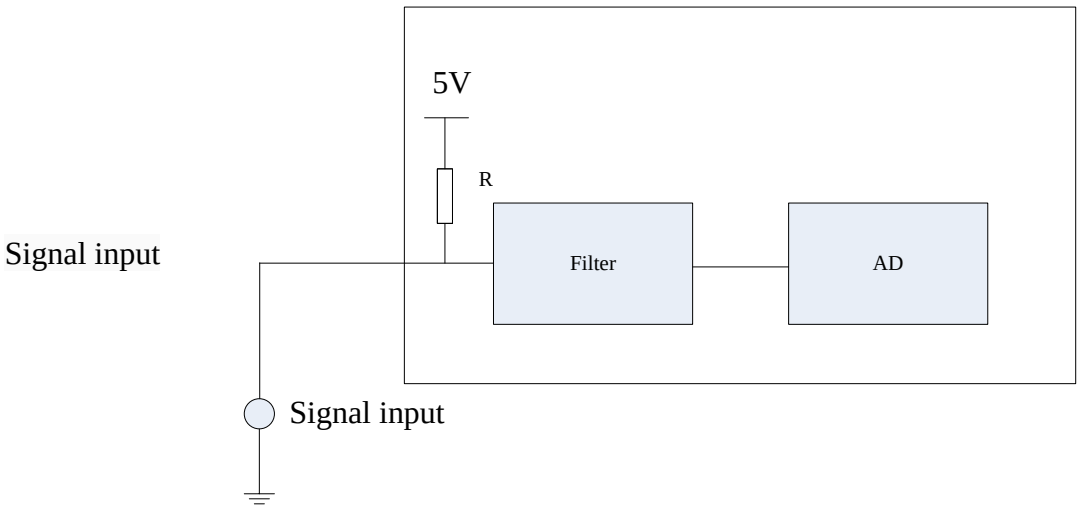
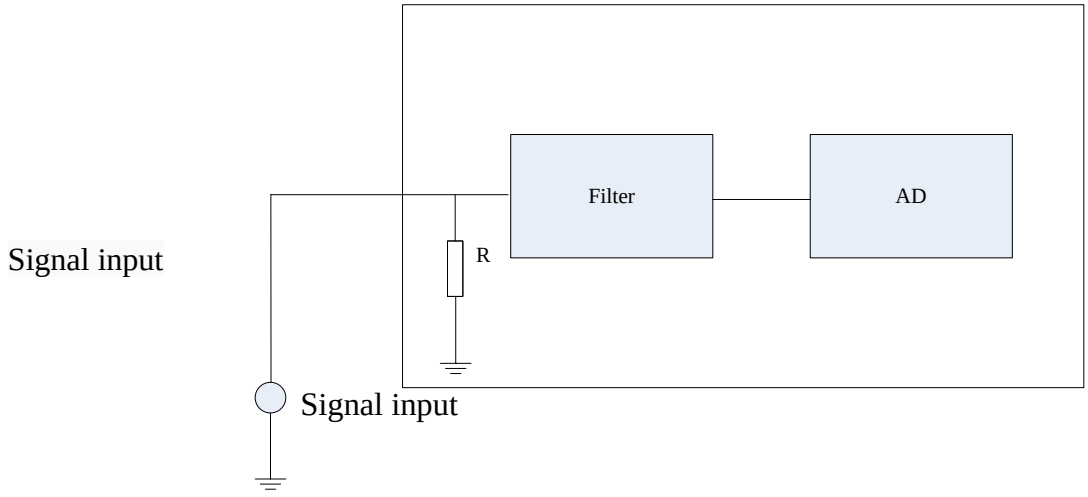
5.3 Analog Inputs

The analog input module has 26 channels, by default for voltage Inputs. It has 0-5V inputs with built-in pull-up resistors, and 0-12V inputs with built-in pull-down resistors.



Pull up



Pull down

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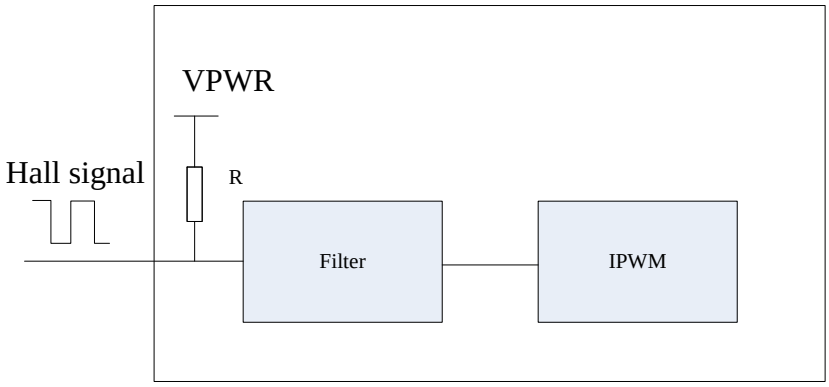
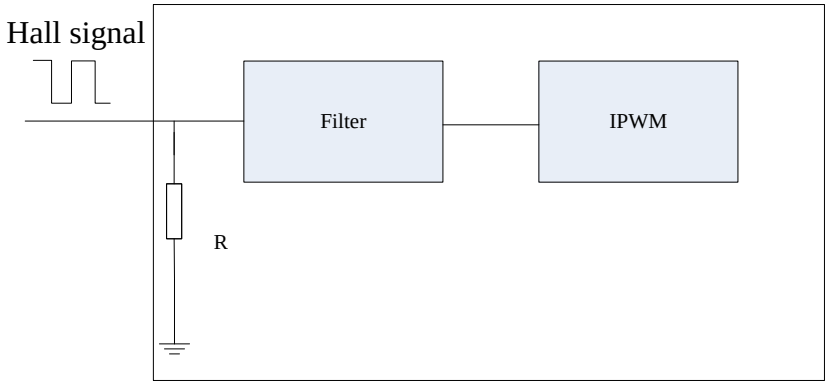
5.4 Hall-effect Signal Inputs

The hall signal input module contains five Hall-type speed sensor measurement channels, for either high level active or low level active switching type Hall signal. The default configuration is low level active, has a pull-up resistor. The user does not need to add an external pull-up (down) resistor because the Hall signal input module has integrated pull-up (down) resistors.



Low level active hall input



High level active hall input

5.5 Low-side Switch

VCU provides 8 Low side switching channels with over-current protection, over-temperature protection and over-voltage protection.4 channels have 1A drive current capability. They can detect the load open / short circuit and other failures. 4 channels have 7A drive current

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capability. They can't detect the load state. And LSO14 and LSO16 support PWM output, and you can run pumps and so on.

If the pin outputs a high-level signal, the corresponding low side switch is turned on; If the pin outputs a low-level signal, the corresponding low side switch is turned off. LSO14, LSO16 can be configured to PWM control modes.

5.6 High-side Switch

High side switch module provides 16 high side switch channels with short circuit protection, over-temperature protection and over-voltage protection, the maximum current is 1.5A.

If the IO output is high level, the corresponding high side switch is turned on. If the IO output is low level, the corresponding high side switch is in the off state. HSO11, HSO12 can be configured to PWM control modes.

5.7 Communication Module

5.7.1 **CAN Communication Module**

5.7.1.1 Basic Introduction

CAN communication module provides three CAN channels, as we called them CANA, CANB, CANC; and all of them are CAN2.0B high speed bus. CANA and CANC have a default terminal resistance, CANB does not.

CANC is for calibration purpose, default for the CCP protocol, and it's used for updating the controller program, as well as calibration and measurement.

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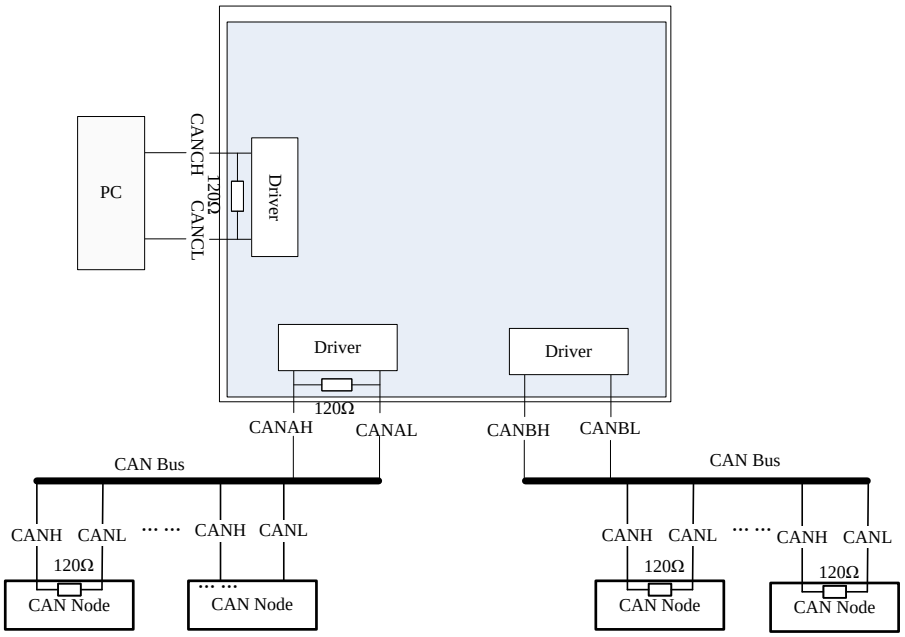

5.7.1.2 CAN Wakeup Function

CANA support CAN wakeup function, VCU can be waked up by CANA, CANB.

When KEYON signal is off, the VCU is power down. If other nodes send messages to CANA or CANB bus, the VCU will be waked up after receive messages, then VCU goes into working mode. CAN wakeup function can be used for VCU remote wakeup from other nodes, or from remote intelligent terminal.

5.7.1.3 CAN Architecture Introduction

In order to support the application layer protocol, CAN communication module is set to some layers. Below are the details:

(1) Drive layer: the data link layer of communication model, including the IO drivers and CAN driver of the microcontroller.

(2) Abstraction layer: the network layer of communication model. It needs to choose the CAN

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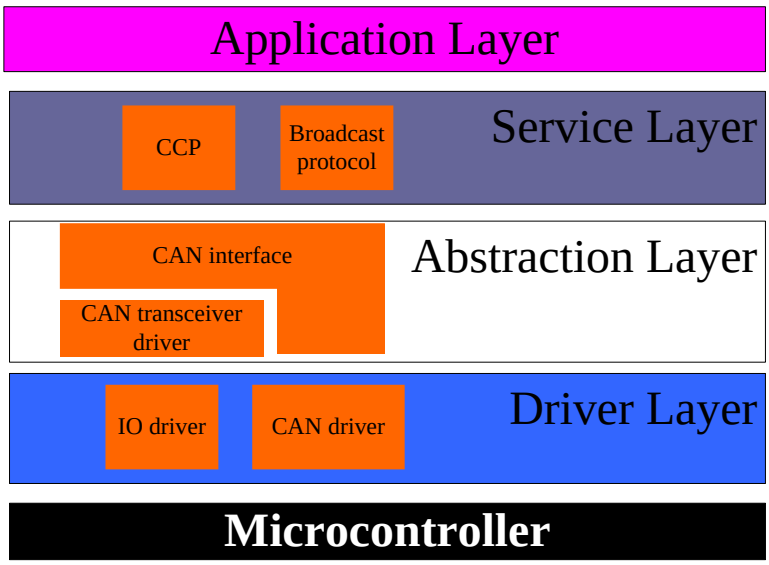
corresponding IO, provide CAN initialization, CAN transmitter and CAN receiver interface for the service layer.

(3) Service layer： the interactive layer of communication model. The implementation of this layer is based on the interface function provided by the abstraction layer, with the Simulink model and s-function to achieve.

(4) Application layer： for the signal or the s-function provided by the service layer to protocol specific implementation.



5.7.1.4 CAN Protocol Implementation

The specific implementation of application layer can use the DBC file or MATLAB “m” file to import the definition of protocol matrix. The code generation process is as below:

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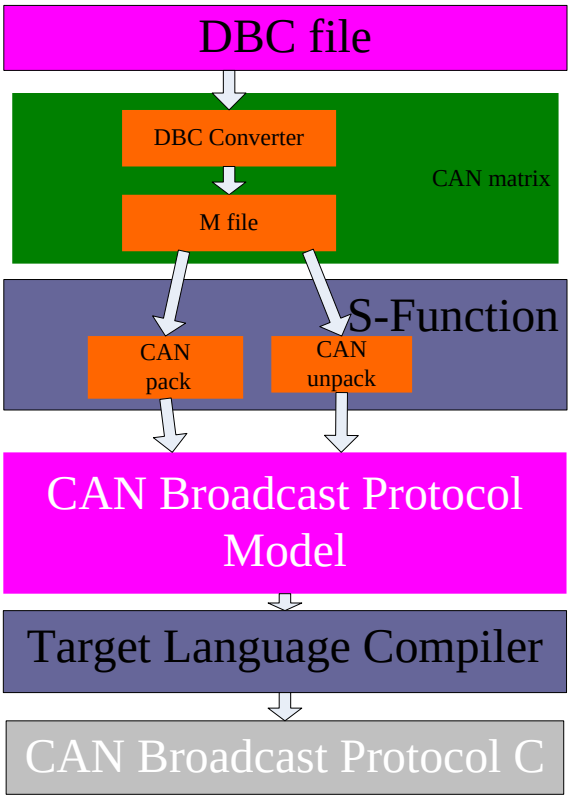
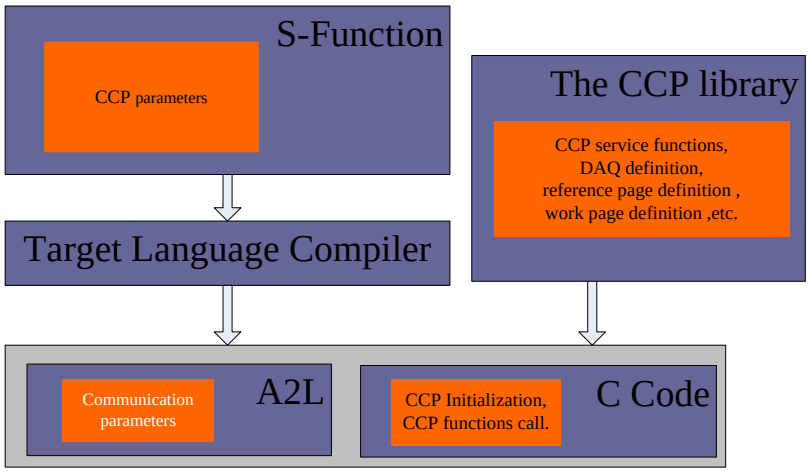


5.7.1.5 CCP Protocol Implementation

CCP service function, DAQ definition and storage page configurations are implemented in the “c” code, or low-level software; while the station address, DTO ID, CRO ID and other basic parameters can be configured in the s-function.



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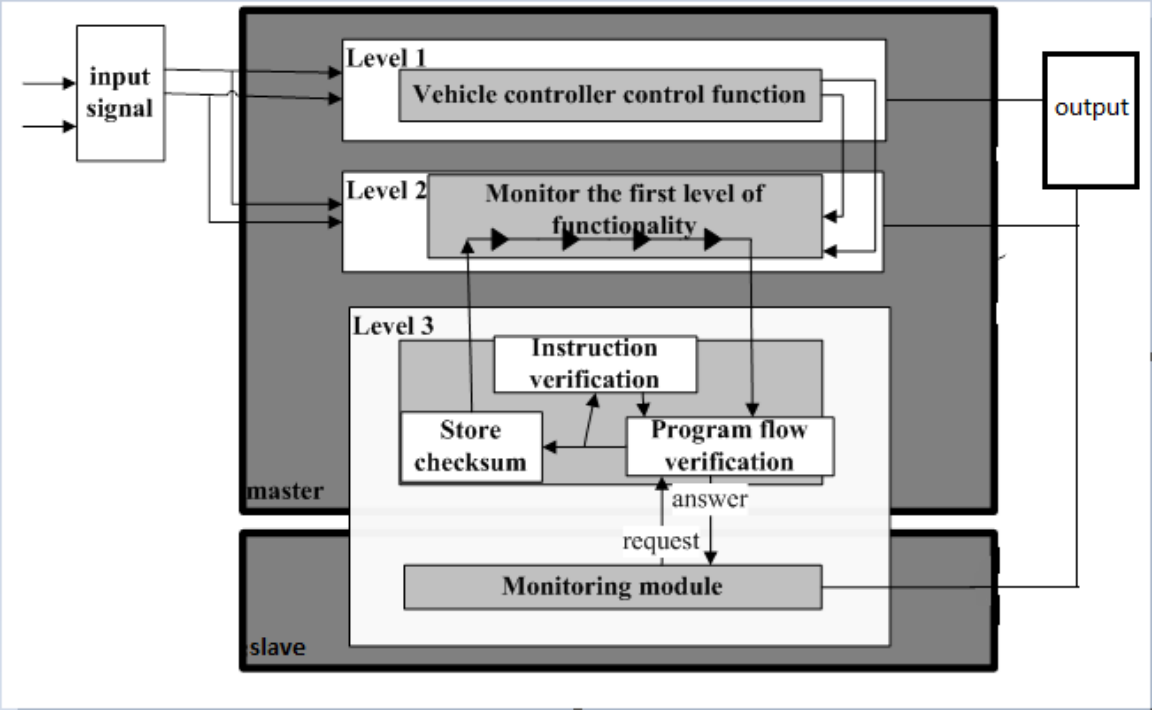
5.8 Torque Safety Monitoring Module

The design of VCU is based on advanced safety monitoring concept. It uses master-slave chip architecture to assure the safety of the system, as shown in Figure, the master chip is a 32-bit microcontroller, the slave chip is an 8-bit automotive chip.



Three-level architecture

Level 1：Vehicle control functions, including all vehicle control functions and fault diagnosis.

Level 2：This is to monitor Level 1 by a redundancy design, and it is independent of Level 1. If there is discrepancy between Level 2 and Level 1, Level 2 will make the torque command in the CAN bus message “Neutral”. “Neutral” means no hazard acceleration.

Level 3：By adding a slave chip to monitor the master controller, the 2 chips cross check each other. If the handshake fails, it will neutralize the torque command, so it does not create hazard situation.

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5.9 Controller Hardware Diagnosis

5.9.1 Chip-level Diagnosis

- Support Flash and RAM diagnostics of the master chip.
- Support kernel self-test diagnostics of the master chip.
- Support diagnosis of the slave chip.

5.9.2 Low-side Switch Diagnosis

LSO01-LSO4 and LSO13-LSO16 are the output channels of the low-side driver circuit. LSO01-LSO4 support the fault diagnosis function. The fault diagnosis is based on the integrated chip diagnosis. LSO13-LSO16 doesn't support the fault diagnosis function.

Full Diagnosis

For full diagnosis there are two diagnostic bits per channel configured as shown in Figure 1.

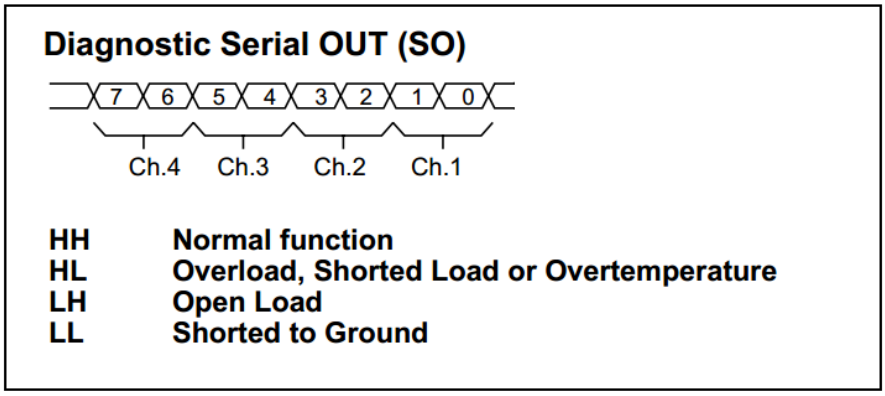

Figure 1: Two bits per channel diagnostic feedback

5.9.3 High-side Switch Diagnosis

The high side drive circuit output channels are HSO01-HSO16. They support the fault diagnosis function. The fault diagnosis is based on the integrated chip diagnosis.

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Chapter 6 Software Compatibility

- MATLAB/Simulink based software development environment.
- Model based design.
- Enhanced Auto code generation – EcoCoder (Refer to "EcoCoder Manual")
- Hardware encapsulation and abstraction
- One click compile and make process.
- CCP/XCP protocols.
- Powerful calibration tool – EcoCAL (Refer to "EcoCAL manual for EV")
- Commercial compiler – Code Warrior.
- Compatibility with INCA, CANape calibration software.
- CAN bus based boot loader – EcoFlash tool.

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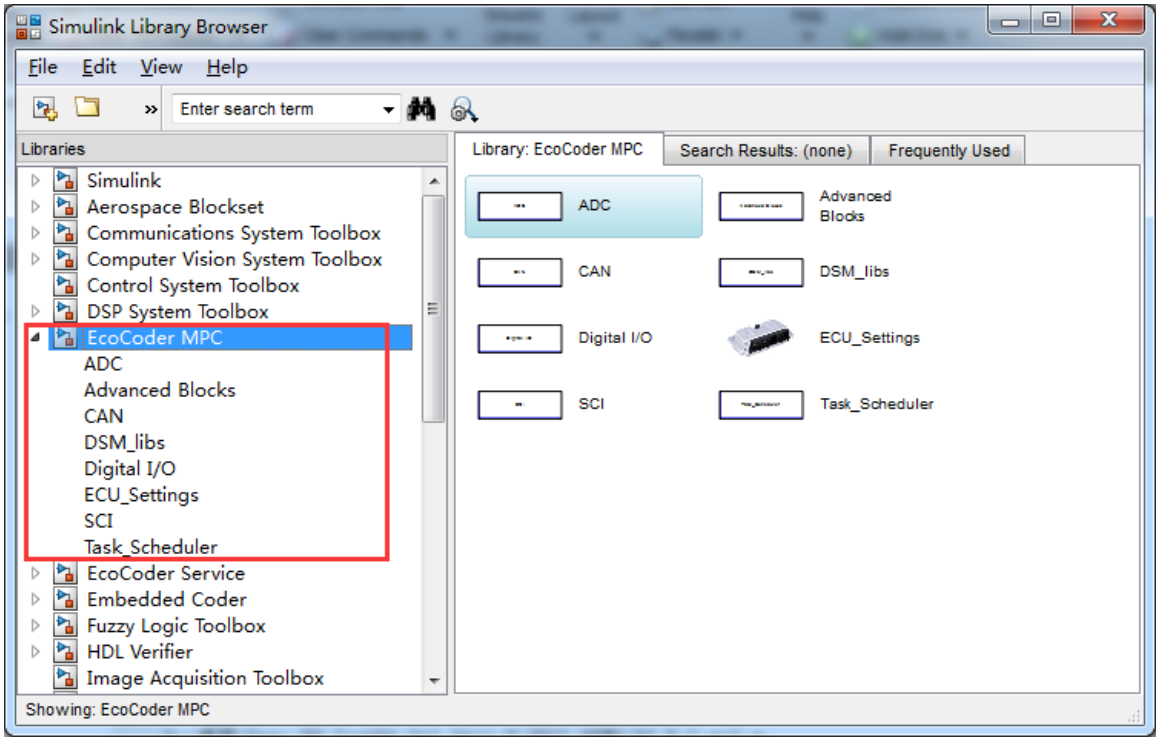
6.1 Prototype/Production Code Generation – EcoCoder

EcoCoder is an enhanced auto code generation library added on top of Simulink's generic Embedded Coder.

It is specifically designed for Ecotron hardware and it bridges the Simulink models directly to the target hardware, providing users the capability to generate the production code by 'ONE CLICK'.

For more details, please refer to the ***EcoCoder User Manual.***



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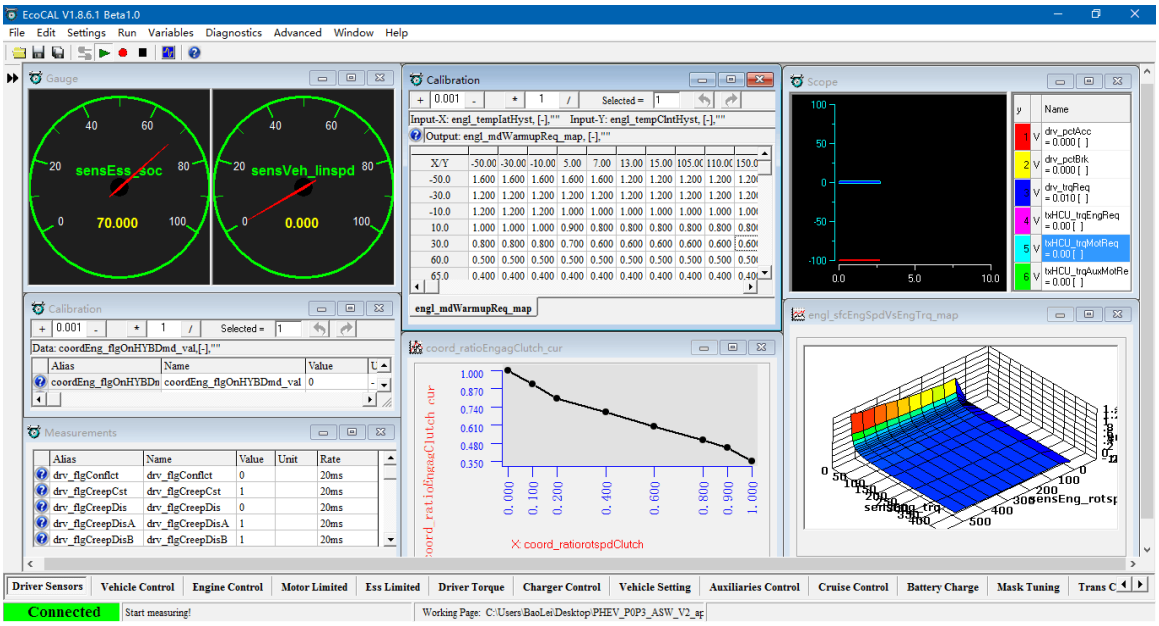
6.2 Powerful Calibration Software – EcoCAL

EcoCAL is a professional calibration tool, developed by Ecotron. It is specifically designed for Ecotron VCUs.

The software is based on the CCP protocol, and uses the CAN bus for data communication with target hardware. It has various measurement tools integrated for different kinds of signals, providing a more user-friendly interface. EcoCAL also integrates data logging function, and provides an integrated data analysis tool.

It parses the standard A2L files, and manages the calibration data in the format of S19 files, Mot files or CAL files.

For more details, please refer to EcoCAL User manual.



6.3 Reprogramming Tool – EcoFlash

EcoFlash is a simple PC based software to program the controller, developed by Ecotron, using

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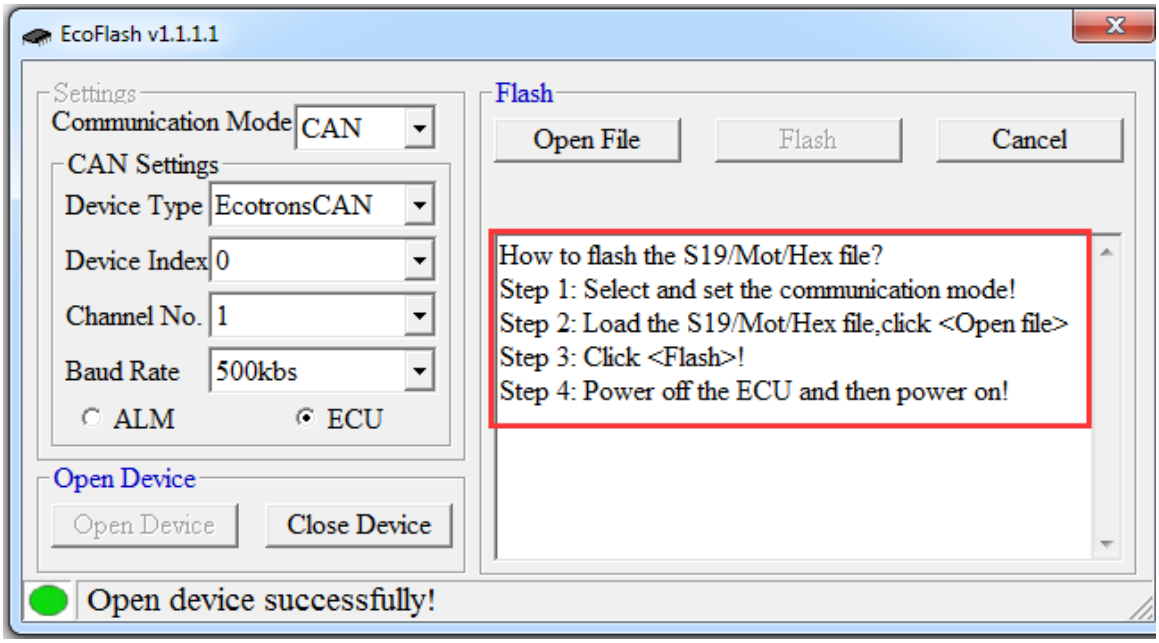
CAN communication for programming, with a typical bootloader pre-programmed in the microprocessor.

For more details, please refer to Ecotron EcoFlash User Manual.



Appendix: Standard Tests

The tables list the standard tests done according to the ISO or SAE standards, by SCU manufacturer or the third party, which is an authorized certification institute.

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For complete test reports, please email support@ecotron.ai.

NO	Test	Description	Test Standard
1	Environmental Tests	Waterproof experiment	IEC/EN 60529 IP67
2		Anti-dust experiment	ISO 16750-3: 2010
3		Salt-fog leakage test	ISO 16750-4: 2010
4		Corrosion test	ISO 16750-4: 2010
5		Mechanical shock test	ISO 16750-3: 2010
6		Drop test	ISO 16750-3: 2010
7		Electrical operation at ambient temperature	ISO 16750-4: 2010
8		High and low temperature operation test	ISO 16750-4: 2010
9		high and low temperature test	ISO 16750-4: 2010
10		Thermal cycling with humidity test	IEC 60068-2-30
11		Constant temperature and humidity test	ISO 16750-4: 2010
12		Vibration test	ISO 16750-3: 2010
13		Thermal shock test	ISO 16750-4: 2010
14		ESD	GMW3097-2015
15	EMC Tests	DC supply voltage	ISO 16750-2: 2012
16		Overvoltage	ISO 16750-2: 2012
17		Superimposed alternating voltage	ISO 16750-2: 2012
18		Slow decrease and increase of supply voltage	ISO 16750-2: 2012
19		Discontinuities in supply voltage (Reset	ISO 16750-2: 2012

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		behaviors at voltage drop)	
20		Discontinuities in supply voltage (Starting profile)	ISO 16750-2: 2012
21		Reverse Polarity	ISO 16750-2: 2012
22		Open circuit tests (Single line interruption)	ISO 16750-2: 2012
23		Open circuit tests (Multiple lines interruption)	ISO 16750-2: 2012
24		Short interrupts	ISO 16750-2: 2012
25		Withstand voltage	ISO 16750-2: 2012
26		Leakage Resistance	ISO 16750-2: 2012
27		Voltage Transient Emissions Test	ISO 7637-2: 2004
28		Conducted emission test-voltage method	CISPR25: 2008
29		Conducted emission test-current probe method	CISPR25: 2008
30		Radiated emission test-ALSE method	CISPR25: 2008
31		Signal line transient conducted immunity test	ISO 7637-3: 2007
32		Bulk Current Injection	ISO 11452-4: 2011
33		Absorber-lined shielded enclosure	ISO 11452-2: 2004
34		Disturbance resistance-magnetic fields	ISO 11452-8: 2007

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