



VCU- EV2106A

Vehicle Control Unit for Electric & Hybrid Vehicles

Datasheet

V1.7



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Revision History

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Sep. 2015	V 1.1	First released spec.
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Chapter 1 General Information

1.1 Introduction

Vehicle Control Unit, or VCU, is the core controller for the electric and hybrid vehicles.

VCU receives the driver input signals, like pedal inputs, vehicle speed signals, and other inputs, manages the system energy, commands the driver demanded torque, coordinates the motor, battery pack, as well as the conventional powertrain in case of hybrid vehicles, and determines the overall vehicle drivability.

VCU is the master of the vehicle control network, or CAN bus based vehicle control network.

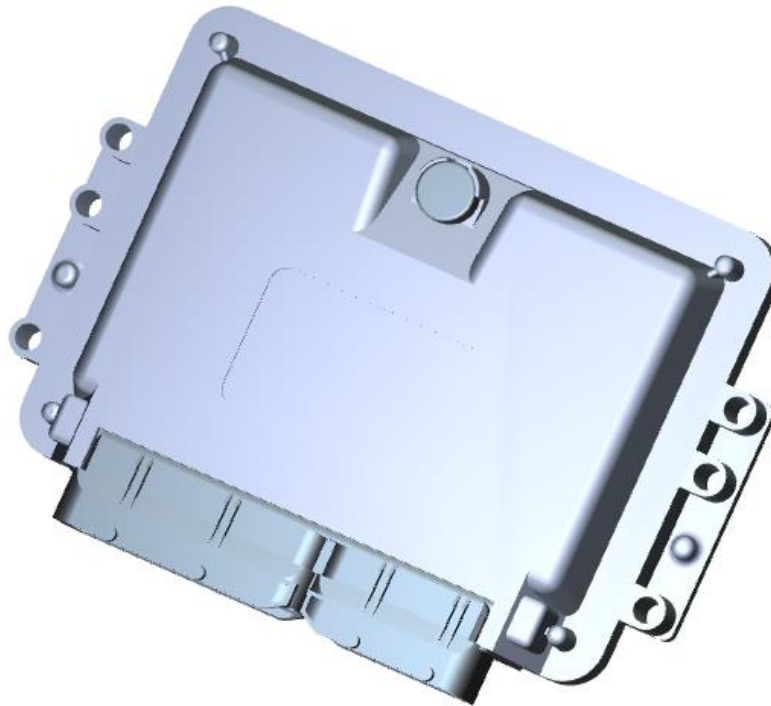
1.2 Features

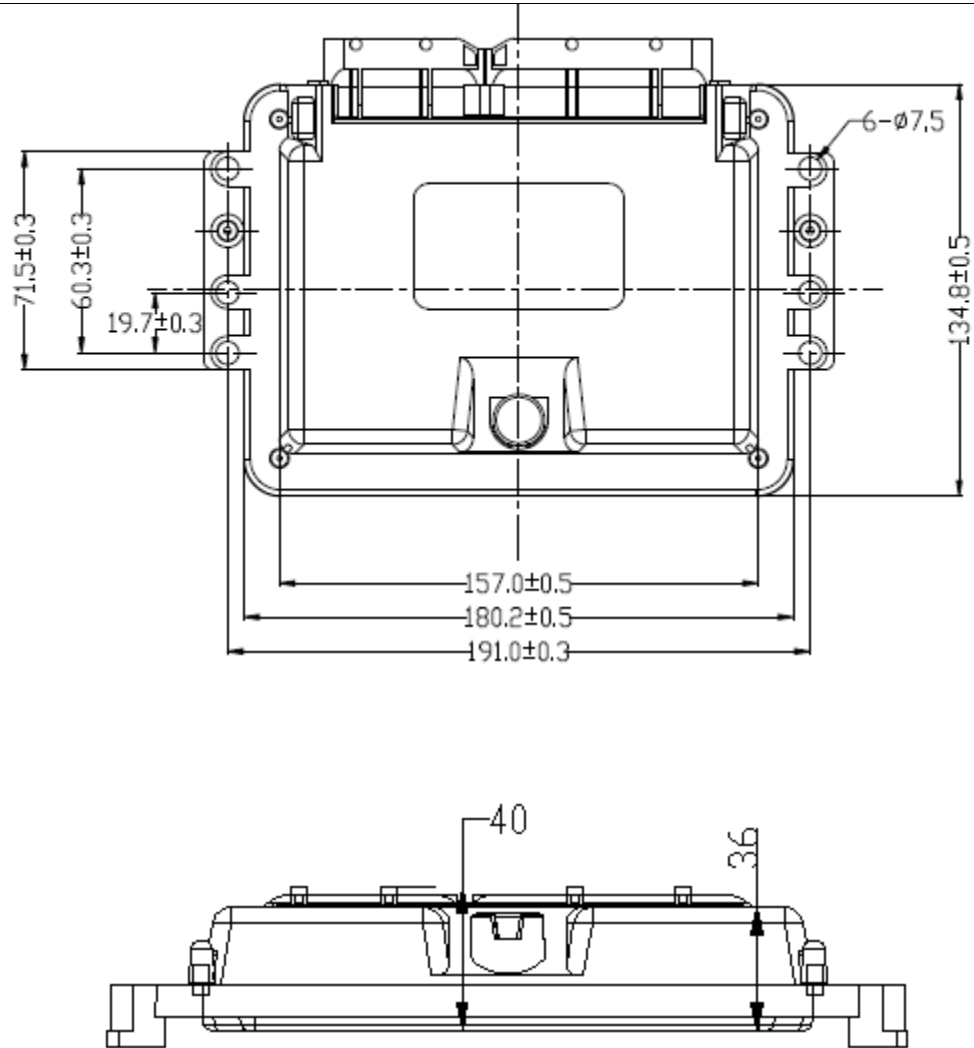
- Ecotrons VCU is designed with ISO26262 function safety in mind, and comes with a main chip and a monitor chip built-in, for safety monitoring.
- Ecotrons VCU comes with the basic software, or BSW, support all typical input / output drivers for vehicle controls. The BSW is encapsulated in the Matlab/Simulink 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 relieve the controls engineer from the challenge of the microprocessor configuration and embedded real-time software.
- Ecotrons VCU comes with a CAN bus based reprogramming tool, supported by the bootloader pre-programmed into the microprocessor.
- Ecotrons VCU supports the CCP/XCP based CAN bus calibration tools, like INCA, CANape, as well as the cost effective EcoCAL, developed by Ecotrons.

Chapter 2 Mechanical Installation

2.1 Mechanical dimensions

The housing dimensions are 207 x 150 x 36 mm. Shell color is silver, made of die-cast aluminum.





2.2 Connectors

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

No.	Name	Type	Supplier
1	PCB needle	1241434-1	TE
2	81P sheath	1473244-1	TE
3	40P sheath	1473252-1	TE
4	Terminal (big)	964282-2	TE
5	Terminal (small)	968220-1	TE
6	81P back	1473247-1	TE
7	40P back	1473255-1	TE

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

Chapter 3 Hardware Parameters

3.1 Hardware features

- Main microprocessor
Freescale MPC5606B: 64MHz, Flash 1M, SRAM 80K, float point capable.
- Monitor microprocessor
Freescale MC9S08: automotive rated 8-bit low-cost microprocessor
- CAN bus: 5 channels
- Support CAN wakeup
- Sensor 5v supply: 3 channels
- Analog inputs: 23channels, 12-bit, supporting both 0-5v inputs and 0-12v inputs.
- Digital inputs: 12 channels, with the default 5 channels 0-12V input, 7 channels 0-5V input
- Frequency inputs: 6 channels, Hall effect type
- Low side driver: 18 channels, the default is 16 channels for 250mA current, 2 channels for 7A current
- High side driver: 9 channels, the default is 6 channels for 1A current, 2 channels for 1.5A current, 1 channel for 7A current.
- H-bridge driver: 1 channels, the current is 7A

3.2 Specifications

name	parameters
Supply voltage	DC 12V(9~16V)
Working temperature	-40~85℃
Humidity	0~95%, no condensation
Storage temperature	-40℃~85℃
Protection	IP67

Mechanical shock	50g
Expected life	10 years
Electric performance	ISO16750,ISO7637 standards
EMC	CISPR25
Dimensions	207×150×36mm
Weight	≤600g

3.3 Test standards

3.3.1 Environmental test standards

Test items	Test standard	Specific indicators
High and low temperature test	ISO16750-4	+105°C 144 hour -40°C 48 hour
Temperature shock	ISO16750-4	+125°C~-40°C 100 circulation
Charged temperature cycle	ISO16750-4	+ 20 ° C to -40 ° C to + 85 ° C, for a total of 30 cycles per 8 hours
Splash test	ISO16750-4	After standing at 85 ° C for 1 hour, the mixture was sprayed with water at 0 ° C to 4 ° C for 10 s, followed by 100 cycles
Salt spray test	ISO16750-4	Salt solution concentration: 5%, spray sedimentation rate: 1 ~ 2ml / (80cm2 * h). The test was performed in 4 cycles, each lasting 7 days, for a total of 28 days.
Dustproof and waterproof test	ISO16750-4	1m deep water, placed for 30 minutes, IP67
Vibration test	ISO16750-3	The frequency of random vibration is 20 ~ 2000Hz, the root mean square value of the spectrum is 107.3m / s ² , the vibration time of X, Y, Z is 8h
Mechanical shock	ISO16750-3	The peak value is 50g, the duration for three-axis six-way half-sine impact is 6ms, each 10 times
Constant temperature and humidity	ISO16750-4	Temperature +40 ° C Humidity 85% RH normal work for 21 days
Temperature and humidity cycle	ISO16750-4	Low temperature operation and temperature + 23 ° C humidity 93% RH cycle, 24 hours per cycle, 10 cycles

3.3.2 EMC test standards

Test items	Test standard	Specific indicators
Conducted interference from electronic components	IEC CISPR 25 2008	AV and PK meet the four requirements
Radiated interference from electronic components	IEC CISPR 25 2008	AV and PK meet the four requirements
Radiated immunity of electronic components to magnetic fields	GMW3097 2006	Frequency Range: Modulation Mode; Intensity: LEVEL2, Function Level A.
Electronic components of the electromagnetic field immunity (BCI)	GMW3097 2006	Frequency Range: Modulation Mode; Intensity: LEVEL2, Function Level A.
CI power supply transient interference	ISO7637-2 2004	Function level A / C
CI on the signal line transient interference	ISO7637-3 2007	Function level A
Electrostatic discharge (non-live mode)	GMW3097 2006	Discharge network: C=150pF R=2k Ω
Electrostatic discharge (remote charge mode)	GMW3097 2006	Discharge network: C=330pF R=2k Ω

3.3.3 Electrical performance test standards

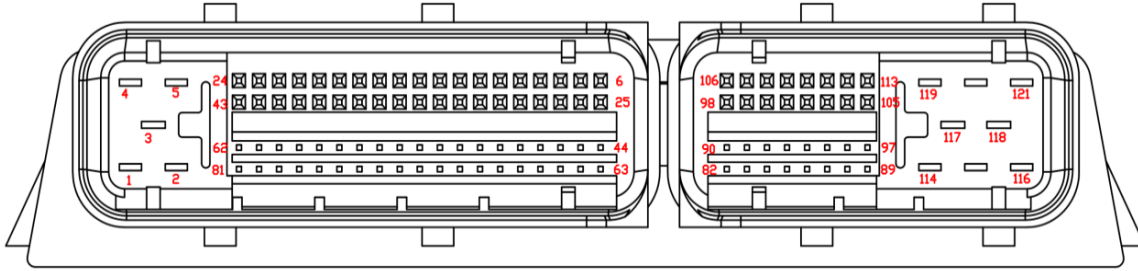
Test items	Test specification
Over - voltage test	36V for 60 minutes
Reverse polarity protection test	-28 V for 60 $\pm$ 6 s
AC voltage superposition test	U _{max} = 32V, U _{pp} 4V for 5 cycles
Supply voltage slow down test	U _{min} = 9V linearly decreases to 0V at a rate of 0.5V $\pm$ 0.1 / min, and then changes from 0V to U _{min} = 9V
Voltage transient drop test	U _{min} = 9V, down to 4.5V, continued for 10ms and then rise. Rise, fall time does not exceed 10ms
Reset performance test	The supply voltage U _{min} = 9V reduced by 5% and maintained for 5s, and then restore the supply voltage to U _{min} = 9V for at least 10s; Repeat the above steps, each time, the voltage reduction increased by 5%, until down to 0%, and then restore

	power supply $U_{min} = 9V$.
Starting voltage test	Simulation of vehicle startup, the voltage fluctuation of the state: the voltage dropped to 6V and continued for 15ms and then returned to normal
Power drift test	Simulation of two or more groups of power supply, there are different power supply on the product
Ground drift test	Simulation of two or more groups of power supply, there is a different impact on the product situation
Quiescent current measurement test	Average quiescent current $\leq 1mA$
Single - wire open circuit test	Then disconnect the sample interface connection, each disconnect time to maintain $10 \pm 1s$, and then restore the connection of the line
Multi - line open circuit test	Disconnect the sample harness connector, disconnect the time to maintain $10 \pm 1s$, and then restore the connection of the line

Chapter 4 Connector Pinouts

4.1 Connector view

The connector is a double row of 121 pins,the pin numbers are arranged as below.



4.2 Pinout and functions

ID	Pin #	Name	Description	Function (recommended)
5V2	51	5V Sensor supply 2	5V power output	
5V3	41	5V Sensor supply 3	5V power output	
5V4	49	5V Sensor supply 4	5V power output	
A01	15	Analog input1	0-5V, low effective	
A02	34	Analog input2	0-5V, low effective	
A03	16	Analog input3	0-5V, low effective	
A04	35	Analog input4	0-5V, low effective	
A05	17	Analog input5	0-5V, low effective	
A06	36	Analog input6	0-5V, low effective	
A07	18	Analog input7	0-12V, high effective	
A08	37	Analog input8	PT type	
A09	71	Analog input9	0-12V, high effective	
A10	32	Analog input10	0-5V, low effective	
A11	24	Analog input11	0-5V, low effective	
A12	62	Analog input12	0-5V, low effective	
A13	13	Analog input13	0-5V,low effective	
A14	33	Analog input14	0-12V,high effective	
A15	20	Analog input15	0-5V,low effective	

A16	22	Analog input16	0-5V,low effective	
A17	79	Analog input17	0-5V,low effective	
A18	23	Analog input18	0-5V,low effective	
A19	61	Analog input19	0-12V,high effective	
A20	72	Analog input20	0-12V,high effective	
A21	14	Analog input21	0-5V,low effective	
A22	12	Analog input22	0-5V,low effective	
A23	10	Analog input23	PT type	
CAN_SHILD1	58	CAN1 Shielded cable		
CAN0_H	56	CAN0_H	CAN0 signal	
CAN0_L	55	CAN0_L	CAN0 signal	
CAN_SHILD2	77	CAN2 Shielded cable		
CAN1_H	57	CAN1_H	CAN1 signal	
CAN1_L	76	CAN1_L	CAN1 signal	
CAN2_H	54	CAN2_H	CAN2 signal	
CAN2_L	73	CAN2_L	CAN2 signal	
CAN3_H	11	CAN3_H	CAN3 signal	
CAN3_L	30	CAN3_L	CAN3 signal	
CAN4_H	9	CAN4_H	CAN4 signal	
CAN4_L	28	CAN4_L	CAN4 signal	
DI01	42	Digital inputA01	0-5V,low effective	
DI02	52	Digital inputA02	0-5V,low effective	
DI03	53	Digital inputA03	0-5V,low effective	
DI04	38	Digital inputA04	0-5V,low effective	
DI05	39	Digital inputA05	0-12V,high effective	
DI06	80	Digital inputA06	0-12V,high effective	
DI07	43	Digital inputA07	0-5V,low effective	
DI08	31	Digital inputA08	0-12V,high effective	
DI09	25	Digital inputB09	0-5V,low effective	
DI10	65	Digital inputB10	0-12V,high effective	
DI11	46	Digital inputB11	0-5V,low effective	
DI12	21	Digital inputB12	0-12V,high effective	
KEYON	59	KEYON	0-12V,high effective	
WAKEUP1	40	AC Wake	0-12V, switch type	
WAKEUP2	81	DC Wake	0-12V, switch type	
DRVP	116	DRVP	9-16V	

DRV1	119	DRV1	9-16V	
BATT1	1	power	9-16V	
BATT2	3	power	9-16V	
GND	2	ground		
GND	4	ground		
GND	5	ground		
GND	48	signal ground		
GND	60	signal ground		
GND	70	signal ground		
GND	74	signal ground		
GND	75	signal ground		
GND	120	power ground		
GND	121	power ground		
HSO01	108	High-side driver 1	1A	
HSO02	100	High-side driver 2	1A	
HSO03	107	High-side driver 3	1A	
HSO04	99	High-side driver4	1A	
HSO05	106	High-side driver 5	1A	
HSO06	98	High-side driver 6	1A	
HSO07	94	High-side driver 7	1.5A	
HSO08	86	High-side driver 8	1.5A	
HSO09	118	High-side driver 9	7A	
LSO01	95	Low-Side-Dirver01	250mA	
LSO02	109	Low-Side-Dirver02	250mA	
LSO03	90	Low-Side-Dirver03	250mA	
LSO04	101	Low-Side-Dirver04	250mA	
LSO05	97	Low-Side-Dirver05	7A	
LSO06	96	Low-Side-Dirver06	7A	
LSO07	110	Low-Side-Dirver07	250mA	
LSO08	89	Low-Side-Dirver08	250mA	
LSO09	112	Low-Side-Dirver09	250mA	
LSO10	111	Low-Side-Dirver10	250mA	
LSO11	102	Low-Side-Dirver11	250mA	
LSO12	103	Low-Side-Dirver12	250mA	
LSO13	88	Low-Side-Dirver13	250mA	
LSO14	113	Low-Side-Dirver14	250mA	
LSO15	104	Low-Side-Dirver15	250mA	
LSO16	105	Low-Side-Dirver16	250mA	

LSO17	93	Low-Side-Dirver17	250mA	
LSO18	92	Low-Side-Dirver18	250mA	
SPEED1	64	SPEED1	Frequency input1	
SPEED2	47	SPEED2	Frequency input2	
SPEED3	66	SPEED3	Frequency input3	
SPEED4	8	SPEED4	Frequency input4	
SPEED5	7	SPEED5	Frequency input5	
SPEED6	6	SPEED6	Frequency input6	
LIN1	78	LINBUS		
Hbridge1A	115	Output of the H-bridge 1A	peak current is 7A	
Hbridge1B	117	Output of the H-bridge 1B	peak current is 7A	

Chapter 5 Function Description

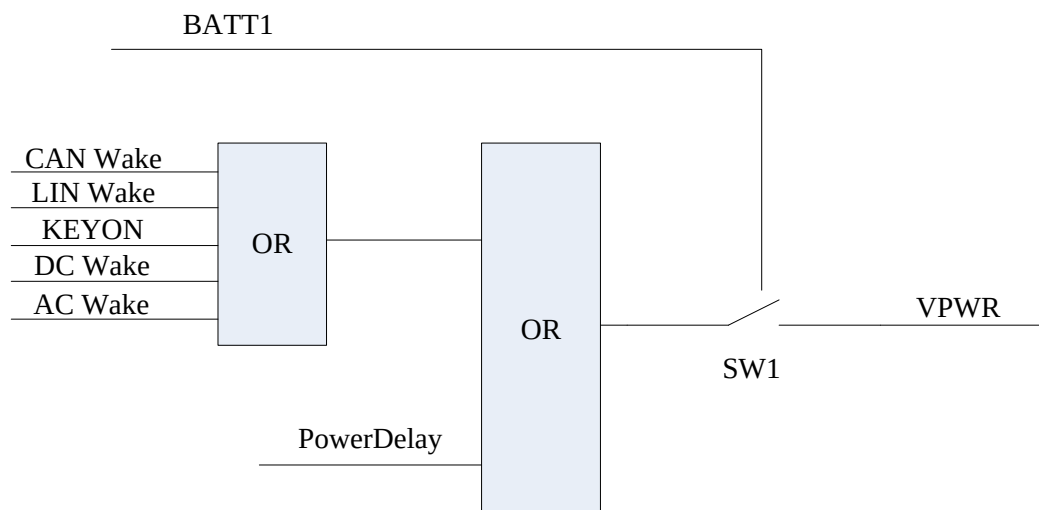
5.1 Power-down delay

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 need 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 Wake,LIN Wake, KEYON, DC Wake, AC Wake and the internal Power Delay has a high level, the switch SW1 is turned on.

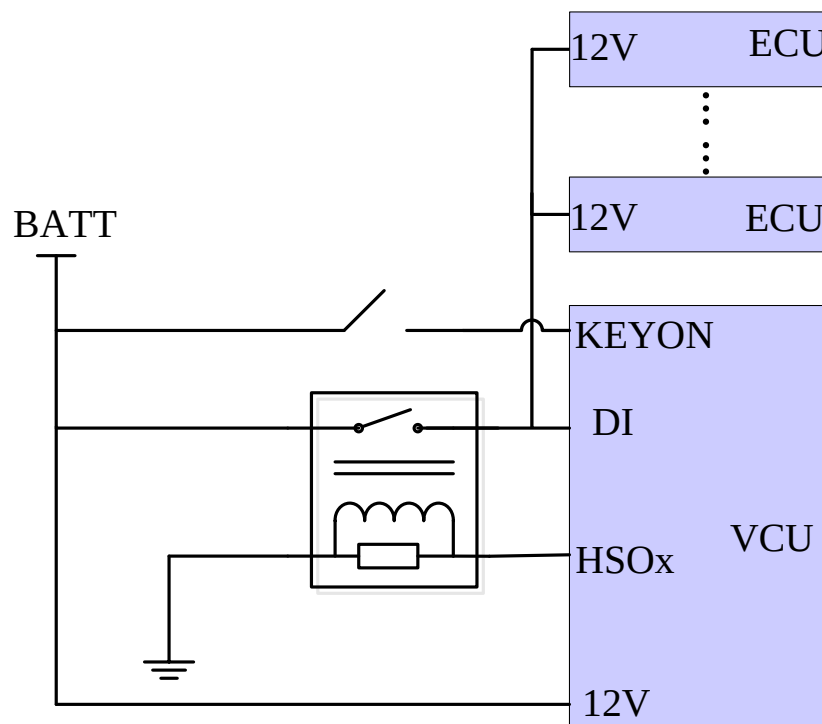
Specific implementation of software: If the external logic level is high, the level of Power Delay is controlled by the internal to high, while the external logic input is low, it will delay for a period of time to turn the level of Power Delay to low.



5.1.2 External relay control

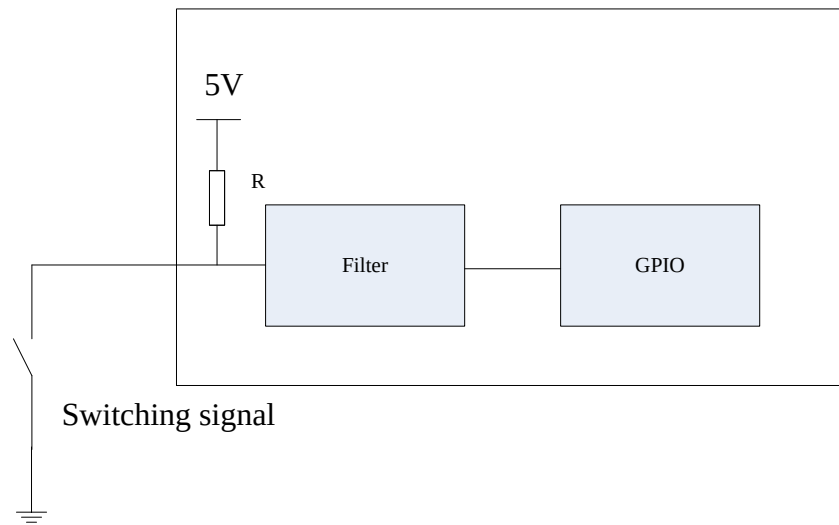
When the power-down delay is controlled by an external relay, the VCU can also control the power-down of other ECUs.

Specific implementation: Firstly, keep Power Delay in low level, if KEYON is in high level, the connect of high-side HSOx is controlled by the VCU, if KEYON turn to low level, it will delay for a period of time to disconnect HSOx. The delayed time is calibrated by the software.

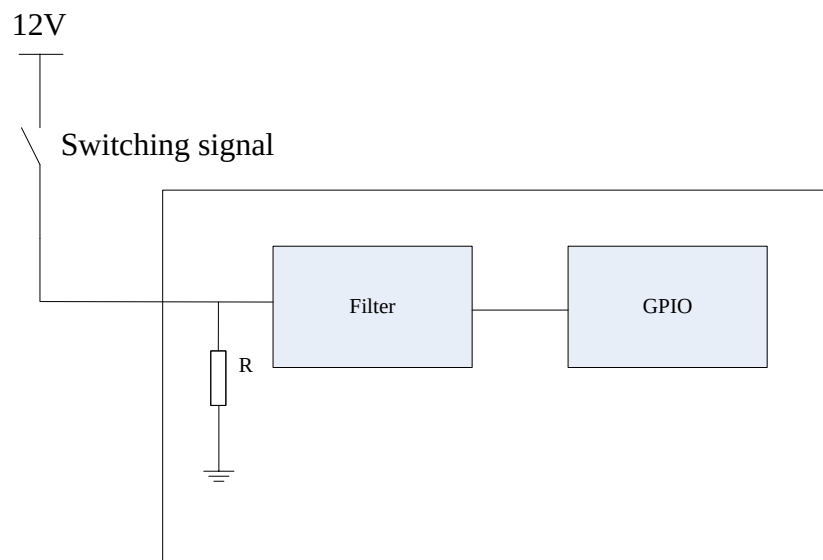


5.2 Switch inputs

The digital input module has 12 channels. DI01-DI04,DI07,DI09,DI11 is by default valid for low level input,and DI05,DI06,DI08,DI10,DI12 is by default valid for high level input .



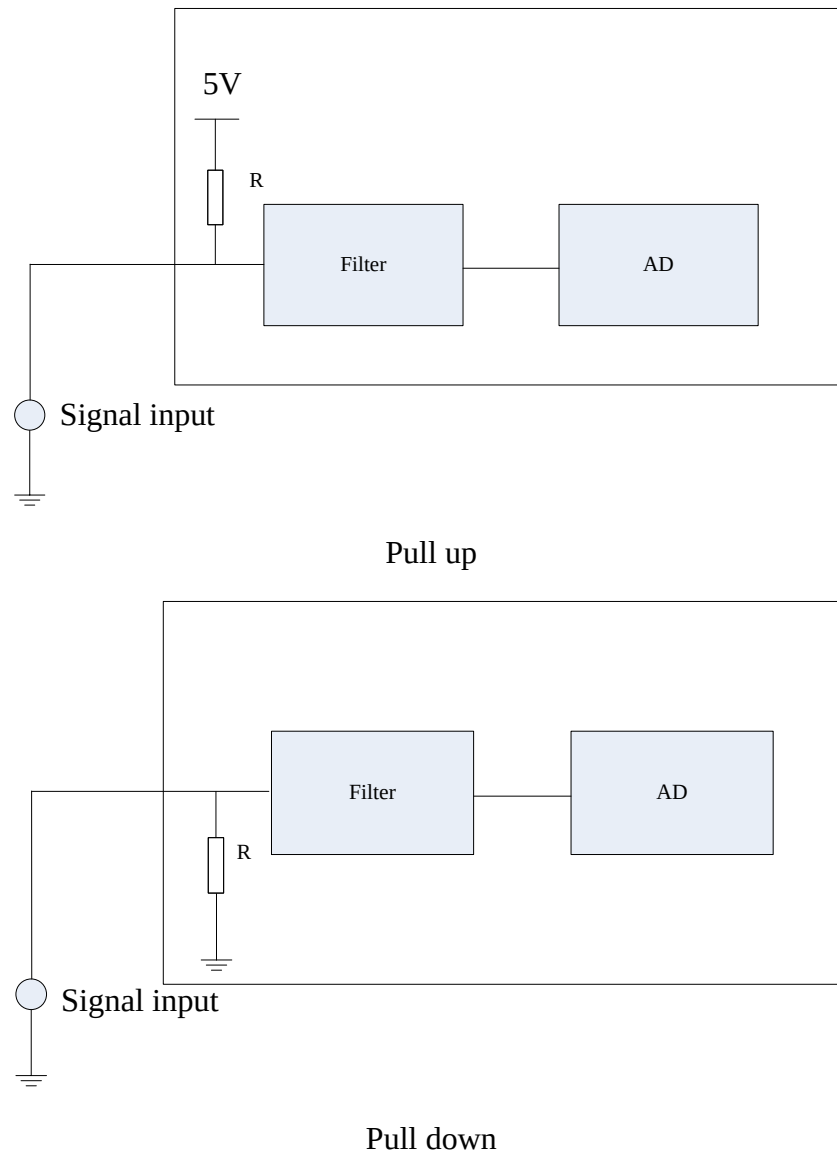
Low level input valid



High level input valid

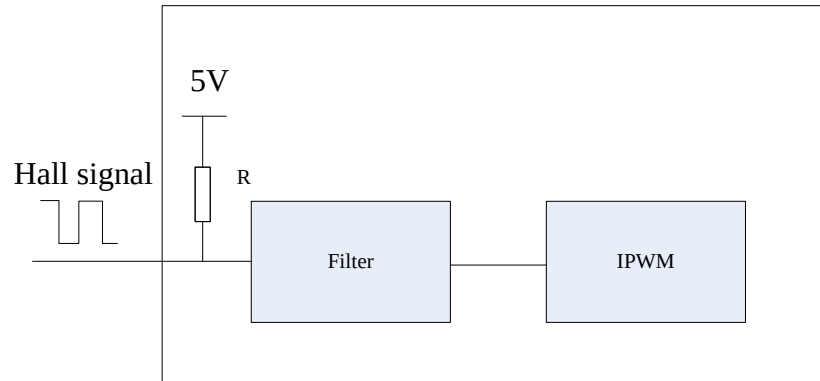
5.3 Analog inputs

The analog input module has 23 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.

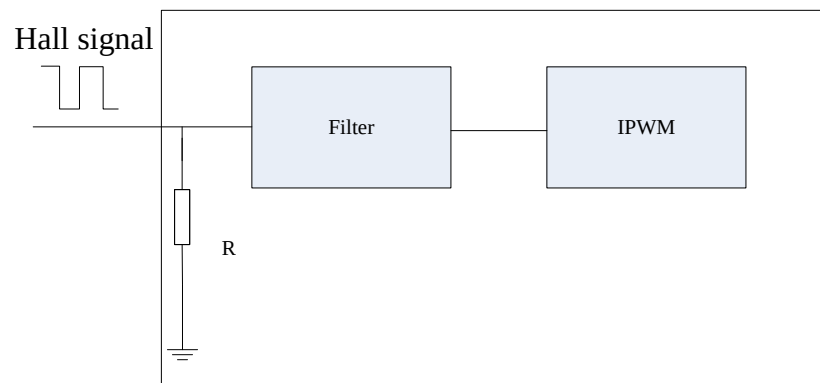


5.4 Hall signal input

The hall signal input module contains 6 Hall-type speed sensor measurement channels, for 6 high level active or low level active switching type Hall signal. The default configuration is low level. The user doesn't 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

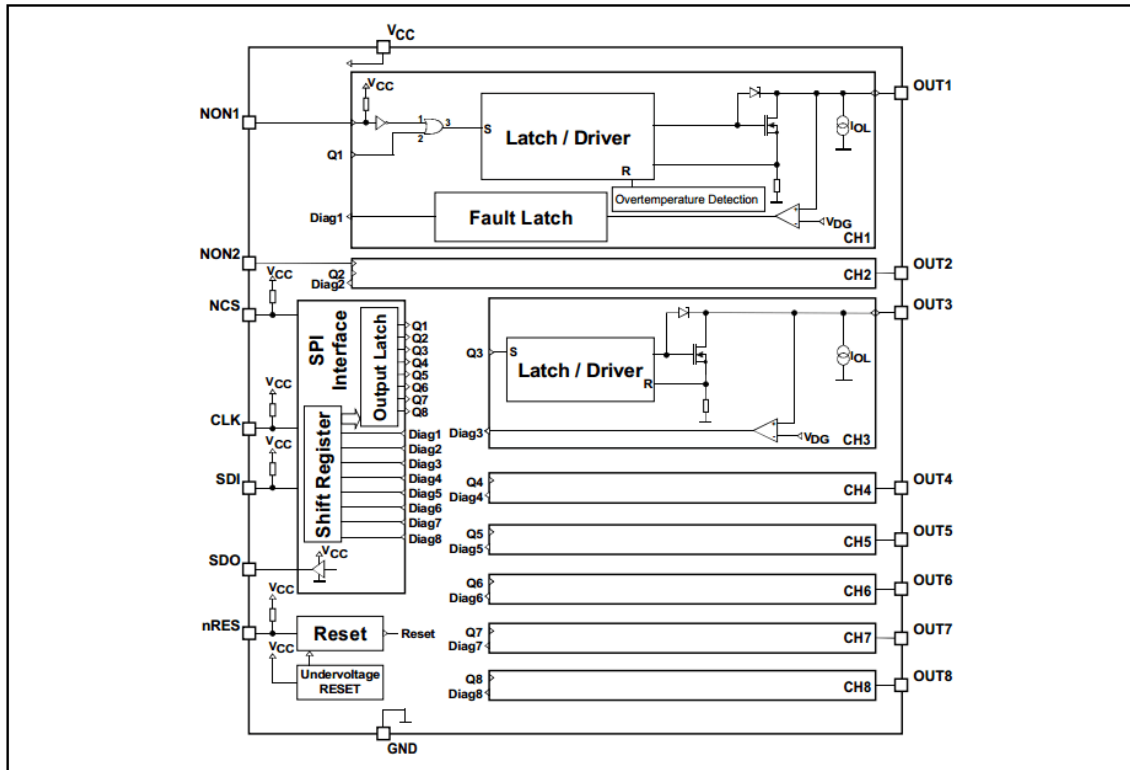


High level active hall input

5.5 Low-side switch

VCU provides 18 Low side switching channels with over-current protection, over-temperature protection and over-voltage protection. 16 channels have 250mA drive current capability. They can detect the load open / short circuit and other failures. 2 channels have 7A drive current capability. They can't detect the load state. And LSO03, LSO05 support PWM output, and you can run pumps and so on.

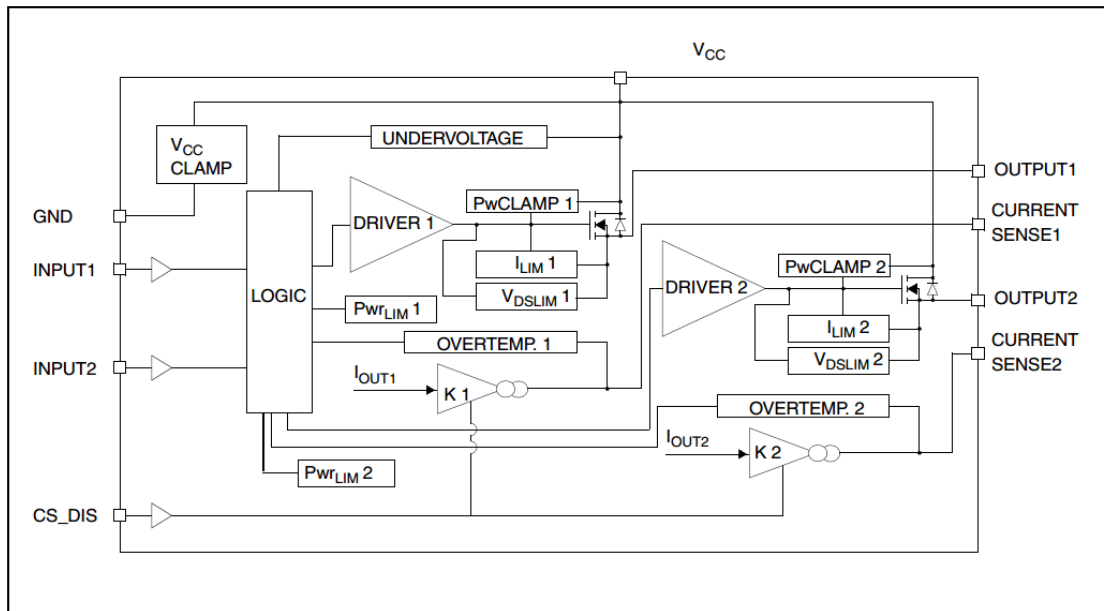
If the pin outputs a high level signal, the corresponding low side switch is turned on; If the pin outputs a low level signal, the corresponding low side switch is turned off. LSO03, LSO05 can be configured to PWM control modes.



5.6 High-side switch

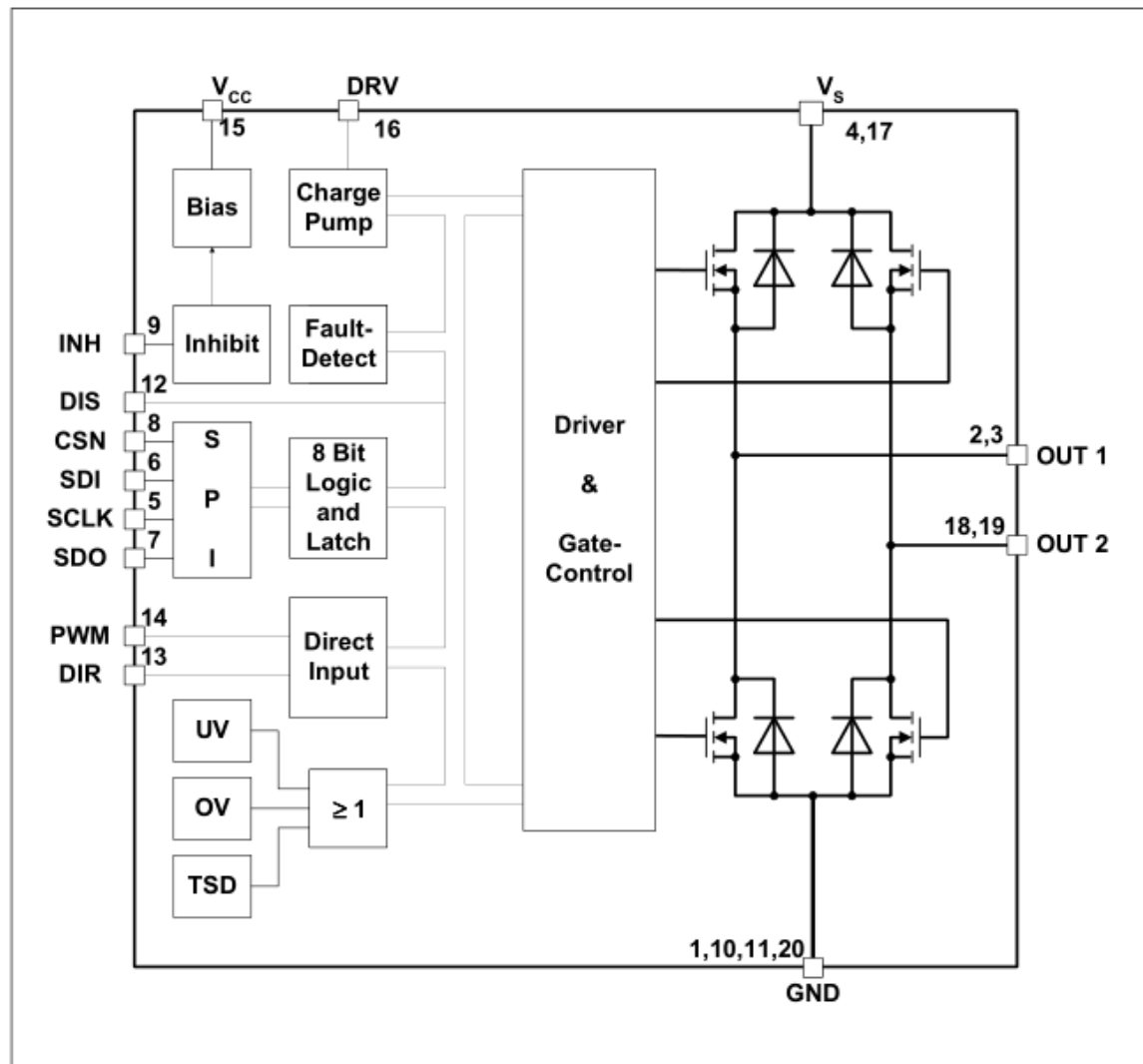
High side switch module provides 9 high side switch channels with short circuit protection, over-temperature protection and over-voltage protection, the maximum current is 7A.

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. HSO02, HSO03, HSO04 can be configured to PWM control modes.



5.7 H-bridge driver

HCU has a built-in H-bridge. It has two outputs, and the maximum current support is 7A, with current limiting function. It can be configured to switch mode, or PWM mode.



5.8 Communication module

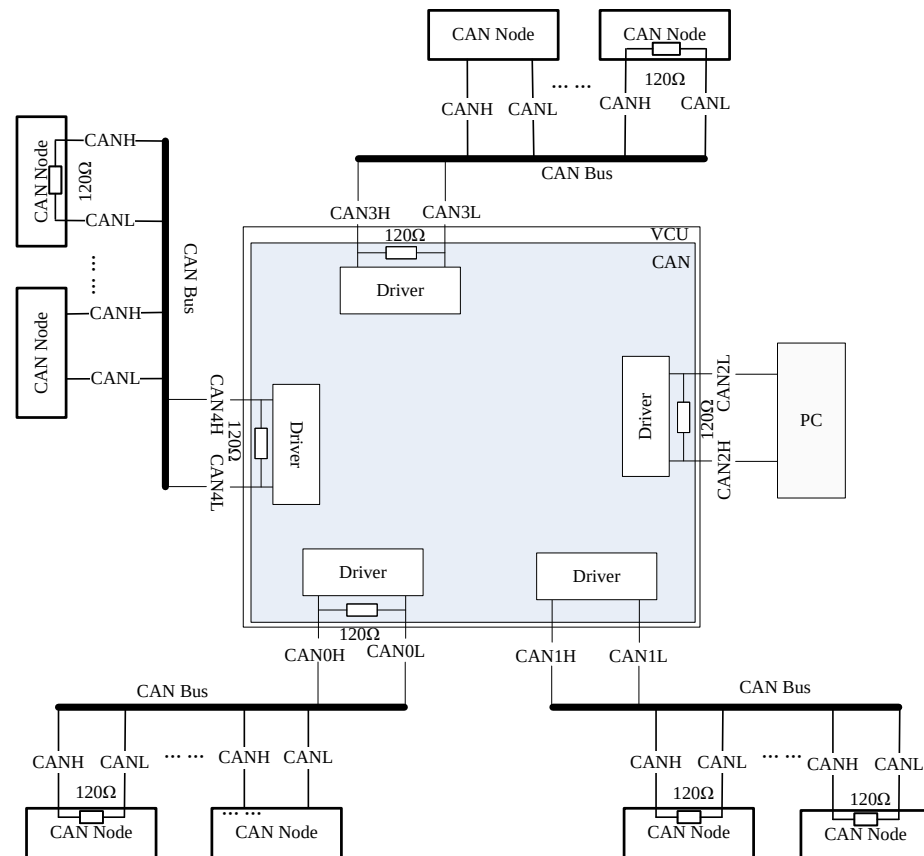
5.8.1 Basic introduction

CAN communication module provides 5 CAN channels, as we called them CAN0, CAN1, CAN2, CAN3, CAN4; and all of them are CAN2.0B high speed bus. CAN0, CAN2, CAN3, CAN4 have a default terminal resistance, CAN1 does not. CAN0 support CAN wakeup function, VCU can be waked up by CAN0.

CAN0, CAN1, CAN3 and CAN4 are four public CAN channels opened to the users. Generally used for vehicle network protocols. The default CAN configuration is

compatible with J1939, and the default baud rate is 250K and the CAN IDs are default the extended frame. All these defaults can be configured by the users. The CAN protocols can be J1979 or ISO15765 compatible, and the baud rate can be 500k or 1M; and the CAN IDs can be standard frames.

CAN2 is for calibration purpose, default for the CCP protocol, and it's used for updating the controller program, as well as calibration and measurement.



5.8.2 CAN architecture introduction

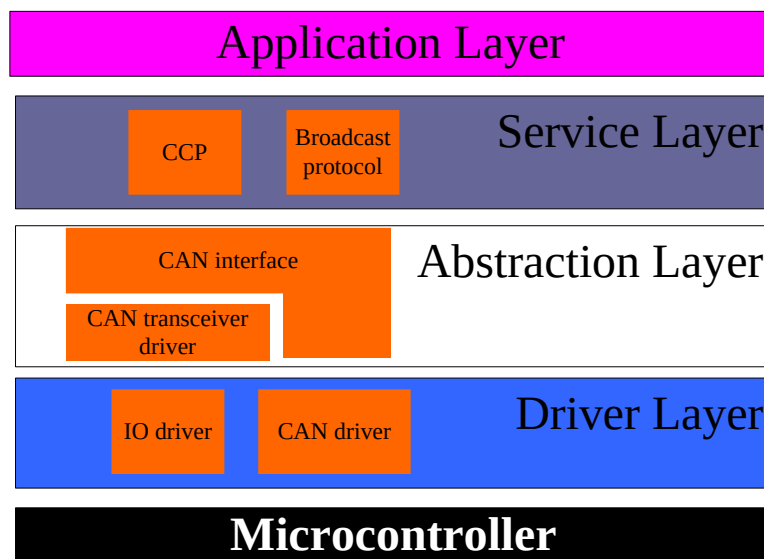
In order to support the application layer protocol, CAN communication module is set to some layers. Below are the details:

(1) Drive layer: the data link layer of communication model, include the IO drives and CAN drive of the microcontroller.

(2) Abstraction layer: the network layer of communication model. It needs to choose the CAN corresponding IO, provide CAN initialization, CAN transmitter and CAN receiver interface for the service layer.

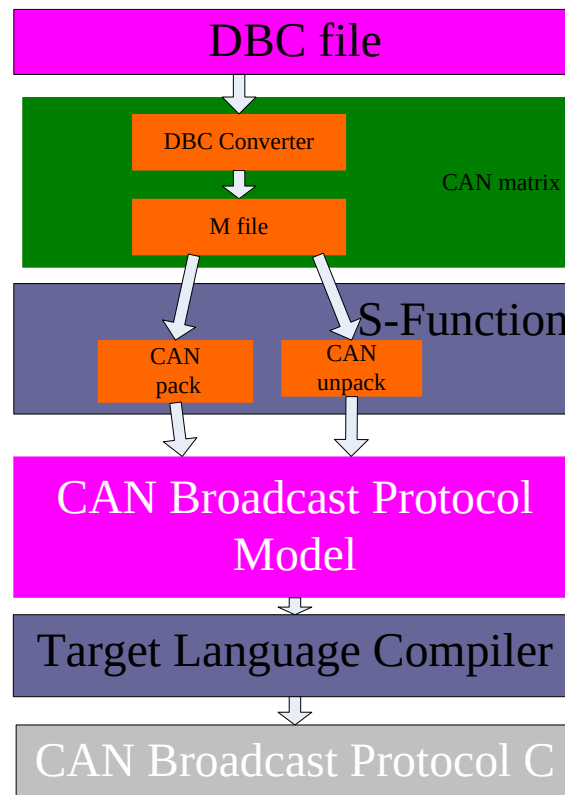
(3) Service layer: the interactive layer of communication model. The implementation of this layer is based on the interface function provided by the abstraction layer, with the Simulink model and s-function to achieve.

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



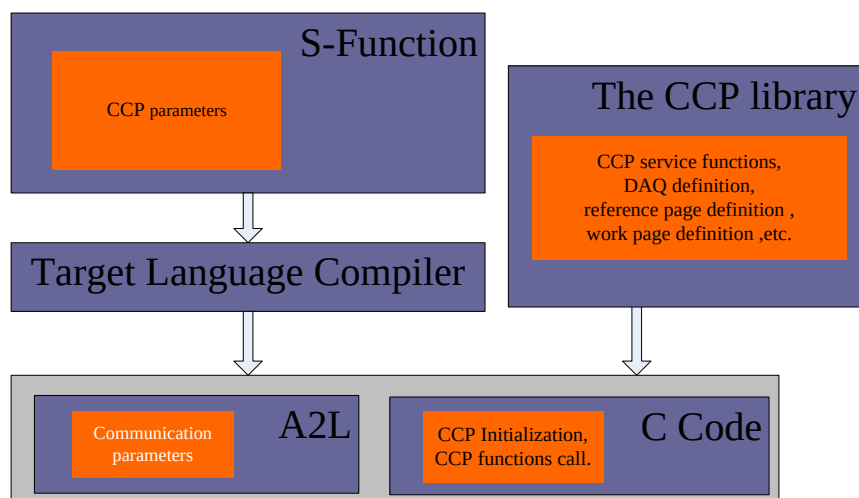
5.8.3 CAN protocol implementation

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 the below:



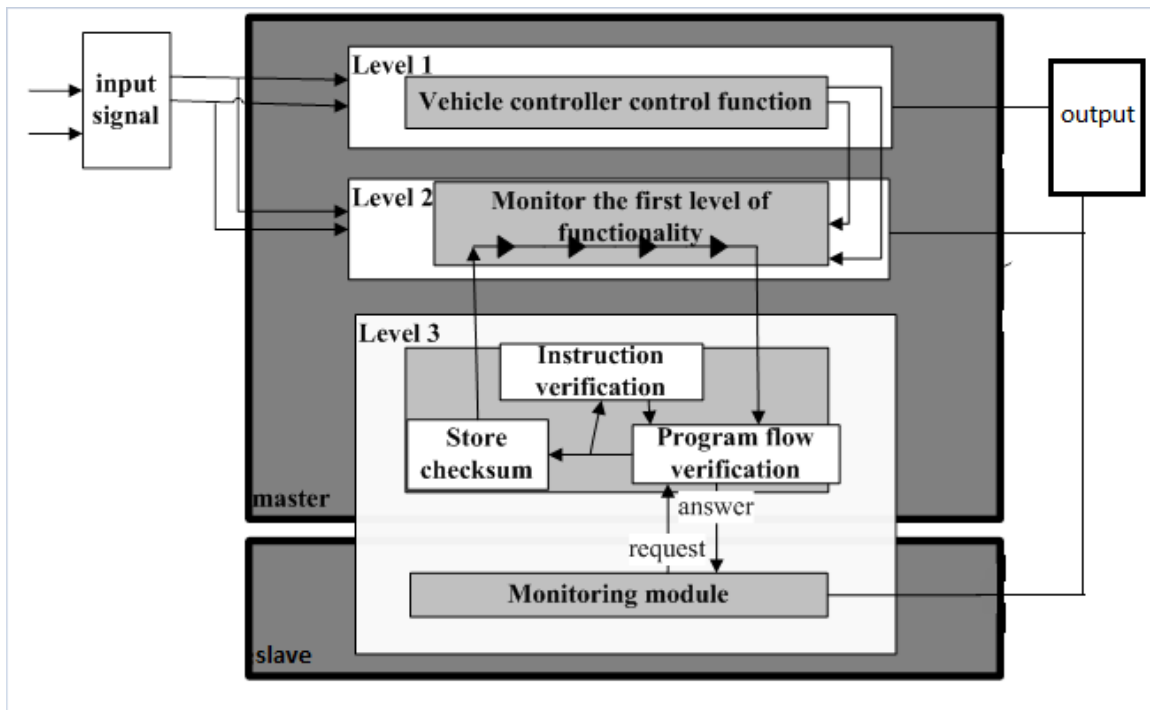
5.8.4 CCP protocol implementation

CCP service function, DAQ definition and storage page configuration 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.



5.9 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 MPC5606B, the slave chip is a 8-bit MC9S08 automotive chip.



Three-level safety monitoring architecture

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

Level 2: this is to monitor the Level 1 by a redundancy design, and it is independent to the Level 1. If there is discrepancy between Level 2 and the 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.

5.10 Controller hardware diagnosis

5.10.1 Chip-level diagnosis

- a) Support Flash and Ram diagnostics of the master chip
- b) Support kernel self-test diagnostics of the master chip
- c) Support diagnosis of the slave chip

5.10.2 Low-side switch diagnosis

LSO01-LSO04 and LSO7-LSO18 uses an integrated chip-driven, low-side drive LSO05, LSO06 uses a circuit driver.

5.10.3 High-side switch diagnosis

The fault diagnosis of high side drive is through the feedback voltage, as well as the feedback current into a voltage to determine the status of the channel. The high sides HSO01 - HSO06 diagnosis through the feedback voltage, HSO07 and HSO08 through the feedback current.

Chapter 6 Software Compatibility

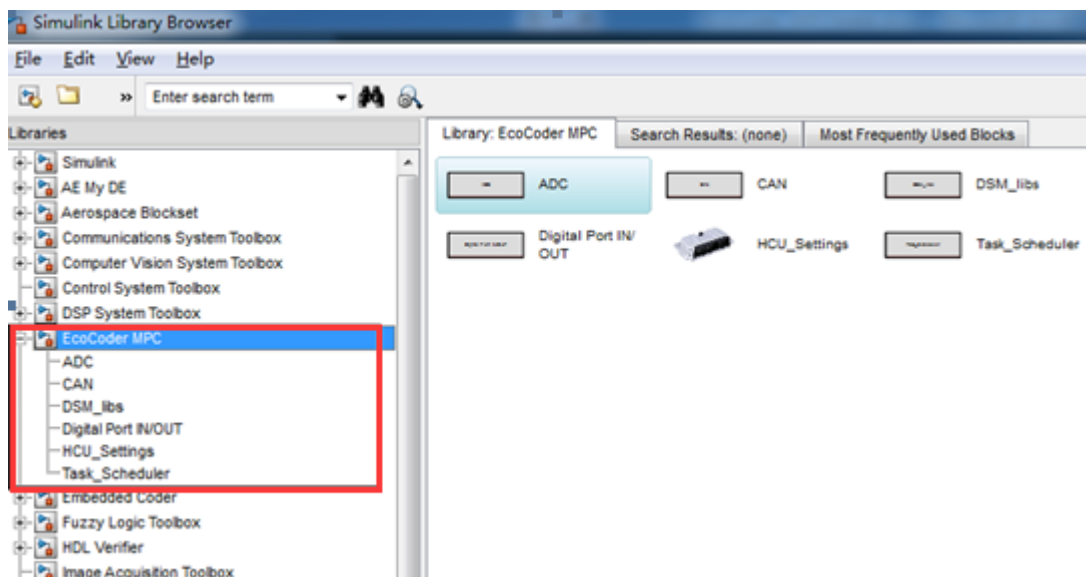
- Matlab/Simulink based software development environment
- Model based design
- Enhanced Auto code generation – EcoCoder
 - Refer to “EcoCoder Manual”
- Hardware encapsulation and abstraction
- One click compile and make process
- CCP/XCP protocols
- Powerful calibration tool – EcoCAL
 - Refer to “EcoCAL manual”
- Commercial compiler – Code Warrior
- Compatibility with INCA, CANape calibration software
- CAN bus based boot loader – Flash GUI tool

6.1 Production code generation - EcoCoder

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

It links the Simulink's models directly to the target, and it gives the user the capability to generate the production code by "ONE CLICK".

Refer to our "EcoCoder manual" for details.



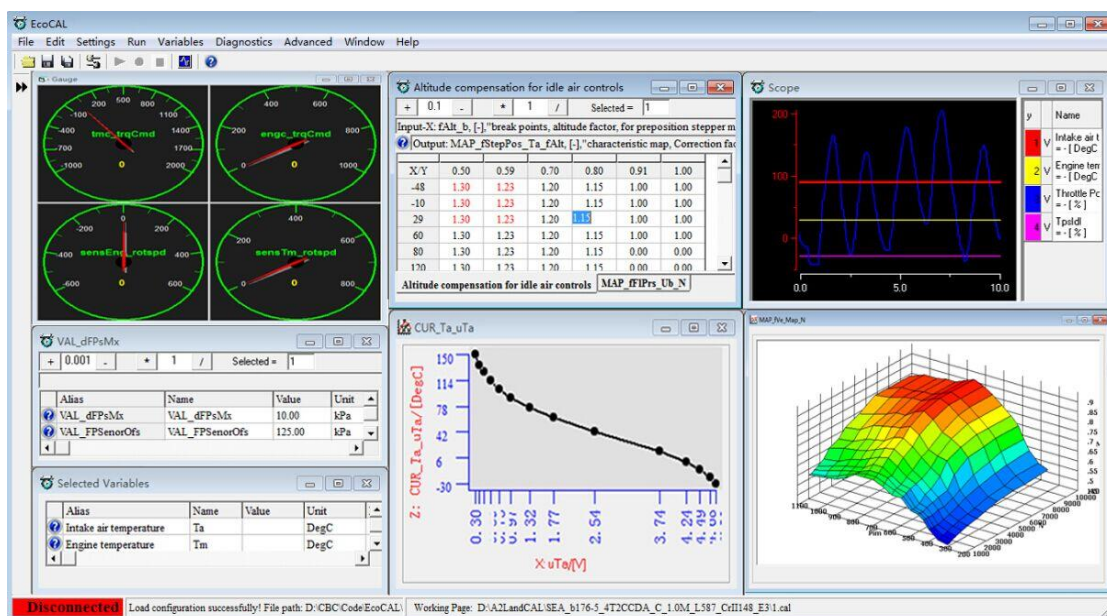
6.2 Powerful calibration software – EcoCAL

EcoCAL is a professional calibration tool, developed by Ecotrons.

It is based on the CCP/XCP protocols, and uses the CAN bus for data communication.

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

Refer to our “EcoCAL manual” for more details.



6.3 Reprogramming tool – Flash GUI

Flash GUI is a simple PC based GUI software tool to reprogram the controller, developed by Ecotrons, using CAN bus for reprogramming, with a typical bootloader pre-programmed in the microprocessor.

