HY-TTC 50/60/90/94/36X/48X/48XS V7

User Manual

Original Instructions

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Approval

Name	Function	Signature

Revision Chart

A revision is a new edition of the document and affects all sections of this document.

Version	Date	Responsible Person	Modification
0.2	27.10.2008	WDI	Initial Creation
0.3	27.10.2008	CSE	Modifications after review
1.0	27.03.2009	WDI	Alternate pin functions specified
1.1	10.09.2009	WDI	Higher load current limit for PWM outputs in static use
2.0	18.12.2009	WDI	Power supply pins description Extended frequency ratings for timer inputs Update for V3: same thresholds for PWM outputs used as input as for standard digital and timer inputs
2.1	25.5.2010	WDI	Power supply pins description Enhanced description of advanced power supply, that enables CPU operation during cranking, used in all variants Application details for resistive sensors added
2.2	1.7.2010	WDI	Typos and formatting corrected
2.3	1.9.2011	WDI	PWM power stage minimum on time changed from 250 to 100us, explanation of proper choice of PWM frequency to prevent static friction added. Abbreviations list added HY-TTC 94 pinning and specification added
2.4	28.9.2011	JOH	Updated numbering of content table
2.5	02.4.2012	HAB	Updated Mini Module and Analog Inputs pin numbers (Mini Module section). Updated product names.
2.6	06.04.2012	JOH	Updated EEPROM size

			HY-TTC 94 CAN2/3 without CAN termination
2.7	11.04.2012	WDI	Load diagnostic function of power stages
2.8	28.08.2012	WDI	List of variants updated, maximum internal supply current dependent of application SW, fast current measurement filter specified
2.9	15.10.2012	FWI	Note for max time for peak none-destructive supply clamping voltage/current added. Chapter 4.17.3 – Footnote added. Max. battery current changed.
2.10	24.10.2012	BAU	Adaption of foot notes for characteristics of idle current consumption
2.11	29.10.2012	FWI	In Chapters 4.13.5, 4.13.6, 4.14.5 and Figures 23, 24, 25, 28 Pull-Up-Resistor (Rpu) added. TTC 36X/48X added to title page. Connector layout and pinning table added/adapted for TTC 36X/48X variants.
2.12	30.10.2012	FWI	Connector Pin 101 for voltage monitoring added. Scaling factor, max. voltage measurement and note1 for voltage monitoring adapted. Paragraph “Wiring hints” adapted.
2.13	06.11.2012	FWI	Chapter 4.18.3 added.
2.14	07.12.2012	JSL	Chapters 4.18.3.2.1, 4.18.3.3.1, 4.18.3.3.2 added. Product Name in Header updated, Fig. 17&18 adapted, Fig. 22 and calculation example added. Rpd values in Tables 4.11.4 & 4.11.5 changed. Chapters 1.1, 1.2, 1.4, 4.9, 4.15 – 4.18 updated according to 36X/48X; Figure 2 added (Connector front view HY-TTC 50); Chapter 2.1 updated according to HY-TTC 50; Table of features of families in chapter 1.5 added. Mistake in fig. 15&16 unremedied. Chapter 4.11.5: additional information to Note 6&7 added.
2.15	11.12.2012	JSL	Fig. 22 adapted, Note 6 in chapter 4.11.5 adapted and calculation example deleted; Numbering updated. Duplicated rows in table in chapter 4.11.5 deleted. Additional information according to product

			family in chapters 1.1, 1.2, 1.4, 4.9, 4.18; Table in chapter 1.5 adapted.
2.16	13.12.2012		Title changed for HW-Version 6; Chapter 1.5updated. Chapter 4.11 adapted according to TTC-36X
2.17	21.01.2013	BAU	Issue51428: Add Chapter 1.2 “Instructions for safe operation” and references to documents describing mounting instructions and connectors/wires
2.18	24.01.2013	BAU	Issue51532: Review of user manual
2.19	28.01.2013	BAU	Issue51428: Changes after review of H&R Analysis
2.20	01.02.2013	BAU	Issue51532:Changes after Review Issue51428:Changes after Review
2.21	05.09.2013	FWI	Added HY-TTC 48XS
2.22	08.04.2014	RHR	Some minor corrections concerning HY-TTC 48XS, Added Disposal Note More detailed pin description added to supply pins in Connector Front View RAM size corrected (includes DPRAM, DSRAM, PSRAM but no SBRAM) Added EC declaration of conformity
2.23	27.11.2014	FBO	Corrected RAM sizes
2.24	07.01.2015	FBO	Removed 2289H CPU Type from overview
2.25	04.02.2015	FBO	issue54939: Changed selectable PWM frequency of high side outputs
2.26	17.02.2015	LMO	Issue67900: mounting and housing information added (both V1 and V2)
2.27	23.03.2015	FBO	Issue74600: 5V analog input, absolute measurement added Issue67900: Updated image of mounting position
2.28	31.03.2015	FBO	Issue73931: Corrected CAN Maximum ratings Corrected HY-TTC 94 safety cert. information

Contents

1 General Description

1.1 Introduction

HY-TTC 50 is a family of electronic control units for sensor/actuator management. HY-TTC 50, HY-TTC 60, HY-TTC 90 and HY-TTC 94 are programmable units (C or CoDeSys); HY-TTC 36X, HY-TTC 48X, and HY-TTC 48XS are CANopen Slave devices. Many configurable I/Os allow its use with different sensor and actuator types. The control unit is part of a complete and compatible product family and designed specifically for vehicles and machines that function in rough environments and at extreme operating temperatures. Its robust die-cast aluminum housing protects against electromagnetic disturbance and mechanical stress.
An 80 MHz Infineon XC2287 integrated microprocessor provides the necessary processing power.

The HY-TTC 50 family consists of the following variants:

- HY-TTC 94: designed to fulfill safety requirements according to ISO 13849 PL d
- HY-TTC 90: designed to fulfill safety requirements according to IEC 61508 SIL2 and ISO 13849 PL d
- HY-TTC 60
- HY-TTC 50
- HY-TTC 36X
- HY-TTC 48X
- HY-TTC 48XS: designed to fulfill safety requirements according to ISO 13849 PL d

This document applies to all available variants HY-TTC 50, HY-TTC 60, HY-TTC 90, HY-TTC 94, HY-TTC 36X/48X, and HY-TTC 48XS. Throughout this document, any reference to HY-TTC 50 includes all family member variants HY-TTC 50, HY-TTC 60, HY-TTC 90, HY-TTC 94, HY-TTC 36X/48X, and HY-TTC 48XS. Wherever specifications are not applicable for all variants, the differences are pointed out within this document.

1.2 Instructions for safe operation

1.2.1 General

For safe operation of the ECUs of the HY-TTC 50 family the following rules have to be obeyed:

- Carefully read the instructions and specifications listed in this document as well as cable harness and connectors /1/ before operating the ECU.
- The ECUs of the HY-TTC 50 family have to be operated by using the type of connector specified in /1/. It is not allowed to use any other connector or cable harness than the specified one.
- It is not allowed to use the HY-TTC 50 ECUs in an environment that violates the specified operational range.
- The HY-TTC 50 family of ECUs have to be operated by skilled personnel only

- When operating the HY-TTC 50 ECUs in an environment close to humans, one has to consider that these ECUs contain power electronics and therefore the housing can have high temperatures.
- It is not allowed to open sealed ECUs
- It is not allowed to operate unsealed ECUs outside the laboratory
- It is not allowed to operate prototype ECUs in a production environment (no matter if they are sealed or unsealed)
- Only skilled and trained personnel is allowed to operate prototype ECUs (no matter if they are sealed or unsealed)
- The HY-TTC 50 does not require maintenance activity by the user/system integrator. The only maintenance activity allowed for the user is exchanging the ECU (for example after it has reached its specified lifetime).

1.2.2 Checks to be done before commissioning the ECU

- Check the supply voltage before connecting the ECU
- Check the ECU connector and the cable harness to be free of defects
- Check the correct dimensioning of the wires in the cable harness
- Be sure that the ECU is mounted in way that humans are not directly exposed to it and physical contact is avoided.
- Be sure to choose a mounting location for the ECU that eliminates the possibility of ambient temperatures greater than the maximum ambient temperature allowed for the ECU.
- The power supply of the ECU has to be secured with a fuse. The threshold value of the fuse has to match the maximum specified input current of the ECU and the cable harness.

1.3 Interfaces and I/Os

All HY-TTC 50 inputs and outputs are protected against electrical surges and short circuits. In addition, internal safety measures allow the detection of open load, overload and short circuit conditions at the outputs.
Proportional hydraulic components can be connected directly to the current controlled PWM outputs.
The HY-TTC 50 family is designed to support various analog and digital sensor types. Many SW-configurable input options can be selected to adapt to different sensor types.
The widely used group of individually configurable analog inputs, well known from HY-TTC 200, is also supported by HY-TTC 50. Additionally a group of analog inputs with voltage range from 0..5V to 0..32V is provided that can be set to different voltage ranges by software for achieving best analog accuracy and resolution.
The interfaces CAN, RS-232 and LIN are available for serial communication.

Note: This feature description, with exception of protected inputs and outputs, does not apply to all variants. A detailed overview of the features can be found in chapter 2.

1.4 Safety and Certification

The variant HY-TTC 90 were designed to comply with the IEC 61508 and ISO13849 international standards. This ECU fulfill SIL 2 (Safety Integrity Level) and PL d requirements respectively.
The variants HY-TTC 94 and HY-TTC 48XS were designed according to ISO13849 international standard and fulfills PL d requirements.

The requirements in the Safety Manual shall be followed if HY-TTC 90, HY-TTC 94 or HY-TTC 48XS are used in safety-critical applications.

1.5 Advanced Programming Possibilities

The unit may be programmed in C or CoDeSys. CoDeSys is one of the most common IEC 61131-3 programming systems that runs under Microsoft Windows®. Several editors are supported, including the Instruction List Editor, the Sequential Function Chart Editor and the Function Block Diagram Editor. CoDeSys produces native machine code for the main processor of HY-TTC 50.

Note: This feature description does not apply to HY-TTC 36X/48X/48XS because they are CANopen Slave devices.

1.6 Features

A detailed overview of all features are given in the table below.

System CPU

- XC2287 (XE167 family), 80MHz, 768KB internal Flash, 82kB int. + 512kB ext. RAM;
  64 kBit EEPROM for devices without safety functions
- XC2287M (XE167 family), 80MHz, 832KB internal Flash, 50kB int. + 512kB ext. RAM;
  64 kBit EEPROM for devices which offer safety functions
- Watchdog CPU - 68HC908
- 1 x RS232 (1200-115200Bd), 1 x LIN (1200Bd – 20000Bd)
- Up to 4 x CAN, 125 to 1000 kbit/s

Power supply

- Supply voltage: 9 to 32 V
- CPU operates down to 4V battery supply during cranking
- Load dump protection (max. steady state supply voltage 35V)
- Low current consumption: 0.15 A at 9 V
- 1 x (8.5 or 10 or 15V / 50mA) sensor supply, voltage selected by software
- 2 x (5V / 50mA) sensor supply
- Board temperature, sensor supply and battery monitoring

Inputs

- 8 x analog in 0 to 5 V or 0 to 20 mA or input for resistive sensors, 10 bit resolution, configured by software (individual setting per input)
- 8 x analog / digital in range selectable, 10 bit resolution,
  range settings 0 to 5V, 0 to 10V, 0 to 15V, 0 to 20V, 0 to 25V, 0 to 30V and 0 to 32V with full 10 bit resolution, voltage selectable by software in groups of 4 inputs
- 4 x digital in (4 counter 10 to 10.000 Hz) supporting sensors with different output stages (push pull, open collector, active high or low) as well as 7/14mA current loop (ABS-type) sensors
- 8 x digital in

Outputs

- 8 x digital out 2.0 A, PWM, short-circuit and open load detection
- current control loop for 4 PWM outputs
- internal safety switch for all 2A PWM outputs
- 8 x digital out 4 A, short-circuit and open load detection

Control Unit / Feature	HY-TTC 50	HY-TTC 60	HY-TTC 90	HY-TTC 94	HY-TTC 36X	HY-TTC 48X	HY-TTC 48XS
External RAM	-	Yes	Yes	Yes	-	-	Yes
Internal RAM	82kB	82kB	50kB	50kB	82kB	82kB	50kB
Internal Flash	768kB	768kB	832kB	832kB	768kB	768kB	832kB
Watchdog	-	-	Yes	Yes	-	-	Yes
PWM-Outputs	8	8	8	8	4	8	8
Power Outputs	8	8	8	8	8	8	8
Analog Inputs	8	16	16	16	8	16	16
Digital Inputs	8	8	8	8	8	8	8
Digital Timer Input	4	4	4	4	8	4	4
Current Measurement	4	4	4	4	4	4	4
Sensor Supply Output	3	3	3	3	3	3	3
Mini-Modul	optional	optional	optional	optional	-	-	-
LIN	1	1	1	1	-	-	-
RS232	1	1	1	1	-	-	-
CAN	2	2	2	4	1	1	1

The Mini-Modul for the HY-TTC 94 is available with restrictions. Details are given in chapter 5.18.

Specifications

- Dimensions: 181 x 174 x 44 mm (with mounted connector)
- Weight: 550 g
- Ambient temperature: -40 °C to +85 °C
- IP67 rated die-cast aluminum housing and 80 pin connector
- Pressure adjusting with water barrier
- Operating altitude: 0 to 4000 m

2 Pin connection

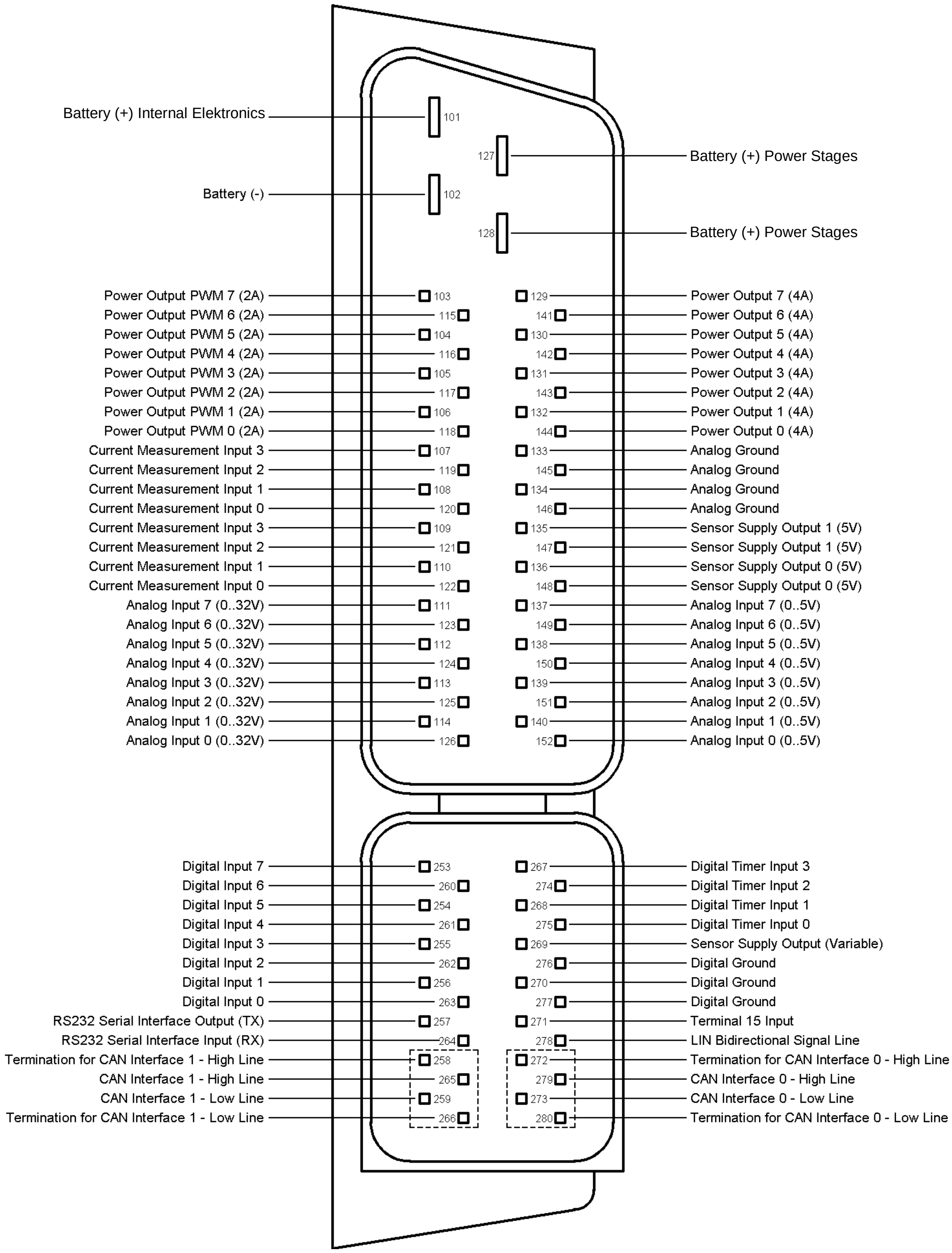


Figure 1: Connector front view HY-TTC 60/90

This pinout is no longer up-to-date.
See Wiring Master List:
https://docs.google.com/spreadsheets/d/1Aw5V6dHQf8hcsgm7JyRWhi5lf4dxvTdplUz4X4UtXvw/edit?usp=sharing

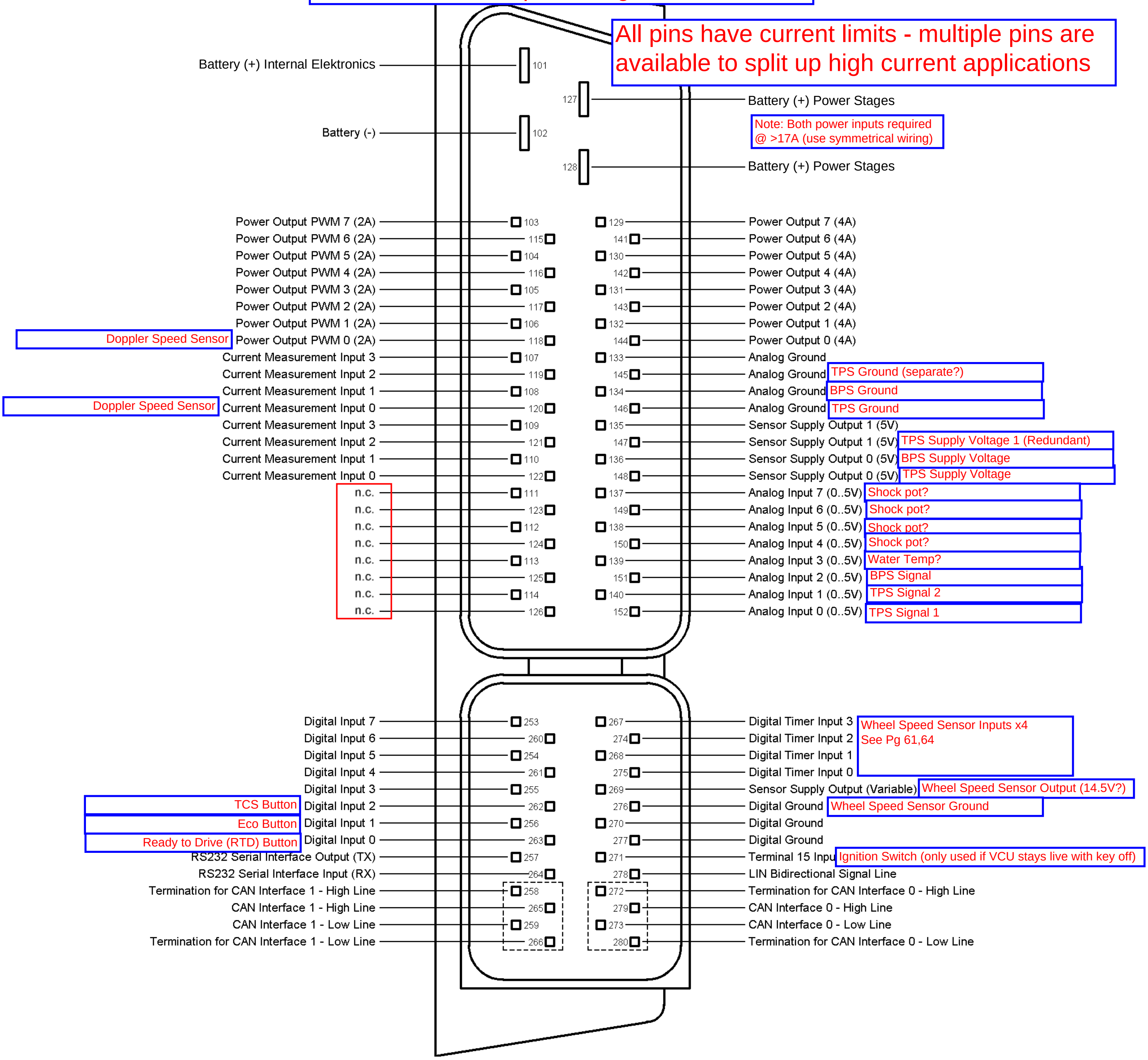


Figure 2: Connector front view HY-TTC 50

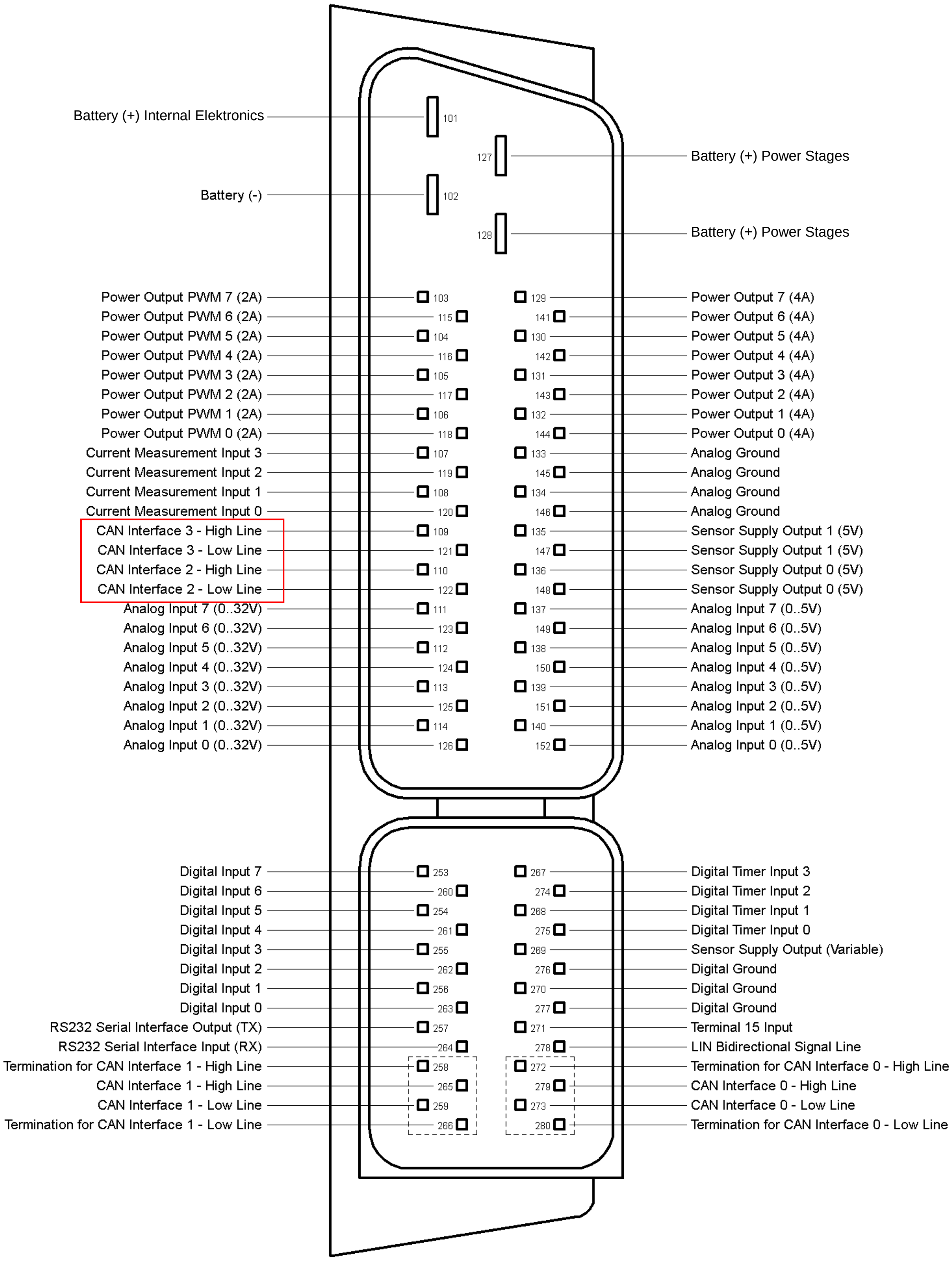


Figure 3: Connector front view HY-TTC 94

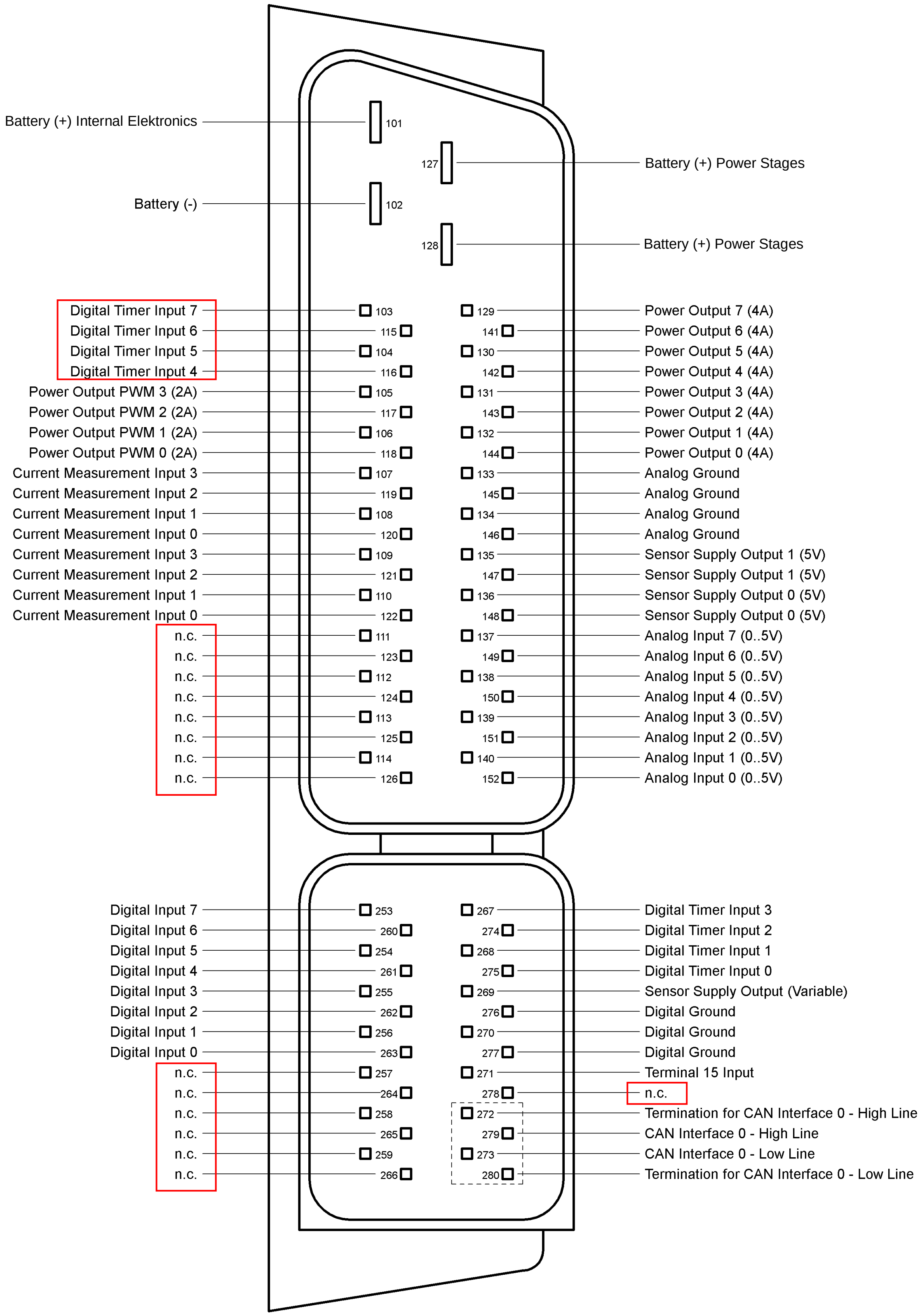


Figure 4: Connector front view HY-TTC 36X

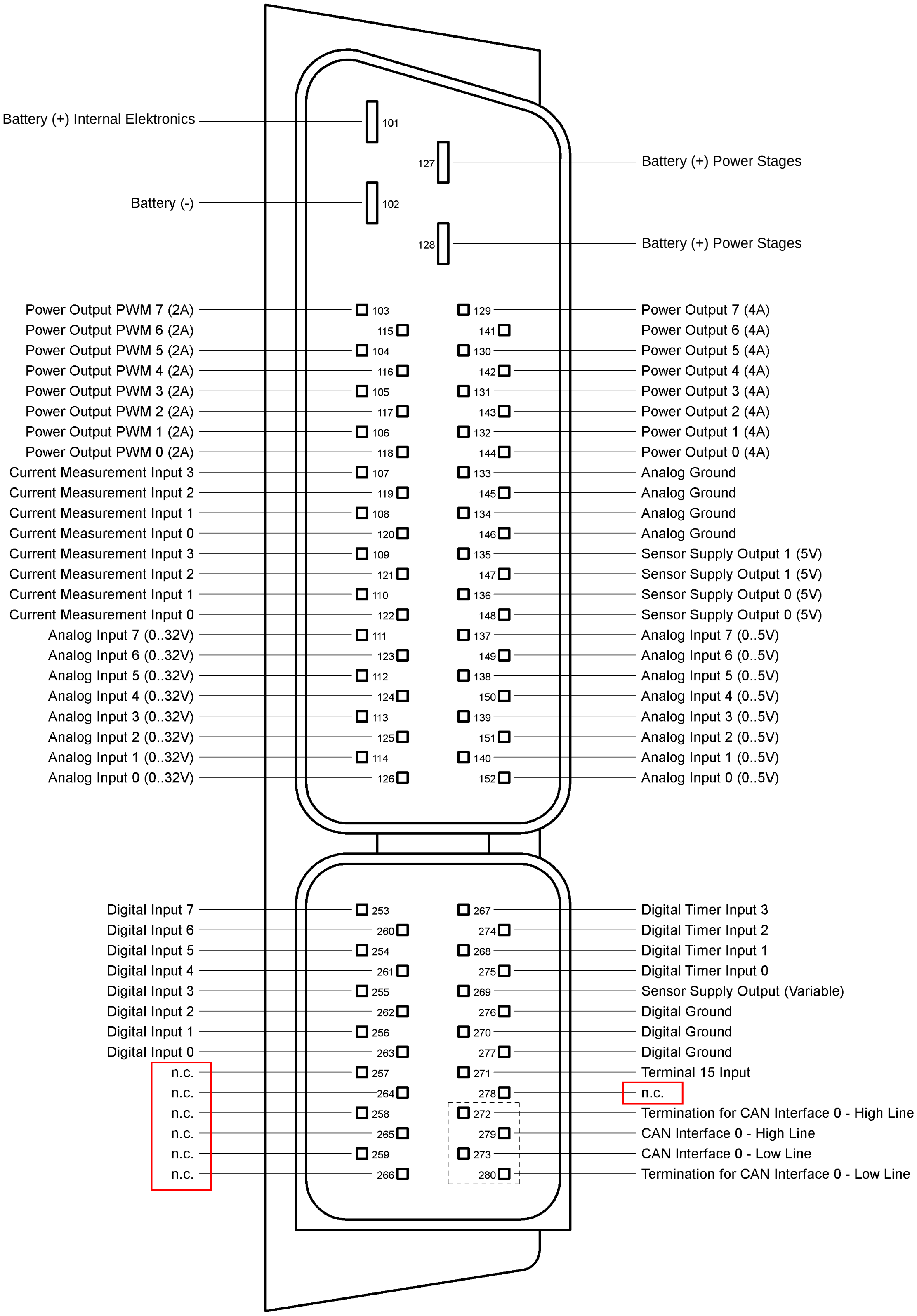


Figure 5: Connector front view HY-TTC 48X/48XS

2.1 Pin connection part 1

Connector Pin Number	Pin description
P101	Battery (+) Supply Input for Internal Electronics
P102	Battery (-) Supply Input
P103	Power Output PWM 7 (2A) (HY-TTC 50/60/90/94/48X/48XS)
	Digital Timer Input 7 (HY-TTC 36X)
P104	Power Output PWM 5 (2A) (HY-TTC 50/60/90/94/48X/48XS)
	Digital Timer Input 5 (HY-TTC 36X)
P105	Power Output PWM 3 (2A)
P106	Power Output PWM 1 (2A)
P107	Current Measurement Input 3
P108	Current Measurement Input 1
P109	Current Measurement Input 3 (HY-TTC 50/60/90/36X/48X/48XS)
	CAN Interface 3 – High Line (HY-TTC 94)
P110	Current Measurement Input 1 (HY-TTC 50/60/90/36X/48X/48XS)
	CAN Interface 2 – High Line (HY-TTC 94)
P111	Analog Input 7 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P112	Analog Input 5 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P113	Analog Input 3 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P114	Analog Input 1 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P115	Power Output PWM 6 (2A) (HY-TTC 50/60/90/94/48X/48XS)
	Digital Timer Input 6 (HY-TTC 36X)
P116	Power Output PWM 4 (2A) (HY-TTC 50/60/90/94/48X/48XS)
	Digital Timer Input 4 (HY-TTC 36X)
P117	Power Output PWM 2 (2A)
P118	Power Output PWM 0 (2A)
P119	Current Measurement Input 2
P120	Current Measurement Input 0
P121	Current Measurement Input 2 (HY-TTC 50/60/90/36X/48X/48XS)
	CAN Interface 3 – Low Line (HY-TTC 94)
P122	Current Measurement Input 0 (HY-TTC 50/60/90/36X/48X/48XS)
	CAN Interface 2 – Low Line (HY-TTC 94)
P123	Analog Input 6 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P124	Analog Input 4 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P125	Analog Input 2 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)

P126	Analog Input 0 (0..32V) (HY-TTC 60/90/94/48X/48XS)
	Not Connected (HY-TTC 36X/50)
P127	Battery (+) Supply Input for Power Stages
P128	Battery (+) Supply Input for Power Stages
P129	Power Output 7 (4A)
P130	Power Output 5 (4A)
P131	Power Output 3 (4A)
P132	Power Output 1 (4A)
P133	Analog Ground
P134	Analog Ground
P135	Sensor Supply Output 1 (5V)
P136	Sensor Supply Output 0 (5V)
P137	Analog Input 7 (0..5V)
P138	Analog Input 5 (0..5V)
P139	Analog Input 3 (0..5V)
P140	Analog Input 1 (0..5V)
P141	Power Output 6 (4A)
P142	Power Output 4 (4A)
P143	Power Output 2 (4A)
P144	Power Output 0 (4A)
P145	Analog Ground
P146	Analog Ground
P147	Sensor Supply Output 1 (5V)
P148	Sensor Supply Output 0 (5V)
P149	Analog Input 6 (0..5V)
P150	Analog Input 4 (0..5V)
P151	Analog Input 2 (0..5V)
P152	Analog Input 0 (0..5V)

2.2 Pin connection part 2

Connector Pin Number	Pin description
P253	Digital Input 7
P254	Digital Input 5
P255	Digital Input 3
P256	Digital Input 1
P257	RS232 Serial Interface Output (TX) (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P258	Termination for CAN Interface 1 – High Line (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P259	CAN Interface 1 – Low Line (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P260	Digital Input 6
P261	Digital Input 4
P262	Digital Input 2
P263	Digital Input 0
P264	RS232 Serial Interface Input (RX) (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P265	CAN Interface 1 – High Line (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P266	Termination for CAN Interface 1 – Low Line (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P267	Digital Timer Input 3
P268	Digital Timer Input 1
P269	Sensor Supply Output (Variable)
P270	Digital Ground
P271	Terminal 15 Input
P272	Termination for CAN Interface 0 – High Line
P273	CAN Interface 0 – Low Line
P274	Digital Timer Input 2
P275	Digital Timer Input 0
P276	Digital Ground
P277	Digital Ground
P278	LIN Bidirectional Signal Line (HY-TTC 50/60/90/94)
	Not Connected (HY-TTC 36X/48X/48XS)
P279	CAN Interface 0 – High Line
P280	Termination for CAN Interface 0 – Low Line

3 Block Diagram

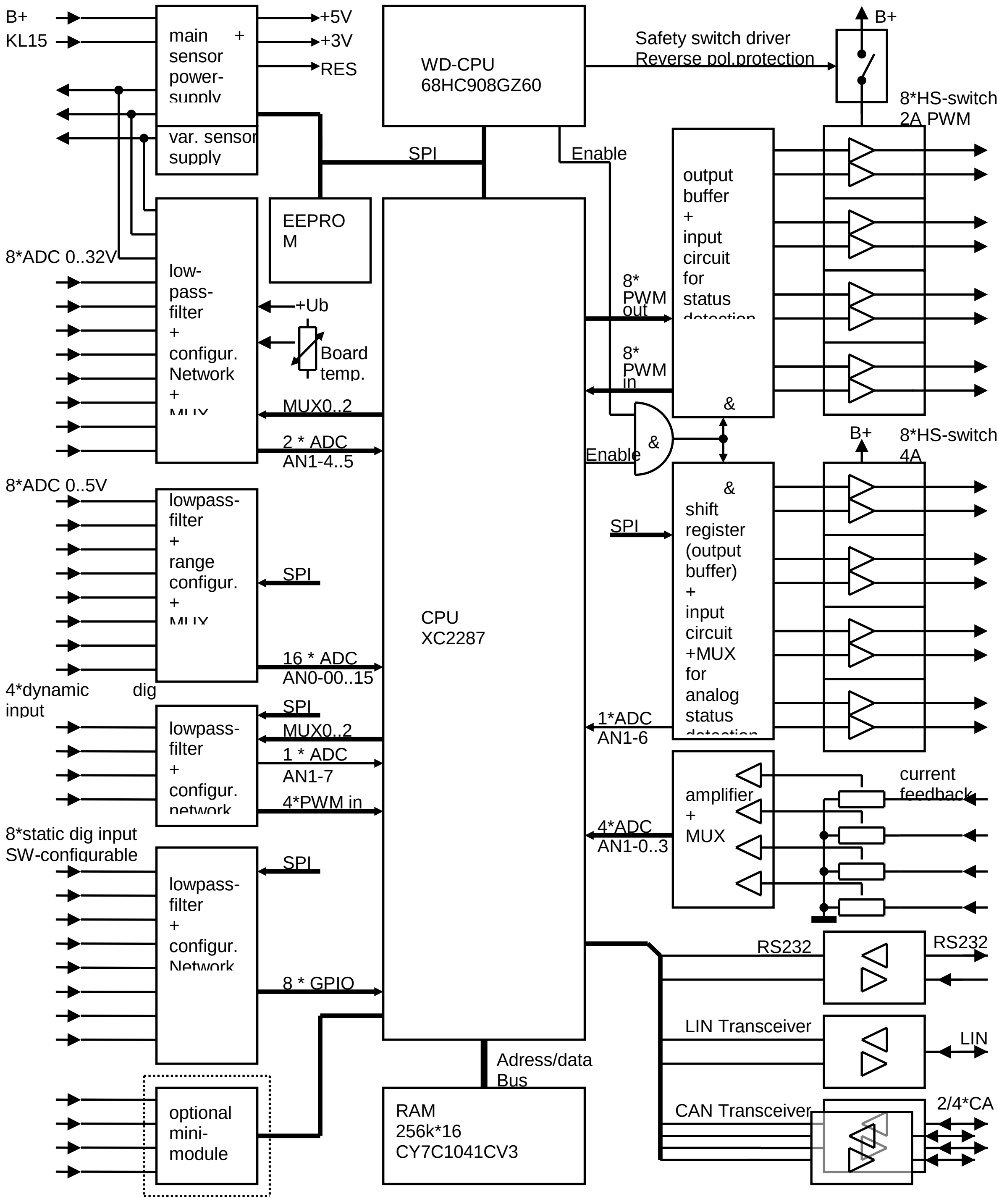


Figure 6: Block diagram

4 Housing and mounting

The housing has been developed in two different versions over the lifetime of the product (denoted as V1 and V2). In this manual both are depicted in the following pages.

4.1 Generic mounting instructions

4.1.1 General advice

It has to be assured that water cannot infiltrate through the wiring harness into the control unit.

4.1.2 Mounting

- Permitted application area: passenger car, off-highway vehicles.
- Permitted mounting position: chassis and engine compartment.
- ECU in mounting position must not bounce.
- Upper limit of surface pressure at specified clamp areas / mounting points: 50 N/mm² for the V2 housing and 10 N/mm² for the V1 housing.
- Upper limit of total clamping force: 400 N.
- ECU should be mounted in such a way that the pressure compensation element and the connector for the wiring harness are not exposed to direct splashing water.
- ECU has to be mounted in such a way that its connector is freestanding in order to allow its female counterpart to be connected without obstructions.

4.1.3 Wiring Harness

- Cable harness needs to be fixed mechanically in the mounting position of the ECU (Distance < 150 mm)
- Cable Harness needs to be fixed in such a way that, in case of an excitation, the wiring harness is in phase with the ECU (e.g. at the fixing point of ECU).

4.1.4 Fitting Position

Permissible fitting axis (g-vector) must be outside cone A and B (see Figure 7).

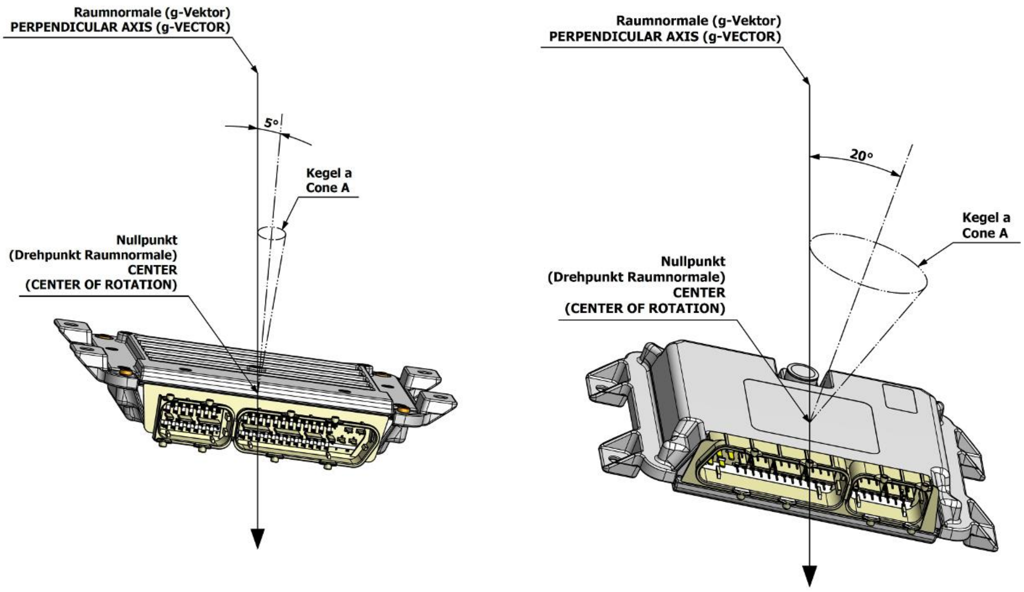


Figure 7 - Fitting position

4.2 Second version housing (V2)

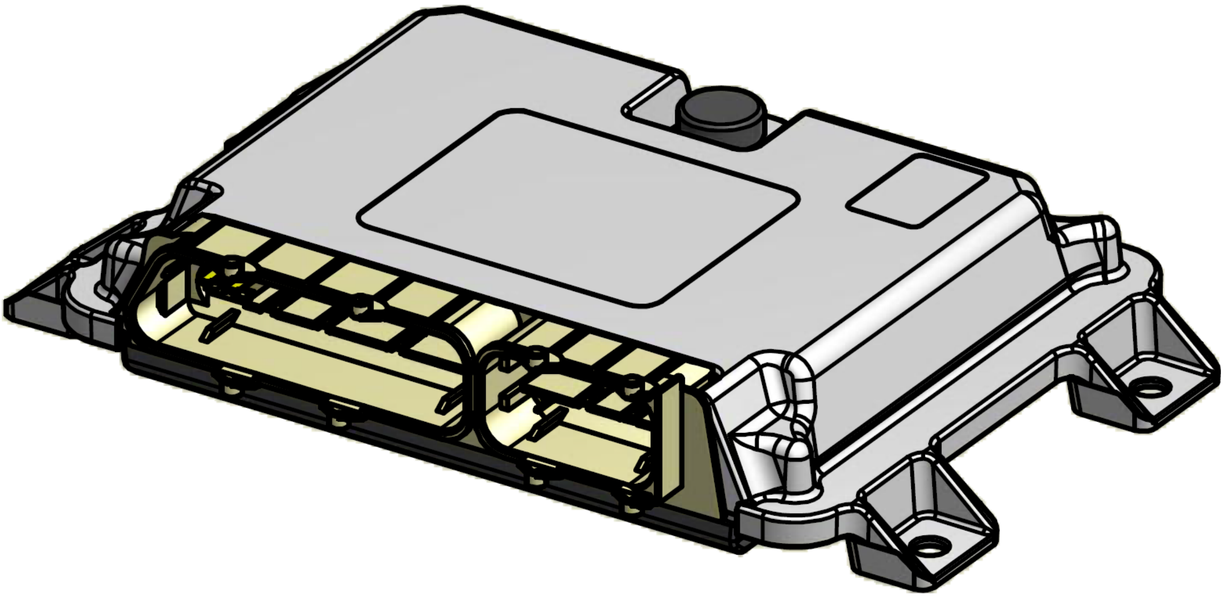
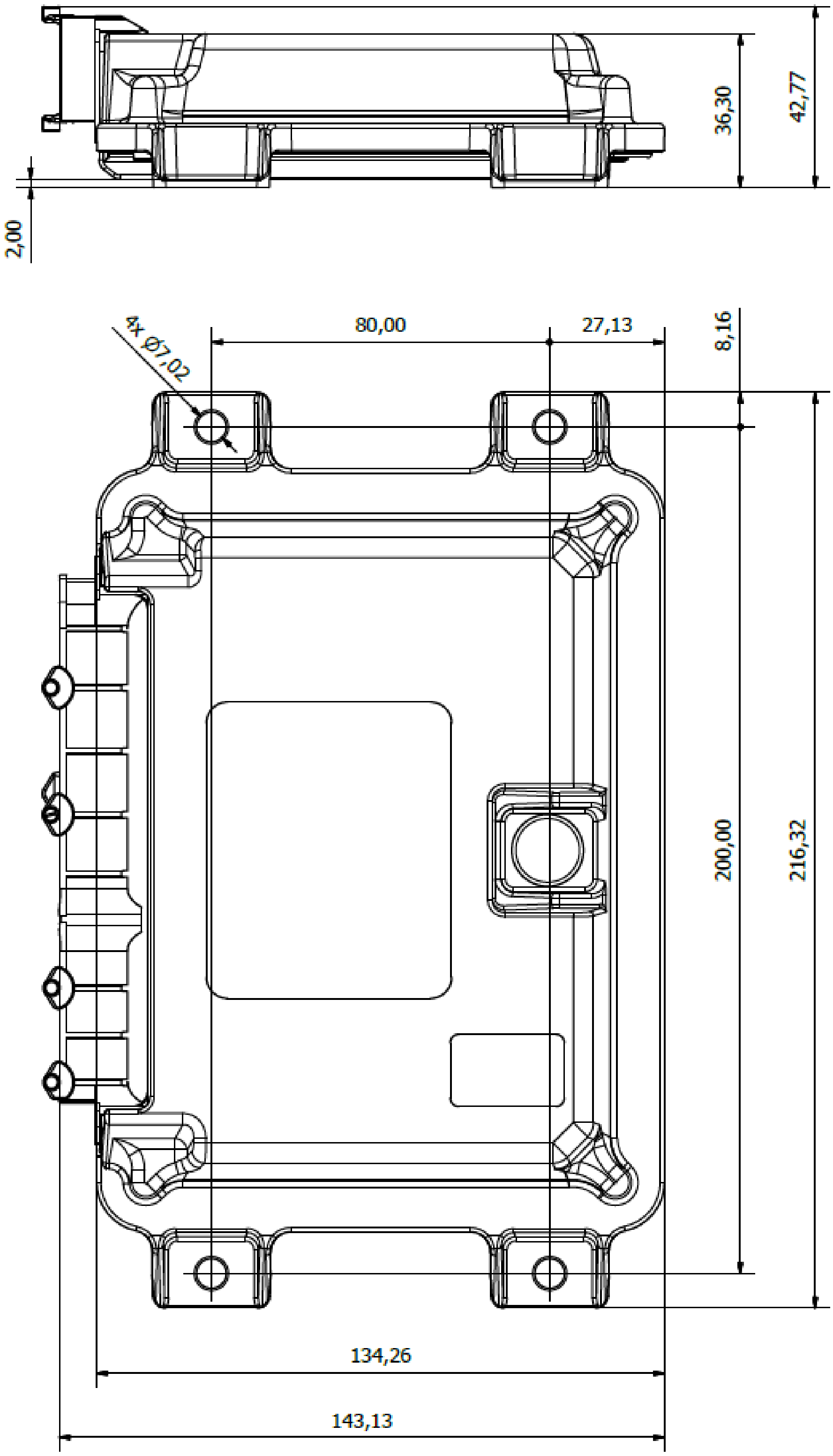


Figure 8 - 3D view of the housing

4.2.1 Detailed outline of the housing



4.2.2 Detailed outline of the connector

For details and dimensions about the connector, please refer to the next chapter. Although the housing is different, the connector does not have any change with respect to the first version (V1).

4.3 First version housing (V1)

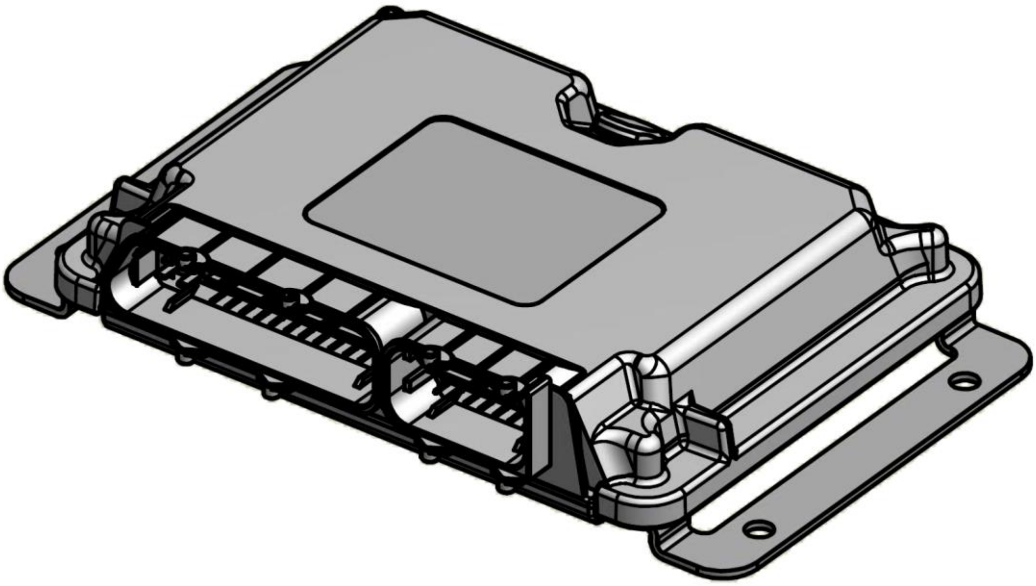
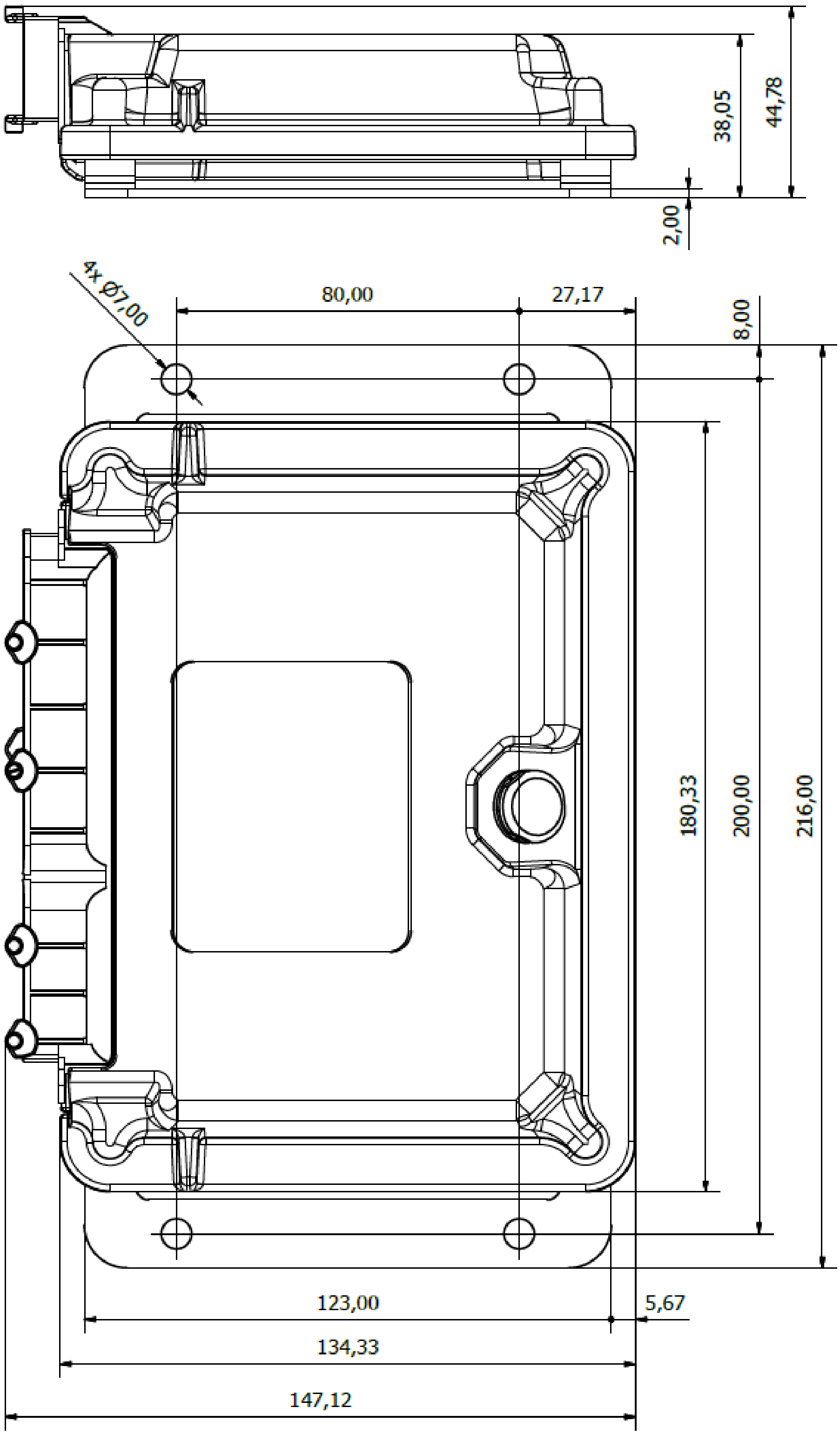
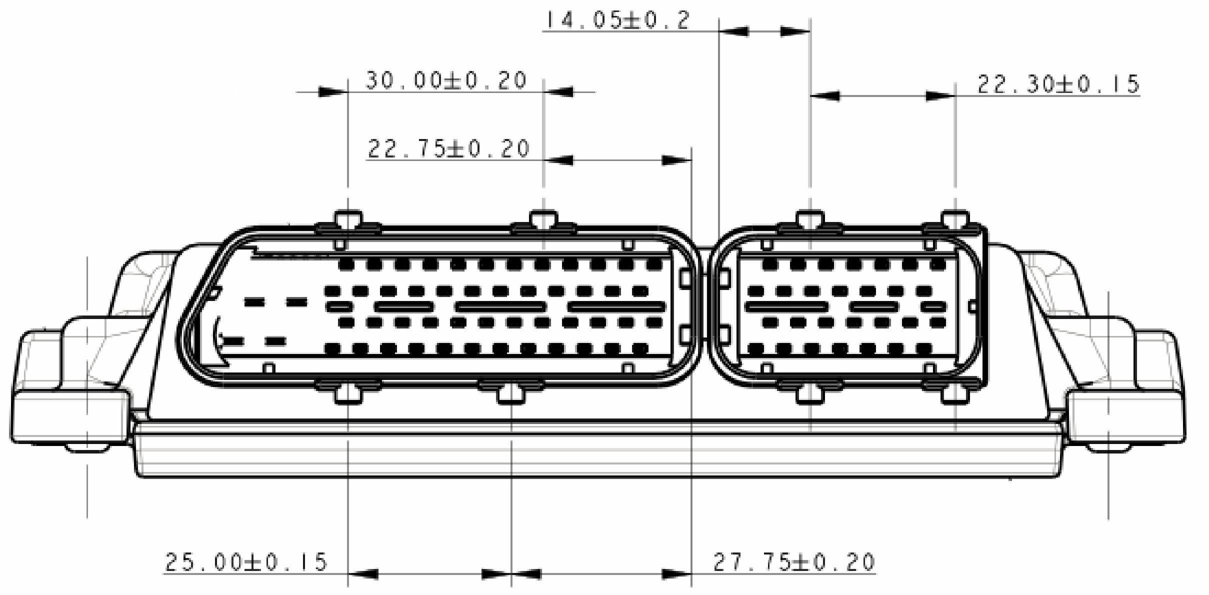


Figure 9 - 3D view of the housing

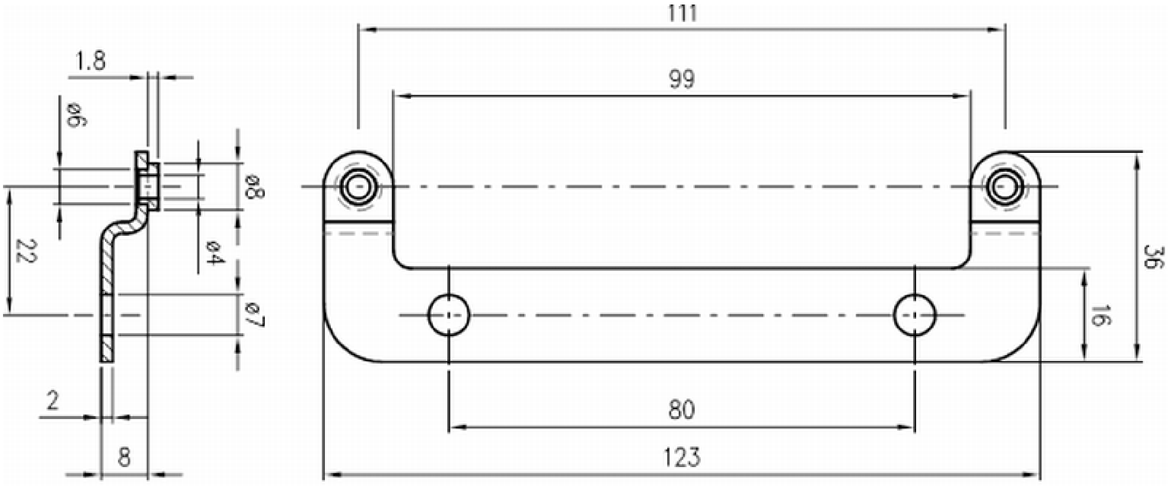
4.3.1 Detailed outline of the housing and the connector





4.3.2 Fixing clamps

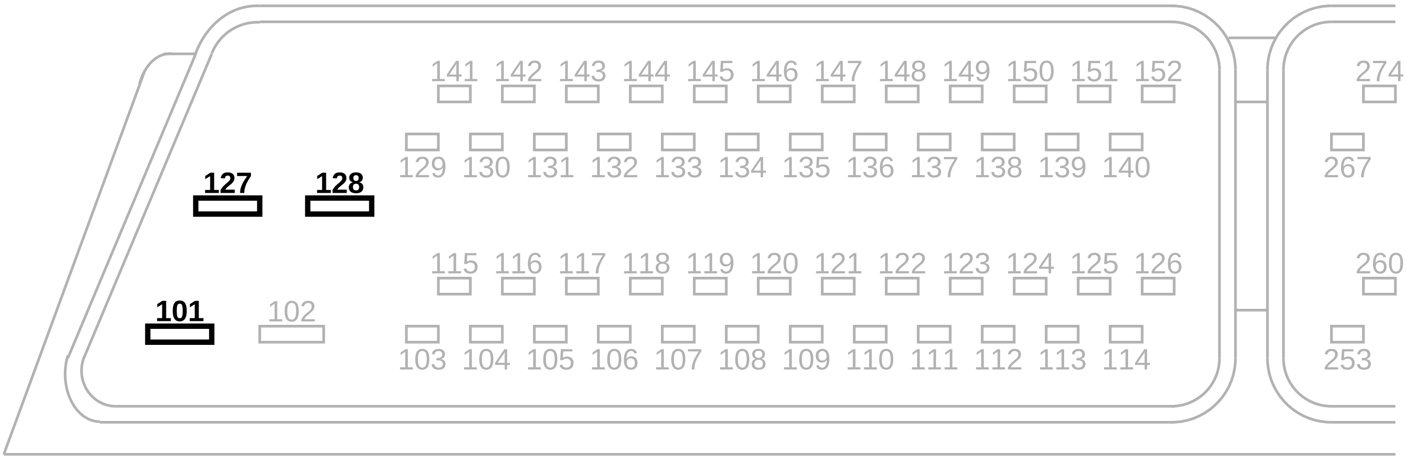
The ECUs of the TTC 50 family built on the previous V1 housing, are delivered with pre-assembled fixing clamps that shall to be used for mounting the ECU in the vehicle. A drawing with the relevant dimensions can be found below.



5 Specification of Inputs and Outputs

5.1 Positive power supply (BAT+)

5.1.1 Pinout



Connector Pin Number	Function
P101	Battery (+) Supply Input for Internal Electronics (connected to ADC for voltage monitoring)
P127	Battery (+) Supply Input for Power Stages
P128	Battery (+) Supply Input for Power Stages

5.1.2 Functional description

Supply pins for positive supply.
One power pin to be used for supplying the internal electronics.
Two power pins to be used in parallel with 2.5mm² wires for total supply current of up to 25A.
For operation at least pin 101 and one of the pins 127 or 128 have to be connected. If the total load current of the power stages exceeds 17A both pins for power stage supply have to be used.
Nominal supply voltage for full operation is 9 .. 32V, including both supply voltage ranges for 12 and 24V battery operation. In this voltage range all I/Os work according to the user manual. For the Variable Senor Supply there is a different supply voltage spec. Transients exceeding this voltage range are suppressed up to the non-destructive limits found in the maximum ratings.
Especially for 12V systems an advanced power supply is used. The CPU is working down to 4V battery supply (voltage drop until the starter motor makes its first turns, described in ISO7637 Part1 for 12V systems). For battery protection this function is limited to 1 second.

5.1.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Ratings for Pin 101, 127 and 128

Symbol	Parameter	Note	min	max	Units
U_{in-max}	permanent none-destructive supply voltage		-32	32	V
U_{in-lim}	peak none-destructive supply clamping voltage	1,2	-40	45	V
I_{in-lim}	peak none-destructive supply clamping current	1,2	-10	+100	A
T_d	Load dump protection according to ISO7637-2, Pulse 5, Level IV (superimposed 174V, R_i=2Ω)	1		350	ms

Ratings for Pin 127 and 128 only

$I_{in-max\_}$	Permanent input current (Pins 127 and 128 in parallel with symmetrical wire connection)			25	A
I_{in-max}	Permanent input current per pin			17	A

Note1: control unit is protected by transient suppressor diode, specified is clamp voltage, current and duration of voltage transient

Note 2: max time for peak none-destructive supply clamping voltage/current $t_{lim-max}$= 1ms

5.1.4 Characteristics

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Capacitance load at input			500	µF
U_{in}	Supply voltage for full operation		9	32	V
U_{in}	Supply voltage for CPU operation	1	4	32	V
T_{crank}	Max. duration low battery voltage below 9V without CPU reset	1	1000		ms
$I_{in\text{-}idle}$	Supply current of unit without load	2,3		0.2	A
$I_{in\text{-}idle}$	Supply current of unit without load	2,4		0.14	A
$I_{in\text{-}idle}$	Supply current of unit without load	2,5		0.1	A
$I_{in\text{-}STBY}$	Standby supply current (KL15 off)	6		0.5	mA
$I_{in\text{-}STBY}$	Standby supply current (KL15 off)	7		1.0	mA

Note 1: Ultra low voltage operation during cranking. For battery protection this function's duration is limited to 1 second.
Note 2: The idle current consumption for the HY-TTC 50 depends on the utilization of the onboard hardware by the application software. The specified current consumption applies for a worst case scenario where all peripheral units of the Microcontroller, the external RAM, EEPROM, etc. are working to full capacity. In a typical example of usage (Codesys Runtime + empty Codesys project with all IO's initialized, external RAM active, cyclic EEPROM reading and cyclic transmission of a CAN message on interconnected CAN 0/1) the idle current consumption is approximately 70% of the specified maximum value.
Note 3: at UBat = 9V
Note 4: at U_{Bat} = 12V
Note 5: at U_{Bat} = 24V
Note 6: at U_{Bat} = 27V / T_{ECU} = $T_{ambient}$ = -40°.. 85°C
These are worst case operating conditions during standby.
Note 7: at U_{Bat} = 32V / T_{ECU} = 85°.. 125°C
These are operating conditions during or immediately after switching to standby:
The battery voltage for the measurement was chosen to be higher than the maximum output voltage of the generators which are built into machines/vehicles with 24V systems.
The ECU was internally heated up to an over temperature of 40K. After some minutes after switching to standby the ECU cools down and the internal temperature is equal to the ambient temperature (max. 85°C). Therefore the current consumption will be reduced to the case specified with Note 6.

5.1.5 Voltage Monitoring

The battery voltage on connector pin 101 is connected to an ADC-input. Battery voltage measurement can be used for voltage compensation for PWM-controlled loads or for diagnostic purpose.
The input voltage is attenuated with a factor of 0.12466 (nom, or divided by 8.02) thus allowing voltage measurement up to 40.106 V (nom.)

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{Out}	Scale factor (nom)	1	0.12466		
f_{g_LP}	Nominal battery supply range that can be measured	2	9	40.106	V
V_{Tol-M}	ADC voltage tolerance (of reading)	3	-4	+4	%
V_{Tol-0}	ADC voltage tolerance (offset)	3	-0.1	+0.1	V
f_{g_LP}	Cut off frequency of 1st order low pass filter	4	30	50	Hz

Note 1: 12V input voltage will be attenuated to 1.496V on the ADC input

Note 2: Low limit is given by minimum supply voltage of the ECU, high limit is full scale limit of ADC

Note 3: Total error is the sum of proportional error and zero reading error:

$$TUE = \pm\left|V_{Tol-M} * U_{Bat} \pm V_{Tol-0}\right|$$

Note 4: A low pass filter (1st order) is provided to remove glitches on the battery voltage from the ADC input

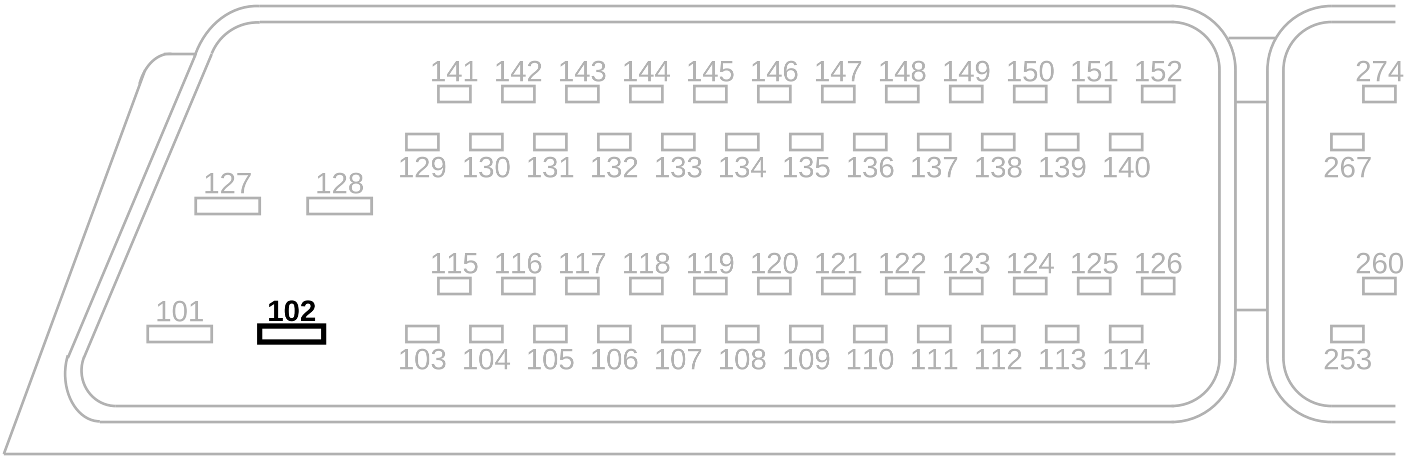
5.1.6 Wiring hints:

The ECU is limited to a total load current of 25A (maximum) for the power stages, connected to pins 127 and 128. When all loads are tied towards ground, the load current will be also carried by these supply pins. Each contact pin is thermally limited to 17A (maximum). 2 supply pins work in parallel for the power stages supply. So the system designer must be careful with the cable harness design to guarantee evenly distribution of supply current on both pins.

Example: It is not ok to use one cable with a length of two meters and large diameter for a connection between a fuse box and the ECU and crimp it to 2 piggy tails with small diameter in the connector area. Small differences in the contact pressure can lead to a big imbalance. In worst case condition 1 contact carries most of the current load and is overloaded at maximum current. It is better to use 2 wires with the same total cross sectional area than this one thick cable. All wires must have exactly the same length and diameter. In this case an evenly distribution of current will be the case even with slightly different contact resistance.

5.2 Negative power supply (BAT-)

5.2.1 Pinout:



Connector Pin Number	Function
P102	Battery (-) Supply Input

5.2.2 Functional description:

Supply pin for negative supply.
Power pin to be used with 1.5mm² or 2.5mm² wires for total return current of 17A.

5.2.3 Maximum ratings

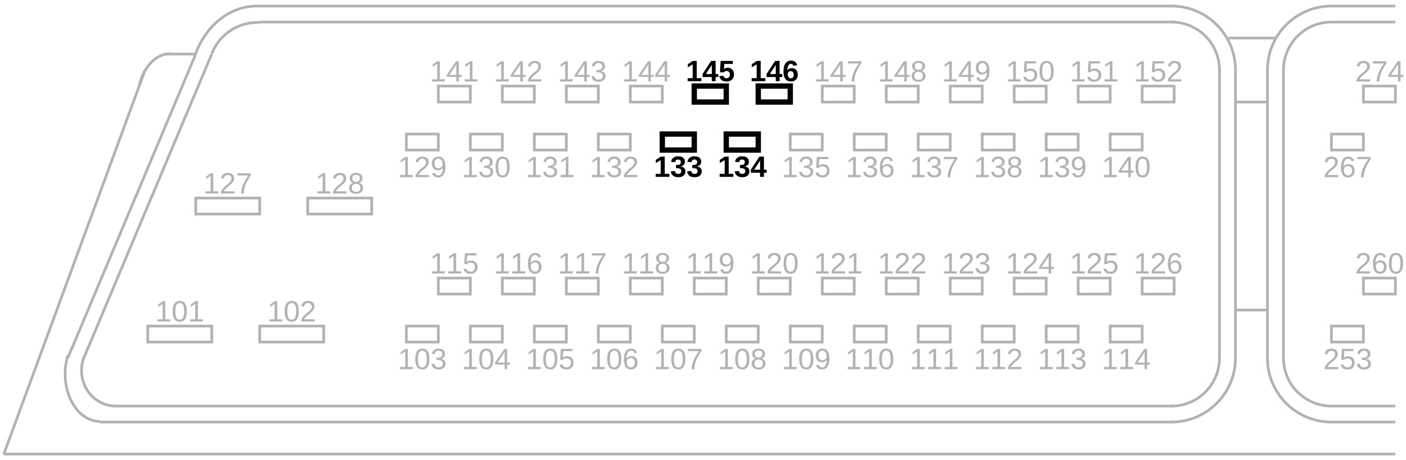
$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	Max	Units
$I_{in\text{-}max}$	Permanent supply current	1		17	A

Note 1: GND supply current in excess of 1A is produced by inductive loads during freewheeling. This is not a continues current but a pulsed current with a duty cycle. For high current values the duty cycle is smaller than 50%. Even with all PWM outputs on at rated current and 50% duty cycle the RMS value will be less than 10A. For calculation of voltage drops please observe the direction of the current. It is negative that means the voltage drop is negative, the overall supply voltage of the HY-TTC50 is **increased** through this voltage drop.

5.3 GND Analog Ground

5.3.1 Pinout:



Connector Pin Number	Function
P133	Analog Ground
P134	Analog Ground
P145	Analog Ground
P146	Analog Ground

5.3.2 Functional description:

Supply pins for analog sensor GND connection.

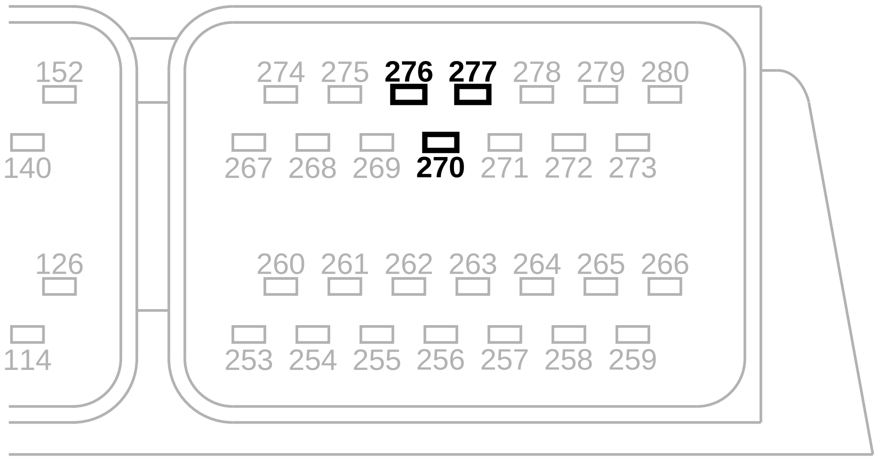
5.3.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
$I_{out-max}$	Permanent current per pin			2	A

5.4 GND Digital Ground

5.4.1 Pinout:



Connector Pin Number	Function
P270	Digital Ground
P276	Digital Ground
P277	Digital Ground

5.4.2 Functional description:

Supply pins for digital sensor GND connection or GND connections for switches.
Can be used as sensor supply GND or for light loads..

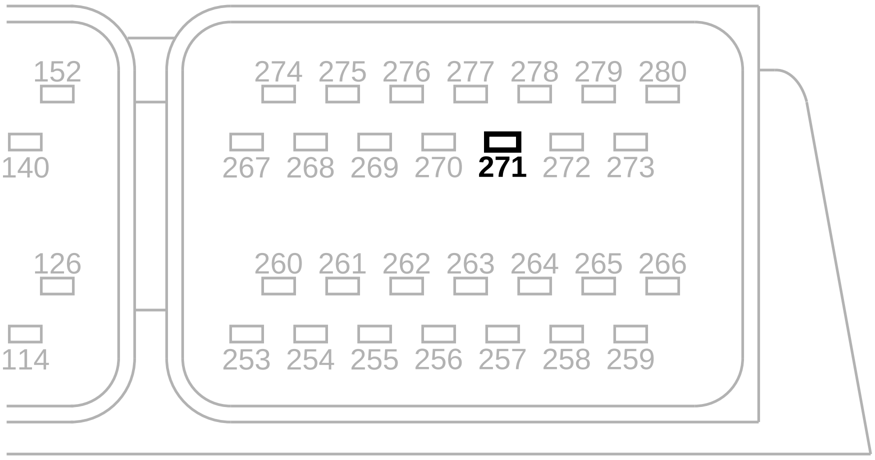
5.4.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
$I_{out-max}$	Permanent current per pin			2	A

5.5 Ignition on switch input / Terminal 15 (Klemme15)

5.5.1 Pinout:



Connector Pin Number	Function
P271	Terminal 15 Input

5.5.2 Functional description:

Only used for permanent supplied systems. When switched to positive supply, this input gives the command to power up the ECU. When switched off, the ECU performs activates its keep-alive functionality and switches off by software.
For systems with main power switch (not permanent supplied) this pin must be tied to the BAT+ pins (101, 127, 128).
This input can also be monitored via a digital input of the CPU.

5.5.3 Maximum ratings

T_{ambint} = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Permanent (DC) input voltage		-32	32	V
V_{in}	Transient peak input voltage 500ms		-50	50	V
V_{in}	Transient peak input voltage 1ms		-100	100	V

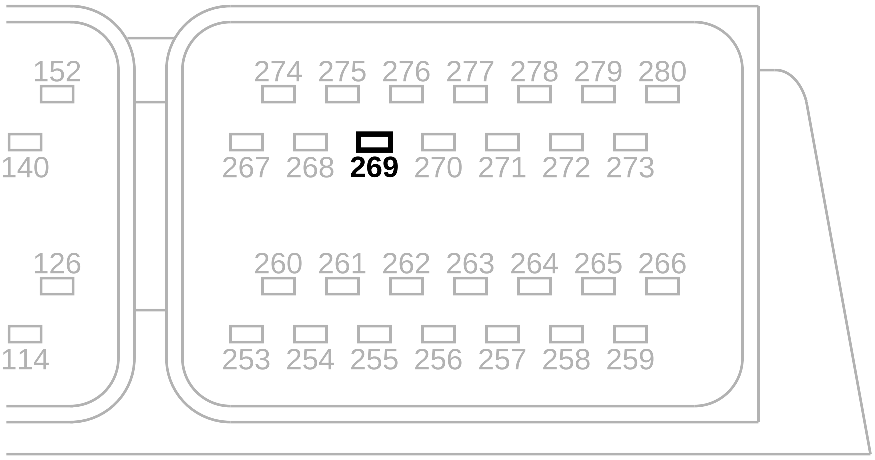
5.5.4 Characteristics

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		40	60	nF
R_{pu}	Pulldown resistor to GND		9.85	10.15	kΩ
V_{IL}	Input voltage for low level		-1	1.8	V
V_{IH}	Input voltage for high level		3.8	U_{Bat}	V
τ_{in}	Input low pass filter		0.4	0.6	ms

5.6 Variable Sensor supply

5.6.1 Pinout:



Connector Pin Number	Function
P269	Sensor Supply Output (Variable)

5.6.2 Functional description:

This sensor supply output is provided for sensors that operate at higher voltages than 5V. Examples are analog or digital current loop sensors that do not withstand direct connection to battery. In this case the sensor supply acts as voltage limiter.
The software can configure this output to one of the following nominal supply voltages:

- 8.5V
- 10.0V
- 14.5V

1GT101DC (wheel speed sensor) accepts 4.5 to 24VDC - good candidate
Our BPS is NOT compatible with this (6V max - so use 5V output instead)

Typical sensors supplied with 14.5V are the current loop (ABS-type) speed sensors and analog transducers /e.g. pressure sensors) with current output.
The actual output voltage is read back by the ADC-unit for monitoring purposes.

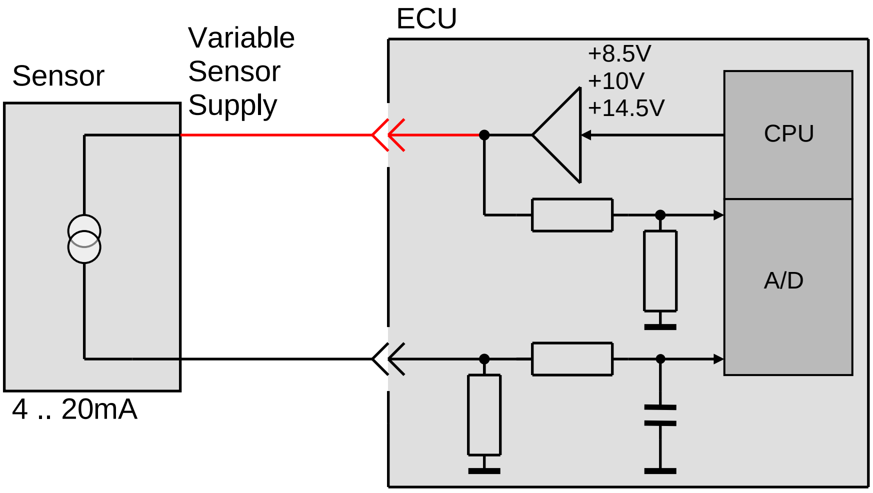


Figure 10: Variable sensor supply used for analog current loop sensor (4..20mA)

5.6.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Output voltage under overload conditions (i.e. short circuit to supply voltages)		-1	32	V

5.6.4 Characteristics

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{out}	Pin output capacitance		4	6	µF
V_{out}	Output voltage, at I_{load} and over $V_{Bat-min}$	1	8	9.2	V
V_{out}	Output voltage, at I_{load} and over $V_{Bat-min}$	2	9.4	10.8	V
V_{out}	Output voltage, at I_{load} and over $V_{Bat-min}$	3	13.8	15.2	V
$V_{Bat-min}$	Battery voltage required for proper output voltage regulation	1,4	10.2	U_{Bat}	V
$V_{Bat-min}$	Battery voltage required for proper output voltage regulation	2,4	11.8	U_{Bat}	V
$V_{Bat-min}$	Battery voltage required for proper output voltage regulation	3,4	16.2	U_{Bat}	V
I_{load}	Load current	5	0	30	mA
I_{load}	Load current 14.5V	6	0	40	mA

Note 1: Output setting to 8.5V
Note 2: Output setting to 10V
Note 3: Output setting to 14.5V
Note 4: This output is provided by a linear voltage regulator.
The battery voltage must be at least 1V higher than the regulated output voltage.
Note 5: For all voltage settings and at highest supply voltage.
Note 6: For voltage setting to 14.5V and at highest supply voltage.

5.6.5 Sensor Supply Voltage Monitoring

$T_{ambient}$ = -40° .. 85°C

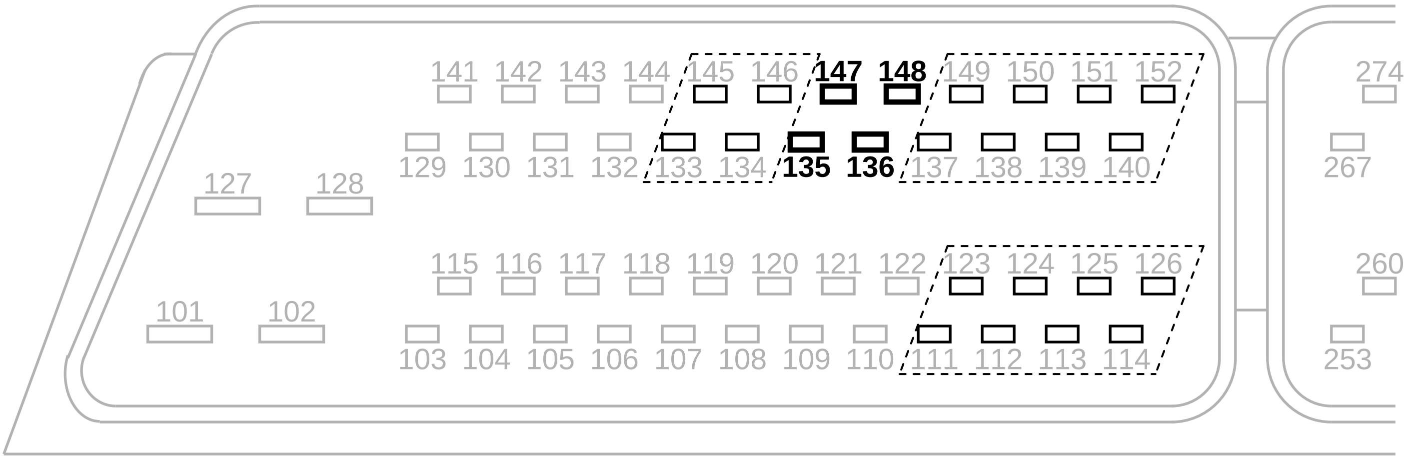
Symbol	Parameter	Note	min	max	Units
α_{UGEB}	Read back attenuation factor	1	0.3140	0.3236	
$V_{UG\text{-}SRC}$	Read back values normal operation 8.5V setting	2	2.462	3.037	V
$V_{UG\text{-}SRC}$	Read back values normal operation 10.0V setting	2	2.893	3.564	V
$V_{UG\text{-}SRC}$	Read back values normal operation 14.5V setting	2	4.247	4.990	V

Note 1: Supply is read back to allow ratiometric measurement. In order to guarantee that the read back input is always in the ADC operating range, an attenuating voltage divider (nom *0.3188) is inserted.

Note 2: Due to tolerances in the actual supply voltage of main- and sensor-supply the read back value may vary in the range specified.
Values outside this window indicate voltage failure in the sensor supply (short circuit or overload) and must set the sensor failure flag.

5.7 Sensor Supply 5V

5.7.1 Pinout:



Connector Pin Number	Function
P136	Sensor Supply Output 0 (5V)
P148	Sensor Supply Output 0 (5V)
P135	Sensor Supply Output 1 (5V)
P147	Sensor Supply Output 1 (5V)

5.7.2 Functional description:

This is required in rules!!!!

Two independent sensor supplies are provided for 3-wire-sensors (i.e. potentiometers, pressure sensors etc.). For fully redundant sensors with 2 sensor supply connections both supplies must be connected to different sensor supplies.
Sensor Supply 1 is defined to be the redundant supply. For detecting short circuits between redundant analog inputs the sensor supply can be switched off by SW.

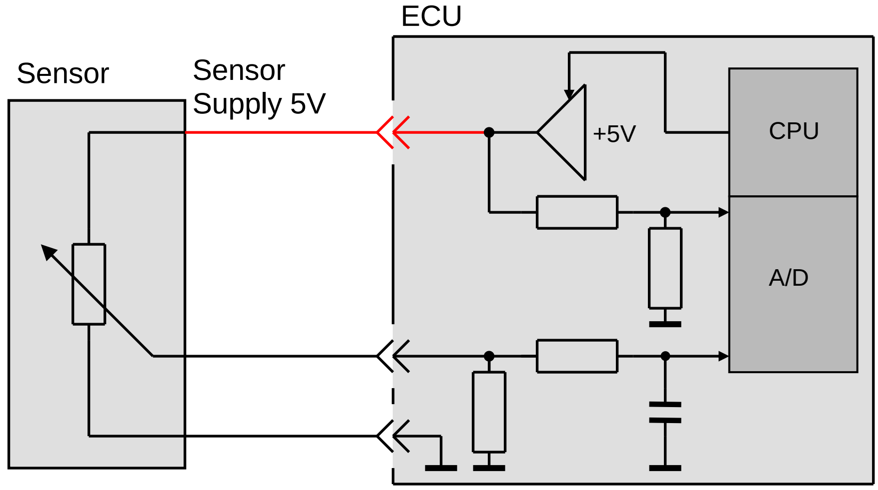


Figure 11: Sensor supply 5V

5.7.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Output voltage under overload conditions (i.e short circuit to supply voltages)		-1	32	V

5.7.4 Characteristics

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{out}	Pin output capacitance		4	6	µF
V_{out}	Output voltage, at I_{load}		4.9	5.1	V
V_{out}	Output voltage differential, at I_{load}	1	-25	+15	mV
I_{load}	Load current		0	50	mA

Note 1: This sensor supply is a tracking regulator to the internal 5V supply which is also the reference voltage of the ADC unit.

5.7.5 Supply Voltage Monitoring and Correction

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
α_{UGEB}	Read back attenuation factor	1	0.9780	0.9789	
V_{UG-SRC}	Read back values normal operation	2	4.865	4.910	V
k_{REF}	Reference correction value		4.8924		V

Note 1: Supply is read back to allow ratiometric measurement. Due to tolerances the sensor supply might be higher than the ADC reference thus exceeding the allowed voltage range. In order to guarantee that the read back input is always in the ADC operating range, an attenuating voltage divider (nom *0.9785) is inserted.

Note 2: When all parameters are nominal value the read back input (referred to ADC reference) will show 4.8924V. Due to tolerances in the actual supply voltage of main- and sensor-supply the read back value may vary in the range specified.
Please note that this window will not affect the measurement accuracy when using the correction formula below.
Values outside this window indicate voltage failure in the sensor supply (short circuit or overload) and must set the sensor failure flag.

5.7.6 Supply Voltage Correction Formula

Correction formula for ratiometric measurement:

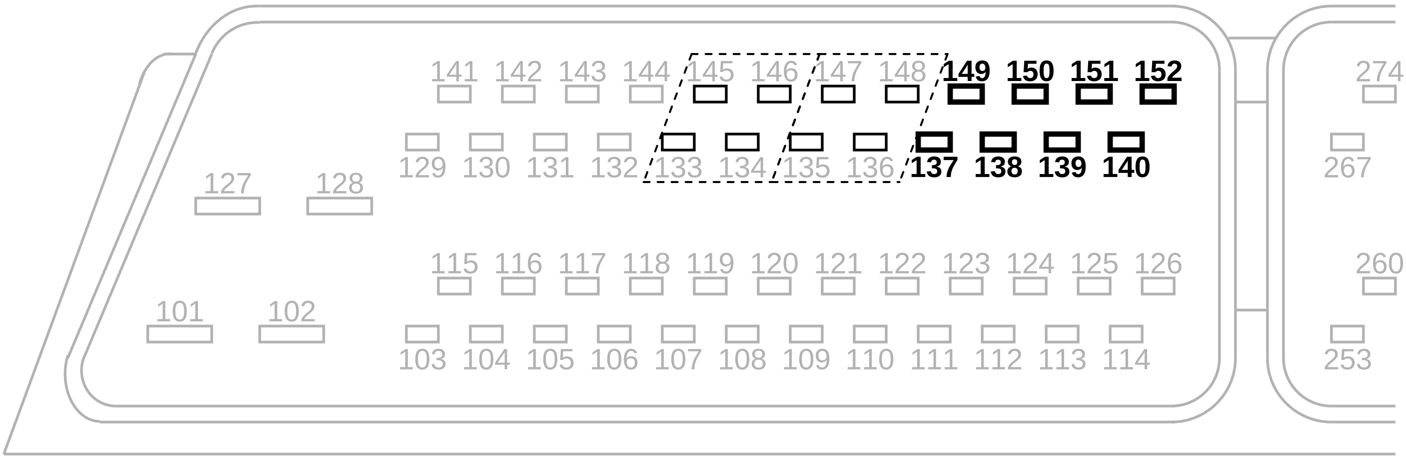
$$U_{IN-rat} = \frac{N_{ADC-ANx}}{N_{ADC-UGEBy}} * k_{REF} \quad [V]$$

$N_{ADC-UGEBy}$	ADC value of sensor supply voltage
$N_{ADC-ANx}$	ADC value of sensor input voltage
U_{IN-rat}	Ratiometric equivalent input voltage Result in volts calculated for a supply of exactly 5V. Example: An input voltage with 20% of sensor supply will show a result of 1.0V regardless of actual sensor supply voltage (within the normal operating range).

The software drivers for ADC 0..5V and ADC 0 .. 32V inputs use this calculation formula for the output result when set to ratiometric input mode.

5.8 Analog input 0..5V with SW- configuration

5.8.1 Pinout:



Connector Pin Number	Function 1	Function 2	Function 3
P152	Analog Input 0 0 .. 5V	Analog Input 0 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P140	Analog Input 1 0 .. 5V	Analog Input 1 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P151	Analog Input 2 0 .. 5V	Analog Input 2 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P139	Analog Input 3 0 .. 5V	Analog Input 3 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P150	Analog Input 4 0 .. 5V	Analog Input 4 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P138	Analog Input 5 0 .. 5V	Analog Input 5 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P149	Analog Input 6 0 .. 5V	Analog Input 6 0 .. 20mA	Analog Input 0 0 .. 65kΩ
P137	Analog Input 7 0 .. 5V	Analog Input 7 0 .. 20mA	Analog Input 0 0 .. 65kΩ

5.8.2 Functional description:

This kind of input can be set to 3 different operation modes individually by SW.
Fits to different types of sensors:

5.8.3 Mode 1: resistive sensors (i.e. NTC/PTC temperature sensors)

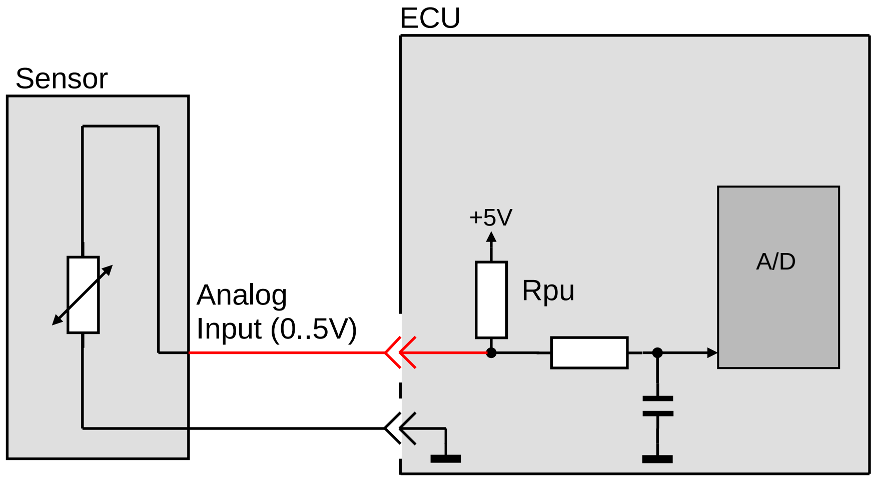


Figure 12: Resistive sensor

This mode may also be used as switch input with switches connected to ground.
The use of switches to BAT+ is not allowed.

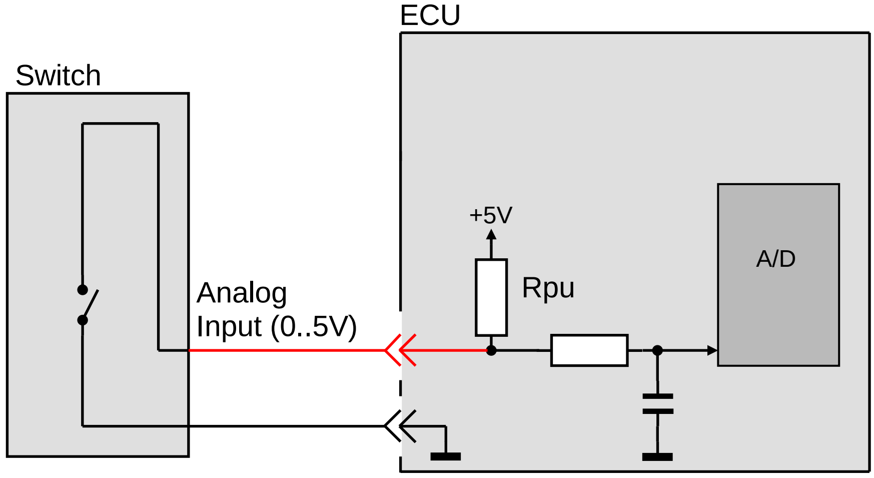


Figure 13: Switch input (only for switches to ground)

5.8.4 Mode 2: current loop active sensors (0..20mA)

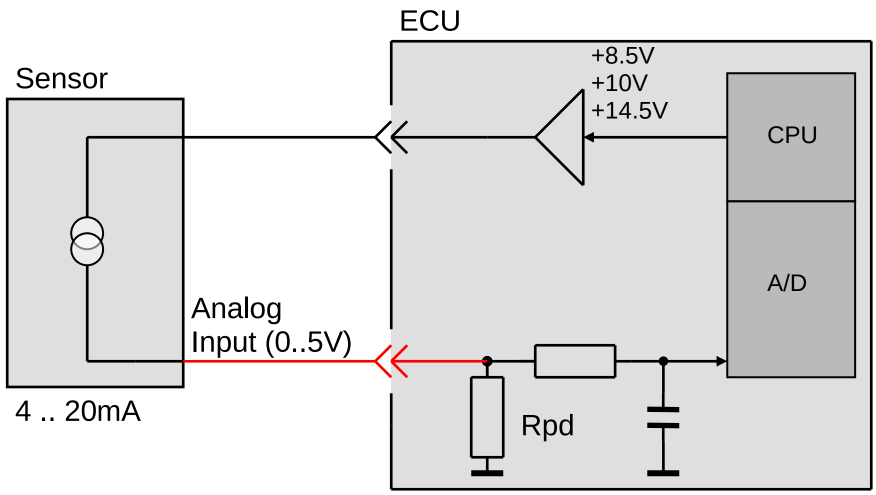


Figure 14: Current loop active sensor

5.8.5 Mode 3: Potentiometric sensors (pedals, joystick etc)

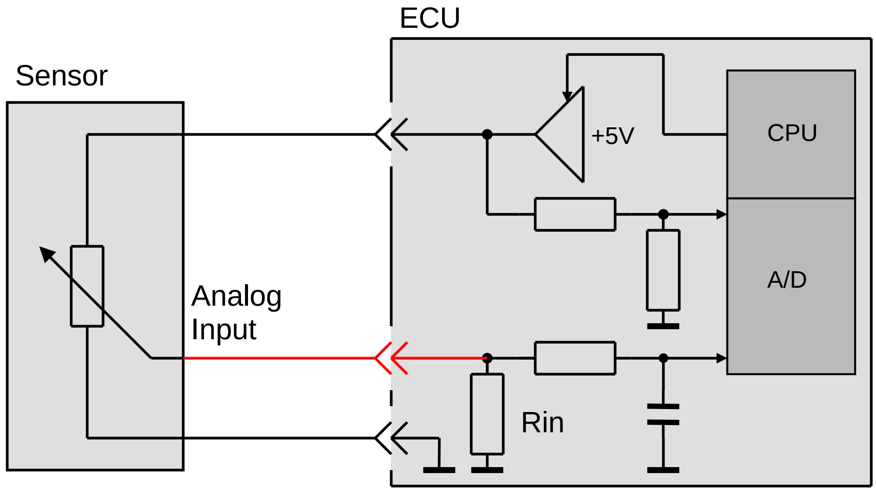


Figure 15: Potentiometric sensor

Most physical sensors (e.g. pressure transducers) are operated in this mode.
Please note that many sensors are offered in 2 variants:

- ***absolute:*** The output voltage is a fixed value and corresponds directly to a physical value. For example 2.5V corresponds to 1bar. Any tolerance in the sensor's and the ECU'S reference voltage **generates additional measurement inaccuracy**.

- ***ratiometric:*** The output voltage is a fixed percentage of the sensor supply, the ratio corresponds to a physical value. For example 50% corresponds to 1bar (or 2.5V if the sensor supply is exactly 5.00V). Any tolerance in the sensor's or the ECU'S reference voltage **is completely compensated and will not generate additional measurement inaccuracy.**

Due to the described behavior ratiometric sensors are generally preferred. Just FYI

Function selection is done by software application for each input independently

5.8.6 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions	1	-1	32	V

Note 1: due to thermal reasons only one of the 8 inputs may be shorted to 32V at the same time. A connection to any supply voltage higher than 5V is not allowed for normal operation.

5.8.7 Characteristics

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
V_{PU}	Supply voltage for reference resistor	1	4.5	5.15	V
R_{pu}	Reference resistor	1	1202	1238	Ω
R_{in}	Input resistance to GND	2	217	230	Ω
R_{pd}	Reference resistor	2	217	223	Ω
R_{in}	Input resistance to GND	3	99.7	102.7	kΩ
τ_{in}	Input low pass filter		0.7	1.3	ms
V_{CC}	ADC reference voltage		4.85	5.15	V
V_{In}	ADC input voltage range		0	V_{CC}	V
V_{Tol}	ADC voltage tolerance	4	-25	+25	mV
LSB	Nominal value of 1 LSB (Full scale / 1024)		4.88		mV

Note 1: configuration mode 1 (resistive sensor)
Note 2: configuration mode 2 (current loop sensor)
Note 3: configuration mode 3 (potentiometric sensor)
Note 4: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC} . For total tolerance including sensor in mode 1 (ratiometric measuring) or mode 3 when using the built in sensor supply (by reading back the offset) V_{CC} is not a parameter in error calculation.

5.8.8 Application Details for Mode 1 (Resistive Sensors)

Resistive sensors are for example PTC resistors for temperature measurement. Best accuracy and resolution can be achieved when the value of sensor resistor equals the reference resistor. For example in a climate control application the 20°C value of the sensor resistor should be around 1 ..1.5kΩ, for coolant water control the 100°C value should be in that range.

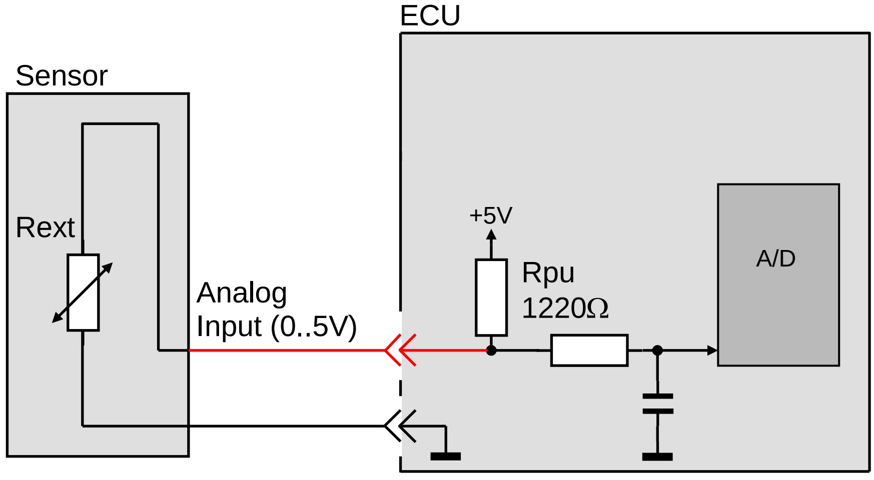


Figure 16: Resistive sensor

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
R_{pu}	Reference resistor		1202	1238	Ω
R_{ext}	Resistance measurement range		0	65535	Ω
R_{ext}	Resistance measurement resolution		1		Ω
V_{Tol}	Resistance value tolerance 0..100Ω	1	-3	+3	Ω
V_{Tol}	Resistance value tolerance 100..4000Ω	2	-3	+3	%RD
V_{Tol}	Resistance value tolerance 4000..65535Ω	2	-10	+10	%RD

Note 1: for low-ohmic sensor values the absolute tolerance in Ohms is specified
Note 2: for medium or high resistance value the tolerance is specified in percent of the actual sensor value (reading)

5.8.9 Application Details for Mode 2 (current loop active sensors 0..20mA)

During power down (KL15 off) the ECU does not disconnect the current sense input. To prevent battery discharge it is not recommended to have the sensors permanently supplied.

We recommend one of the following 2 options:

Option 1:
You can use a digital output for supplying the sensor. When switching off, the ECU can perform an application controlled shut-down, for example to operate a cooling fan to cool down an engine until the temperature is low enough or to store data in the non-volatile memory of the ECU. When the application controlled shut-down is finished, the ECU switches off and consumes less than 1mA of battery current (including sensors).

Option 2:
KL15 is used to directly supply the current loop sensor. Please keep in mind that often KL15 is used for directly switching relays or other inductive loads. This may cause transients in excess of +/-50V, for which the sensor must be specified.

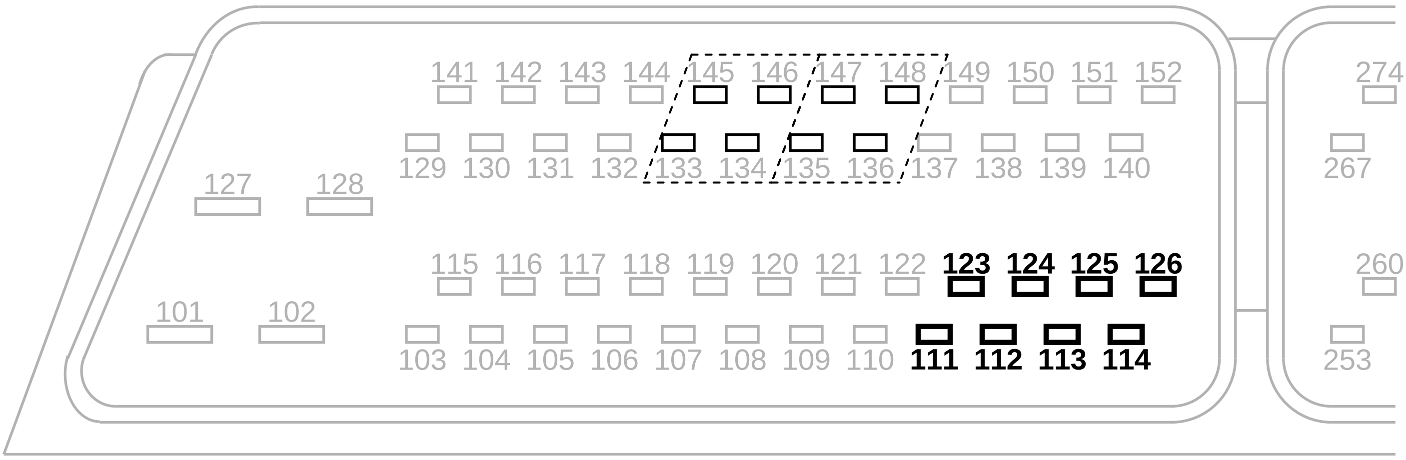
Please also observe HY-TTC50 / 55 / 60 / 36X / 48X Application Note: Power Supply (D-TTC04-AN-02-001).

We don't have these pins - instead use pins 137-140 and 149-152 (0-5V only)

5.9 Analog and digital input with range select 0..32V

Note: The analog inputs with range select are available on HY-TTC 60, HY-TTC 90, HY-TTC 94, HY-TTC 48X and HY-TTC 48XS, not on HY-TTC 50 and HY-TTC 36X.

5.9.1 Pinout:



Connector Pin Number	Function
P126	Analog input (from 0..5 up to 0..32V) 0
P114	Analog input (from 0..5 up to 0..32V) 1
P125	Analog input (from 0..5 up to 0..32V) 2
P113	Analog input (from 0..5 up to 0..32V) 3
P124	Analog input (from 0..5 up to 0..32V) 4
P112	Analog input (from 0..5 up to 0..32V) 5
P123	Analog input (from 0..5 up to 0..32V) 6
P111	Analog input (from 0..5 up to 0..32V) 7

5.9.2 Functional description:

Eight multi-purpose analog input with 10 bit resolution are provided, divided into 2 input groups, each with 4 pins.

The inputs are intended to be used with:

- analog sensors 0..5V ratiometric or with absolute reference.
- analog sensors with higher output voltage than 5V and absolute reference.
- each group can be adapted to different full scale voltages up to 0..32V per SW
- standard settings: 0..5V, 0..10V, 0..15V, 0..20V, 0..25V, 0..30V, 0..32V
- full 10bit resolution for any range.
- digital switch input with switches that may be connected either to ground or to battery supply.

The ADC values can be referenced either to internal supply or sensor supply (ratiometric mode) or to a internal accurate reference voltage (absolute reference) for each channel individually.

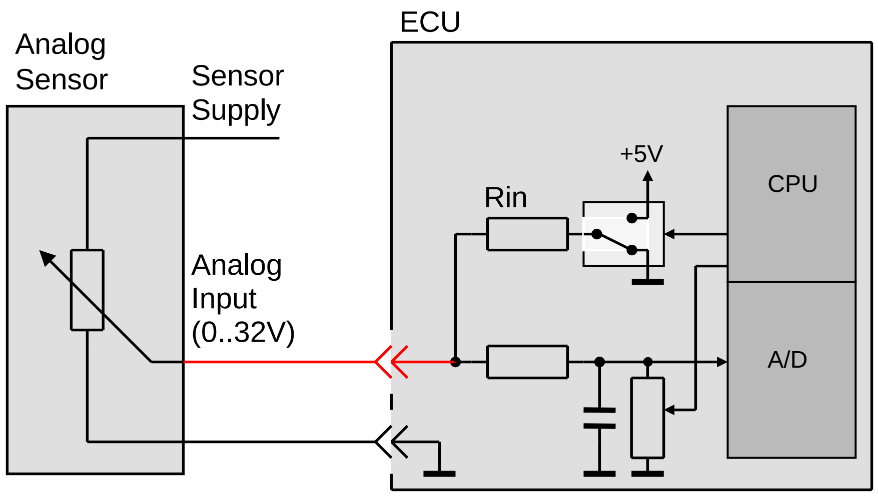


Figure 17: Analog sensor input 0..32V

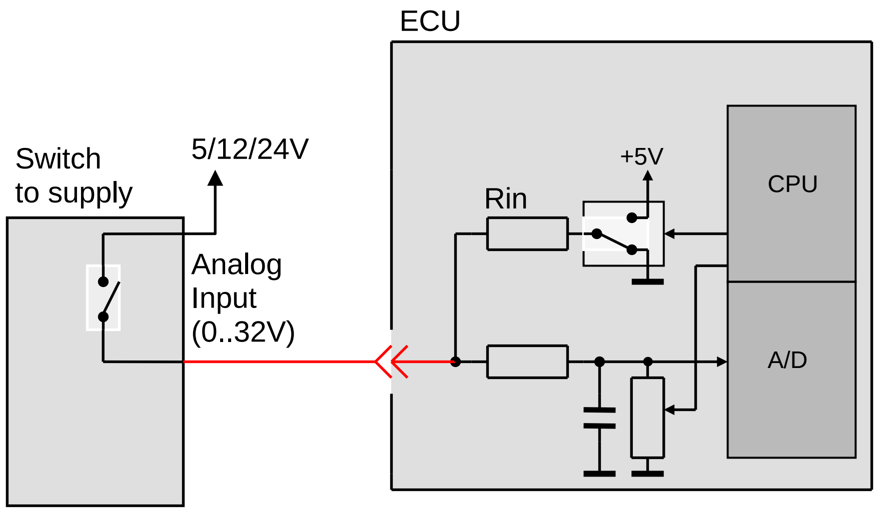


Figure 18: Switch to Sensor Supply or BAT+ connected to sensor input 0..32V

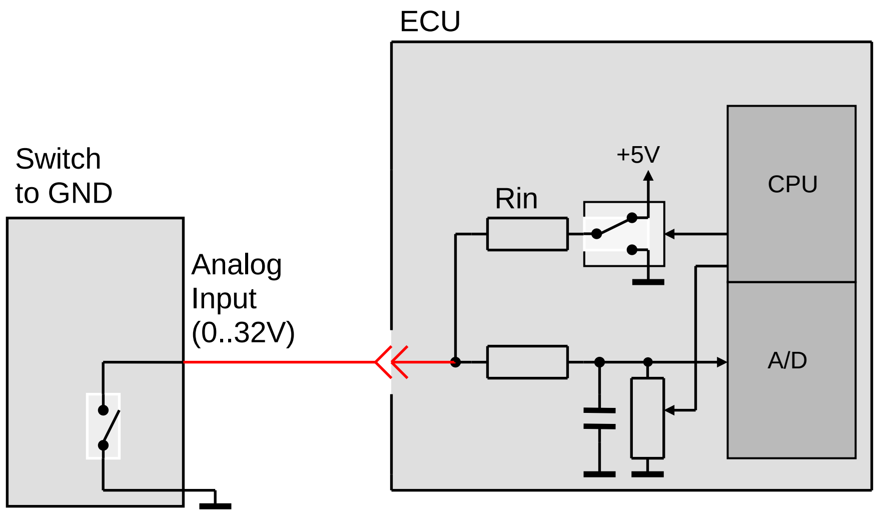


Figure 19: Switch to GND connected to sensor input 0..32V

5.9.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions		-1	32	V

5.9.4 Characteristics

$T_{ambient}$ = -40° .. 85°C

5.9.5 Parameters for 5V ratiometric setting

For 3 pin sensors that are supplied with one of the HY-TTC50's sensor supplies and use this supply as reference for the output signal. Output voltages of these sensors are typically described as percentage of the supply voltage.
The software compares the input voltage with the actual sensor supply voltage. The calculated output value is a portion of the supply voltage. Any deviation of either sensor supply or internal supply voltage from the typical value (in the operating range) will **not** influence the output value. Therefore ratiometric measurement will be in most cases more accurate compared to measurement where sensor and ECU uses each there built in references. In this case the sum of the tolerance of both references has to be added to the ADC error.

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
R_{in}	Input resistance to V_{CC}	1	9.85	10.25	kΩ
R_{in}	Input resistance to GND	1	9.85	10.25	kΩ
τ_{in}	Input low pass filter		40	55	ms
V_{CC}	ADC reference voltage V_{CC}	2	4.85	5.15	V
V_{In}	ADC input voltage range		0	V_{CC}	V
V_{Tol-0}	ADC voltage tolerance (zero)	3	-25	+25	mV
V_{Tol-M}	ADC voltage tolerance (full scale)	3	-50	+25	mV

Note 1: Depending on SW-setting.
Note 2: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC} .
Note 3: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC} . For total tolerance including sensor with ratiometric measuring mode using the built in sensor supply (by reading back the offset) V_{CC} is not a parameter in error calculation.

5.9.6 Parameters for 5V absolute measurement setting

This setting is for sensors that work only with an internal reference. For this reason the HY-TTC50 can make use of an internal precision reference with better accuracy than the ADC reference.

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
R_{in}	Input resistance to V_{CC}	1	9.85	10.25	kΩ
R_{in}	Input resistance to GND	1	9.85	10.25	kΩ
τ_{in}	Input low pass filter		40	55	ms
V_{CC}	ADC reference voltage V_{CC}	2	4.85	5.15	V
V_{In}	ADC input voltage range		0	4.85	V
V_{Tol-0}	ADC voltage tolerance (zero)	3	-25	+25	mV
V_{Tol-M}	ADC voltage tolerance (full scale)	3	-150	+125	mV
V_{Tol-R}	ADC voltage tolerance (full scale)	3	-3.0	+2.5	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		4.88		mV

Note 1: Depending on SW-setting.
Note 2: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC} .
Note 3: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC} . For non-ratiometric sensors the ADC reference voltage tolerance is included in this oval all error calculation.

5.9.7 Parameters for voltage range 10 .. 32V absolute measurement setting

This setting is for sensors that work only with an internal reference. For this reason the HY-TTC 50 can make use of an internal precision reference with better accuracy than the ADC reference.

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
R_{in}	Input resistance to V_{CC}	1	9.85	10.25	kΩ
R_{in}	Input resistance to GND	1	9.85	10.25	kΩ
τ_{in}	Input low pass filter		7	25	ms
V_{CC}	ADC reference voltage V_{CC}	2	4.85	5.15	V
10V setting for range selection					
V_{In}	ADC input voltage range		0	10	V
$V_{Tol\text{-}R}$	ADC voltage tolerance (zero)		-3	+3	LSB
$V_{Tol\text{-}R}$	ADC voltage tolerance (full scale)		-4.0	+4.0	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		9.765		mV
15V setting for range selection					
V_{In}	ADC input voltage range		0	15	V
$V_{Tol\text{-}R}$	ADC voltage tolerance (zero)		-3	+3	LSB
$V_{Tol\text{-}R}$	ADC voltage tolerance (full scale)		-4.0	+4.0	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		14.65		mV
20V setting for range selection					
V_{In}	ADC input voltage range		0	20	V
$V_{Tol\text{-}R}$	ADC voltage tolerance (zero)		-3	+3	LSB
$V_{Tol\text{-}R}$	ADC voltage tolerance (full scale)		-4.0	+4.0	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		19.5		mV
25V setting for range selection					
V_{In}	ADC input voltage range		0	25	V
$V_{Tol\text{-}R}$	ADC voltage tolerance (zero)		-2	+2	LSB
$V_{Tol\text{-}R}$	ADC voltage tolerance (full scale)		-4.0	+4.0	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		24.4		mV
30V setting for range selection					
V_{In}	ADC input voltage range		0	30	V
$V_{Tol\text{-}R}$	ADC voltage tolerance (zero)		-2	+2	LSB
$V_{Tol\text{-}R}$	ADC voltage tolerance (full scale)		-4.0	+4.0	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		29.3		mV
32V setting for range selection					
V_{In}	ADC input voltage range	3	0	32	V
$V_{Tol\text{-}R}$	ADC voltage tolerance (zero)		-2	+2	LSB
$V_{Tol\text{-}R}$	ADC voltage tolerance (full scale)		-4.0	+4.0	%
LSB	Nominal value of 1 LSB (Full scale / 1024)		32.2		mV

Note 1: Depending on SW-setting.
Note 2: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC} .
Note 3: nominal full scale value is 33.65V. This is higher than the max. permanent input voltage with 32V.

5.10 Board temperature sensor

5.10.1 Pinout:

Connector Pin Number	Function
No connector pin, internal sensor.	Board Temperature Sensor

5.10.2 Functional description:

On board PTC-type temperature sensor. Allows monitoring ECU internal temperature for diagnostic purpose and safety features (strategy to bring machine to safe state and switch off loads in case of over temperature detected)

5.10.3 Characteristics

$T_{ambient}$ = -40° .. 85°C

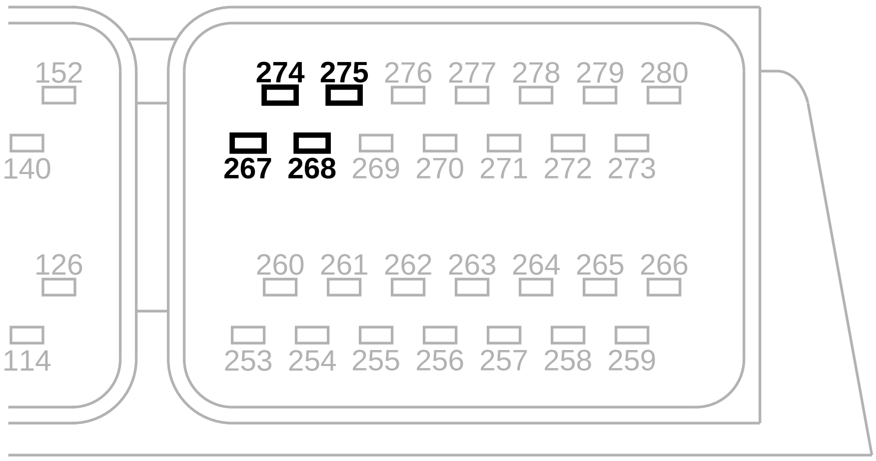
Symbol	Parameter	Note	min	max	Units
T_{op}	measure temperature range		-40	+130	°C
α_{ADC}	Resolution per K at –40°C	1	1.54		LSB
α_{ADC}	Resolution per K at +20°C	1	1.68		LSB
α_{ADC}	Resolution per K at +130°C	1	1.12		LSB
V_{Tol-m}	Temperature tolerance at 120°C	3	-6	+6	K

Note 1: due to characteristic of the sensor the resolution (change of ADC value per degree K) will depend on actual temperature value. Characteristic values are listed for 3 different temperatures.

Wheel Speed Sensor Input (x4) -> Pulses from Vin (14.5V? pg 40) to 0.4V (or lower / gnd)

5.11 Digital input for frequency / timing measurement

5.11.1 Pinout:



Connector Pin Number	Function
P275	Digital Timer Input 0
P268	Digital Timer Input 1
P274	Digital Timer Input 2
P267	Digital Timer Input 3
P116	Digital Timer Input 4 (only for HY-TTC 36X)
P104	Digital Timer Input 5 (only for HY-TTC 36X)
P115	Digital Timer Input 6 (only for HY-TTC 36X)
P103	Digital Timer Input 7 (only for HY-TTC 36X)

5.11.2 Functional description:

Four digital inputs with timer function are provided to process input signals like frequency (rotational speed), pulse count and quadrature decoding (incremental length measurement), PWM etc.
The inputs can be configured with different pull-up / pull-down resistors and input thresholds by software individually to adapt to different sensor types like:
-3pin NPN-type sensors
-3pin PNP-type sensors
-2pin current loop sensors (ABS-type with 7 / 14mA output signal)
-2pin sensors with minimum load current requirement
The input is overload protected in all settings (including current input setting).

Additionally the inputs can also be set to standard digital or analog input with the same pull-up / pull-down options. Supported analog measurement modes are absolute and ratiometric.

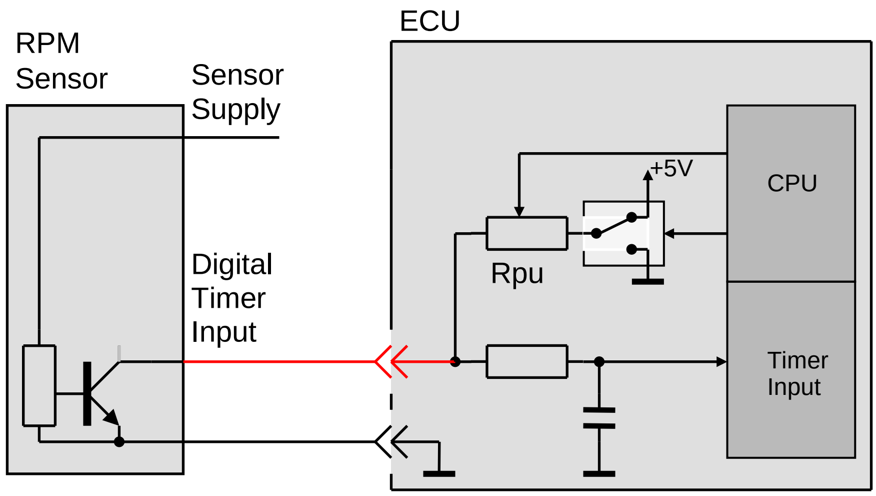


Figure 20: Digital input for frequency / timing measurement with NPN-type 3pole sensor

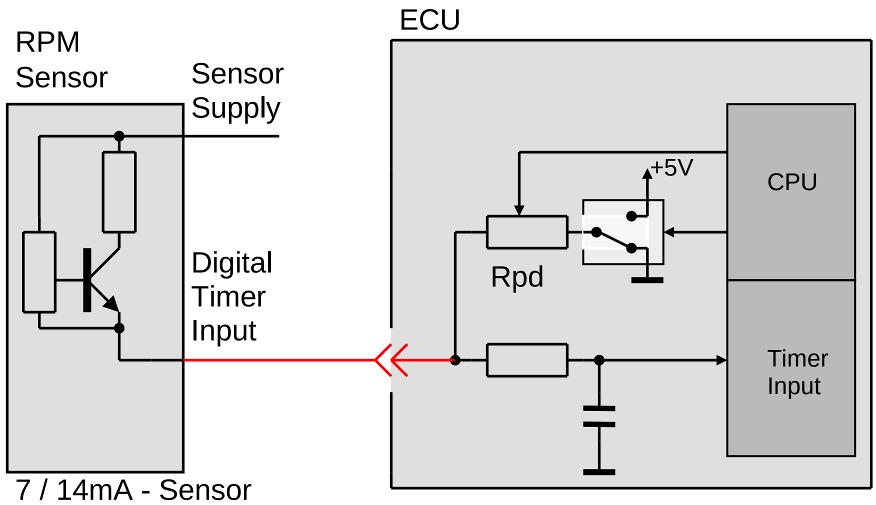


Figure 21: Digital input for frequency / timing measurement with ABS-type 7/14mA 2pole sensor

The quadrature decode function is an input function that uses two dedicated input channel pairs (Digital Timer Input 0+1 and 2 + 3) to decode a pair of out-of-phase signals in order to increment or decrement a (position) counter. It is particularly useful for decoding position and direction information from an encoder in motion control systems, thus replacing expensive external solutions.

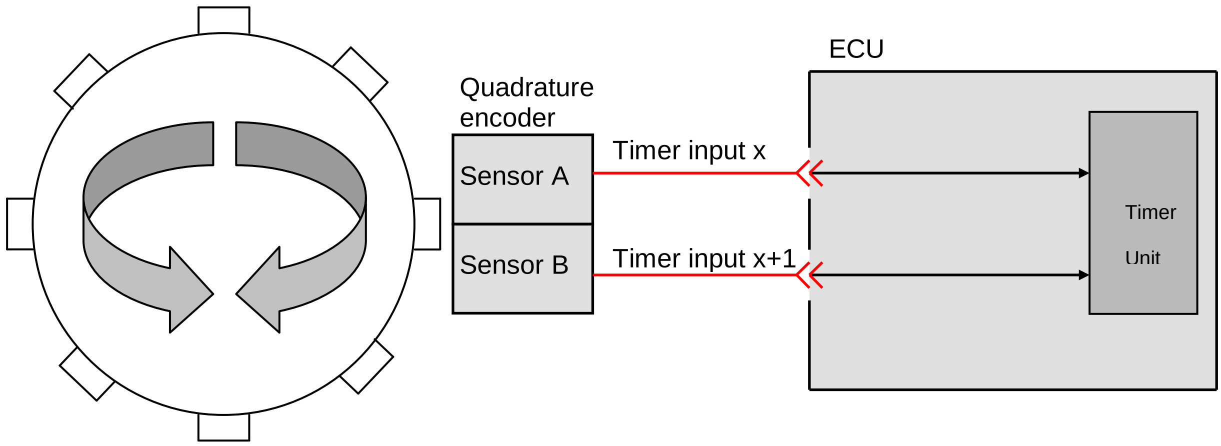


Figure 22: Digital input pair for quadrature encoder

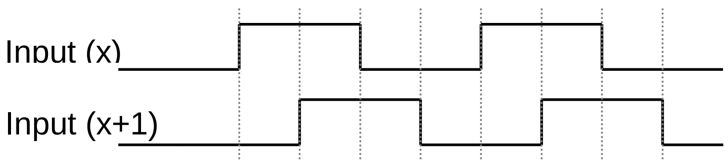


Figure 23: Direction A – channel X leading channel X+1

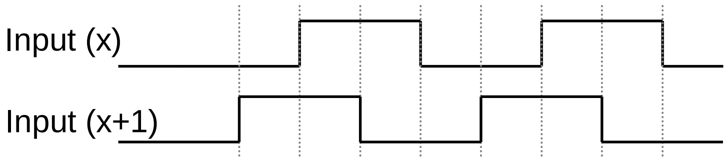


Figure 24: Direction B – channel X lagging channel X+1

Brake rotor will have 10-20 "scallops" (peaks)
80mph = 235 - 470 Hz
10mph = 29 - 59 Hz
1mph = 3 - 6 Hz

5.11.3 Maximum ratings

T_{ambint} = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions		-1	32	V

5.11.4 Characteristics digital parameters

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
R_{pu}	Pullup resistor to V_{CC}	1	9.5	10.5	kΩ
R_{pd}	Pulldown resistor to GND (standard)	2	9.5	10.5	kΩ
R_{pd}	Pulldown resistor to GND (strong)	3	1.75	1.85	kΩ
R_{pd}	Pulldown resistor to GND (current loop)	4	105	115	Ω
τ_{in}	Input low pass filter (digital path)	10	4	6	µs
τ_{in}	Input low pass filter (digital path)	11	8	12	µs
F_{max}	Maximum input frequency range	5	10		kHz
F_{max}	Maximum input frequency range	6	20		kHz
F_{min}	Minimum input frequency	7	0.02		Hz
t_{min}	Minimum pulse / pause length to be measured by Timer unit	7	20		µs
V_{IL}	Input voltage for low level	8	-1	1.8	V
V_{IH}	Input voltage for high level	8	3.2	U_{Bat}	V
V_{IL}	Input voltage for low level	9	-1	1.1	V
V_{IH}	Input voltage for high level	9	1.3	U_{Bat}	V
V_{IL}	Input voltage for low level	11	-0.5	1.8	V
V_{IH}	Input voltage for high level	11	4.2	U_{Bat}	V

Note 1: with software setting for pull up resistor
Note 2: with software setting for pull down resistor
Note 3: with software setting for strong pull down resistor
Note 4: with software setting for current loop sensors (for 7 / 14mA ABS-type sensors)
Note 5: limit for sensors with open drain / open collector output due to input capacitance
Note 6: limit for sensors with either push-pull or current loop output
Note 7: dependent on configuration of timer prescaler in software; due to the dynamic range of the timer there is a minimum frequency when timer overflow will occur. At lower frequencies the output value will be read as 0 Hz.
Note 8: with software setting for standard threshold
Note 9: with software setting for current loop sensors (for 7 / 14mA ABS-type sensors)
Note 10: Digital Timer Input 0-3
Note 11: Digital Timer Input 4-7

5.11.5 Characteristics analog parameters

This chapter doesn't apply for the Digital Timer Inputs 4-7.

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
R_{pu}	Pullup resistor to V_{CC}	1	9.5	10.5	kΩ
R_{pd}	Pulldown resistor to GND (standard)	2	9.5	10.5	kΩ
R_{pd}	Pulldown resistor to GND (strong)	3	1.75	1.85	kΩ
R_{pd}	Pulldown resistor to GND (current loop)	4	105	115	Ω
$I_{7\text{-}14min}$	Input current 7/14mA sensor SRC low	5	4	5	mA
$I_{7\text{-}14max}$	Input current 7/14mA sensor SRC high	6	20	21	mA
V_{In}	ADC input voltage range		0	VCC	V
τ_{in}	Input low pass filter (analog path)		0.7	1.3	ms
V_{Tol}	ADC voltage tolerance	7	-25	+25	mV
LSB	Nominal value of 1 LSB (Full scale / 1024)		4.88		mV

Note 1: with software setting for pull up resistor
Note 2: with software setting for pull down resistor
Note 3: with software setting for strong pull down resistor
Note 4: with software setting for current loop sensors (for 7 / 14mA ABS-type sensors)
Note 5: failure detection window for defect 7/14mA sensor with too low current
Note 6: failure detection window for defect 7/14mA sensor with too high current. If the current exceeds the maximal input current, then the overload protection gets active.
Note 7: V_{CC} is the reference voltage of the ADC. Therefore measurement is referred to V_{CC}. For total tolerance including sensor in mode 3 (ratiometric measuring) when using the built in sensor supply (by reading back the offset) V_{CC} is not a parameter in error calculation. Mode 1 and mode 2 are not supported.

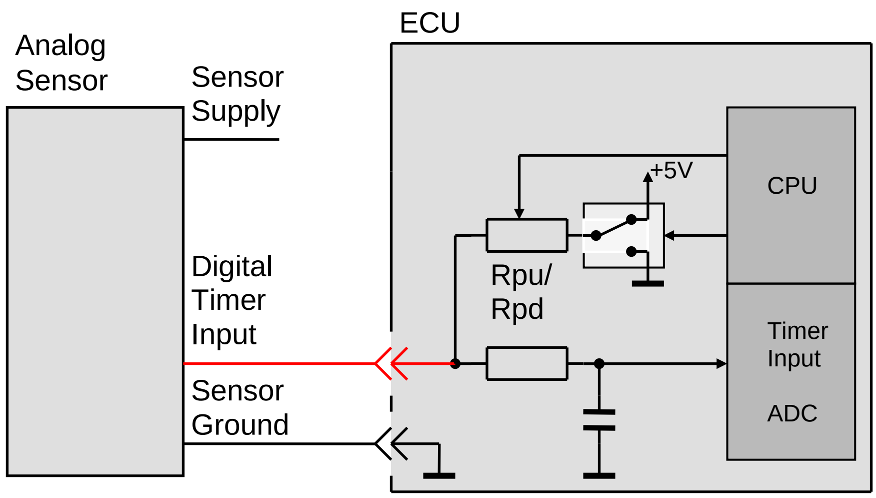
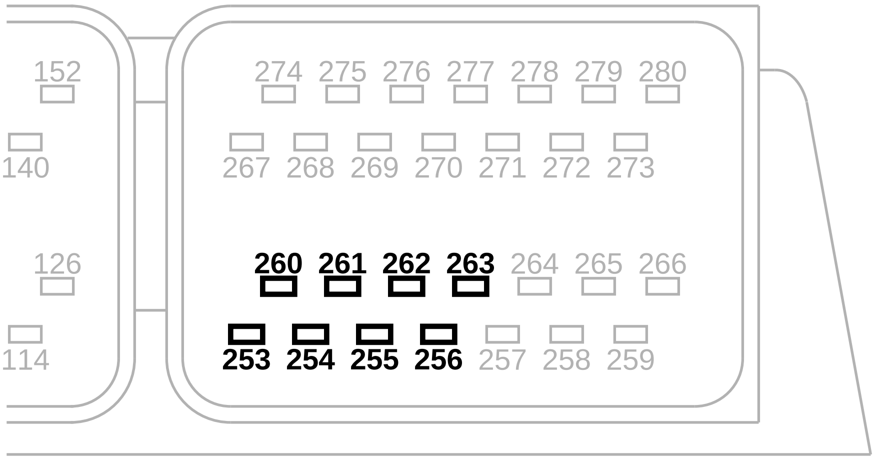


Figure 25: Digital input used for measuring analog voltages

5.12 Digital inputs

5.12.1 Pinout:



Connector Pin Number	Function
P263	Digital Input 0
P256	Digital Input 1
P262	Digital Input 2
P255	Digital Input 3
P261	Digital Input 4
P254	Digital Input 5
P270	Digital Input 6
P253	Digital Input 7

5.12.2 Functional description:

General purpose digital input, typically used to read switch settings. The input can be tied to ground or supply voltage (Sensor Supply or BAT+) or left open.

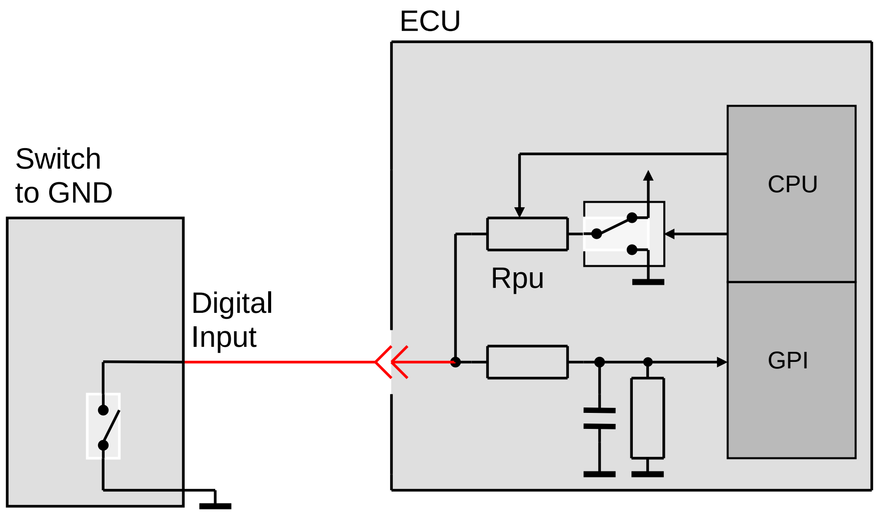


Figure 26: Digital input for reading switch connected to ground.

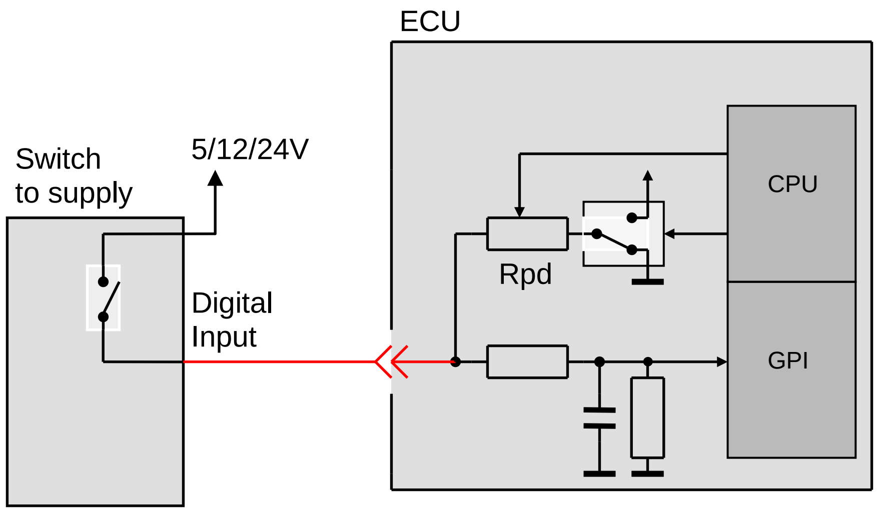


Figure 27: Digital input for reading switch connected to (battery) supply voltage

5.12.3 Maximum ratings

T_{ambint} = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions		-1	32	V

5.12.4 Characteristics

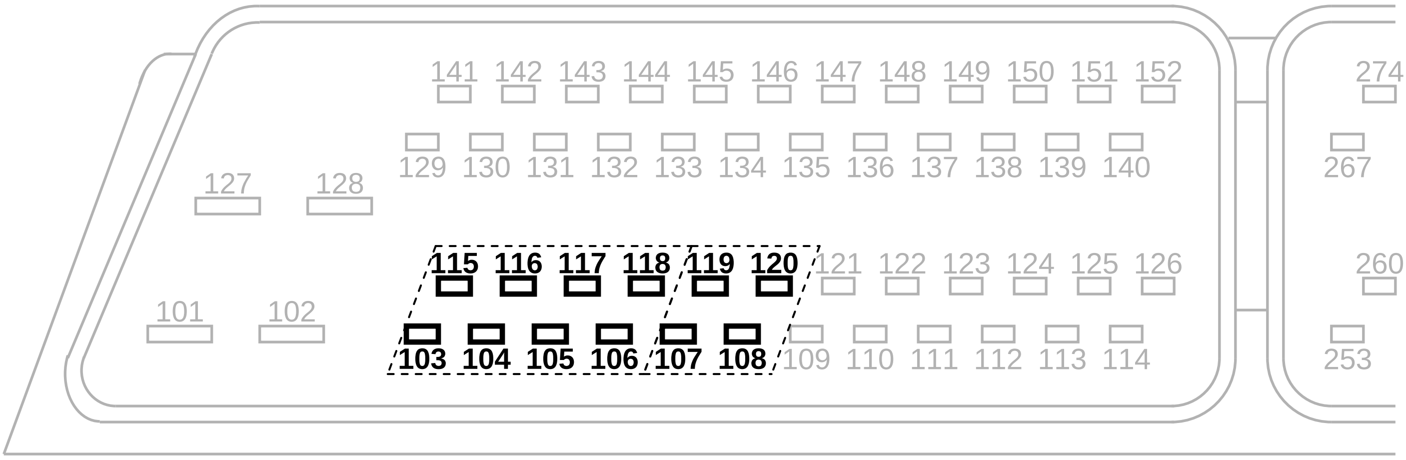
$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		4	6	nF
R_{pu}	Pullup resistor to V_{CC}	1	9.00	9.25	kΩ
R_{pd}	Pulldown resistor to GND (standard)	2	9.00	9.25	kΩ
R_{pd}	Pulldown resistor to GND (strong)	3	1.75	1.80	kΩ
τ_{in}	Input low pass filter		1	1.5	ms
V_{IL}	Input voltage for low level		-1	1.8	V
V_{IH}	Input voltage for high level		4.2	U_{Bat}	V

Note 1: with software setting for pull up resistor
Note 2: with software setting for pull down resistor
Note 3: with software setting for strong pull down resistor

5.13 Power output 2A high side with PWM-control

5.13.1 Pinout:



Connector Pin Number	Function
P118	Power Output PWM 0
P106	Power Output PWM 1
P117	Power Output PWM 2
P105	Power Output PWM 3
P116	Power Output PWM 4 (not for HY-TTC 36X)
P104	Power Output PWM 5 (not for HY-TTC 36X)
P115	Power Output PWM 6 (not for HY-TTC 36X)
P103	Power Output PWM 7 (not for HY-TTC 36X)
P120 (+ optional 122)	Current Measurement Input 0
P108 (+ optional 110)	Current Measurement Input 1
P119 (+ optional 121)	Current Measurement Input 2
P107 (+ optional 109)	Current Measurement Input 3

For optional pins please see section 5.18 Mini Module and 5.17 CAN interface ISO 11898.

This sounds like cool stuff if we wanted to do, say, active aero/steering

5.13.2 Functional description:

Power output stage with freewheeling diode for inductive loads with low-side connection.
Load current is controlled with PWM.
For better accuracy and diagnostics a current measurement/feedback loop is provided.

Static friction and stiction can cause a hysteresis and make the control of a hydraulic valve erratic and unpredictable. In order to counteract these hysteretic effects, small vibrations about the desired position shall be created in the valve. This constantly breaks the static friction ensuring that it will move even with small input changes, and the effects of hysteresis are average out. A proper setting of PWM frequency according to the resonance frequency of the actuator allows to adjust this desired small vibration, low enough in amplitude to prevent noticeable oscillations on the hydraulic output but sufficient high to prevent friction.
The PWM frequency can be set in the range of 50 .. 1000Hz, a typical range for hydraulic valves to operate without friction is 90 .. 160Hz. The max frequency is 1000Hz, but be careful, the power switches work only correct with max. 200Hz at full load. If the frequency is higher than 200Hz and the full load is applied on the power output, this can damage the power stages!

Output stage will be disabled (off state) by either watchdog CPU or main CPU if an error is detected in a safety-critical resource.

For diagnostic and safety reasons the actual PWM output signal is looped back to a timer input and the measured value is compared to the set value. For safety critical applications fast error detection is necessary. For this reason a permanent PWM output is available, setting a minimum pulse / pause to 100/250µs instead of 0 or 100% duty cycle. This means, there is a reliable periodical state change of the output allowing permanent load monitoring independent of the operation point. So even when the load is not powered a short on the load can be detected.

5.13.3 Alternate functions:

When the pulse width modulation is not needed, the output can be configured as simple digital output. Instead of comparing output PWM to loopback PWM value the static level is compared.

When the output is not used, the loop-back input can be used as timer input with frequency or pulse width measurement mode (see section *5.11 digital input for frequency / timing measurement*). The sensor's output stage shall be either open collector / open drain or push-pull type.

The current sense path can be used either for PWM load current measurement or as digital output. See chapter 5.13.9 Current Measurement Inputs.

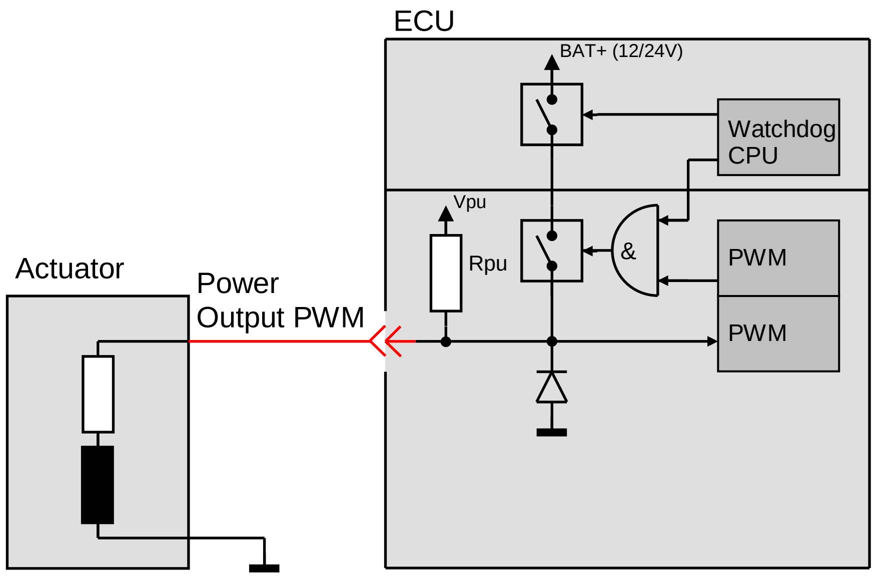


Figure 28: Power output 2A high side without current monitoring

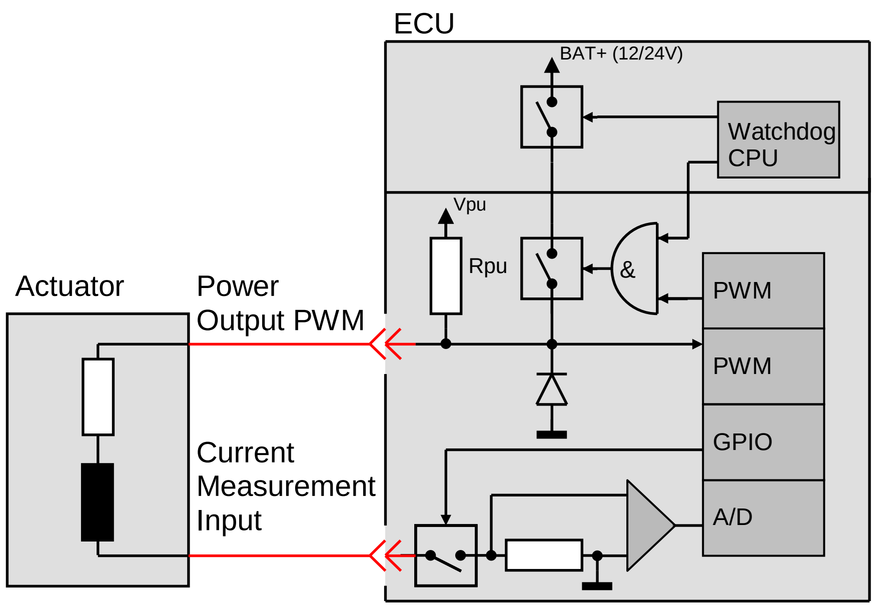


Figure 29: Power output 2A high side with current monitoring

5.13.4 Maximum ratings

T_{ambint} = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions		-0.5	U_{Bat}+0.5	V

5.13.5 Characteristics of PWM high side output stage

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{out}	Pin input capacitance		8	12	nF
R_{pu}	Pullup resistor to internal 5V supply		9.5	10.5	kΩ
V_{pu}	Internal supply for pull up		4.85	5.25	V
f_{PWM}	PWM-frequency	1	50	1000	Hz
T_{min-on}	Minimum pulse	2	100		µs
$T_{min-offM}$	Minimum pause	2	250		µs
R_{on}	On-resistance			200	mΩ
I_{load}	Nominal load current		0	2.0	A
$I_{load-lim}$	Internal current limitation for PTC-type loads	3	9		A

Note 1: The max frequency is 1000Hz, but be careful, the power switches work only correct with max. 200Hz at full load. If the frequency is higher than 200Hz and the full load is applied on the power output, this can damage the power stages!
Note 2: Instead of 0% resp. 100% output a minimum pulse resp. pause duration is inserted automatically when the output is configured to be safety critical. This is necessary for optimal load diagnostic.
Note 3: incandescent lamps with cold filament have a surge current 10 times higher than nominal current.

5.13.6 Characteristics of static (on/off) high side output stage

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{out}	Pin input capacitance		8	12	nF
R_{pu}	Pullup resistor to internal 5V supply		9.5	10.5	kΩ
V_{pu}	Internal supply for pull up		4.85	5.25	V
R_{on}	On-resistance			200	mΩ
I_{load}	Nominal load current		0	2.0	A
I_{load}	Nominal load current	1	0	2.0	A
I_{load}	Nominal load current per output stage	2	0	4.0	A
$I_{load(sum)}$	Total load current for all PWM-type output stages	2		16.0	A
$I_{load-lim}$	Internal current limitation for PTC-type loads	3	9		A

Note 1: 2.0A is the maximum current per output stage. The load off all other output stages does not influence this value.
Note 2: Higher load current is possible (up to 4A) if the total current of all 8 outputs of this group (with a mix of outputs either used as PWM- or as static output) will be less than 16A.
For PWM operation the maximum current is 2A per output stage, in case of PWM operation on all PWM outputs the total current is in any case less than 16A (8*2A).
Note 3: incandescent lamps with cold filament have a surge current 10 times higher than nominal current.

5.13.7 Characteristics of frequency input (alternate function of output stage)

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		8	12	nF
R_{pu}	Pullup resistor to internal 5V supply		9.5	10.5	kΩ
V_{pu}	Internal supply for pull up		4.85	5.25	V
τ_{in}	Input low pass filter		3.5	6.5	µs
F_{max}	Maximum input frequency	1	5		kHz
F_{max}	Maximum input frequency	2	10		kHz
F_{min}	Minimum input frequency	3	10		Hz
t_{min}	Minimum pulse / pause length to be measured by timer input		50		µs
V_{IL}	Input voltage for low level		-0.5	1.8	V
V_{IH}	Input voltage for high level		4.2	U_{Bat}	V

Note 1: with open collector / open drain sensor output
Note 2: with push / pull sensor output stage or sensor internal pull-up of 10kΩ or below.
Note 3: due to the dynamic range of the timer there is a minimum frequency when timer overflow will occur. At even lower frequency the output value will be read as 0 Hz.

5.13.8 Load Diagnostic Function PWM High Side Output

Load monitoring means detection of overload, external short circuits of the load output to positive or negative supply (BAT+ / BAT-) or any other power output and detection of loss of load.
Overload protection and temperature sensing is integrated in the output stage.

The diagnostic functions are different between PWM and digital operation:

5.13.8.1 for PWM operated High Side Output (duty cycle 0% < X <100%)

Under normal load conditions the status signal follows the corresponding PWM output. In case of a disconnected load (open load) the signal is pulled to 5V (high level) by an internal resistor. If a short circuit to ground exists, the status signal is constant zero (low level). A short circuit to U_{BAT} implicates that the status signal is also pulled to U_{BAT} (high level).

Output Signal	Status Signal			
	Normal	Open Load	Short to GND	Short to U_{BAT}
0% < X < 100%	●	●	●	●

● detected / ok
○ not detected

5.13.8.2 for Digital operated High Side Output (duty cycle 0 or 100%)

When the power stage is switched off the monitoring interface will read back low level if the load is properly connected or if a short circuit to ground exists. In case of open load or a short circuit to UBAT+ the monitoring interface will read back high level.
When the power stage is switched on, a high level will be read back in case of normal operation. In case of excessive overload or short circuit to ground the output switches off in order to protect the output stage. In this case the monitoring interface will read back a low-level.

Output Signal	Status Signal			
	Normal	Open Load	Short to GND	Short to U_{BAT}
on	●	○	●	○
off	●	●	○	●

● detected / ok
○ not detected

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
$R_{load\text{-}nom}$	Load resistance for proper operation (24V supplied system: V_{BATmax} =32V)	1	13 (0.5)	1700	Ω
$R_{load\text{-}nom}$	Load resistance for proper operation (12V supplied system: V_{BATmax} =16V)	1	6.5 (0.5)	1700	Ω
$R_{openload}$	Open load threshold	2		20	kΩ
$I_{load\text{-}OVL}$	Temperature limited current	3	4		A
$I_{load\text{-}lim}$	Internal current limitation for PTC-type loads	4	9		A
$I_{load\text{-}lim}$	Internal current limitation	5	2.30	2.60	A

Note 1: Resistance values in that range will neither generate overload (min-value) nor open load (max-value) detection.
Loads with any resistor value in that window will be detected as normal load.
For PWM current controlled inductive loads there is only a virtual lower limit (value in brackets) to keep the control loop stable.

Note 2: Resistance values higher than this threshold will be detected as open load.

Note 3: Overload is defined by chip temperature. Due to the thermal design of the ECU this limit will be influenced by the number of outputs activated with high current simultaneously and ambient temperature. This is the worst case value for maximum allowed over-all load and highest temperature.

Note 4: Internal current limit for short circuit protection to limit excessive power dissipation.
Overload protection is done typically by detecting over temperature.

Note 5: For protection of the current sense resistors the output duty cycle will be regulated by software to a maximum load current of 2.45A typ.

5.13.9 Current Measurement Inputs

For actuators requiring precision current control this type of input provides a measurement unit with overload protection. The current flows through a sensing resistor is amplified and low pass filtered to deliver an average value and suppress ripple current introduced by PWM-control.
In case of overload a switch disconnects the overloaded input for 1 second and then switches on again. 4 inputs of this type are available to support up to 8 PWM outputs. In case of 2 loads that will never be operated at the same time, 2 outputs can share 1 input, for example 2 proportional valves, one for forward, the other for backward movement. For that reason in standard configuration (without mini module) any current measurement input is connected to a pair of connector pins.

If a current input is not needed, it can be also used as low side switch with diagnostic function.

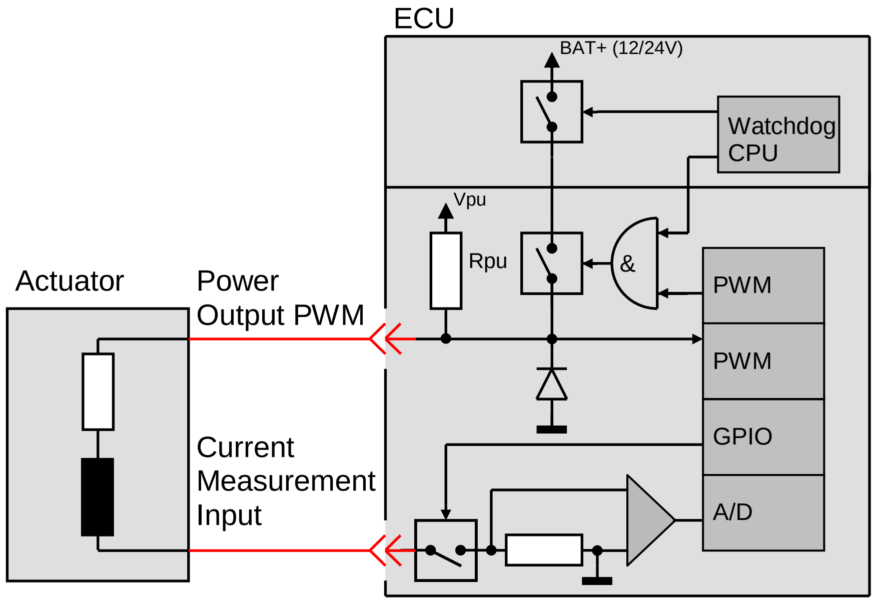


Figure 30: Power output 2A high side with current monitoring

5.13.10 Characteristics of Current Measurement Input

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{Out}	Shunt factor	1	2.00		V/A
I_{FS}	Full scale nominal current	1	2.50		A
$I_{Tol\text{-}M}$	Accuracy	2	-5	+5	%[FS]
	Proportional factor (at nominal load current)	2	-125	+125	mA
$I_{Tol\text{-}0}$	Accuracy	3	-2.0%	+2.0%	%[FS]
	Zero reading (no load current)	3	-50	+50	mA
f_{g_LP}	Cut off frequency of 3rd order low pass filter	4	6	10	Hz
		5	10	20	Hz

Note 1: current is measured with a ground referenced shunt, amplified and connected to an ADC input.
1A load current will bring 2V ADC input voltage.
Please note that 2.45A is the nominal current without any tolerance.
0 .. 2.30A is the nominal operating range for peak current.

Note 2: Current measurement gives absolute values and does not work ratiometric to the ADC's reference. Therefore absolute tolerance of ADC supply is also included.

Note 3: The ADC can only measure positive values.
With a negative zero reading current a small output current of the same absolute value is necessary to get ADC-values greater than zero.

Total error is the sum of proportional error and zero reading error:

$$TUE = \pm \left| I_{Tol-M} * I_L \pm I_{Tol-0} \right|$$

Note 4: An active low pass filter (3rd order) is provided to remove current ripple from the ADC input

Note 5: Variants with this kind of fast filter are available on request.

5.13.11 Alternate Function Low Side Output

If a current input is not needed, it can be also used as low side switch with diagnostic function. When using highly inductive loads operated at high current values the maximum switch-off energy must be calculated carefully not to overload the output clamping. For inductive actuators exceeding the dissipation limit an external freewheeling diode must be added.

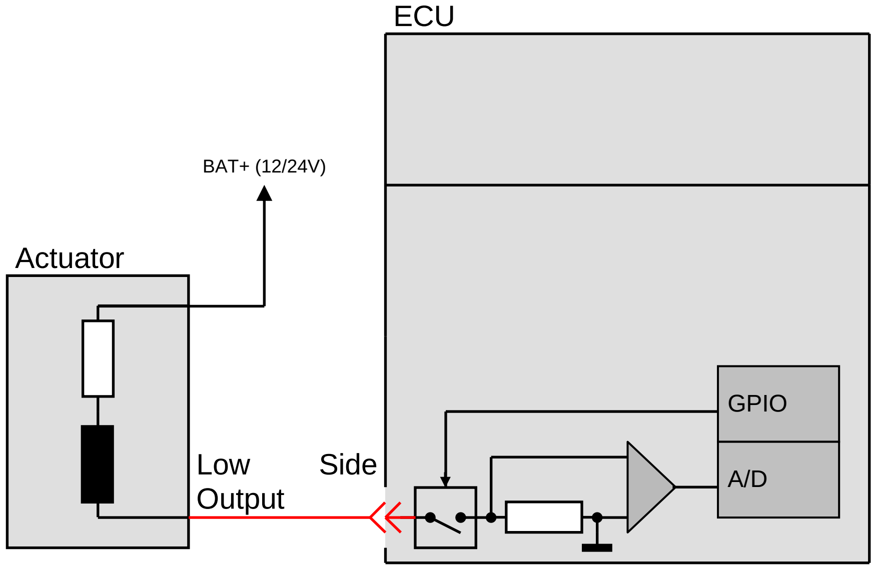


Figure 31: Power output 2A low side

5.13.12 Example for switch off energy calculation for inductive loads:

In this example an inductive load is operated at 24V and the actuator draws the maximum specified output current of 2A. When switching off the stored energy in the inductance, the output is driven to negative until the output stage clamps. In this example this happens at approx. 50V referred to GND. The current linearly decreases from 2A to 0 within 1ms at almost constant clamp voltage. So also the power dissipated in the output stage decreases, from 100W (2A*50V) down to 0. For a time of 1ms the average power in the clamping phase is 50W, which equals to 50mWs or 50mJ, which is well below the limit of 170mJ.

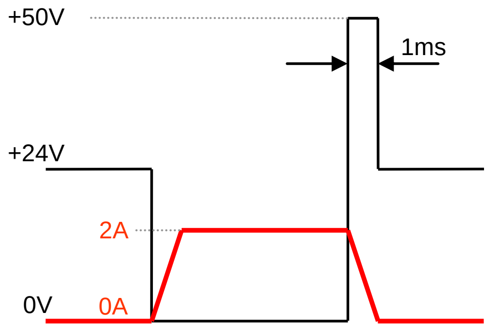


Figure 32: Power output 2A switch off waveform

5.13.13 Characteristics of Low Side Switch

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter (single power stage)	Note	min	max	Units
C_{in}	Pin input capacitance		8	12	nF
R_{on}	On-resistance			200	mΩ
I_{load}	Nominal load current		0	2	A
I_{load}	Permanent load current	1	0.03	2.3	A
$I_{load\text{-}lim}$	Internal current limitation for PTC-type loads	2	9		A
E_{AS}	Maximum switch off energy dissipation	3		170	mJ
$Z_{l\text{-}max}$	Maximum switchable inductive load	3		20	mH

Note 1: Load diagnostic is based on current measurement during on-phase.
The limits are the minimum / maximum permanent (DC) current that will not trigger low load detection or overload protection

Note 2: incandescent lamps with cold filament have a surge current 10 times higher than nominal current.

Note 3: with I_{load} = 2A, Z_L = 20mH, R_{DC} = 0Ω. Typical electromagnetic valves have R_{DC} in excess of 5Ω, thus reducing the energy to be clamped by the output stage.

5.13.14 Load Diagnostic Function

Load monitoring means detection of overload, external short circuits of the load output to positive or negative supply (BAT+ / BAT-) or any other power output and detection of loss of load.

With this output stage load diagnostic is based on current measurement. Therefore short circuit / open load detection is both made during on-phase. In case of excessive overload or short circuit to BAT+ the output switches off in order to protect the output stage.

Output Signal	Status Signal			
	Normal	Open Load	Short to GND	Short to U_{BAT}
on	●	●	○	●
off	●	○	○	○

● detected / ok
○ not detected

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter (single power stage)	Note	min	max	Units
$R_{load\text{-}nom}$	Load resistance for proper operation (24V supplied system: V_{BATmax} =32V)	1	16	800	Ω
$R_{load\text{-}nom}$	Load resistance for proper operation (12V supplied system: V_{BATmax} =16V)	1	8	400	Ω
$R_{openload}$	Open load threshold	2		5	kΩ
$I_{load\text{-}OVL}$	Protection limited current	3	2.3	2.5	A
$I_{load\text{-}lim}$	Internal current limitation for PTC-type loads	4	9		A

Note 1: Resistance values in that range will neither generate overload (min-value) nor open load (max-value) detection.
Loads with any resistor value in that window will be detected as normal load.

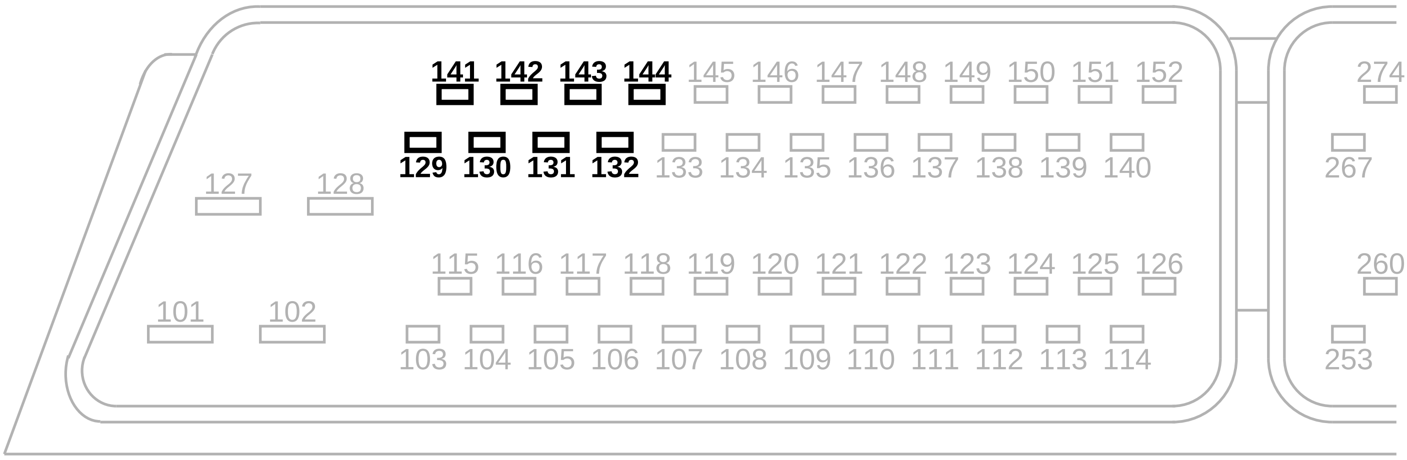
Note 2: Resistance values higher than this threshold will be detected as open load.

Note 3: After some milliseconds operated in or above this current range the internal overload protection will switch off the output.

Note 4: Internal current limit for short circuit protection to limit excessive power dissipation.

5.14 Power output 4A high side

5.14.1 Pinout:



Connector Pin Number	Function
P144	Power Output 0
P132	Power Output 1
P143	Power Output 2
P131	Power Output 3
P142	Power Output 4
P130	Power Output 5
P141	Power Output 6
P129	Power Output 7

5.14.2 Functional description:

Power output stage for resistive loads with low-side connection.
Suitable loads are lamps, valves, relays etc.
When using highly inductive loads operated at high current values the maximum switch-off energy must be calculated carefully not to overload the output clamping. For inductive actuators exceeding the dissipation limit an external freewheeling diode must be added.

Output stage will be disabled (off state) by either watchdog CPU or main CPU if an error is detected in a safety-critical resource.

For diagnostic reasons the output signal is looped back to the CPU and the measured value is compared to the set value. When the output is not used, the loop-back signal can be used as analog input with an internal 10kΩ pullup resistor. Absolute and ratiometric modes (referred to a sensor supply) are supported.

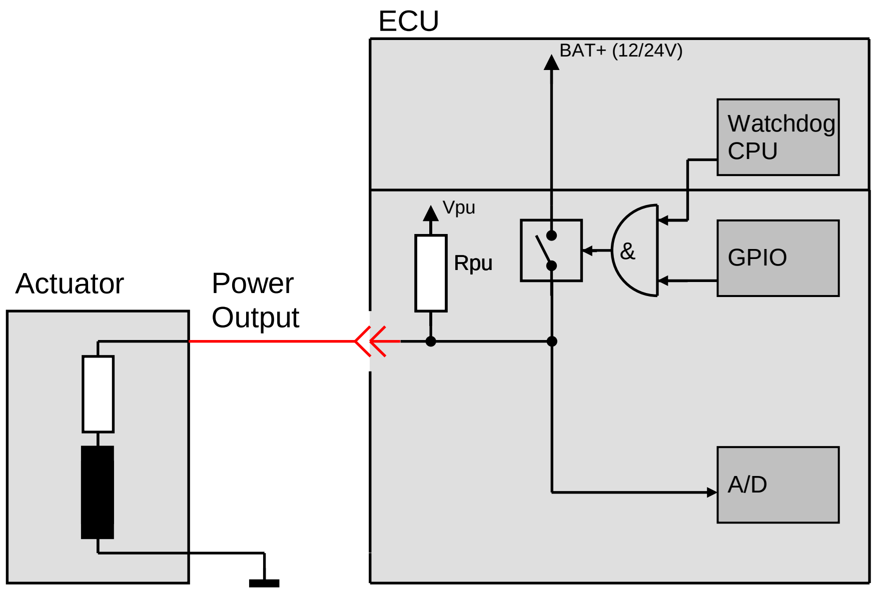


Figure 33: Power output 4A high side

5.14.3 Example for switch off energy calculation for inductive loads:

In this example an inductive load is operated at 24V and the actuator draws the maximum specified output current of 4A. When switching off the stored energy in the inductance, the output is driven to negative until the output stage clamps. In this example this happens at 50V (24+26V, referred to BAT+). The current linearly decreases from 4A to 0 within 1ms at almost constant clamp voltage. So also the power dissipated in the output stage decreases, from 200W (4A*50V) down to 0. For a time of 1ms the average power in the clamping phase is 100W, which equals to 100mWs or 100mJ, which is well below the limit of 170mJ.

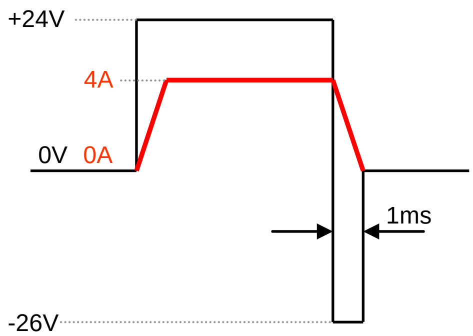


Figure 34: Power output 4A switch off waveform

5.14.4 Maximum ratings

T_{ambint} = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	In-/output voltage under overload conditions	1	-1	U_{bat}+0.5	V

Note 1: inductive load negative transients will be clamped internally to <52V referred to BAT+.

5.14.5 Characteristics of output stage

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter (single power stage)	Note	min	max	Units
C_{in}	Pin input capacitance		8	12	nF
R_{pu}	Pullup resistor to internal 5V supply		9.5	10.5	kΩ
V_{pu}	Internal supply for pull up		4.85	5.25	V
R_{on}	On-resistance			200	mΩ
I_{load}	Nominal load current		0	4	A
$I_{load-lim}$	Internal current limitation for PTC-type loads	1	9		A
E_{AS}	Maximum switch off energy dissipation	2		170	mJ
Z_{l-max}	Maximum switchable inductive load	2		20	mH

Note 1: incandescent lamps with cold filament have a surge current 10 times higher than nominal current.

Note 2: with I_{load} = 4A, Z_L = 20mH, R_{DC} = 0Ω . Typical electromagnetic valves have R_{DC} in excess of 5Ω, thus reducing the energy to be clamped by the output stage.

5.14.6 Characteristics of analog input (alternate function of output stage)

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{in}	Pin input capacitance		8	12	nF
R_{pu}	Pullup resistor to internal 5V supply		9.5	10.5	kΩ
V_{pu}	Internal supply for pull up		4.85	5.25	V
τ_{in}	Input low pass filter		0.7	1.3	ms
V_{CC}	ADC reference voltage		4.85	5.15	V
V_{CC}	ADC reference voltage		4.85	5.15	V
V_{In}	ADC input voltage range		0	V_{CC}	V
V_{Tol}	ADC voltage tolerance		-25	+25	mV
LSB	Nominal value of 1 LSB (Full scale / 1024)		4.88		mV

5.14.7 Load Diagnostic Function

Load monitoring means detection of overload, external short circuits of the load output to positive or negative supply (BAT+ / BAT-) or any other power output and detection of loss of load.
Overload protection and temperature sensing is integrated in the output stage.

When the power stage is switched off the monitoring interface will read back low level if the load is properly connected or if a short circuit to ground exists. In case of open load or a short circuit to UBAT+ the monitoring interface will read back high level.

When the power stage is switched on, a high level will be read back in case of normal operation. In case of excessive overload or short circuit to ground the output switches off in order to protect the output stage. In this case the monitoring interface will read back a low-level.

Output Signal	Status Signal			
	Normal	Open Load	Short to GND	Short to U_{BAT}
on	●	○	●	○
off	●	●	○	●

● detected / ok
○ not detected

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter (single power stage)	Note	min	max	Units
$R_{load\text{-}nom}$	Load resistance for proper operation (24V supplied system: V_{BATmax} =32V)	1	8	1700	Ω
$R_{load\text{-}nom}$	Load resistance for proper operation (12V supplied system: V_{BATmax} =16V)	1	4	1700	Ω
$R_{openload}$	Open load threshold	2		20	kΩ
$I_{load\text{-}OVL}$	Temperature limited current	3	4		A
$I_{load\text{-}lim}$	Internal current limitation for PTC-type loads	4	9		A

Note 1: Resistance values in that range will neither generate overload (min-Value) nor open load (max-value) detection.
Loads with any resistor value in that window will be detected as normal load.

Note 2: Resistance values higher than this threshold will be detected as open load.

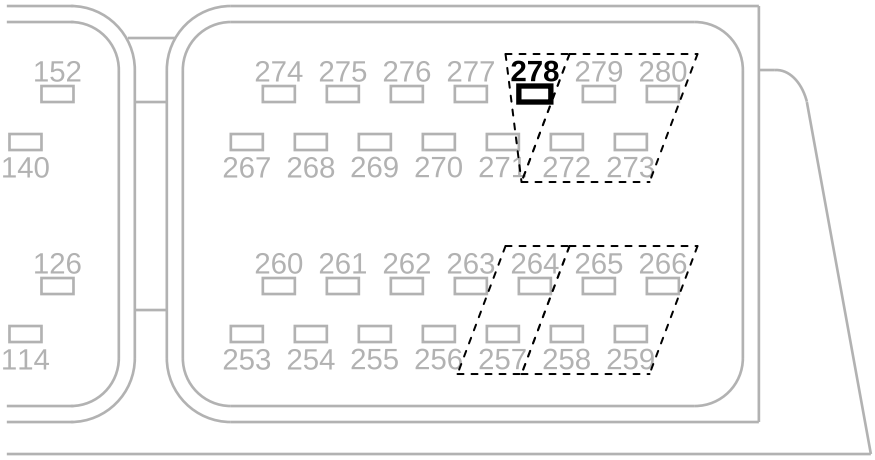
Note 3: Overload is defined by chip temperature. Due to the thermal design of the ECU this limit will be influenced by the number of outputs activated with high current simultaneously and ambient temperature. This is the worst case value for maximum allowed over-all load and highest temperature.

Note 4: Internal current limit for short circuit protection to limit excessive power dissipation.
Overload protection is done by detecting over temperature.

5.15 LIN interface

Note: The LIN interface is not available on HY-TTC 36X/48X/48XS.

5.15.1 Pinout:



Connector Pin Number	Function
P278	Lin Bidirectional Signal Line

5.15.2 Functional description:

LIN[1] is a bidirectional half duplex serial bus for up to 10 nodes.

[1] Note1: The HY-TTC 50 is the LIN master. The LIN standard is only defined for 12V supply.

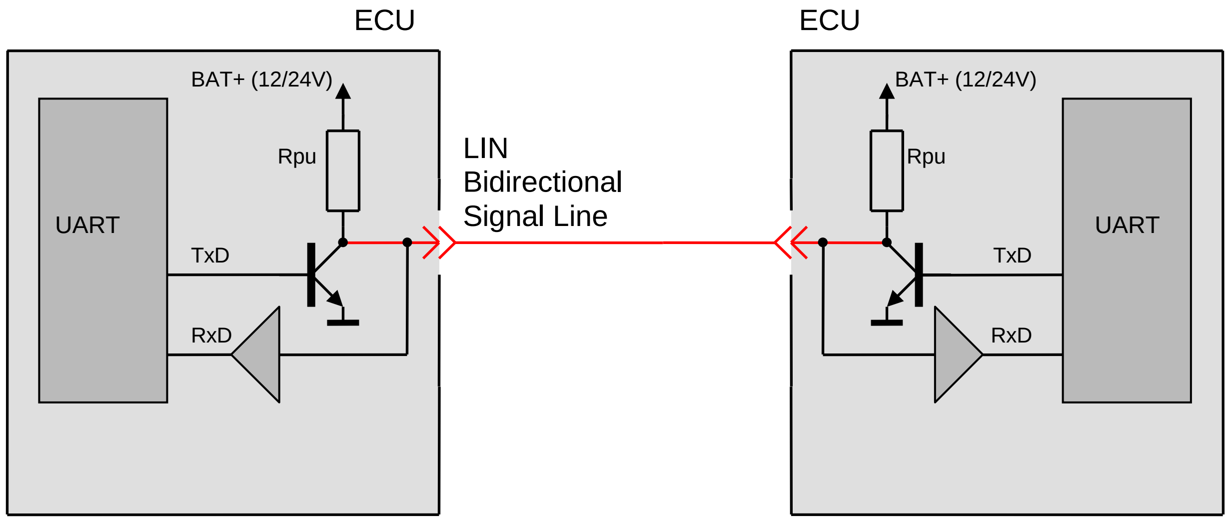


Figure 35: half duplex interface

Please note that a common ground (chassis) or a proper ground connection is necessary for LIN operation. In case of connecting via connectors (e.g. to a PC with LIN-interface) please make sure that the maximum voltage ratings are not violated when connecting to or disconnecting from the LIN-connection.

5.15.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{LIN}	Bus voltage under overload conditions (i.e short circuit to supply voltages)		-1	32	V

5.15.4 Characteristics

$T_{ambient}$ = -40° .. 85°C

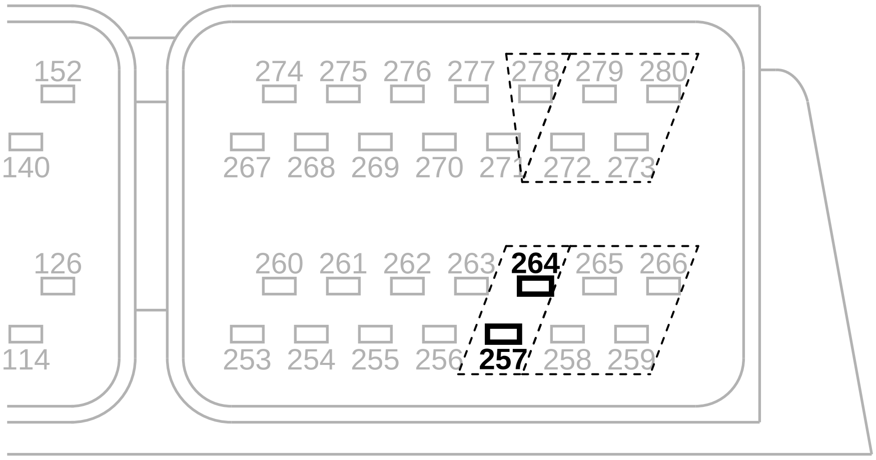
Symbol	Parameter	Note	min	max	Units
C_{out}	Pin output capacitance		100	150	pF
V_{IL}	Input voltage for low level		-1	0.3*U_{Bat}	V
V_{IH}	Input voltage for high level		0.7*U_{Bat}	U_{Bat}	V
V_{OL}	Output low voltage @ 10mA			1.1	V
V_{pu}	Pullup supply voltage	1	U_{Bat} –1.5	U_{Bat}	V
V_{pu}	Pullup supply voltage	2	13	15	V
R_{pu}	Pullup resistor		0.9	1.1	kΩ
S_{Tr}	Data-rate			20	kbd

Note 1: with reverse polarity protection diode, for battery supply voltage less than 14.5V
Note 2: with voltage limiter active, for battery supply voltage higher than 14.5V

5.16 RS232 interface

Note: The RS232 interface is not available on HY-TTC 36X/48X/48XS.

5.16.1 Pinout:



Connector Pin Number	Function
P257	RS232 Serial Interface Output (TX)
P264	RS232 Serial Interface Input (RX)

5.16.2 Functional description:

RS232 is used as a full duplex serial interface. Note that handshake lines (RTS, CTS, …) are not available.

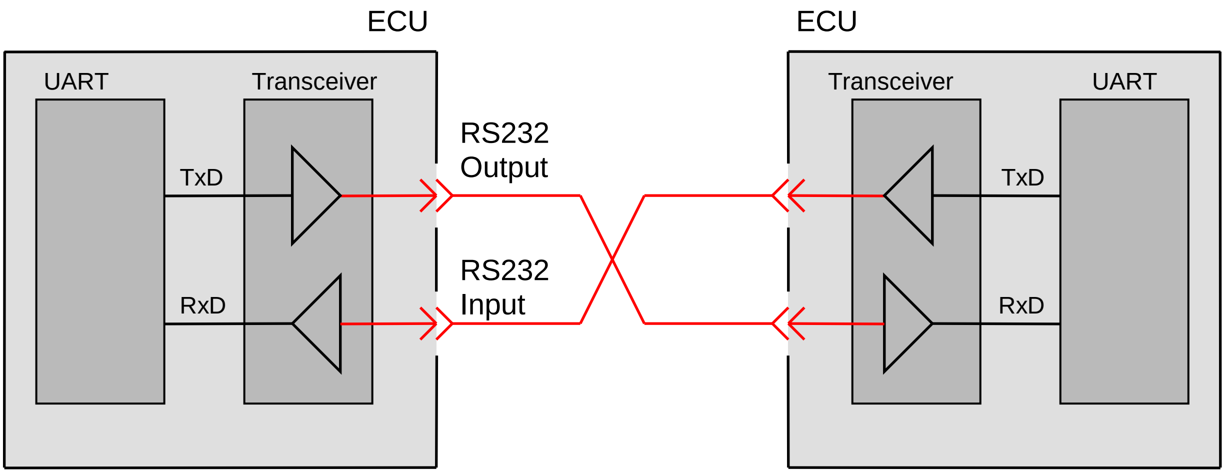


Figure 36: RS232 interface

Please note that a common ground (chassis) or a proper ground connection is necessary for RS232 operation. In case of connecting with an external device (e.g. PC with RS232-interface) please make sure that the maximum voltage ratings are not violated when connecting to or disconnecting from the RS232-connection.

5.16.3 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{RS232x}	Bus voltage under overload conditions (i.e short circuit to supply voltages)		-15	32	V

5.16.4 Characteristics

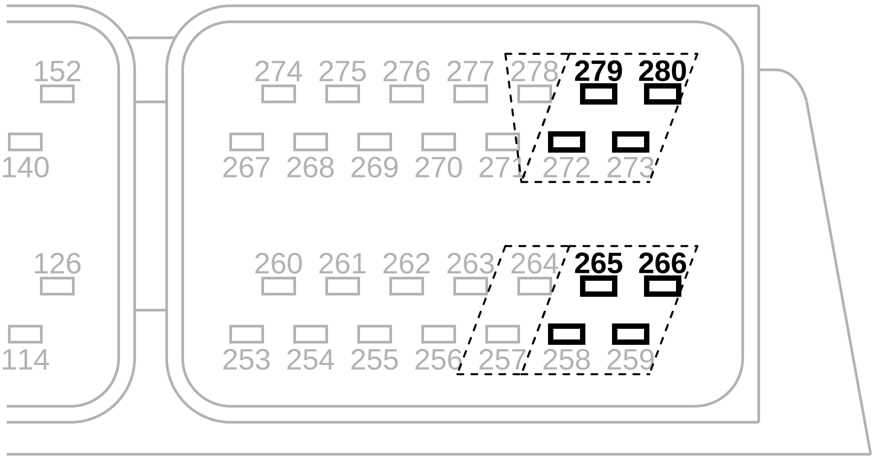
$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{out}	Pin output capacitance		100	150	pF
V_{IL}	Input voltage for low level		-15	+0.8	V
V_{IH}	Input voltage for high level		+2.4	+15	V
R_{pd}	Input resistor (to GND)		3	7	kΩ
V_{OL}	Output voltage for low level		-9	-5	V
V_{OH}	Output voltage for high level		+5	+9	V
S_{Tr}	Data-rate		1200	115	kbd

5.17 CAN interface ISO 11898

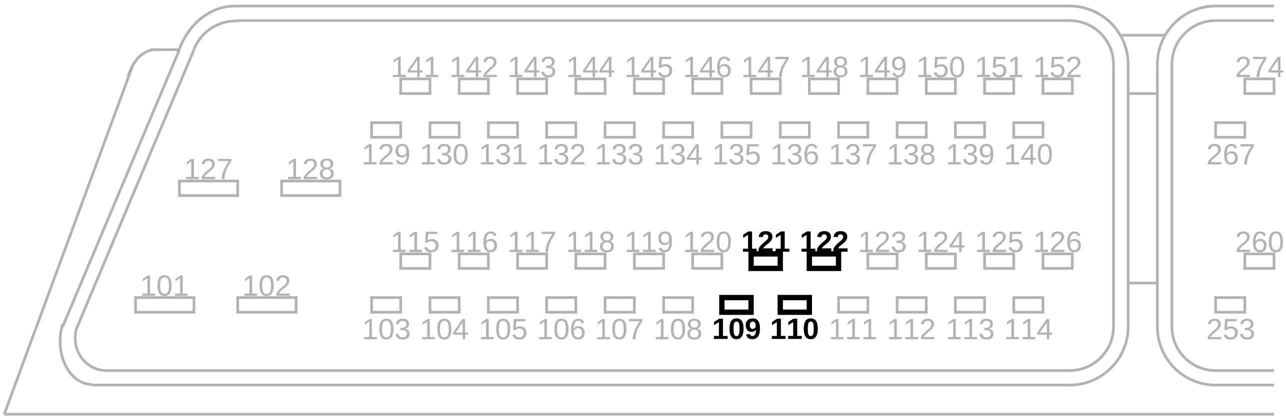
Note: There is only CAN interface 0 available on HY-TTC 36X/48X/48XS.

5.17.1 Pinout CAN 0 and CAN 1:



Connector Pin Number	Function
P279	CAN Interface 0 – High Line
P273	CAN Interface 0 – Low Line
P272	Termination for CAN Interface 0 – High Line
P280	Termination for CAN Interface 0 – Low Line
P265	CAN Interface 1 – High Line
P259	CAN Interface 1 – Low Line
P258	Termination for CAN Interface 1 – High Line
P266	Termination for CAN Interface 1 – Low Line

5.17.2 Pinout CAN 2 and CAN 3 (HY-TTC 94 only):



Connector Pin Number	Function
P110	CAN Interface 2 – High Line
P122	CAN Interface 2 – Low Line
P109	CAN Interface 3 – High Line
P121	CAN Interface 3 – Low Line

5.17.3 Functional description:

Bidirectional twisted pair bus.
Needs termination with 120Ω in 2 control units[2] whereas the others remain un-terminated.
Termination must be fit at the ends of the bus line to prevent wave reflection and is necessary to enter the recessive state.
For easy configuration on CAN 0 and CAN 1 there are 2*2 pin-pairs for activating / deactivating termination.

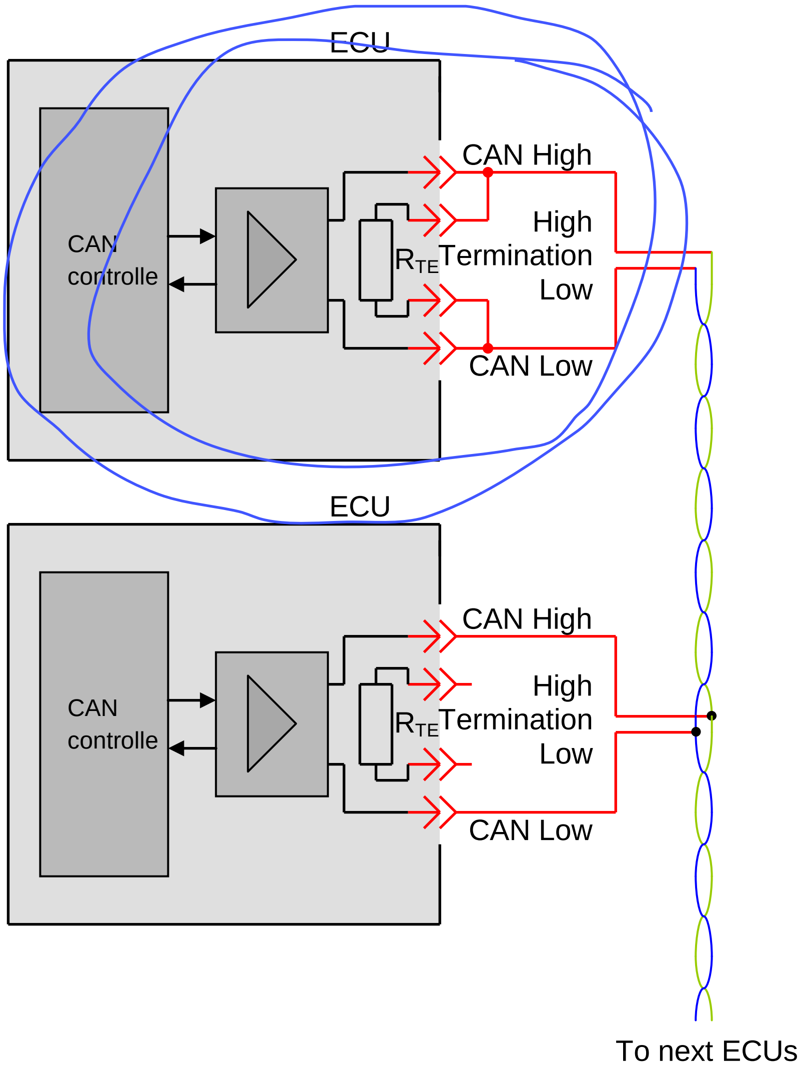


Figure 37: CAN interface (CAN 0 and CAN 1)

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[2] The 120 Ω termination of a control unit is realized with two serial 60 Ω resistors (split termination).
To get an impedance of 60 Ω on the whole bus, a termination resistor of 120 Ω is required in two control units.

CAN 2 and CAN 3 (HY-TTC 94 only) are not terminated with 120Ohm.

Please note that a common ground (chassis) or a proper ground connection is necessary for CAN operation. In case of connecting with an external device (e.g. PC with CAN-interface for downloading software) please make sure that the maximum voltage ratings are not violated when connecting to or disconnecting from the CAN-connection.

5.17.4 Maximum ratings

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{CAN_CNH} V_{CAN_CNL}	Bus voltage under overload conditions (i.e. short circuit to supply voltages)		-20	32	V

5.17.5 Characteristics

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
C_{out}	Pin output capacitance			100	pF
$V_{in\text{-}CMM}$	Input common mode range	1	-2	7	V
$V_{in\text{-}dif}$	Differential input threshold voltage (V_{CAN_CNH} - V_{CAN_CNL})		0.5	0.9	V
$V_{out\text{-}dif}$	Differential output voltage dominant state (V_{CAN_CNH} - V_{CAN_CNL})		1.5	3.0	V
$V_{out\text{-}dif}$	Differential output voltage recessive state (V_{CAN_CNH} - V_{CAN_CNL})		-0.1	+0.1	V
V_{CAN_CNL} V_{CAN_CNH}	Common mode idle voltage (recessive state)		2	3	V
I_{CAN_CNL}	Output current limit		-40	-200	mA
I_{CAN_CNH}	Output current limit		40	200	mA
S_{Tr}	Bit-rate	2		1000	kBit/s
S_{Tr}	Bit-rate	3		500	kBit/s
R_{Ter}	Termination resistance		115	125	Ω

Note 1: due to high current in the wiring harness the individual ground potential of control units may differ up to several Volts. This difference will appear also between a transmitting and receiving control unit as common mode voltage and does not influence the differential bus signal as long as it is within the common mode limits.

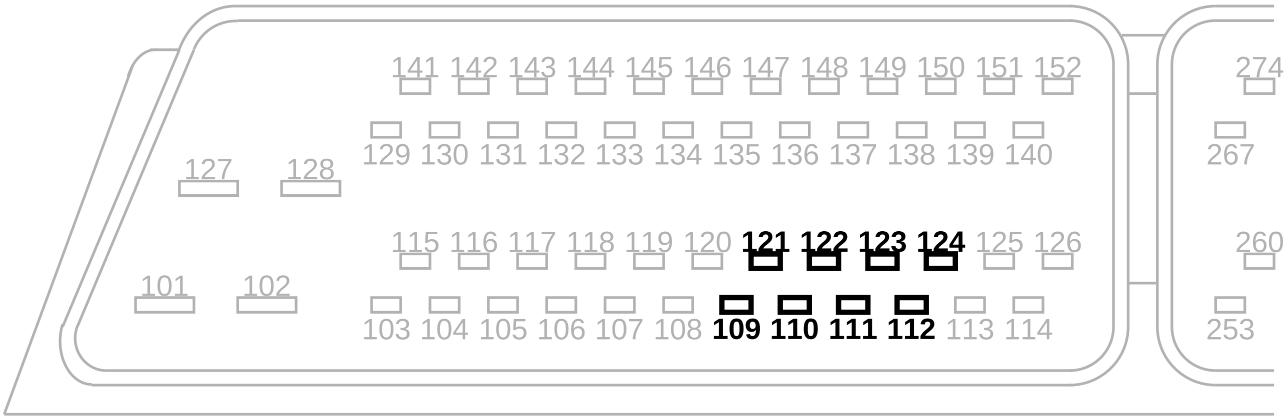
Note 2: please observe the limitations of CAN. The arbitration process will allow 1Mbit/s operation only in small networks and reduced wire length. As example a so called “private CAN”, a short point to point connection (less than 10m) between only 2 nodes can be operated at 1MBit/s.

Note 3: for typical network size and topology (network with stub wires) and more than 2 nodes the practical limit is 500kBit/s.

5.18 Mini Module / Current measurement

Note: The Mini Module is not available on HY-TTC 36X/48X/48XS. The HY-TTC 94 can use only the Mini Module Connection 4 to 7.

5.18.1 Pinout:



The Mini Module shares connector pins with other I/Os.

Connector Pin Number	Function (HY-TTC 50/60/90)
P122	Mini Module Connection 0
	Current Measurement Input 0, 2nd connection pin (HY-TTC 50/60/90)
P110	Mini Module Connection 1
	Current Measurement Input 1, 2nd connection pin (HY-TTC 50/60/90)
P121	Mini Module Connection 2
	Current Measurement Input 2, 2nd connection pin (HY-TTC 50/60/90)
P109	Mini Module Connection 3
	Current Measurement Input 3, 2nd connection pin (HY-TTC 50/60/90)
P124	Mini Module Connection 4
	Analog input (from 0..5 up to 0..32V) 4
P112	Mini Module Connection 5
	Analog input (from 0..5 up to 0..32V) 5
P123	Mini Module Connection 6
	Analog input (from 0..5 up to 0..32V) 6
P111	Mini Module Connection 7
	Analog input (from 0..5 up to 0..32V) 7

Connector Pin Number	Function (HY-TTC 94)
P122	Not available for Mini Module use
	CAN Interface 2 - Low Line (HY-TTC 94 only)
P110	Not available for Mini Module use
	CAN Interface 2 - High Line (HY-TTC 94 only)
P121	Not available for Mini Module use
	CAN Interface 3 - Low Line (HY-TTC 94 only)
P109	Not available for Mini Module use
	CAN Interface 3 - High Line (HY-TTC 94 only)
P124	Mini Module Connection 4
	Analog input (from 0..5 up to 0..32V) 4
P112	Mini Module Connection 5
	Analog input (from 0..5 up to 0..32V) 5
P123	Mini Module Connection 6
	Analog input (from 0..5 up to 0..32V) 6
P111	Mini Module Connection 7
	Analog input (from 0..5 up to 0..32V) 7

5.18.2 Functional description:

Optionally a customer specific Mini Module may be mounted that can make use of up to 8 connector pins as listed in the table above.
On the Mini Module a microcontroller can be placed as well as small power stages or complex user specific circuits.

The Mini Module shares connector pins with other I/Os.

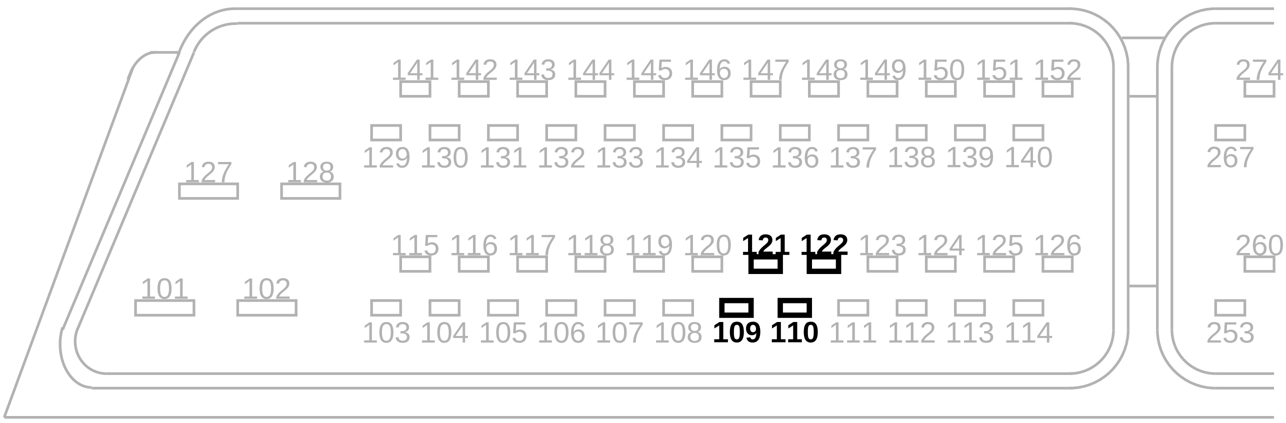
For HY-TTC 50/60/90 four connector pins are used in parallel for analog inputs.
The current measurement inputs are routed to pin pairs. When using a mini module there are only single pins available. However, the current measurement function is still available.
If the Mini Module needs 4 ..7 connector pins the analog input (from 0..5 up to 0..32V) number 4 .. 7 are replaced by Mini Module connections.

For mini modules with current measurement the same characteristic of the measurement circuitry can be assumed as for the built in current measurement on the main board of the ECU.

For HY-TTC 94 four connector pins are used in parallel for analog inputs as well.
The other four pins are used for two additional CAN-channels and are not available for mini module use.

5.18.3 Current measurement Mini Module

5.18.3.1 Pinout



Connector Pin Number	Function
P122	Current Measurement Input 0
P110	Current Measurement Input 1
P121	Current Measurement Input 2
P109	Current Measurement Input 3

5.18.3.2 Current Measurement Inputs

For actuators requiring precision current control this input provides a measurement unit with overload protection. The current flows through a sensing resistor is amplified and low pass filtered to deliver an average value and suppress ripple current introduced by PWM-control.
In case of overload a switch disconnects the overloaded input for 1 second and then switches on again.

If a current input is not needed, it can be also used as low side switch with diagnostic function (4.18.3.3).

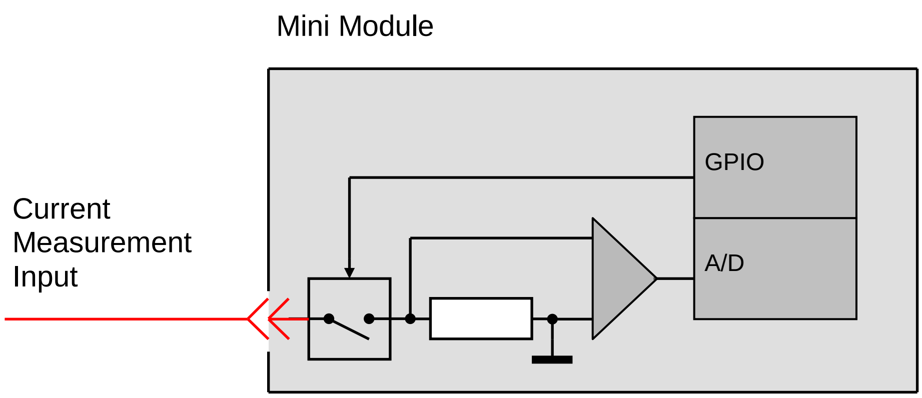


Figure 38: Mini Module – Current Measurement Input

5.18.3.2.1 Maximum ratings

T_{ambint} = -40° .. 60°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions		-0.5	U_{Bat}+0.5	V
I_{in-max}	Permanent input current	1		2.5	A

Note 1: Short circuit and overload protection by the software .

T_{ambint} = 60° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{in}	Input voltage under overload conditions		-0.5	U_{Bat}+0.5	V
I_{in-max}	Permanent input current	1		1	A

Note 1: Short circuit protection by the software. The user is responsible for the overload protection (current higher than 1A).

5.18.3.2.2 Characteristics of Current Measurement Inputs

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter	Note	min	max	Units
V_{Out}	Shunt factor	1	2.00		V/A
I_{FS}	Full scale nominal current	1, 2	2.50		A
I_{Tol-M}	Accuracy	3	-5	+5	%[FS]
	Proportional factor (at nominal load current)	3	-125	+125	mA
I_{Tol-0}	Accuracy	4	-2.0%	+2.0%	%[FS]
	Zero reading (no load current)	4	-50	+50	mA
f_{g_LP}	Cut off frequency of 3rd order low pass filter	5	6	10	Hz
		6	10	20	Hz

Note 1: Current is measured with a ground referenced shunt, amplified and connected to an ADC input.
1A load current will bring 2V ADC input voltage.
Please note that 2.45A is the nominal current without any tolerance.
0 .. 2.30A is the nominal operating range for peak current.

Note 2: The maximum current has to be limited to 1A for a temperature range between 60°C .. 85°C.

Note 3: Current measurement gives absolute values and does not work ratiometric to the ADC's reference. Therefore absolute tolerance of ADC supply is also included.

Note 4: The ADC can only measure positive values.
With a negative zero reading current a small output current of the same absolute value is necessary to get ADC-values greater than zero.

Total error is the sum of proportional error and zero reading error:

$$TUE = \pm\left|I_{Tol-M} * I_L \pm I_{Tol-0}\right|$$

Note 5: An active low pass filter (3rd order) is provided to remove current ripple from the ADC input

Note 6: Variants with this kind of fast filter are available on request.

5.18.3.3 Alternate Function Low Side Output

If a current input is not needed, it can be also used as low side switch with diagnostic function. When using highly inductive loads operated at high current values the maximum switch-off energy must be calculated carefully not to overload the output clamping. For inductive actuators exceeding the dissipation limit an external freewheeling diode must be added.

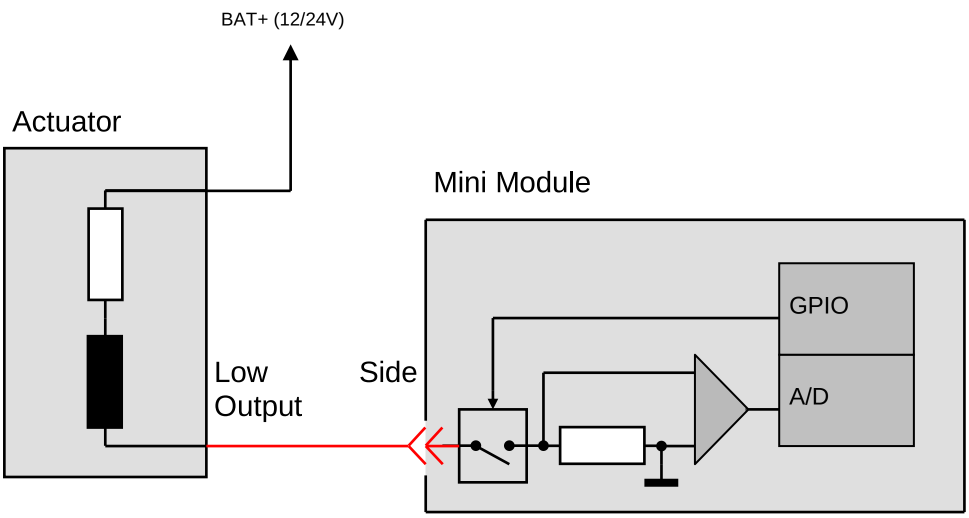


Figure 39: Power output 2A low side

5.18.3.3.1 Example for switch off energy calculation for inductive loads

In this example an inductive load is operated at 24V and the actuator draws the maximum specified output current of 2A. When switching off the stored energy in the inductance, the output is driven to negative until the output stage clamps. In this example this happens at approx. 50V referred to GND. The current linearly decreases from 2A to 0 within 1ms at almost constant clamp voltage. So also the power dissipated in the output stage decreases, from 100W (2A*50V) down to 0. For a time of 1ms the average power in the clamping phase is 50W, which equals to 50mWs or 50mJ, which is well below the limit of 170mJ.

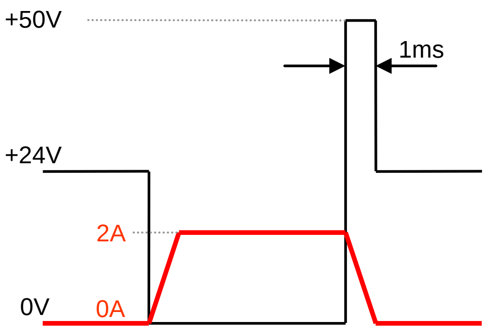


Figure 40: Power output 2A switch off waveform

5.18.3.3.2 Characteristics of Low Side Switch

$T_{ambient}$ = -40° .. 85°C

Symbol	Parameter (single power stage)	Note	min	max	Units
C_{in}	Pin input capacitance		8	12	nF
R_{on}	On-resistance			200	mΩ
I_{load}	Nominal load current		0	2	A
I_{load}	Permanent load current	1,2	0.03	2.3	A
$I_{load-lim}$	Internal current limitation for PTC-type loads	3	9		A
E_{AS}	Maximum switch off energy dissipation	4		170	mJ
Z_{l-max}	Maximum switchable inductive load	4		20	mH

Note 1: Load diagnostic is based on current measurement during on-phase.
The limits are the minimum / maximum permanent (DC) current that will not trigger low load detection or overload protection

Note 2: The maximum current has to be limited to 1A for a temperature range between 60°C .. 85°C.

Note 2: incandescent lamps with cold filament have a surge current 10 times higher than nominal current.

Note 3: with I_{load} = 2A, Z_L = 20mH, R_{DC} = 0Ω. Typical electromagnetic valves have R_{DC} in excess of 5Ω, thus reducing the energy to be clamped by the output stage.

5.18.4 Suitable functions for the Mini Module:

- user specific sensor interfaces
- user specific actuator interfaces
- user specific actuator/position feedback interface an control loop
- high resolution ADC-units
- analog outputs

…….

6 Application Notes

6.1 Wiring Harness

In order to enable a safe operation a few general rules for the layout of the wiring harness have to be obeyed.

For the dimensioning the power supply cables please refer to section 5.1.6 (wiring hints).

6.2 Load Distribution

The 16 power stages of the HY-TTC 50 would theoretically deliver a total current of 48A if switched on concurrently. The HY-TTC 50's permanent input current $I_{in\text{-}max}$ is 25A because there is a thermal and a contact current limit.

As the power stages have not negligible power dissipation each load current leads to a rise of temperature. To ensure proper operation of the HY-TTC 50 in its temperature range (-40 °C to +85 °C) the total current driven by the power stages has to be limited and the load evenly distributed.

One first rule of thumb is that if two output states are mutually exclusive (e.g. output A is only activated in state 1, output B is only activated in state 2) these outputs should be driven by one double-channel power stage, so that only one channel is used at a time.

Another way to reduce the overall power dissipation is to drive different power stages in parallel for high currents.

7 Abbreviations

ADC Analog Digital Converter

DC Direct current, used for specifications where no frequency is applied

PL Performance Level defined in ISO 13849

KL15 Synonym for “Terminal 15” in countries using German language

LSB least significant bit of an analog / digital converter.
This stands for the step size of voltage change that is necessary to change the measured output signal by one bit.

NTC negative temperature coefficient, stands for resistive temperature sensors that decrease resistance value towards higher temperatures

PTC positive temperature coefficient, stands for resistive temperature sensors that increase resistance value towards higher temperatures

PU Pull-up resistor

PD Pull-down resistor

RPM rotations per minute
(RPM-Sensor means rotation speed sensor)

SIL Safety Integrity Level (SIL) is defined as a relative level of risk-reduction provided by a safety function in IEC 61508

TUE total unadjusted error of an analog / digital converter
Total Unadjusted Error is a specification that includes linearity errors, gain error, and offset error. It is the worst-case deviation from the ideal device performance.

Vcc Internal supply voltage that determines the maximum input swing of the analog / digital converter,

8 Obligatory information for 2006/42/EC directive on machinery

The following information must be contained in the user instructions according to the document /2006/42/EC/.

- The EC declaration of conformity can be found in the document /ECDOC/.
- The HY-TTC 50/60/90/94/36X/48X/48XS does not exceed a noise emission of 70dB(A)

9 References

[1] TTControl, HY-TTC_50_Connectors_Wires_V104.pdf, TTControl GmbH 2014

Disposal Note

If disposal has to be undertaken at the end of a device's life span, the respective applicable country-specific regulations must be taken into consideration.

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