Technion Control Unit
TEC132
Technical manual

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1 Overview

This document specifies Technion Control Unit (TEC132) electrical and mechanical details and gives brief functional overview of the controller.

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2 Abbreviations and terminology

CAN	Controller Area Network
TBD	To Be Defined
CLAMP-15, cl15	Automotive power rail which is supplied when ignition switch is closed
CLAMP-30, cl30	Automotive power rail that has permanent power supply regardless of ignition switch state.
AI	Analog input
DI	Digital input
DO	Digital output
FI	Frequency input
PWM	Pulse width modulation. In this document this refers to digital output with pulse width modulation capability.
EMC	Electromagnetic compatibility
I/O	Input / Output
SW	Software
System SW	Software preprogrammed to device by Technion Oy
Application SW	Software customized by/for customer - a C language program or IEC-61131 program
Wetting current	Minimum current flow through switch to break any oxidation on the switch contacts

3 General

TEC132 is a general purpose controller for mobile vehicles. Mobile vehicles consist of but not limited to following utility, forest, construction, mining, load and container handling machinery. TEC132 is intended to be a part of the control system in vehicle. The control unit will control lights, valves and other actuator, read different kind of sensors and communicate with other control units forming a complete control system. The TEC132 is intended for mounting directly to vehicle body or inside the cabin.

3.1 Limited Responsibility

This Product is designed and intended to be used for machine / equipment controlling purposes. Technion Ltd or any of its subsidiaries shall not assume any responsibility for this Product being fit for any specific application, unless Technion has so expressly stated in writing.

Technion Ltd or any of its subsidiaries requires that applicable machine / equipment safety guidelines, requirements, directives, machine / equipment warning labelling and rules are adhered to in the country/market where the product is used.

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Technion Ltd or any of its subsidiaries reserves the right to alter the contents of this Technical Manual as well as the right to improve its products without further notice.

4 Product data

4.1 Mechanics

Material(s): Glass Fiber Reinforced PA, electroplated steel
Protection Class: IP67
Weight: 0,7 kg
Dimensions: 152 mm x 152 mm x 59 mm (W x L x H) excluding mating connectors
Mounting: 2 holes at module edges for M6 bolts.
Connectors: Straight mount, located at top side of the casing

Mechanical drawing is presented in Chapter 9.

4.1.1 Mounting recommendations

Following guidelines shall be followed:

- TEC132 module shall be mounted to flat surface.
- TEC132 module mounting location shall be protected against:
  - high pressure cleaner
  - gravel bombardment
  - high level of vibration
  - locations with high electromagnetic disturbances
  - high temperature radiation or conduction from other sources
  - insufficient air flow (that prevents proper cooling)
  - continuous exposure to liquids
- Cable harness shall be mounted to same rigid body as TEC132 with distance less than 150 mm.

4.2 Electrical connection

Module has three connectors. Connector types and usage is presented in Table 1. Connector orientation and location is presented in mechanical drawing (see Chapter 9).

Table 1- TEC132 connectors

Ref	Pins	Module connector	Contact plating	Mating connector	Usage
X1	14	AMPSEAL 1-776262-1 BLACK	Gold	AMPSEAL 776273-1 BLACK	Power input, CAN, RS-232, DO
X2	35	AMPSEAL 776231-1 BLACK	Tin	AMPSEAL 776164-1 BLACK	DO, DI, AI, sensor reference
X4[1]	4	M12 socket, A-coded	Gold		RS-485, power output

Note: Mating of tin coated contacts to gold coated contacts is not recommended. Tin-to-gold contacts are susceptible to fretting corrosion related failures. Lubrication of contacts improves reliability and prevents fretting corrosion for both tin-to-tin and gold-to-gold contacts. See references [1] – [2] for more details.

[1] X4 is available only in selected TEC132 product variants. See order options.

Power and ground signals have multiple parallel pins on the module. Wiring harness design shall guarantee an equal current distribution between parallel pins. This is achieved in most cases when each parallel pin is connected using identical wire (length and diameter) directly to its source.

4.3 Marking

Product is marked with the Technion part number and serial number.

4.4 Order options

TEC132 product family has several product variants. This documents covers following products.

Table 2- TEC132 order codes covered by this manual

Order code	Application development environment	RS-485
TEC132-001-04	C-programming language	-
TEC132-002-02	CODESYS V2.3	YES
TEC132-003-02	C-programming language	YES
TEC132-004-02	CODESYS V2.3	-

This document version applies only to specific module version. Version information is provided in separate PCN documents.

5 Electrical data

5.1 System block diagram

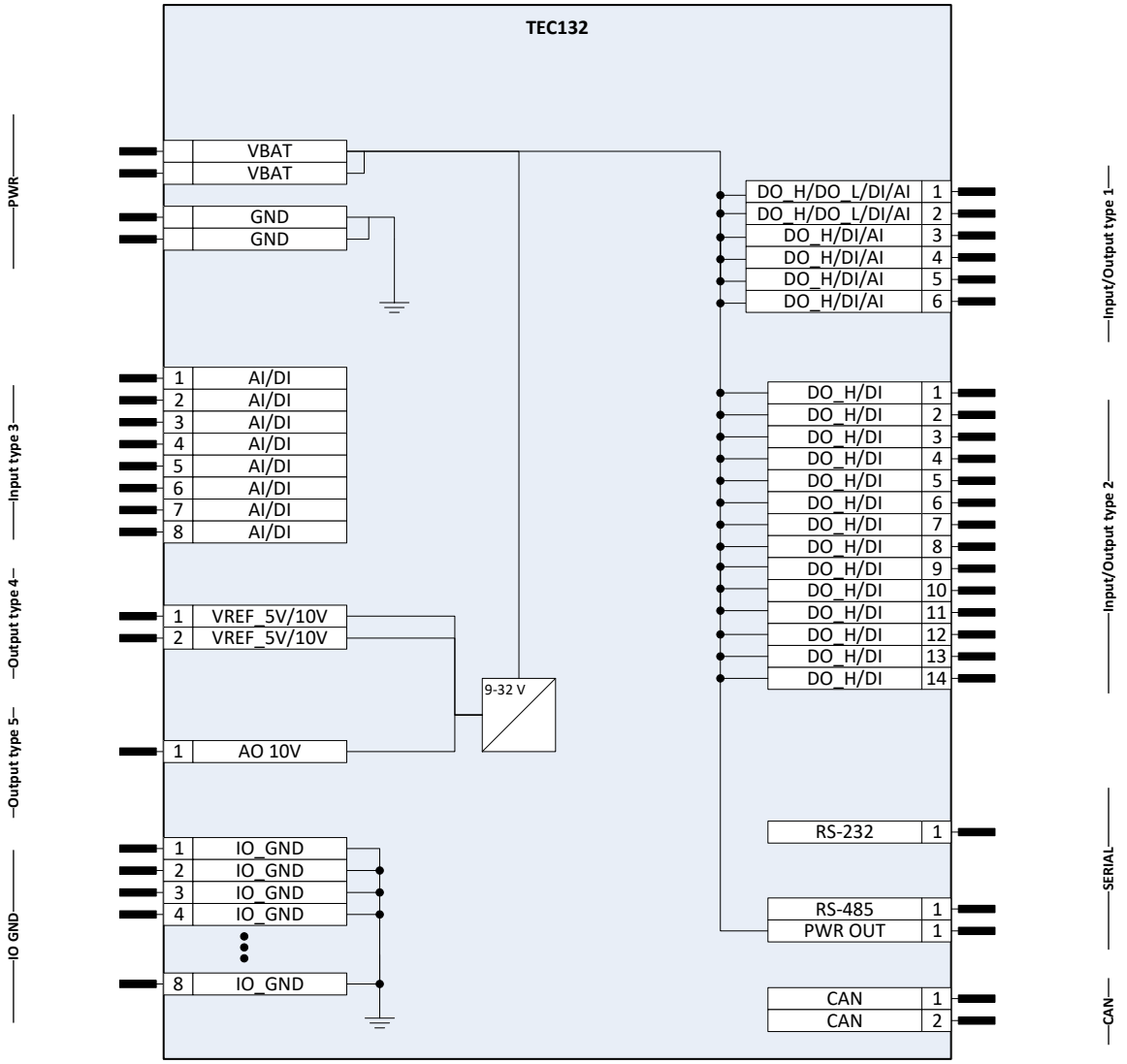


Figure 1 - TEC132 I/O block diagram

5.2 System properties

TEC132 has 32-bit CPU architecture that is capable to handle common machine control tasks. TEC132 application can be developed either using CODESYS V2.3 or C-language with readymade board support package. Memory resources are presented below.

Memory	Size
RAM (total)	96 KiB
RAM (CODESYS application)	16 KiB
Program Flash (total)	512 KiB
Program Flash (application)	224 KiB
Data EEPROM	63 KiB

IEC-61131 (i.e. CODEYS) application is executed and located in "program flash (application)" memory. EEPROM memory can be used to store for example application parameters and/or failure / diagnostics log.

Module start-up time

Parameter	Time (typical)	Notes
Start-up time from power-up to application software start[2]	1000 ms	CODESYS application

TEC132 CPU has integrated watch-dog that monitors program execution. If watch-dog is not refreshed for 4 seconds module is re-started. During re-start all I/O is set to default state (described in chapter 6). Behavior after restart depends on product variant. TEC132 with CODESYS module execution is halted after restart and program execution can be restarted only by reconnection module power input somehow.

Controller internal temperature can measured in application using internal temperature sensor. If temperature is out of operational range application software should switch off all outputs to prevent unexpected behavior.

Item		Min	Typ	Max	Unit	Notes
Internal temperature measurement range		-45		125	°C	
Accuracy			±5		°C	

[2] Application software is located and executed from flash memory (simple application toggling digital output).

5.3 Power supply

TEC132 module can operate either in 12V or 24V electrical system. 24V system allows using all TEC132 I/O functions. In 12V system some of the I/O functions are not available see Table 3 for more details.

Item		Min	Nom	Max	Unit	Notes
Supply voltage (12V system) [3]		9	12	32	V	Extended voltage range compared to ISO 16750-2 code C
Supply voltage (24V system)		16	24	32	V	Voltage range according to ISO 16750-2 code F
Overvoltage 1				36	V	Controller operates normally during overvoltage (32 V – 36 V). Maximum overvoltage 1 duration that module withstands is 60 minutes.[4]
Reverse voltage		-28			V	MAX 20A external fuse is mandatory. Module has internal connection from GND to POWER. Module is damaged without fuse.
Under voltage shutdown			5,7		V	
Under voltage detection (12V system)			7,9		V	Automatic module shutdown after 30 seconds
Under voltage detection (24V system)			14		V	Automatic module shutdown after 30 seconds
Supply current: module/logic			0,15		A	VBAT= 24V, all outputs OFF
Supply current: outputs				20	A	
External FUSE				20	A	Mandatory for reverse polarity protection

Table 3 – 12V & 24V system I/O availability differences

I/O	12V system	24V system
VREF	5 V outputs only	5 V and 10 V outputs
AO 0-10V	NOT AVAILABLE	0 – 10 V

5.3.1 Power supply input

Supply voltage must be within in the module operating range. Module has common power input for both logic and outputs. Input is protected against polarity reversal with internal diode. External fuse (max. 20A) must be used. TEC132 will damage without external fuse.

[3] All I/O functions are not available in 12V system (AO 0-10V and VREF 10V)
[4] Some I/O functions do not tolerate overvoltage during short circuit to battery conditions. See detailed I/O specifications.

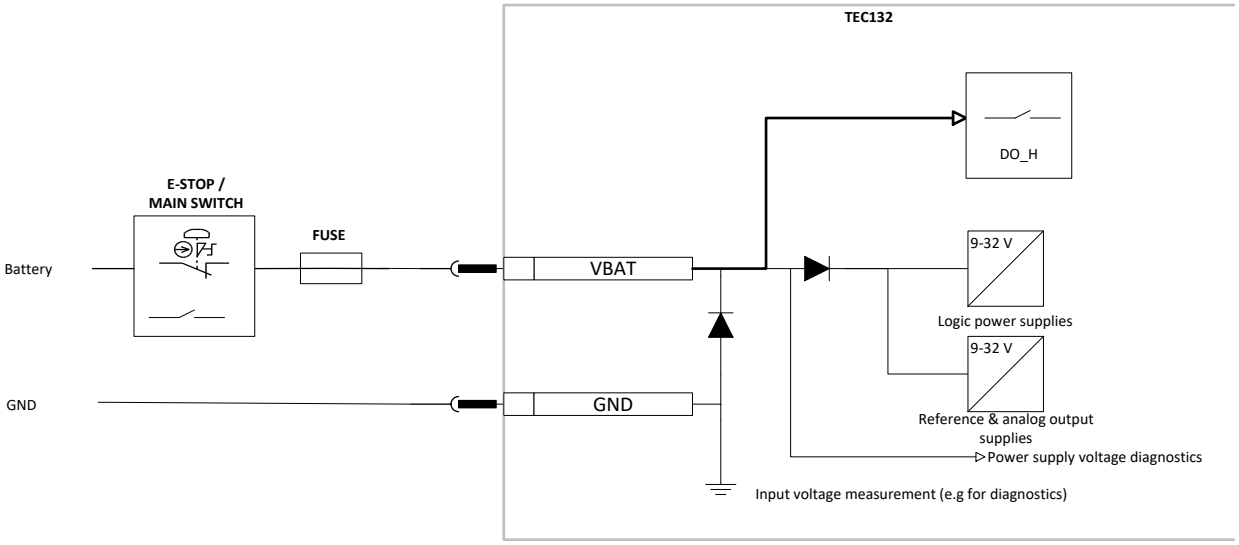


Figure 2 – VBAT power input topology

Module VBAT power input voltage (i.e. system/battery voltage) can be measured in application level.

Table 4 – VBAT input diagnostics

Item		Min	Nom	Max	Unit	Notes
VBAT voltage measure-ment range		0		48	V	
Measurement accuracy % FS				±1	%FS	

Reverse feed

Note! If module is not powered by power supply pins and there is external voltage in output pin(s). As a consequence the module is powered through the output pin! There is also voltage in power supply pins at this time. Module does not withstand reverse feed from outputs. Electrical system must be designed so that reverse feed is not possible.

Note! This applies also to inputs that are shared with output pins.

Table 5 - Power input signals

Signal	Type	Description
VBAT	PWR	Power supply input for module logic functions, sensors and outputs
GND	-	Ground for logic and output power supply

5.3.2 Module grounding

TEC132 grounding shall be designed carefully in system level to prevent false operation and module damage. Typically high currents are driven in 12V or 24V mobile vehicles. These currents may cause differences in ground potential at vehicle level. At least following shall be considered when designing grounding topology:

- All TEC132 ground pins are connected internally together (i.e. there is no isolated interfaces).
- All ground pins shall be connected to single ground point in vehicle (to prevent ground currents through module.
- Reference ground pins (IO GND) shall not be connected to general ground point. Instead direct connection between sensitive sensors and TEC132 is recommended to prevent measurement errors caused be system ground potential differences. However extra care must be taken to verify that sensor has only one ground connection (through TEC132) otherwise unwanted ground currents are introduced.

6 General I/O functionality

All I/O functions (every connector pin) have short circuit protection against ground (GND) short circuit. Most I/O pins are protected against short circuit to system supply voltage (max 32V). I/O pins that share output and input functionality cannot withstand voltage higher than current supply voltage.

Sensor ground pins are able to break 10 A fuse during short circuit to battery.

6.1 I/O List

TEC132 controller has versatile set of I/O types. Different I/O types/functions are presented in Table 6. Detailed description of the I/O types is provided in Chapters 6.2 and 6.3. TEC132 I/O pins can be configured to several I/O functions. I/O configuration is presented in Table 7. Configuration is selected in SW.

Table 6 - TEC132 I/O types

I/O Type	Abbreviation
Digital output high-side, PWM or ON/OFF 3.5A	DO_{H3A5}
Digital output low-side ON/OFF	DO_{L}
Digital input PNP (high active)	DI_{H}
Analog input - voltage measurement 0-5V Analog input - voltage measurement 0-10V Analog input - voltage measurement 0-27V	AI_{5V} AI_{10V} AI_{27V}
Actuator or sensor ground	IO GND
Voltage reference output for analog input (output voltage)	$VREF_{5V/10V}$
Analogue output	AO_{10V}
CAN	CAN
RS-232	RS232
RS-485	RS485

Note 1: Each input/output can have several subtypes. Subtype number is shown after I/O-type e.g. $DI_{H.1}$ (i.e. Digital input, high-active, type 1)

Table 7 - TEC132 I/O configuration

I/O Group	Pcs	I/O Types	Notes
HIGH SIDE DIGITAL OUTPUTS (Configurable input / output #1) (6 pcs)	2	$DO_{H\_3A5.1}$ $DI_{H.1}$ $AI_{10V.1}$ $AI_{27V.1}$ $DO_{L.1}$	Digital output 3,5A, high side Digital input (PNP / active high) Analog input 0-5 V Analog input 0-27 V Digital output 1 A, low side
	4	$DO_{H\_3A5.1}$ $DI_{H.1}$ $AI_{10V.1}$ $AI_{27V.1}$	Digital output 3,5A, high side Digital input (PNP / active high) Analog input 0-5 V Analog input 0-27 V
HIGH SIDE DIGITAL OUTPUTS (Configurable input / output #2)	14	$DO_{H\_3A5.2}$ $DI_{H.2}$	Digital output 3,5A, high side Digital input (PNP / active high)
PRECISION INPUTS (Configurable input / #3)	8	$DI_{H.3}$ $AI_{5V.2}$ $AI_{10V.2}$	Digital input (PNP / active high) Analog input 0-5 V Analog input 0-10 V
REFERENCE OUTPUTS (Configurable output #4)	2	$VREF_{5V.1}$ $VREF_{10V.1}$	Voltage reference output 5 V Voltage reference output 10 V
ANALOG OUTPUT	1	$AO_{10V.1}$	Analog output 0-10 V
GND	8	GND	Ground for sensors and actuators
Module power supply	2 2	VBAT GND	Power supply module logic and outputs VBATT ground
CAN	2	CAN	
RS-232	1	RS232	CODESYS programming interface
RS-485	1	RS485	In selected variants only

6.2 I/O definition

Every configurable I/O type has its own specification.

I/O functions presented in following chapters have several protection and diagnostics functions to detect failures either in module, wiring or sensor/actuator. Failure mode diagnostic capability depends on I/O type. Failure types are presented in table below.

Table 8 - I/O protection and failure diagnostic features

Failure	
Open load	OL
Short circuit to ground	SC_G
Short circuit to battery	SC_B
Over Current	OC

Each IO-type is named according to Figure 3. TEC132 has several IO types that have same functionality and subtype but different electrical specification. Extra care has to be taken on electrical specification when selecting IO-type / pin for application.

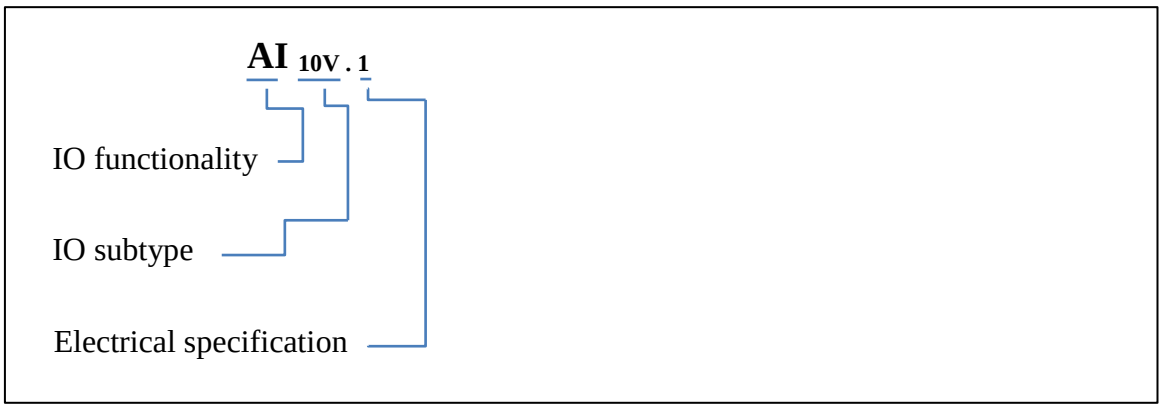


Figure 3 - IO-type naming

6.2.1 Input, DI PNP ($DI_{H.1}$ & $DI_{H.2}$)

Active high i.e PNP digital input is used to interface sensors / switches powered from TEC132 output. For example following sensors can be connected to this input:

- Mechanical on/off switches
- Semiconductor switches
- Inductive sensors

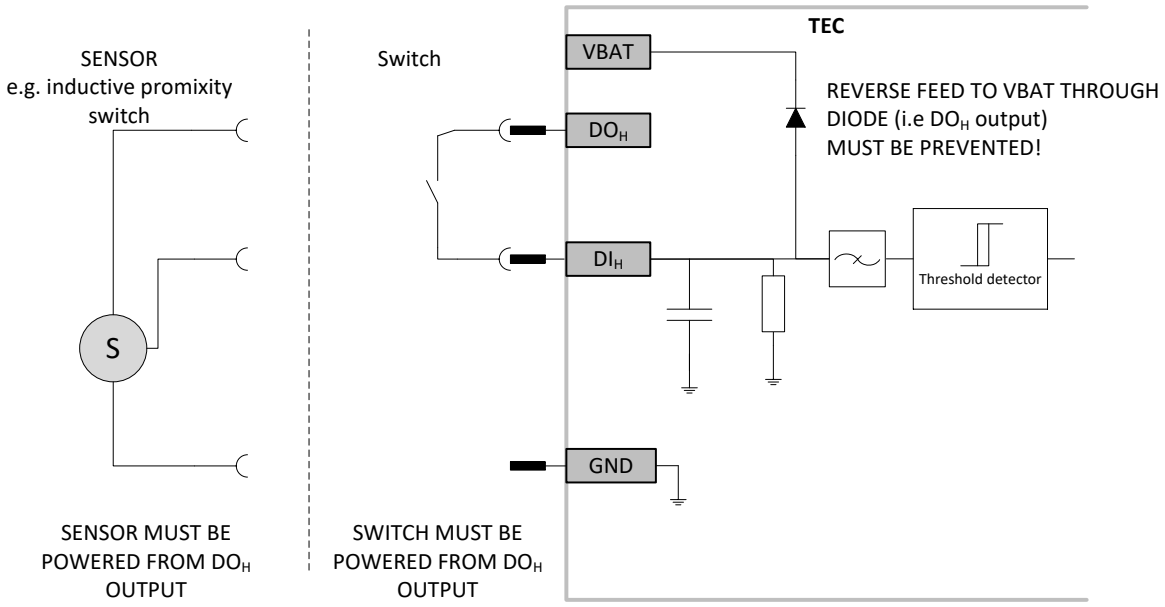


Figure 4- $DI_{H.1}$ usage

Input of this type shall not be connected to voltage higher than module power input voltage (VBAT). All input devices (switches, sensors …) must be powered from TEC132 DO_H output or directly from TEC132 VBAT pin.

Table 9 - Electrical specification

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.1}$** Digital input PNP, Active high						
Voltage range	U_{in}	0		32	V	Input voltage must be ≤ VBAT in all conditions	
Over voltage				VBAT	V		
Threshold low	U_{low}	2			V		
Threshold high	U_{high}			7	V		
Hysteresis	U_{hyst}		3		V		
Cutoff frequency	f_{-3dB}		1,15		kHz	HW filter	
Input leakage	I_{leak}	-350		100	uA	Leakage current from DO_H (positive value outgoing from DO_H)	
Input capacitance			22		nF		
Pull-down resistance	R_{PD}		7		kΩ	U_{in} ≤ 27 V	
Protection		SC_G, SC_B				Input voltage ≤ VBAT	

Table 10 - Electrical specification

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.2}$** Digital input PNP, Active high						
Voltage range	U_{in}	0		32	V	Input voltage must be ≤ VBAT in all conditions	
Over voltage				VBAT	V		
Threshold low	U_{low}	2			V		
Threshold high	U_{high}			7,5	V		
Hysteresis	U_{hyst}	1			V		
Cutoff frequency	f_{-3dB}		10		kHz	HW filter	
Input leakage	I_{leak}	-350		100	mA	Leakage current from DO_H (positive value outgoing from DO_H)	
Input capacitance			22		nF		
Pull-down resistance	R_{PD}		6		kΩ	U_{in} ≤ 12 V	
Protection		SC_G, SC_B				Input voltage ≤ VBAT	

Reverse feed

Note!
If $DI_{H.1}$ / $DI_{H.2}$ input voltage is higher than VBAT voltage there will be internal reverse feed from DI_H to VBAT supply voltage. TEC132 module does not withstand reverse feed. **Reverse feed will damage** the TEC132 module. Electrical system must be designed so that reverse feed is not possible. Reverse feed can be prevented by using DO_H, or $VREF_{5V/10V}$ outputs to supply $DI_{H.1}$ / $DI_{H.2}$.

Table 11 - DI signals

Signal	Dir	Description
DI_H	In	Digital input

6.2.2 Input, DI PNP ($DI_{H.3}$)

Active high i.e PNP digital input is used to interface sensors / switches powered from TEC132 output or directly from battery.

- Mechanical on/off switches
- Semiconductor switches
- Inductive sensors

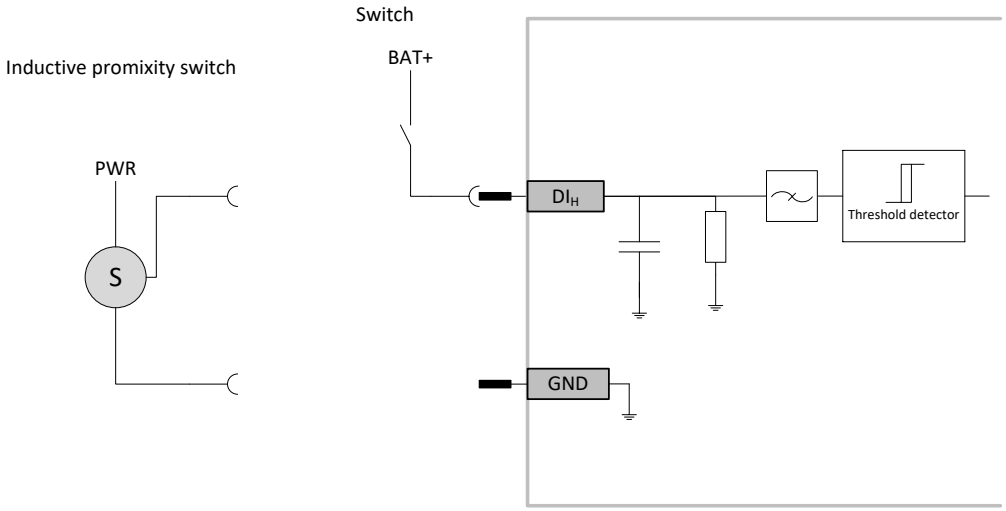


Figure 5- $DI_{H.3}$ usage

Table 12 - Electrical specification

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.3}$** Digital input PNP, Active high						
Voltage range	U_{in}	0		32	V		
Over voltage				36	V		
Threshold low	U_{low}	2			V		
Threshold high	U_{high}			7	V		
Hysteresis	U_{hyst}		3		V		
Cutoff frequency (HW)	f_{-3dB}		1,15		kHz		
Input capacitance			5		nF		
Pull-down resistance	R_{PD}		22,5		kΩ	U_{in} < 10V	
Protection		SC_G, SC_B					

Table 13 - DI signals

Signal	Dir	Description
DI_H	In	Digital input

6.2.3 Input, Analog input, 0-5V / 0-10V ($AI_{5V.2}$ & $AI_{10V.2}$)

Analog input type is software configurable. For example, following sensors can be connected to input.

- Potentiometer (3-wire) / joysticks
- Temperature transduces
- Pressure sensors
- Voltage output sensors

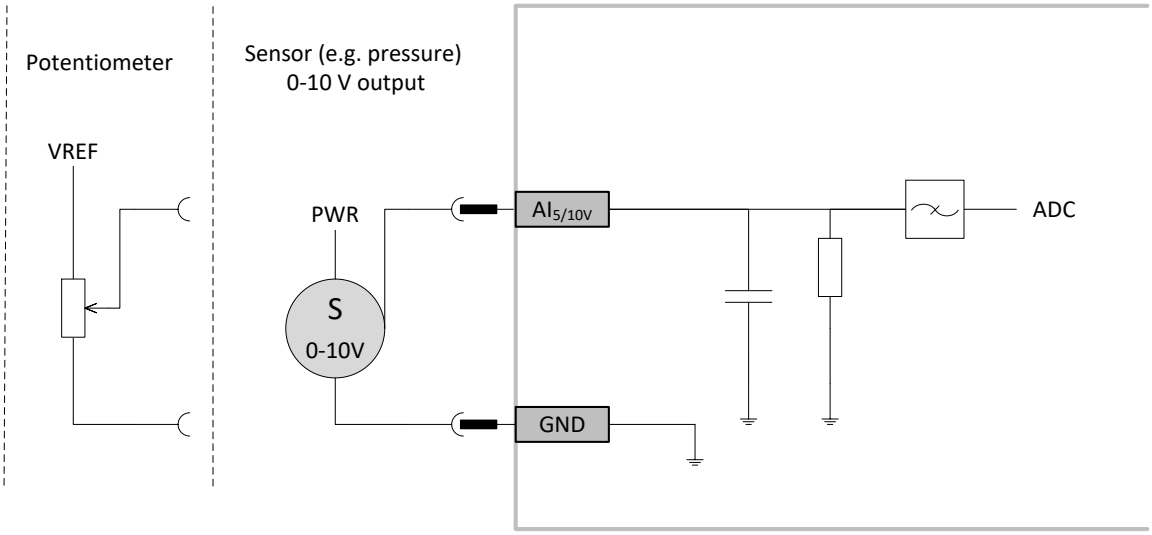


Figure 6 - $AI_{5V.2}$ / $AI_{10V.2}$ usage

Table 14 - Analog input electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Resolution			12		bits		
Protection		SC_G, SC_B					
Type	**$AI_{5V.2}$ 0-5V Voltage input**						
Input voltage range		0		5	V	Voltage input	
Over voltage				32	V		
Accuracy % FS				±1,5	%FS		
Accuracy, typical			0,6+0,2		%	±(% of reading + % FS)	
Input resistance			44,1		kΩ	*Uin < 5V*	
Input capacitance			4,7		nF		
Input cut-off frequency	f_{-3dB}		0,6		kHz	HW filter	
Type	**$AI_{10V.2}$ 0-10V Voltage input**						
Voltage range		0		10	V	Voltage input	
Over voltage				32	V		
Accuracy % FS				±1,5	%FS		
Accuracy, typical			0,6+0,2		%	±(% of reading + % FS)	
Input resistance			22,8		kΩ	*Uin < 10V*	
Input capacitance			4,7		nF		
Input cut-off frequency	f_{-3dB}		1,15		kHz	HW filter	

Table 15 - AI signals

Signal	Dir	Description
$AI_{V.2}$	In	Configurable analog input
IO_GND		Ground pin for sensor return signal

6.2.4 Input, Analog input, 0-10V / 0-27V ($AI_{10V.1}$ & $AI_{27V.1}$)

Analog input type is software configurable. For example following sensors can be connected to input.

- Temperature sensors
- Pressure sensors
- Voltage output sensors

Interface is not recommended for resistive sensors / potentiometers due to input internal leakage current.

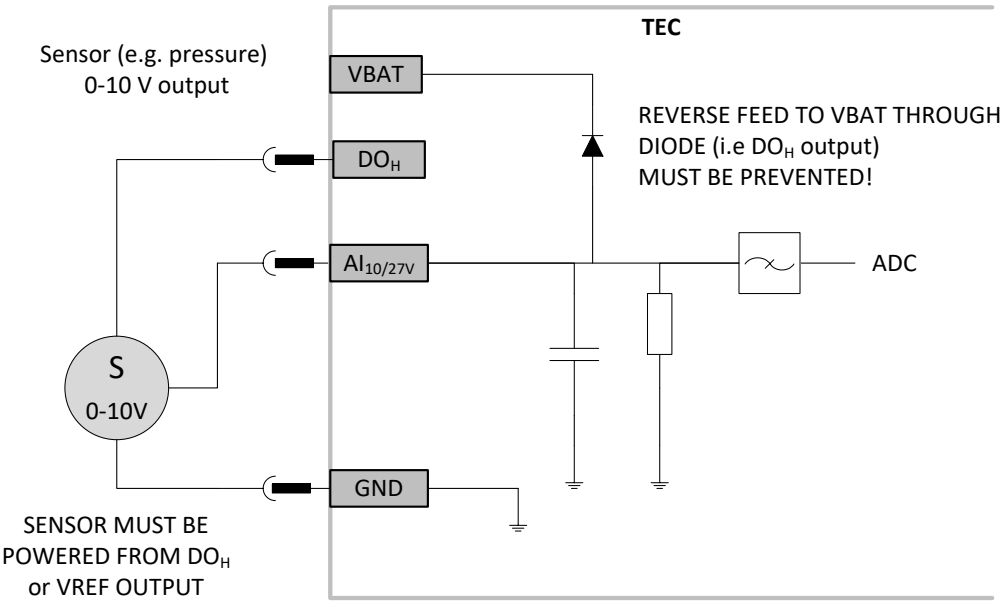


Figure 7 - $AI_{10V.1}$ / $AI_{27V.1}$ usage

Table 16 - Analog input electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Resolution			10		bits		
Protection		SC_G, SC_B				Input voltage ≤VBAT	
Type	**$AI_{10V.1}$ 0-10V Voltage input**						
Input voltage range		0		10	V	Voltage input	
Over voltage				VBAT	V	Module supply voltage shall not be exceeded	
Accuracy % FS				±4	%FS		
Input resistance			7,6		kΩ	*Uin ≤ 10V*	
Input capacitance			22		nF		
Input cut-off frequency			0,6		kHz	HW filter	
Input leakage	I_{leak}	-350		100	uA	Leakage current from DO_H (positive value outgoing from DO_H)	
Type	**$AI_{27V.1}$ 0-27V Voltage input**						
Voltage range		0		27	V	Voltage input	
Over voltage				VBAT	V	Module supply voltage shall not be exceeded	
Accuracy % FS				±4	%FS		
Input resistance			7,1		kΩ	*Uin ≤ 27V*	
Input capacitance			22		nF		
Input cut-off frequency			1.15		kHz	HW filter	
Input leakage	I_{leak}	-350		100	uA	Leakage current from DO_H (positive value outgoing from DO_H)	

Reverse feed

Note!
If $AI_{10V.1}$ / $AI_{27V.1}$ input voltage is higher than VBAT voltage there will be internal reverse feed from AI to VBAT supply voltage. TEC132 module does not withstand reverse feed. **Reverse feed will damage** the TEC132 module. Electrical system must be designed so that reverse feed is not possible. Reverse feed can be prevented by using DO_H, or $VREF_{5V/10V}$ outputs to supply $AI_{10V.1}$ / $AI_{27V.1}$

Table 17 - AI signals

Signal	Dir	Description
$AI\_{V.1}$	In	Configurable analog input
IO_GND		Ground pin for sensor return signal

6.2.5 Output, Voltage reference output 5 V / 10V ($VREF_{5V.1}$, $VREF_{10V.1}$)

Output can be used as reference voltage output for sensors (i.e. ratiometric measurement) or supply voltage source for external sensors.
Output voltage can be configured in application software.

Note! 10 V reference output voltage cannot be used if system nominal voltage is 12V.

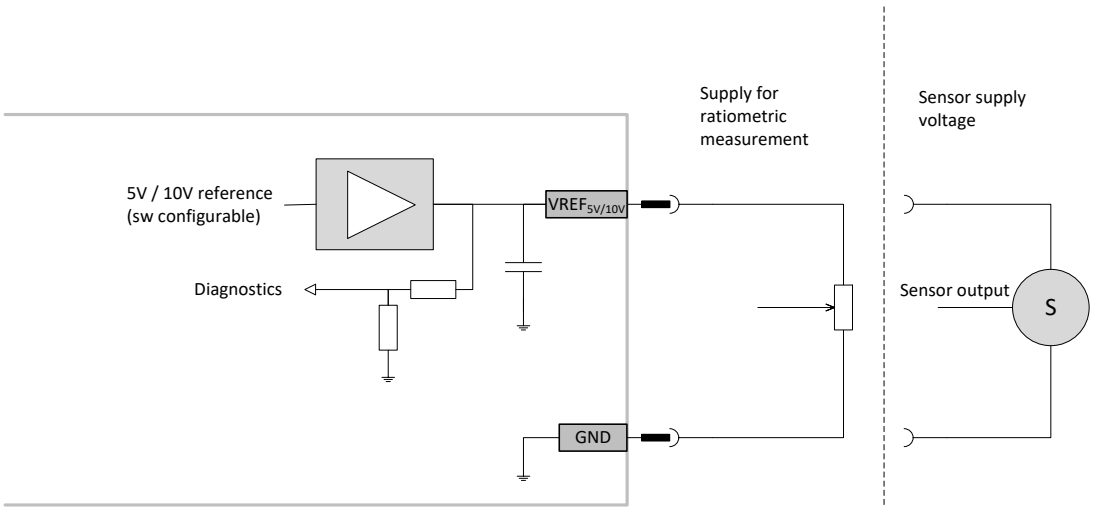


Figure 8- VREF usage

Table 18 - Voltage reference output electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	$VREF_{5V.1}$, $VREF_{10V.1}$						
Default state		OFF					
Output voltage	U_{out}		5 10		V V	10V mode is available on in 24V system	
Output accuracy % FS				±0,5	%FS		
Output over voltage		-3		32	V	Output short circuit to battery	
Output current				50	mA		
Protection		SC_G, SC_B					
Output voltage feedback measurement range		0		10,5	V		
Output voltage feedback measurement accuracy % FS				±1	%FS		

Table 19 - VREF signals

Signal	Dir	Description
$VREF_{V.1}$	OUT	Configurable reference output
IO_GND		Ground pin for sensor return signal

6.2.6 Output, high side PWM or ON/OFF ($DO_{H\_3A5.1}$ & $DO_{H\_3A5.2}$)

TEC132 high-side outputs can be used either in ON/OFF or open-loop PWM mode. External free-wheeling diode is mandatory with inductive loads.

TEC132 high-side output load examples:
- ON/OFF hydraulic valve
- Solenoid
- Proportional valve (open-loop control)
- Bulb lamp
- Led lamp (with external led driver)
- Heaters (and other resistive loads)
- Relay

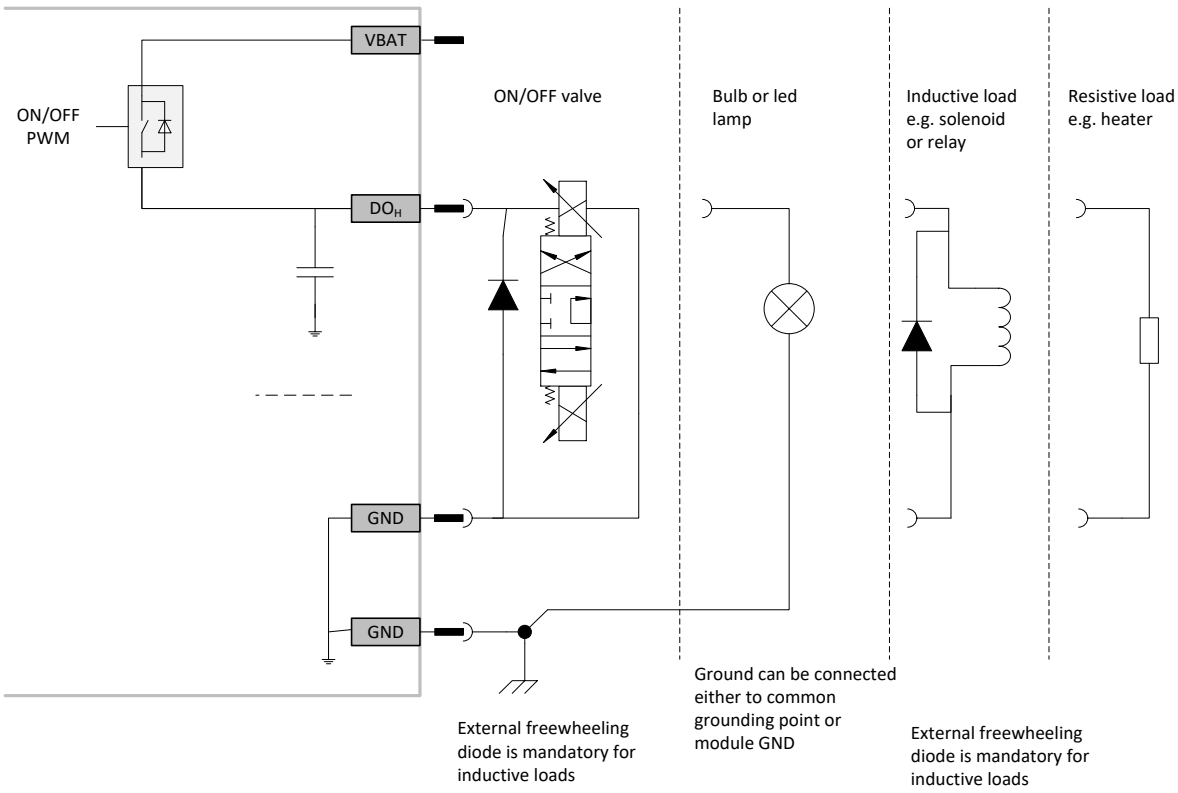


Figure 9 – DO_{H_3A5} usage

Table 20- DO_{H3A5} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		**$DO_{H\_3A5.1}$** & **$DO_{H\_3A5.2}$** High-side output					
Default state		OFF					
Voltage range		9		32	V		
Over voltage				36	V		
Output current				3.5	A	Parallel connection of the channels is allowed for higher output current in ON/OFF mode only with dedicated CODESYS block	
Voltage drop load 1 A load 3.5 A				 0.1 0.3	 V V	U(VBAT) – U(DO_H)	
Output current				3.5	A		
Short circuit current limit			7		A		
Leakage current in off state		-350		100	uA	Leakage current from DO_H (positive value outgoing from DO_H)	
PWM frequency		20 50		1000 1000	Hz Hz	**$DO_{H\_3A5.1}$** **$DO_{H\_3A5.2}$**	
PWM duty cycle resolution			0,1 0,4		% %	**$DO_{H\_3A5.1}$** **$DO_{H\_3A5.2}$**	
Protection	SC_G, SC_B						

Inductive loads (e.g. relays or valves) Free-wheeling diode

Note!
TEC132 module has not internal free-wheeling diode. Inductive load (relay or valve coil) turn-off generates voltage spike that will **damage** TEC132 module.

External free-wheeling diode must be used always with inductive loads!

Free-wheeling diode must be either regular (pn) diode or schottky diode. Varistor and/or TVS diode usage is forbidden. Free-wheeling diode shall have adequate voltage and current rating for the application. Diode voltage rating should be >100 V (>600 V is recommended).

DO_H output short circuit to battery voltage

Note!
If any of the DO_H outputs is short-circuited to battery voltage U_S higher than module supply voltage (VBAT/DO_H) reverse current will flow through module. This current will flow through output FET parasitic diode and there now way to prevent this to happen. During this condition following will happen:

- All other DO_H channels are powered through failing channel
- Complete electrical system powered through failing channel (current is flowing through VBAT)

Reverse feed will damage the TEC132 module permanently and may cause unexpected device behavior.

Table 21 - DO_H signals

Signal	Dir	Description
DO_{H_3A5}	OUT	High-side output
IO_GND		Ground pin for load return signal

6.2.6.1 Parallel connection of DO_H outputs

Two DO_H outputs can be connected parallel to increase output current. When outputs are connected parallel only ON/OFF control of the outputs is possible (no PWM control). Parallel connection must be done using special CODESYS block (this block guarantees simultaneous switching of the parallel channels). Otherwise outputs may not behavior correctly or TEC132 module may be damaged. When outputs are connected parallel maximum output current is doubled.

Channels that can be connected parallel are presented in the Table 22. Other connections are not possible. Parallel channels must be connected to each other also in wire harness. Parallel wires shall be connected together on actuator side (not directly at TEC132 connector) to balance current sharing between channels (parallel wiring minimizes the effect of possible contact resistance differences on TEC132 connector). Otherwise TEC132 may be damaged.

Table 22 – DO_H Parallel connections

#	CH A	CH B	Notes
1	X2-24	X2-1	DO_{H3A5}
2	X2-2	X2-3	DO_{H3A5}
3	X2-25	X2-26	DO_{H3A5}
4	X2-4	X2-5	DO_{H3A5}
5	X2-6	X2-7	DO_{H3A5}
6	X2-8	X2-9	DO_{H3A5}
7	X2-10	X2-11	DO_{H3A5}
8	X2-12	X2-33	DO_{H3A5}
9	X2-34	X2-35	DO_{H3A5}
10	X1-11	X1-13	DO_{H3A5}

6.2.7 Output, low side ON/OFF ($DO_{L.1}$)

TEC132 low side output load examples
- Relays
- ON/OFF valves
- Resistive loads

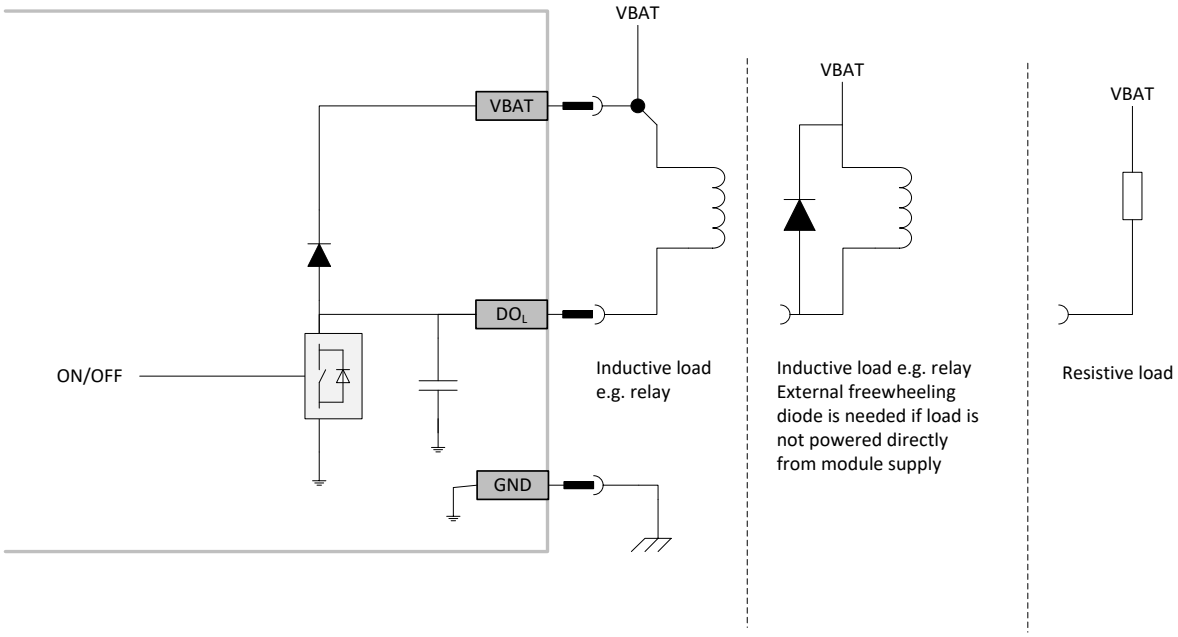


Figure 10 - DO_L usage

Table 23 - Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		$DO_{L.1}$ Low-side output					
Default state		OFF					
Voltage range		9		32	V		
Over voltage				48	V		
Voltage drop load 1 A				0,5	V		
Output current				1	A		
Freewheeling diode current				*0.5*	A	Average current	
Short circuit current limit			*7*		A		
Leakage current in off state				*350*	µA		
Protection	SC_G, SC_B						

Internal freewheeling diode & reverse polarity

Note 1!
TEC132 DO_L has internal freewheeling diode connected to SUPPLY voltage. If voltage at DO_L pin is higher than in VBAT pin reverse current will flow inside the TEC132. Reverse current can damage TEC132. DO_L controlled loads shall be powered either

1) directly from module VBAT pin OR
2) from module DO_H output

Note 2!
DO_L output switch has parasitic diode that will be activated if DO_L voltage is reversed. Excessive reverse current will damage TEC132 module.

1) DO_L shall be protected against reverse current externally (e.g. series diode or power supply from DO_H output) OR
2) reverse current has to be limited <<1A

Table 24 – DO_L interface signals

Signal	Dir	Description
DO_L	Out	Low side digital output

6.2.8 Output, Analog output 0-10V ($AO_{10V.1}$)

General purpose analog output can be used for example to control external actuators. Analog output can only be used in 24V systems (VBAT equals to 16-32V).

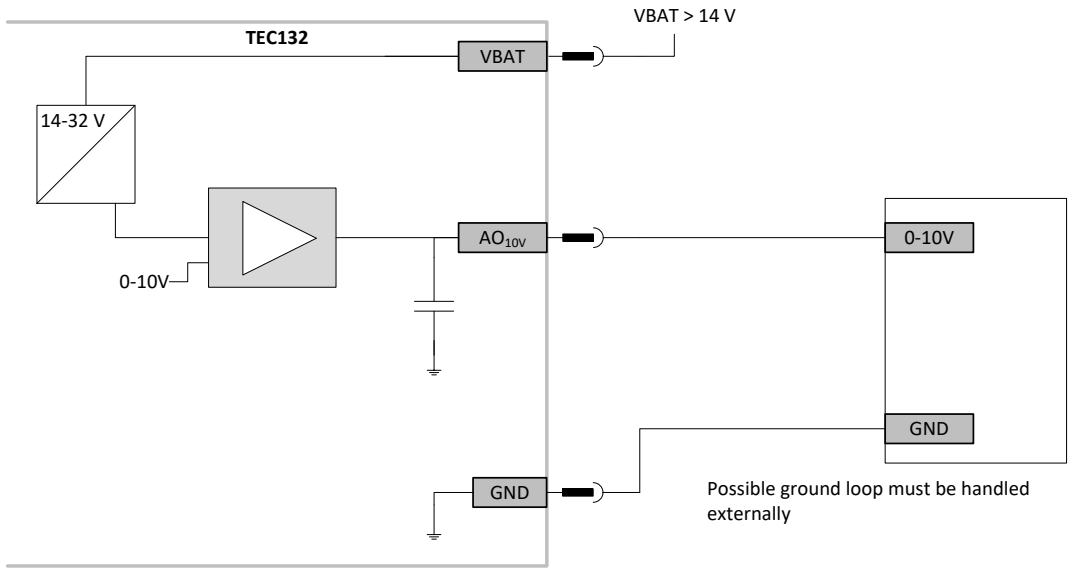


Figure 11- AO_{10V} usage

Table 25 - Analog output electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	$AO_{10V.1}$, Analog output 0-10V						
Default state		0 V / OFF					
Output voltage	U_{out}	0		10	V		
Resolution				10	bit		
Output accuracy % FS			±0,1	±0,5	%FS		
Output over voltage		0		32	V	Output short circuit to battery	
Output current				10	mA	Minimum output load is 1kΩ	
Capacitive loading				1	µF		
Protection		SC_G, SC_B					

Table 26 – Analog output signals

Signal	Dir	Description
$AO_{10V.1}$	Out	Analog output 0-10V
IO_GND		Ground pin for load return signal

6.2.9 IO GND (actuator / sensor return signal)

TEC132 module has several IO GND pins that can be used to connect load / actuators / sensor return signals. IO GND is internally connected to module GND pins. It is essential to use strictly controlled grounding principle e.g. for analog signals to prevent measurements errors caused be ground currents. Sensors and loads shall be grounded only in module side to prevent ground loops (IO_GND pin or star-grounding near module GND pin).

Table 27 – IO GND electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	IO_GND, Ground signal for sensors and actuators						
Input current				10	A		

6.2.10 System status LEDs

There are two LEDs that are visible to the user. LEDs are located on cover near type label (Ch. 8.1). First (green) led indicates module operational or fault state other (yellow) is user application programmable. Module status LED (green) functionality is according to Table 28.

Table 28 – Status led operation

LED (green) state	Description
Constant ON	Power ON – system software not running
2 blinks	Application SW running
3 blinks	Reserved for future use
4 blinks	Application / system SW reprogramming
5 blinks	Reserved for future use
6 blinks	Module under voltage
OFF	Power failure
LED (yellow) state	**Description**
ON/OFF (default OFF)	Application specific, freely programmable

6.3 Communication definition

6.3.1 CAN

Module has two CAN 2.0 A/B communication interfaces. CAN physical layer is according to ISO 11898-2.

Parameter		Value	Description
Physical layer		ISO 11898-2	High speed CAN
Termination resistor		no internal termination	
Communication speed		40 kbps – 1 Mbps	
Common mode voltage		-25 V …+25 V	
Short circuit protection		-28 V … +36 V	
CAN_H / CAN_L leakage current		5µA	Max leakage current during power-off, $U_{CAN\_H/CAN\_L} < 5$ V

Table 29 - CAN interface signals

Signal	Dir	Description
CAN_H	In / Out	CAN transmit / receive high
CAN_L	In / Out	CAN transmit / receive low

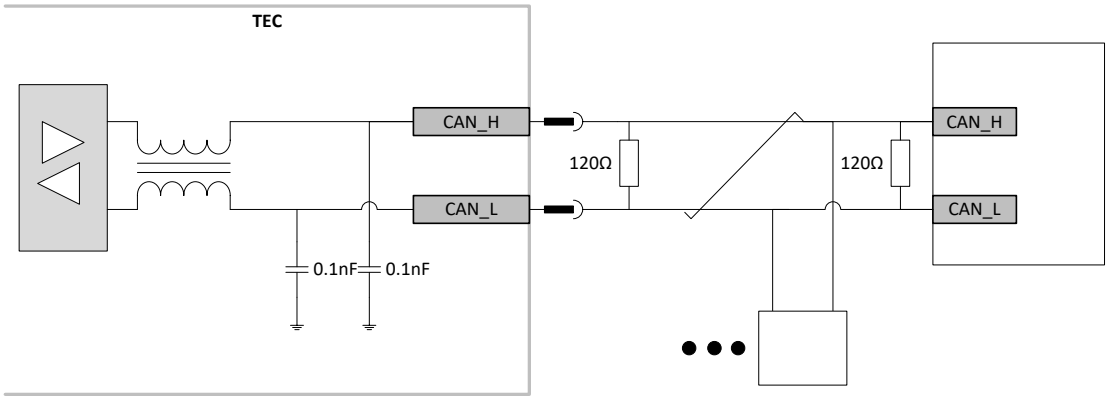


Figure 12- CAN usage

6.3.2 RS-232

RS-232 interface has two operation modes that depend on used TEC132 product variant. In TEC132 models that include CODESYS application development environment RS-232 port can only be used as CODESYS V2.3 development port. TEC132 models with C-libraries have full support for RS-232 in application level.

Parameter		Value	Description
Communication speed		max. 115200 bps	
Input capacitance		typ. 1,5 nF	

Table 30 – RS-232 interface signals

Signal	Dir	Description
RS-232_TXD	Out	Transmit data
RS-232_RXD	In	Receive data
IO_GND		Reference ground signal

6.3.3 RS-485

RS-485 interface can be used to connect TEC132 to other ECUs. TEC132 supports MODBUS-RTU protocol. TEC132 can also supply power to other modules.

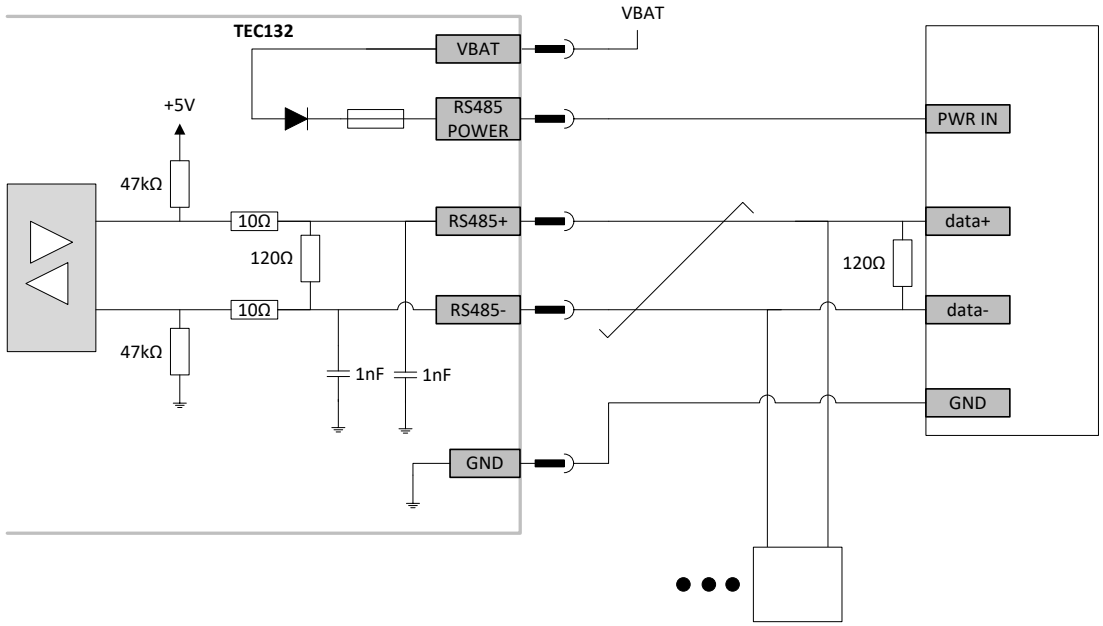


Figure 13- RS-485

Parameter		Value	Description
Physical layer		TIA/EIA-485	
Termination resistor		120 Ω	
Communication speed		max. 115,2 kbps	
Input common mode voltage		-10 V …+15 V	
Short circuit protection		-28 V … +36 V	
RS485+/RS485- leakage current		*250*µA	Max leakage current during power-off, $U_{RS485+/RS485-}$ < 5 V
RS485+/RS485- input capacitance		1 nF	
RS-485 POWER output voltage		Min. $U_{(VBAT)}$ – 2V	
RS-485 POWER output current		Max. 0,5 A	

Table 31 – RS-485 interface signals

Signal	Dir	Description
RS485+	In / Out	Non-inverted TX/RX data
RS485-	In / Out	Inverted TX/RX data
RS485_POWER_OUT	PWR	Power output for external bus device
GND		Reference ground signal

7 Environmental specification

7.1 General

Electrical and environmental requirements are based on standard ISO 16750.

7.2 Ambient temperature

The TEC132 is to be designed to operate directly in vehicle body or inside the cabin. The function of the TEC132 will not deteriorate in an unacceptable manner, throughout the environmental extremes, for normal life time of the product.

Item		Min	Nom	Max	Unit	Notes
Operating temperature		-40	-	75	°C	
Storage temperature		-40	-	85	°C	

7.3 Technical conformity

EN 13309:2010	Construction machinery - Electromagnetic compatibility of machines with internal power supply
EN ISO 14982:2009	Agricultural and forestry machinery. Electromagnetic compatibility. Test methods and acceptance criteria (ISO 14982:1998)
ISO 13766:2006	Earth-moving machinery -- Electromagnetic compatibility

7.4 Functional safety

TEC132 is not a safety component according to the machine directive 2006/42/EC. TEC132 is not SIL classified.

8 Connector pin mapping

8.1 Connector locations

Figure 14 - Connector locations

8.2 Main connectors pin map

Table 32 – Connector X1 pinout

Connector A – TYCO AMPSEAL 1-776262-1 BLACK					
Pin		**Dir**	**Function(s)**	**Group**	**Notes**
X1	1	PWR[1)]	VBAT		Power input, both X1-1 and X1-10 shall be connected
X1	2	I/O	CANA_H		
X1	3	I/O	CANA_L		
X1	4	O	RS232_TXD		
X1	5	GND[1)]	GND		System ground
X1	6	I/O	CANB_H		
X1	7	I/O	CANB_L		
X1	8	I	RS232_RXD		
X1	9	GND[1)]	GND		System ground
X1	10	PWR[1)]	VBAT		Power input, both X1-1 and X1-10 shall be connected
X1	11	O	$DO_{H\_3A5.2}$,$DI_{H.2}$	O#2	Input voltage must be ≤ VBAT in all cases
X1	12	GND	IO GND		
X1	13	O	$DO_{H\_3A5.2}$,$DI_{H.2}$	O#2	Input voltage must be ≤ VBAT in all cases
X1	14	GND	IO GND		

1) *Several parallel pins are needed for output current rating*

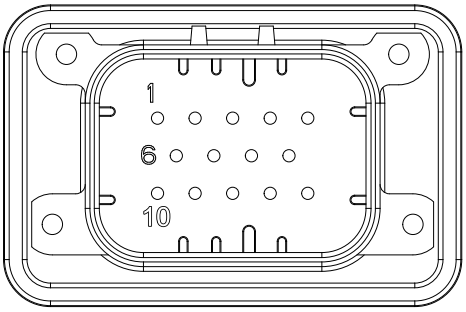


Figure 15 – X1 connector pin numbering

Table 33 – Connector X2 pinout

Connector A – TYCO AMPSEAL 776231-1 BLACK					
Pin		Dir	Function(s)	Group	Notes
X2	1	I/O	$DO_{H\_3A5.1}$,$DI_{H.1}$,$AI_{10V.1}$,$AI_{27V.1}$,$DO_{L.1}$	I/O#1	Input voltage must be ≤ VBAT in all cases
X2	2	I/O	$DO_{H\_3A5.1}$,$DI_{H.1}$,$AI_{10V.1}$,$AI_{27V.1}$	I/O#1	Input voltage must be ≤ VBAT in all cases
X2	3	I/O	$DO_{H\_3A5.1}$,$DI_{H.1}$,$AI_{10V.1}$,$AI_{27V.1}$	I/O#1	Input voltage must be ≤ VBAT in all cases
X2	4	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	5	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	6	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	7	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	8	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	9	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	10	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	11	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	12	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	13	GND	IO GND		
X2	14	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	15	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	16	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	17	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	18	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	19	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	20	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	21	I	$AI_{5V.2}$,$AI_{10V.2}$,$DI_{H.3}$	I#3	
X2	22	O	$VREF_{5V.1}$,$VREF_{10V.1}$	O#4	
X2	23	O	$VREF_{5V.1}$,$VREF_{10V.1}$	O#4	
X2	24	I/O	$DO_{H\_3A5.1}$,$DI_{H.1}$,$AI_{10V.1}$,$AI_{27V.1}$,$DO_{L.1}$	I/O#1	Input voltage must be ≤ VBAT in all cases
X2	25	I/O	$DO_{H\_3A5.1}$,$DI_{H.1}$,$AI_{10V.1}$,$AI_{27V.1}$	I/O#1	Input voltage must be ≤ VBAT in all cases
X2	26	I/O	$DO_{H\_3A5.1}$,$DI_{H.1}$,$AI_{10V.1}$,$AI_{27V.1}$	I/O#1	Input voltage must be ≤ VBAT in all cases
X2	27	O	$AO_{10V.1}$	O#5	
X2	28	GND	IO GND		
X2	29	GND	IO GND		
X2	30	GND	IO GND		
X2	31	GND	IO GND		
X2	32	GND	IO GND		
X2	33	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	34	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases
X2	35	I/O	$DO_{H\_3A5.2}$,$DI_{H.2}$	I/O#2	Input voltage must be ≤ VBAT in all cases

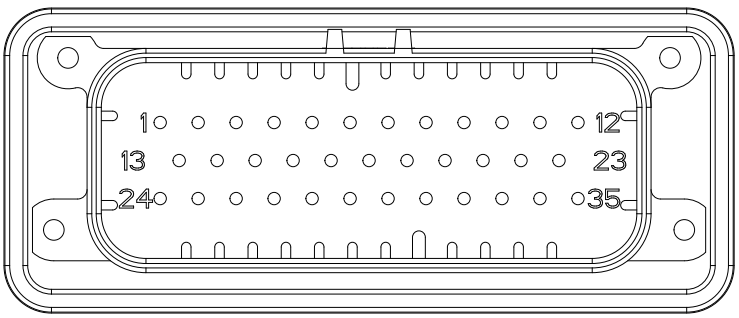


Figure 16 – X2 connector pin numbering

8.3 RS-485 M12 (Female, A-coded)

Table 34 – Connector X4 pinout

Connector X4 – M12 socket A-coded					
Pin		**Dir**	**Function(s)**	**Group**	**Notes**
X4	1	PWR	RS485_POWER_OUT		Power output
X4	2	I/O	RS485+		RX/TX data+
X4	3	GND	GND		GND
X4	4	I/O	RS485-		RX/TX data-

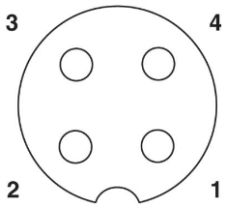
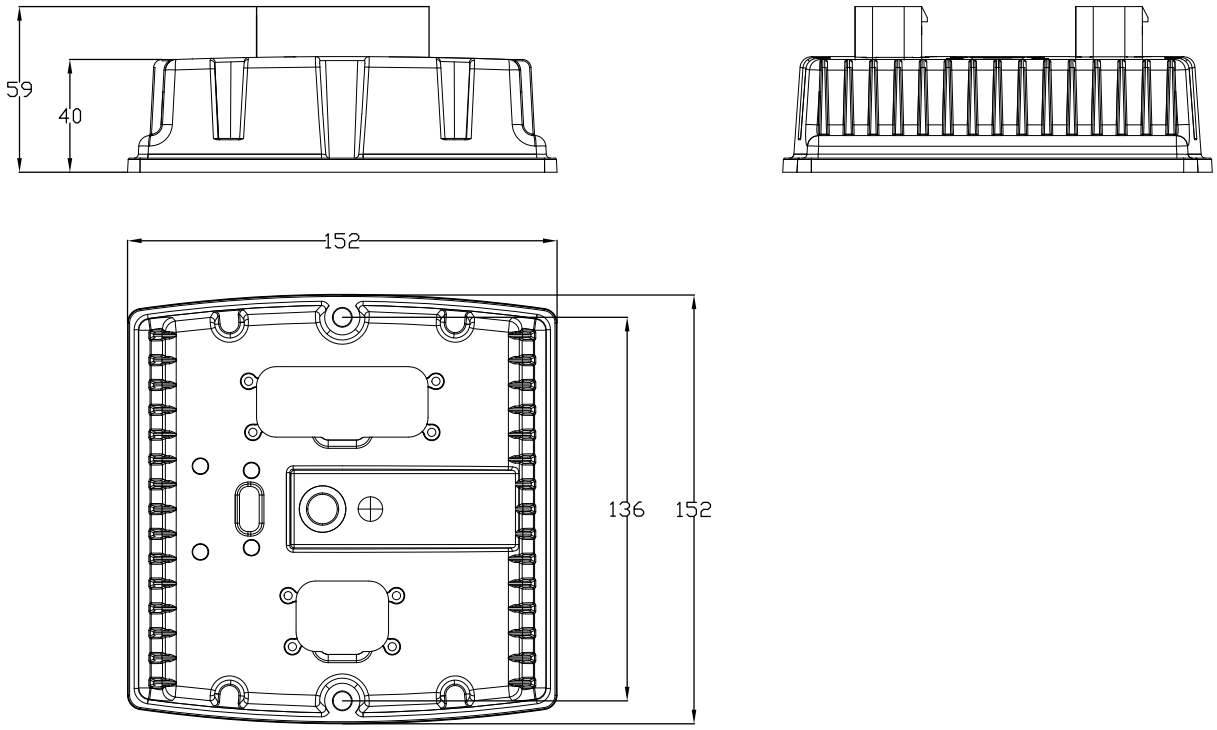


Figure 17 – X4 RS-485 connector pin numbering from front view of the TEC132 connector

9 Mechanical drawings



10 Reference documents

Item	Document name	Description	Rev.
[1]	Technical Report: The Tin Command-ments:Guidelines For The Use Of Tin On Connector Contacts, AMP Incorporated	http://www.te.com/documentation/whitepapers/pdf/sncomrep.pdf	7/31/96
[2]	Technical Report: Golden Rules: Guide-lines For The Use Of Gold On Connector Contacts, AMP Incorporated	http://www.te.com/documentation/whitepapers/pdf/aurulrep.pdf	7/29/96

11 Version History

Version	Date	Description	Author	Approval
1.0	10.10.2014	Initial version (new documentation layout)		
1.1	16.3.2015	Minor updates in chapters 3-6 & 10		
1.2	27.6.2018	Updates in following chapters: Ch. 4.1.1 Chapter added Ch. 4.2 Connection guidelines added Ch. 4.4 Product codes covered in this document updated Ch. 5.3.2 Chapter added Ch. 6.2.3 $AI_{5V.2}$ & $AI_{10V.2}$ accuracy specification improved Ch. 6.2.6 DO_H reverse feed note added Ch. 6.2.6.1 Added guidelines for parallel connection Ch. 6.2.7 DO_L connection guidelines added Ch. 6.2.10 Chapter added Ch. 6.3.1 Minimum communication speed updated Ch. 8.2 CAN bus naming convention changed		