Technion Control Unit
TEC152
Technical manual

Table of contents

1 Overview

This document specifies Technion Control Unit (TEC152) electrical and mechanical details and gives brief functional overview of the controller.

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 – i.e. CODESYS IEC-61131 program
Wetting current	Minimum current flow through switch to break any oxidation on the switch contacts

3 General

TEC152 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. TEC152 is intended to be a part of the control system in vehicle. The control unit will control valves and other actuator, read different kind of sensors and communicate with other control units forming a complete control system. The TEC152 is intended for mounting directly to vehicle body or inside the cabin.

Functionality of application is developed by CODESYS V3 freely by customer. Technion offers supportive libraries for I/O mapping and field communication interfaces.

3.1 Limited Responsibility

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

Technion Oy 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.

WARNING. The Product including the System software and libraries can fail in operation causing serious damage.

Technion Oy recommends that for each machine / equipment type in which the Product is used a separate professional safety analysis be performed. The machine / equipment builder and system integrator shall analyze all aspects of the Product and the operation conditions and the applications. The machine / equipment builder is alone responsible for making the final selection of components and systems integrated into its product. The machine/equipment builder is alone responsible for any and all consequences that may occur. Technion Oy does not have responsibility for any consequencies, be it direct or indirect, caused by failures or malfunctions. Furthermore, Technion Oy does not have any responsibility for accidents caused by incorrectly mounted or maintained machinery/equipment and it does not assume any liability for Technion Oy components which have been incorrectly applied or the system having been programmed in a manner which jeopardizes safety.

The specifics and features of the Product should always be appropriately documented in the machine and equipment owner/user manuals in a way that the machine and equipment operator has the data to enable him to operate the machine / equipment correctly and in a safe manner.

Technion Oy shall not be liable for loss of production, loss of profit, loss of use or any other consequential damages, punitive damages and/ or indirect losses, irrespective of the cause thereof. In case claims based on product liability are brought against Technion Oy for which Technion Oy may be liable, Technion Oy's liability is limited to the coverage covered under normal product liability insurances. The equipment/machinery builder shall compensate Technion Oy to the extent Technion Oy might be liable to pay damages as a result of claims based on product liability.

Technion Oy 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: Aluminum casing
Protection Class: IP67
Weight: 1.5 kg
Dimensions: 215 mm x 200 mm x 45 mm (W x L x H)
Mounting: 5 holes at module corners for M6 bolts
Connectors: Right angle mount, located at side of the casing

Mechanical drawing is presented in Chapter 9.

4.1.1 Mounting recommendations

Following guidelines shall be followed:

- TEC152 module shall be mounted to flat surface.
- TEC152 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 TEC152 with distance less than 150 mm.

4.2 Electrical connection

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

Table 1- TEC152 connectors

Ref	Module connector	Contact plating	Mating connector	Usage
A	TE Connectivity 1241434-1	Tin	TE Connectivity 1473244-1 [1]	Power, inputs, outputs
B	TE Connectivity 1241434-1	Tin	TE Connectivity 1473252-1 [1]	Inputs, outputs

[1] Lever assembly and MQS retainer are also needed, see TE Connectivity connector datasheets and instruction sheet 411-78008 [3]

Maximum current for single connector pin is MAX 3 A (MQS pin) and 10 A (JPT pin). 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.

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.

4.3 Marking

Product is marked with type label. Type label contains following information: Technion part number, serial number and production date.

4.4 Order options

This documents covers following products.

Table 2 – TEC152 order codes covered by this manual

Order code	Description
TEC152-001	Standard version

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

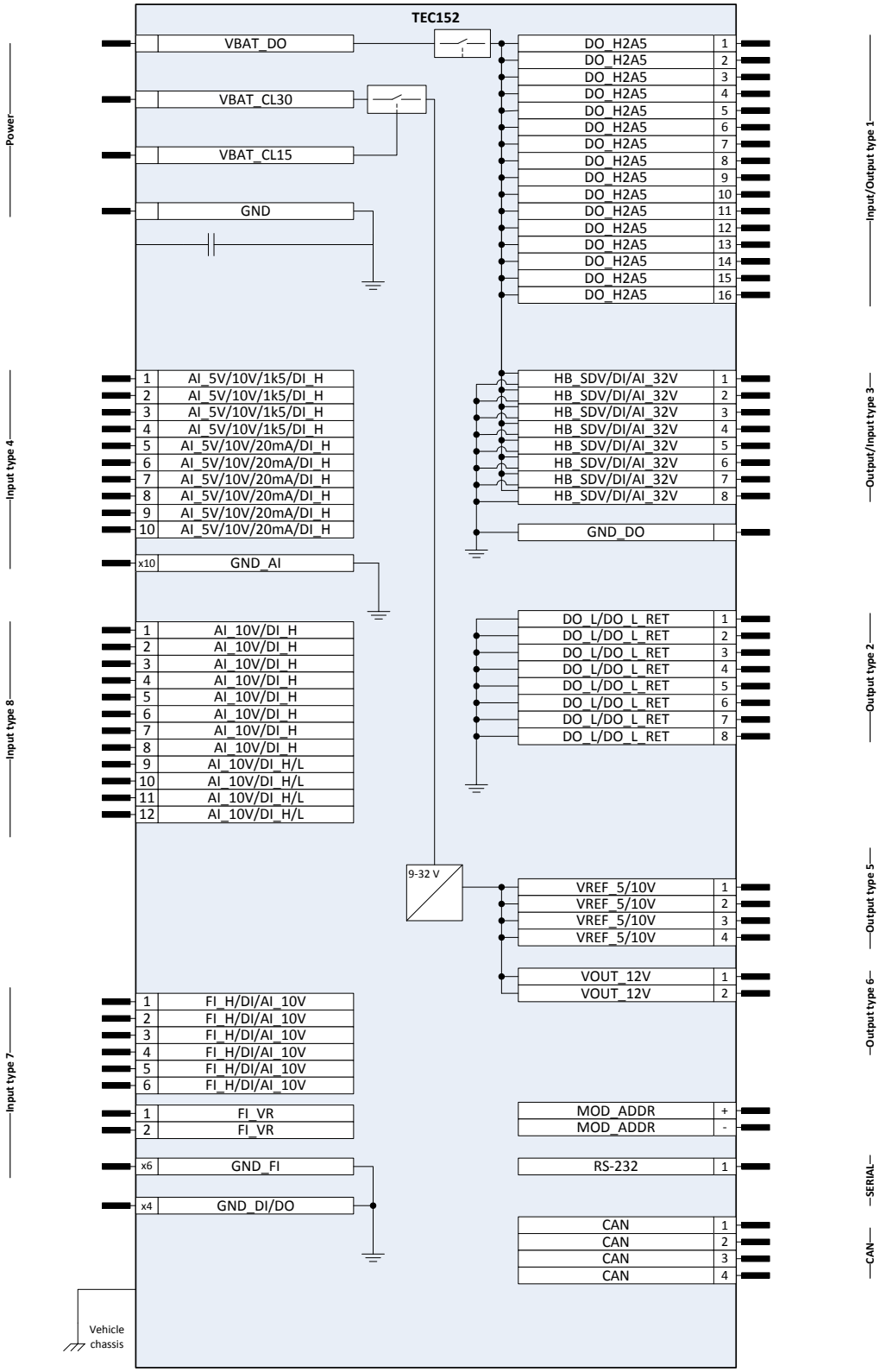


Figure 1 - TEC152 I/O block diagram

5.2 System properties

TEC152 has following system properties.

Memory	Size
CPU type	MPC5674F
CPU architecture	e200z7 Power Architecture
CPU performance	600 DMIPS

TEC152 memory resources are presented below.

Memory resources	Size
RAM (total)	1.25 MiB
RAM (application)	0.75 MiB
Program Flash (total)	4 MiB
Program Flash (application)	2 MiB
Data Flash (total)	16 MiB
Data Flash (application)	9.5 MiB
Retain data memory	3.5 KiB

CODESYS (IEC-61131) application is executed and located in "program flash (application)" memory. Data flash can be used to store for example application parameters and/or failure / diagnostics log. Retain data memory is a fast non-volatile memory. Data in retain data memory remain unaltered on power failure (unintended VBAT_cl30 power loss).

Retain data memory parameters:

Item		Min	Nom	Max	Unit	Notes
Endurance		25			years	
Data refresh time			10		ms	data is refreshed automatically
Data retention		10			years	TEC152 power-OFF time shall not exceed data retention time, otherwise data may be corrupted. During power-ON data is automatically refreshed

Module start-up time

Parameter	Time (min)	Time (nom)	Time (max)
Start-up time from power-up to application software start[1]		400 ms	

5.2.1 Internal system monitoring

TEC152 has external hardware watch-dog that monitors system software execution. External watch-dog time out period is maximum 750 ms. If watchdog is activated (maximum kick time is exceeded) all outputs are switched OFF (OFF is expected to be output safe state). System software is restarted automatically and SW failure information is forwarded to application software. Application software execution can be monitored using CODESYS task watch-dog. Application software programmer may decide if automatic application restart is accepted or not.

Controller monitors internal temperature. If internal temperature exceeds safe range all outputs are put to safe state (OFF) and program execution is halted. Internal temperature is readable in application SW. Controller will send critical warning to application before automatic output turn-off.

[1] Application software is located and executed from flash memory (simple application toggling digital output, system software v3.7.0.9).

Item		Min	Nom	Max	Unit	Notes
Internal temperature measurement range		-45		130	°C	
Accuracy				±5	°C	

5.3 Power supply

TEC152 module can operate either in 12V or 24V electrical system.

Item		Min	Nom	Max	Unit	Notes
Supply voltage	U_S	9	24	32	V	
Overvoltage 1				36	V	Controller operates normally during overvoltage (32 V – 36 V). Maximum overvoltage 1 duration that module withstands is 60 minutes. [2]
Overvoltage 2				48	V	Controller does not operate during overvoltage 2 (36 V – 48 V). If overvoltage 2 is exceeded module will be damaged.
Reverse voltage		-28			V	
Under voltage detection			8		V	Automatic shutdown after 60 seconds
Under voltage shutdown			5.4		V	
$VBAT_{cl15}$ threshold voltage			8	9		
$VBAT_{cl15}$ input pull-down resistance			3.3		kΩ	
Supply current: module/logic ($VBAT_{cl30}$)			0.2		A	@ 28V, sensor supply output not included current
$VBAT_{cl30}$ fuse rating			4		A	Includes -30% fuse derating, supply voltage range 9-32V, maximum load conditions.
Standby Supply current: module ($VBATcl_{30}$ + $VBAT_{DO}$)			2.6		mA	$VBAT_{cl15}$ < 2 V, VBATcl30 ≈ 24 V, $VBAT_{DO}$ ≈ 24 V, module is turned to OFF state
Supply current: outputs ($VBAT_{DO}$)				20	A	

Controller has under and over voltage monitor. During $VBAT_{CL30}$ under voltage all outputs are switched off (i.e. safe state) and user application is shut down; during $VBAT_{DO}$ under voltage all outputs are switched off, but the user application remains active and output control can be restored if supply voltage reaches minimum value. Exceeding Overvoltage 1 maximum value causes immediate shutdown of the module. If Overvoltage 2 maximum value is exceeded module will be damaged permanently.

Module monitors $VBAT_{DO}$ total current. If maximum current is exceeded all outputs are switched OFF and power off-on cycle is required for returning to normal operation.

Power supply fault events are reported for user application.

5.3.1 Power supply input

Supply voltage must be within the module operating range. Module has two separate power inputs and one control input. Separate power inputs are for module logic ($VBAT_{CL30}$) and outputs ($VBAT_{DO}$) power. $VBAT_{CL30}$ supplies power to internal logic circuitry and input functions (including power supply for the sensors). $VBAT_{DO}$ power supply provides power for high-side outputs (DO_H) and Sauer-Danfoss valve control (HB_{SDV}) outputs. Module power is controlled using one dedicated control signal $VBAT_{cl15}$. Module is started after $VBAT_{cl15}$ is activated. Power-off is controlled either from software or $VBAT_{cl15}$ signal. $VBAT_{cl15}$ signal can be used e.g. to implement delayed power-off functionality.

[2] Some I/O functions do not tolerate overvoltage during short circuit to battery conditions. See detailed I/O specifications.

TEC152 power inputs $VBAT_{CL30}$ and $VBAT_{DO}$ voltage can be measured in application software.

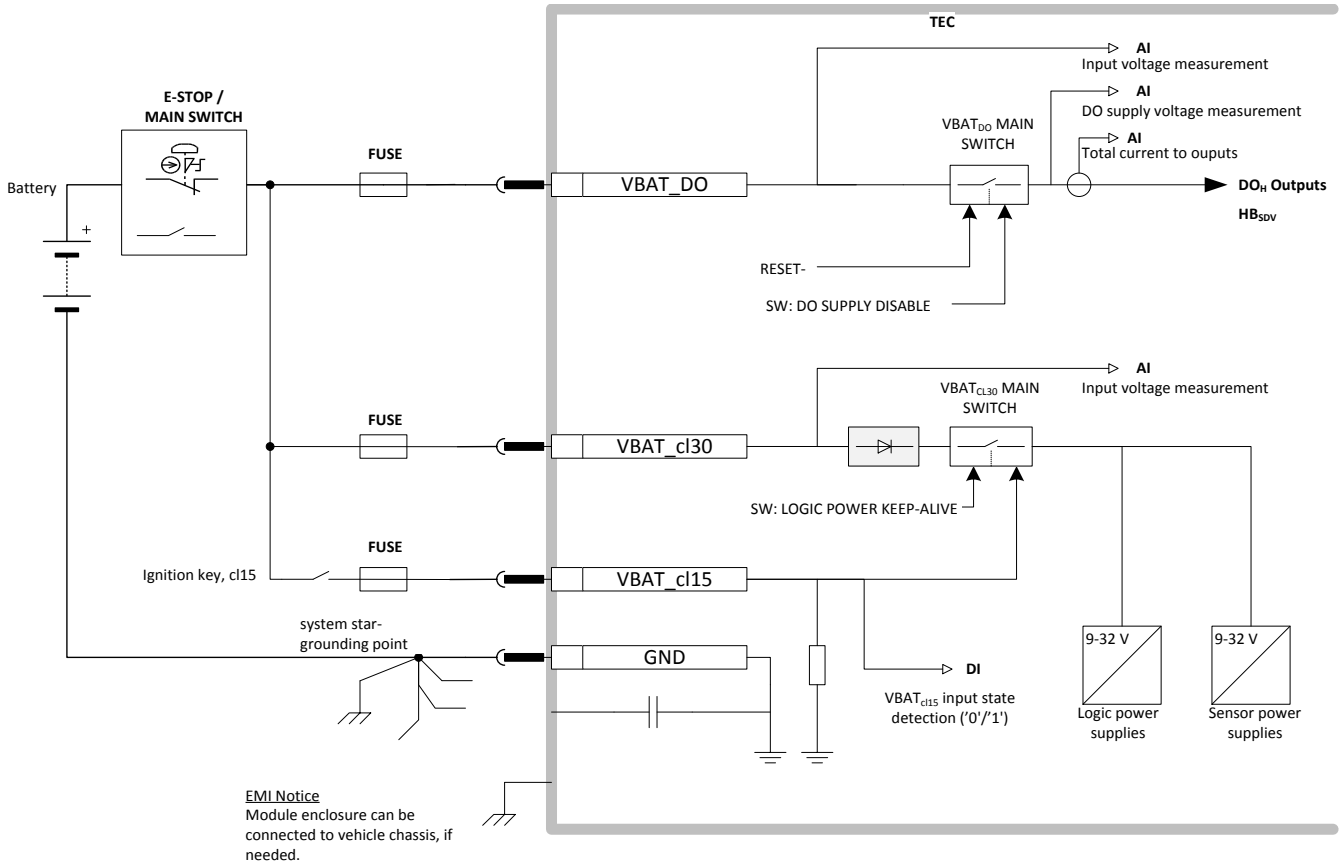


Figure 2 – VBAT power input topology

Table 3 – VBAT input diagnostics

Item		Min	Nom	Max	Unit	Notes
$VBAT_{CL30}$ & $VBAT_{DO}$ voltage measurement range		0		48	V	
Measurement accuracy % FS				±1	%FS	
Accuracy, typical			0.7+0.2		%	± (% of reading + % FS)

Table 4 - Functional specification

Item	Value	Notes
$VBAT_{cl30}$ main switch control	Power supply for logic and sensor supplies are supplied through internal "main switch". Logic operation is started when $VBAT_{cl15}$ is powered. Module is powered-down after both $VBAT_{cl15}$ is switched off and software control signal (logic power keep-alive) is negated.	
$VBAT_{DO}$ main switch control	Digital output (DO_H) outputs are supplied through single $VBAT_{DO}$ main switch. Main switch is enabled when: 1) Controller logic power supplies are stable (reset = '1') AND 2) Application SW asserts main switch control signal (do_supply_disable = '0')	

Item	Value	Notes
$VBAT_{DO}$ main switch reverse current protection	Main switch is reverse protected when disabled (i.e turned OFF). Then short circuit to battery on DO_H cannot supply power to $VBAT_{DO}$ pin (=vehicle battery / cl30)	

Table 5 - Power input signals

Signal	Type	Description
$VBAT_{cl30}$	PWR	Power supply input for module logic functions and sensors
$VBAT_{DO}$	PWR	Power supply input for outputs (DO_H and HB_{SDV})
$VBAT_{cl15}$	IN	Control input for module power supply
GND	-	Ground for logic and output power supply

5.3.2 Module grounding

TEC152 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 TEC152 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 (GND_{AI} / GND_{FI} / GND_{DI}) shall not be connected to general ground point. Instead direct connection between sensitive sensors and TEC152 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 TEC152) otherwise unwanted ground currents are introduced.
- TEC152 enclosure has not connected directly to module ground pins. Instead enclosure is connected capacitively to module ground. This connection reduces electromagnetic interference in most cases if module enclosure is well grounded to vehicle chassis.

6 General I/O functionality

All I/O functions (every connector pin) have short circuit protection against system supply voltage (max 32V) and GND short circuit.

6.1 I/O List

TEC152 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. TEC152 I/O pins can be configured to several I/O functions. I/O configuration is presented in Table 7. Configuration is mainly selected in SW.

Table 6 - TEC152 I/O types

I/O Type	Abbreviation
Digital input PNP (high active)	DI_H
Digital input PNP/NPN (high or low active)	$DI_{H/L}$
Digital output high-side, PWM or ON/OFF 2,5 A	DO_{H2A5}
Digital output/input return signal (GND)	$GND_{DO/DI}$
Current measurement input for DO_H (current control operation mode) 1A / 2A range	$DO_{L\_RET1A/2A}$
Digital output low-side ON/OFF	DO_L
Half-Bridge output for Sauer-Danfoss valve control (PVE actuator)	HB_{SDV}
Analog input - voltage measurement 0-5V Analog input - voltage measurement 0-10V	AI_{5V} AI_{10V}
Analog input - current measurement 4-20mA	AI_{20mA}
Analog input – resistance measurement (internal 1k5 pull-up)	$AI_{1.5k\Omega}$
Analog input – sensor ground	GND_{AI}
Voltage reference output 5 V / 10 V	$VREF_{5V/10V}$
Sensor power supply output 12 V	$VOUT_{12V}$
Sensor power supply ground	GND_{VOUT}
Frequency / pulse input high active	FI_H
Frequency / pulse input – variable reluctance sensor	FI_{VR+} FI_{VR-}
Controller address input	MOD_{ADDR}
RS-232	RS-232
CAN	CAN

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 - TEC152-001 I/O configuration

TEC152-001			
I/O Group	**Pcs**	**I/O Types**	**Notes**
HIGH SIDE DIGITAL OUTPUTS (Output #1)	16	$DO_{H2A5.1}$	Digital output 2,5A, high side, PWM
LOW SIDE DIGITAL OUTPUTS / PWM CURRENT CONTROL INPUTS (Configurable output #2)	8	$DO_{L.1}$ $DO_{L\_RET1A/2A.1}$	Digital output 1 A, low side Current measurement input (CC PWM with DO_{H2A5})
RATIOMETRIC OUTPUT (Configurable output #3)	8	$HB_{SDV.1}$ $AI_{32V.5}$ $DI_{H.5}$	Sauer-Danfoss valve control (PVE) Analog input 0-32 V Digital input (PNP / active high)
HIGH PRECISION INPUTS (Configurable input #4) (10 pcs)	4	$AI_{5V.1}$ $AI_{10V.1}$ $AI_{1k5\Omega.1}$ $DI_{H.1}$	Analog input 0-5 V Analog input 0-10 V Analog input resistance Digital input (PNP / active high)
	6	$AI_{5V.1}$ $AI_{10V.1}$ $AI_{20mA.1}$ $DI_{H.1}$	Analog input 0-5 V Analog input 0-10 V Analog input 0-20 mA Digital input (PNP / active high)
GND (for AI sensors)	10	GND_{AI}	
REFERENCE OUTPUTS (Configurable output #5)	4	$VREF_{5V.1}$ $VREF_{10V.1}$	Voltage reference output 5 V Voltage reference output 10 V
SENSOR SUPPLY VOLTAGE (Configurable output #6)	2	$VOUT_{12V.1}$	Sensor supply voltage 12 V
GND (for sensor supply voltage)	2	GND_{VOUT}	
PULSE INPUTS (Configurable input #7) (10 pcs)	6	$FI_{H.1}$ $DI_{H.3}$ $AI_{10V.3}$	Pulse input (active high) Digital input (PNP / active high) Analog input 0-10 V
	2	FI_{VR+} FI_{VR-}	Variable reluctance sensor pulse input
GND (for FI sensors)	6	GND_{FI}	
GENERAL PURPOSE INPUT (Configurable input #8) (12 pcs)	8	$DI_{H.2}$ $AI_{10V.2}$	Digital input (PNP / active high) Analog input 0-10 V
	4	$DI_{H/L.2}$ $AI_{10V.2}$	Digital input (PNP/NPN) Analog input 0-10 V
GND (for in-puts/outputs)	5	$GND_{DO/DI}$	
Controller Address	1	MOD_ADDR	Module address input
Module power supply	1 1 1	$VBAT_{cl15}$ $VBAT_{cl30}$ $VBAT_{OUT}$ GND	Power supply control signal Power supply for module logic and inputs Power supply for outputs (DO & PWM) VBAT ground
CAN	4	CAN	
RS-232	1	RS232	

6.2 I/O definition

Every configurable I/O type has its own specification. Each specification part is divided to two parts:

1) electrical specification and
2) functional 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 features

Failure	Abbreviation
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. TEC152 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.

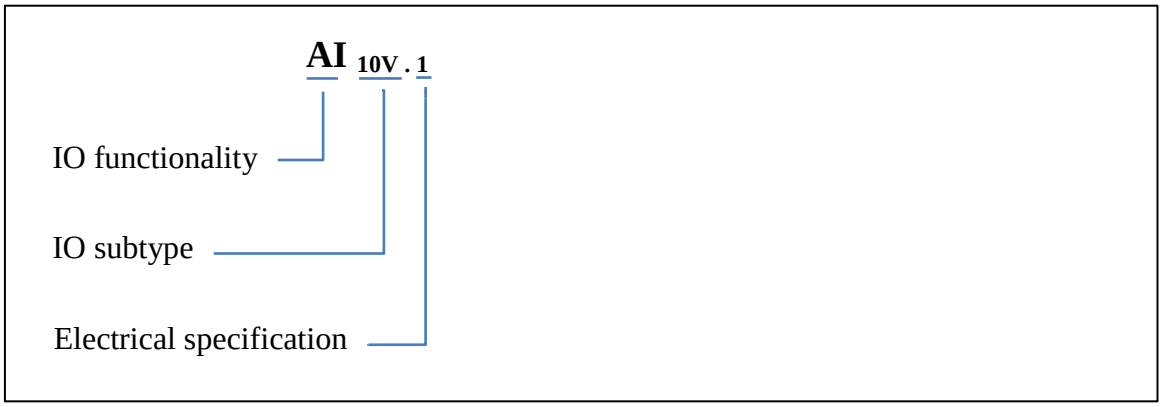


Figure 3 - IO-type naming

6.2.1 Input, PNP, [$DI_{H.1}$ / $DI_{H.2}$ / $DI_{H.3}$]

Active high i.e PNP digital input is used interface sensors / switches connected to battery voltage or TEC152 power supply outputs. For example following sensors can be connected to this input:

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

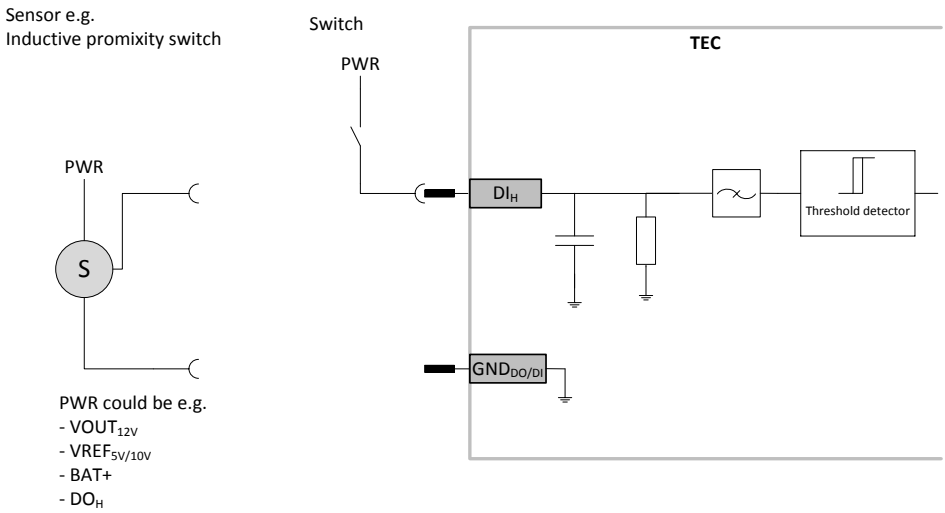


Figure 4- DI_H usage (Note! $DI_{H.1}$ shall not be fed from BAT+)

Table 9 - Electrical specification $DI_{H.2}$

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.2}$** Digital input PNP, Active high, sw controlled threshold levels						
Voltage range	U_{in}	0		32	V		
Over voltage				36	V		
Threshold low	U_{low}	1	3	5	V	Software controlled	
Threshold high	U_{high}	2	7	9	V	Software controlled	
Threshold accuracy	U_{acc}		0.3		V		
Threshold adjustment resolution			0.1		V		
Hysteresis	U_{hyst}	*depends on threshold level*				MIN U_{hyst} = U_{high} - U_{low} - 2 * U_{acc}	
Cutoff frequency	f_{-3dB}		50		Hz	HW filter	
Wetting current	I_w		9.5		mA	at 28 V	
Pull-down resistance	R_{PD}		3		kΩ	U_{in} ≤ 10 V	
Input capacitance			4.7		nF		
Protection		SC_G, SC_B					

Table 10 - Electrical specification $DI_{H.1}$

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.1}$** Digital input PNP, Active high, sw controlled threshold levels, high input impedance						
Voltage range	U_{in}	0		32	V		
Over voltage				36	V		
Threshold low	U_{low}	1	3	5	V	Software controlled	
Threshold high	U_{high}	2	7	9	V	Software controlled	
Threshold accuracy	U_{acc}		0.3		V		
Threshold adjustment resolution			0.1		V		
Hysteresis	U_{hyst}	*depends on threshold level*				MIN $U_{hyst} = U_{high} - U_{low} - 2 * U_{acc}$	
Cutoff frequency	f_{-3dB}		1.6		kHz	HW filter	
Wetting current	I_w		1		mA	at 28 V	
Pull-down resistance	R_{PD}		50		kΩ	$U_{in} \leq 10$ V	
Input capacitance			4.7		nF		
Protection		SC_G, SC_B				NO reverse polarity protection	

Reverse polarity

Note!
Input type $DI_{H.1}$ shall only be used to interface with switches and sensors that are supplied from the module voltage output DO_H, $VREF_{5V/10V}$ or $VOUT_{12V}$. This input is **not protected against reverse polarity** ($U_{in} < 0$ V).

Table 11 - Electrical specification $DI_{H.3}$

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.3}$** Digital input PNP, Active high, sw controlled threshold levels, high input impedance						
Voltage range	U_{in}	0		32	V		
Over voltage				36	V		
Threshold low	U_{low}	1	3	5	V	Software controlled	
Threshold high	U_{high}	2	7	9	V	Software controlled	
Threshold accuracy	U_{acc}		0.3		V		
Threshold adjustment resolution			0.1		V		
Hysteresis	U_{hyst}	*depends on threshold level*				MIN $U_{hyst} = U_{high} - U_{low} - 2 * U_{acc}$	
Cutoff frequency	f_{-3dB}		50		Hz	HW filter	
Wetting current (@28V)	I_w		2.5		mA	at 28 V	
Pull-down resistance	R_{PD}		11		kΩ	$U_{in} \leq 10$ V	
Input capacitance			4.7		nF		
Protection		SC_G, SC_B					

Table 12 - Functional specification

Item	Value	Notes
Input refresh rate	100Hz	
Digital filter cutoff frequency f_{-3dB}	40Hz	Digital filter implemented in system software
Digital filter stop-band attenuation	Typical 20dB at f > 100Hz	

Table 13 - DI signals

Signal	Dir	Description
DI_H	In	Active high digital input
$GND_{DO/DI}$		Reference ground for DO/DI

6.2.2 Input, PNP, [$DI_{H.5}$]

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

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

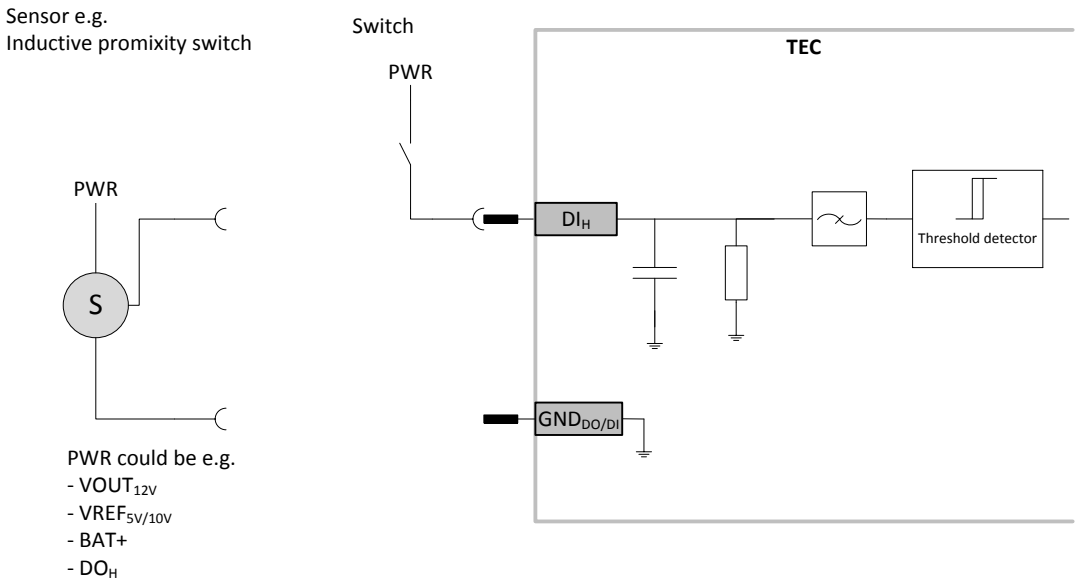


Figure 5- $DI_{H.5}$ usage

Table 14 - Electrical specification $DI_{H.5}$

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H.5}$** Digital input PNP, Active high, sw controlled threshold levels						
Voltage range	U_{in}	0		32	V		
Over voltage				32	V		
Threshold low	U_{low}	1	3	5	V	Software controlled	
Threshold high	U_{high}	2	7	9	V	Software controlled	
Threshold accuracy	U_{acc}		0.3		V		
Threshold adjustment resolution			0.1		V		
Hysteresis	U_{hyst}	*depends on threshold level*				MIN U_{hyst} = U_{high} - U_{low} - 2 * U_{acc}	
Cutoff frequency	f_{-3dB}		100		Hz	HW filter	
Wetting current	I_w		8		mA	at 28 V	
Pull-down resistance	R_{PD}		3.4		kΩ		
Input capacitance			27		nF		
Protection		SC_G, SC_B					

Table 15 - Functional specification

Item	Value	Notes
Input refresh rate	100Hz	
Digital filter cutoff frequency f_{-3dB}	40Hz	Digital filter implemented in system software
Digital filter stop-band attenuation	Typical 20dB at f > 100Hz	

Table 16 - DI signals

Signal	Dir	Description
DI_H	In	Active high digital input
$GND_{DO/DI}$		Reference ground for DO/DI

6.2.3 Input, PNP/NPN, [$DI_{H/L.2}$]

SW configurable active high or low (i.e PNP/NPN) digital input is used for interface sensors / switches connected to battery voltage.

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

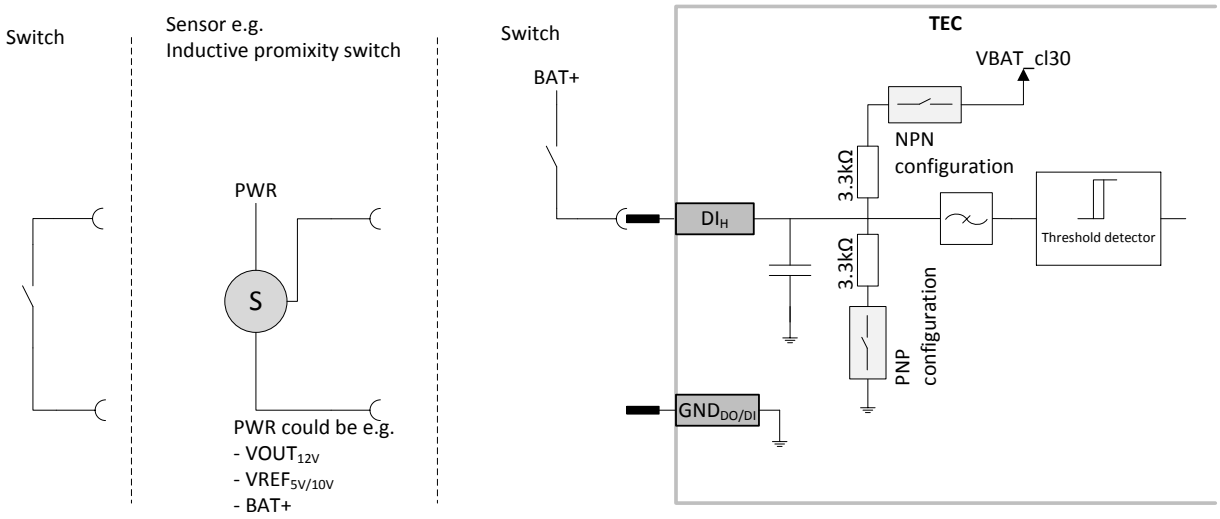


Figure 6- DI_H usage

Table 17 - Electrical specification

Item		Min	Nom	Max	Unit	Description	ID
Type	**$DI_{H/L.2}$** Digital input PNP/NPN, Active high, sw controlled threshold levels						
Voltage range	U_{in}	0		32	V		
Over voltage				36	V		
Threshold low	U_{low}	1	3	5	V	Software controlled	
Threshold high	U_{high}	2	7	9	V	Software controlled	
Threshold accuracy	U_{acc}		0.3		V		
Threshold adjustment resolution			0.1		V		
Hysteresis	U_{hyst}				V	MIN U_{high} - U_{low} - 2 * U_{acc}	
Cutoff frequency (HW)	f_{-3dB}		50		Hz		
Wetting current (@28V)	I_w		9.5		mA	at 28 V	
Pull-down resistance	R_{PD}		3		kΩ	SW controlled (PNP)	
Pull-up resistance	R_{PU}		3.3		kΩ	SW controlled (NPN)	
Input capacitance			4.7		nF		
Protection		SC_G, SC_B					

Table 18 - Functional specification

Item	Value	Notes
Input refresh rate	100Hz	
Digital filter cutoff frequency f_{-3dB}	40Hz	Digital filter implemented in system software
Digital filter stop-band attenuation	Typical 20dB at f > 100Hz	

Table 19 - DI signals

Signal	Dir	Description
$DI_{H/L}$	In	Active high/low digital input
$GND_{DO/DI}$		Reference ground for DO/DI

6.2.4 Input, Frequency / Pulse input [$FI_{H.1}$]

Configurable frequency input can be used to interface e.g. following sensors:

- Incremental encoder (quadrature signals, push-pull or PNP output)
- Incremental encoder (direction and increment signals, push-pull or PNP output)
- Incremental encoder with index/reference signal (push-pull or PNP output)
- Inductive/HALL sensors (frequency / pulse counter, push-pull or PNP output)

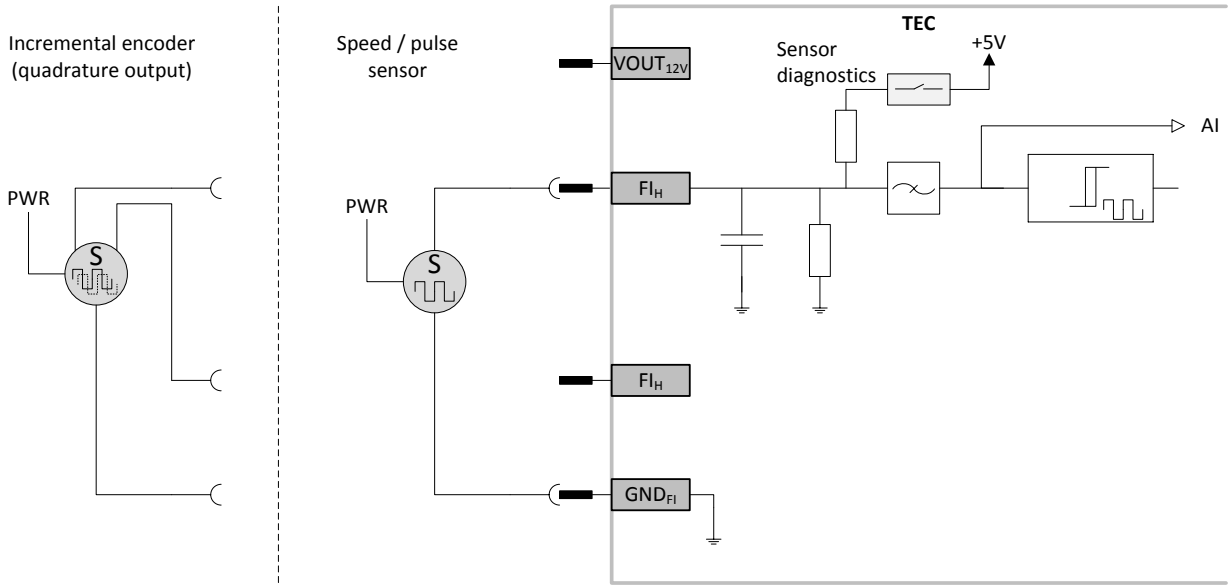


Figure 7- FI_H usage

Table 20 - FI_H Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	**$FI_{H.1}$ Frequency/pulse input**						
Input frequency range		1		25000	Hz	Rising edge frequency at one channel	
Minimum pulse width (HI or LO)		16			µs	push-pull 0V/5V input signal, R_{in}≈100Ω, t_r/t_f≈100ns	
Pulse length measure-ment mode time jitter				15	µs	push-pull 0V/5V input signal, R_{in}≈100Ω, t_r/t_f≈100ns	
Input voltage range		0		32	V		
Over voltage				36	V		
Threshold low				2	V		
Threshold high		4			V		
Hysteresis		0.2	0.5		V		
Cutoff frequency (HW)	f_{-3dB}		25		kHz	HW filter	
Input resistance			11		kΩ		
Input capacitance			4.7		nF		
Protection	SC_B, SC_G						

Table 21 - Functional specification

Item	Value	Notes
Incremental encoder mode	High resolution mode is supported (i.e. all edges of the quadrature signal are evaluated). Counter event frequency can be four times the single channel input signal frequency, i.e. counter value can change 40 000 times per second when individual encoder inputs receive 10 kHz signal. **Pins used as encoder inputs must be allocated in pairs from the following list:** FI1 (A14) & FI2 (A15) FI3 (A16) & FI4 (A17) FI5 (A18) & FI6 (A19) FI7 (A20/A39) & FI8 (A21/A40) With encoder type providing a pulse signal and direction signal, the direction signal must be connected to the latter of the listed channels (the one with higher FI-channel index).	
Pulse counter mode	Rising, falling or both edges can be counted (application specific configurability). Counter event frequency can be two times the input frequency (if both edges are counted).	
Frequency measurement mode	Resolution of frequency values: 1 Hz. Frequency evaluation interval: Maximum 1 second (software configurable). Polling interface: The last evaluated frequency value is given.	
Period or pulse length measurement mode	Measurement is configurable for rising or falling edge (pulse period measurement) or for either pulse high time or low time (pulse length measurement). Resolution: 1 microsecond. Polling interface: The last evaluated frequency value is given.	
Input capture mode	Input events (rising, falling or either edge) are time stamped. Resolution of timestamps: 1 microsecond. Polling interface: The last captured timestamp value is given. Alternatively, counter value from another pulse input can be recorded when input event occurs.	
Digital input mode	State of frequency input pin is readable while in pulse counter / measurement modes.	

Table 22 – Frequency input interface signals

Signal	Dir	Description
FI_H	In	Configurable frequency input
GND_{FI}	In	FI reference grounds

6.2.5 Input, Frequency / Pulse input for variable reluctance sensors [FI_{VR}]

This input is dedicated for variable reluctance type sensor (VR). TEC152 VR sensor interface has electrically differential input to minimize interference from electrical system disturbances. The input filter is effective below intended maximum input frequency to maximize immunity to noise. This is possible because input signal amplitude is proportional to input frequency. Input can be used as pulse/frequency counter or incremental (quadrature) encoder input. Twisted-pair cabling shall be used to minimize interference from other circuits.

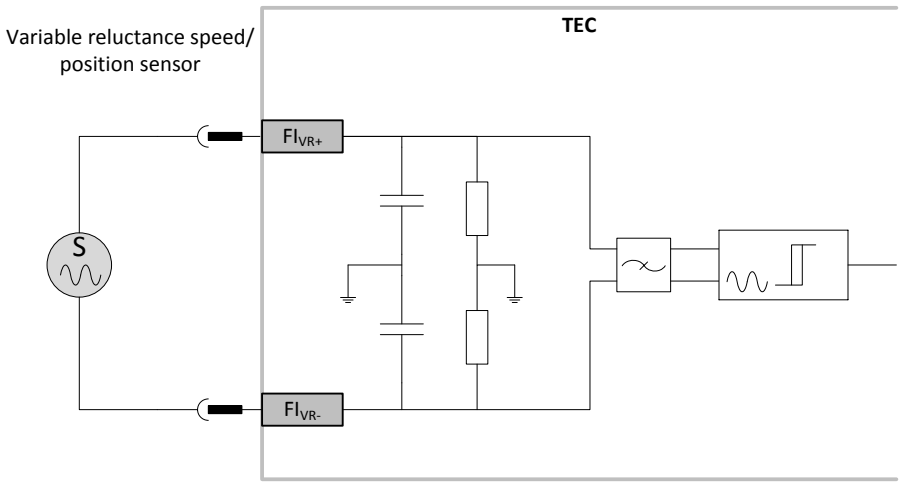


Figure 8- FI_{VR} usage

Table 23 - FI_{VR} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	**FI_{VR+} Frequency / Pulse input for Variable Reluctance-Sensor**						
Input frequency range		1		25000	Hz		
Input voltage range		-90		90	V		
Over voltage				90	V		
Minimum threshold voltage			50		mV		
Cutoff frequency (HW)	f_{-3dB} $f_{-6.5dB}$ $f_{-10.3dB}$		8 15 25		kHz kHz kHz	HW filter	
Input resistance			15		kΩ		
Input capacitance			4.7		nF		
Protection	SC_B, SC_G						

Table 24 - Functional specification

Item	Value	Notes
Pulse input filter length	1 µs (pulses shorter than filter length are ignored)	

Item	Value	Notes
Incremental encoder mode	High resolution is supported (i.e. all edges of the quadrature signal are evaluated). Counter event frequency can be four times the single channel input signal frequency, i.e. counter value can change 40 000 times per second when individual encoder inputs receive 10 kHz signal. **Pins used as encoder inputs must be a sequential pair; e.g. $FI7_{VR}$ and $FI8_{VR}$**	
Pulse counter mode	Rising, falling or both edges can be counted (application specific configurability). Counter event frequency can be two times the input frequency (if both edges are counted).	
Frequency measurement mode	Resolution of frequency values: 1Hz. Frequency evaluation interval: Maximum 1 second (software configurable). Impact of high frequency on CPU load is negligible. Polling interface: The last evaluated frequency value is given.	
Period or pulse length measurement mode	Measurement is configurable for rising or falling edge (pulse period measurement) or for either pulse high time or low time (pulse length measurement). Resolution: 1 microsecond. Impact of high frequency on CPU load is negligible. Polling interface: The last evaluated frequency value is given.	
Input capture mode	Input events (rising, falling or either edge) are time stamped. Resolution of timestamps: 1 microsecond. Polling interface: The last captured timestamp value is given.	

Table 25 – Frequency input interface signals

Signal	Dir	Description
FI_{VR+}	In	Differential sensor input+
FI_{VR-}	In	Differential sensor input-

Twisted-pair cable shall be used.

6.2.6 Input, Controller address [MOD_{ADDR}]

Controller address input is used to configure module ID-number / address in control system. ID-number can be used in application SW to identify each controller's intended functionality. Addressing supports 32 individual addresses. Resistor between two address pins defines the module address. Address resistor should be connected to mating connector using short wires (< 0,1 m).

Module address pin configuration other than presented in Table 27 returns error code. If module address pins are shorted together module start-up time is increased by 1 second.

Table 26 - MOD_{ADDR} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Address configu-ration resistor		0.22		82	kΩ	Value is selected from E12-series.	
Address resistor tolerance				1	%		
Address resistor temperature drift				100	ppm/K		
Address resistor power rating		125			mW		

Table 27 – Module address / resistor coding

Module address	Resistor value
1	220 Ω
2	270 Ω
3	330 Ω
4	390 Ω
5	470 Ω
6	560 Ω
7	680 Ω
8	820 Ω
9	1 kΩ
10	1,2 kΩ
11	1,5 kΩ
12	1,8 kΩ
13	2,2 kΩ
14	2,7 kΩ
15	3,3 kΩ
16	3,9 kΩ
17	4,7 kΩ
18	5,6 kΩ
19	6,8 kΩ
20	8,2 kΩ
21	10 kΩ
22	12 kΩ
23	15 kΩ
24	18 kΩ
25	22 kΩ
26	27 kΩ
27	33 kΩ
28	39 kΩ
29	47 kΩ
30	56 kΩ
31	68 kΩ
32	82 kΩ
No address	open (MOD_{ADDR} pins not connected) Module base address is used
Not valid	shorted (MOD_{ADDR} pins connected together)

Table 28 – Module address interface signals

Signal	Dir	Description
MOD_ADDR+	In	Module address resistor
MOD_ADDR-	In	Module address resistor reference

6.2.7 Input, High precision analog input, 0-5V / 0-10V / 0-20mA / Resistance, [$AI_{5V.1}$ / $AI_{10V.1}$ / $AI_{20mA.1}$ / $AI_{1k5\Omega.1}$]

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

- Potentiometer (3-wire)
- Temperature sensors (PTC or NTC)
- Pressure sensors
- Variable resistance
- Voltage output sensors
- 4 – 20 mA current output sensors

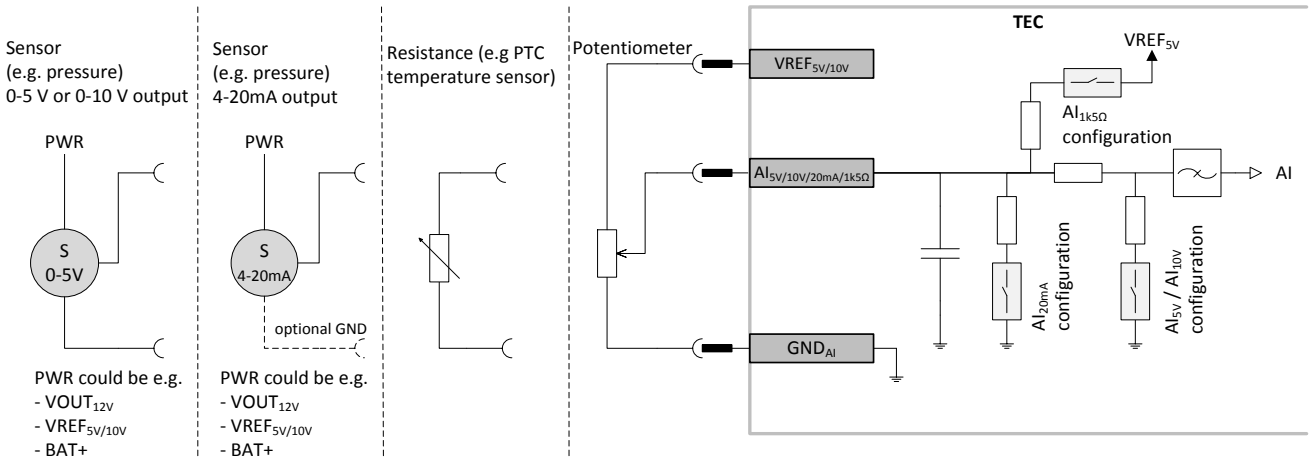


Figure 9 - AI usage

Table 29 - Analog input electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Resolution			12		bits		
Protection		SC_G, SC_B				NO reverse polarity protection	
Type	**$AI_{5V.1}$ 0-5V Voltage input**						
Input voltage range		0		5	V	Voltage input	
Over voltage				32	V		
Accuracy % FS				±1	%FS		
Accuracy, typical			0.1+0.3		%	± (% of reading + % FS)	
Input resistance			47		kΩ		
Input capacitance			4.7		nF		
Input cut-off frequency	f_{-3dB}		0.9		kHz	HW filter	
Type	**$AI_{10V.1}$ 0-10V Voltage input**						
Voltage range		0		10	V	Voltage input	
Over voltage				32	V		
Accuracy % FS				±1	%FS		
Accuracy, typical			0.4+0.3		%	± (% of reading + % FS)	
Input resistance			50		kΩ		
Input capacitance			4.7		nF		
Input cut-off frequency	f_{-3dB}		1.6		kHz	HW filter	
Type	**$AI_{20mA.1}$ 0…20mA current input**						
Current range Nominal Actual		 4 0		 20 22.5	mA	 for diagnostics purposes	

Parameter		Min	Nom	Max	Unit	Description	ID
Over current protection				>22.5	mA	Input is switched to voltage mode	
Accuracy % FS				±1	%FS		
Accuracy, typical			0.5+0.3		%	± (% of reading + % FS)	
Input resistance			220		Ω		
Input capacitance			4.7		nF		
Input cut-off frequency	f_{-3dB}		1		kHz	HW filter	
Type	**$AI_{1k5\Omega.1}$ Resistance input**						
Measurement range		0.015		70	kΩ	Error < 15 % RD	
Accuracy				±2	%RD	Reading 180 Ω - 6.9 kΩ (for details see Figure 10)	
Resolution						Depends on reading see Figure 11	
Input resistance (pull-up)			1.5		kΩ		
Pull-up reference voltage		4.97	5	5.03	V		
Input capacitance			4.7		nF		
Input cut-off frequency	f_{-3dB}		1		kHz	HW filter	

Reverse polarity

Note!
Input type $AI_{5V.1}$, $AI_{10V.1}$ & $AI_{20mA.1}$ shall only be used to interface with switches and sensors that are supplied from the module voltage output DO_H, $VREF_{5V/10V}$, $VOUT_{12V}$ or have external protection against input reverse polarity. This input is **not protected against reverse polarity** (U_{in} < 0 V).

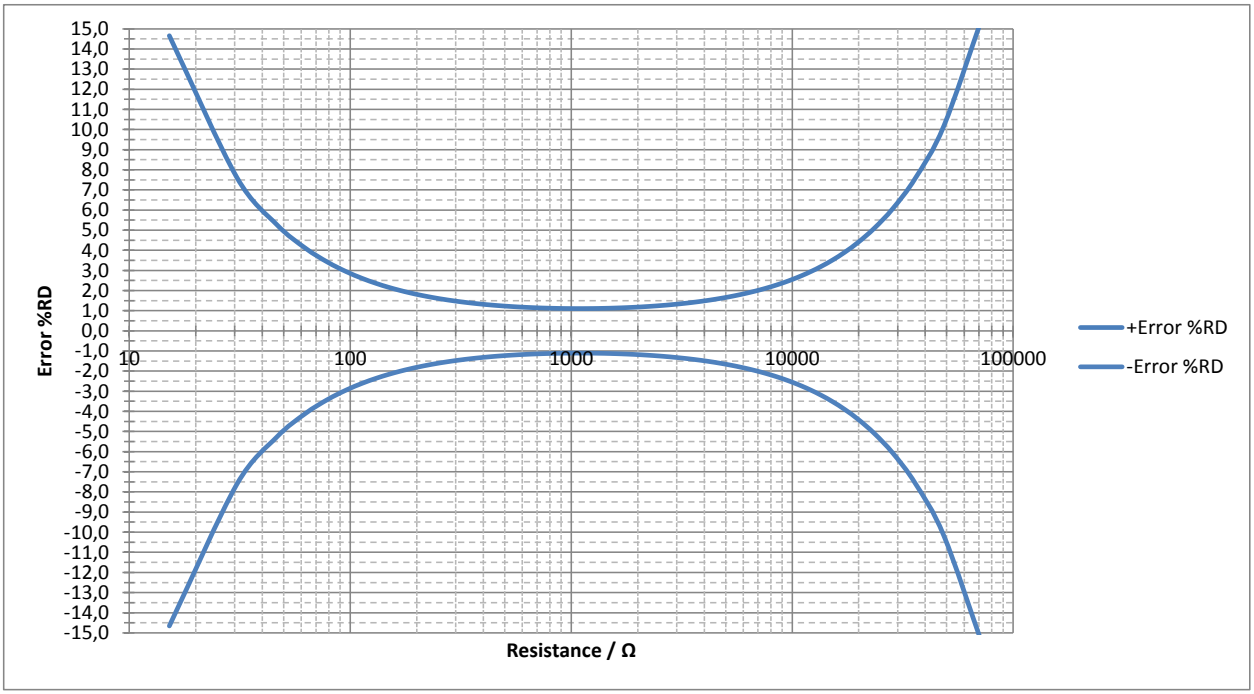


Figure 10 – $AI_{1k5\Omega.1}$ accuracy

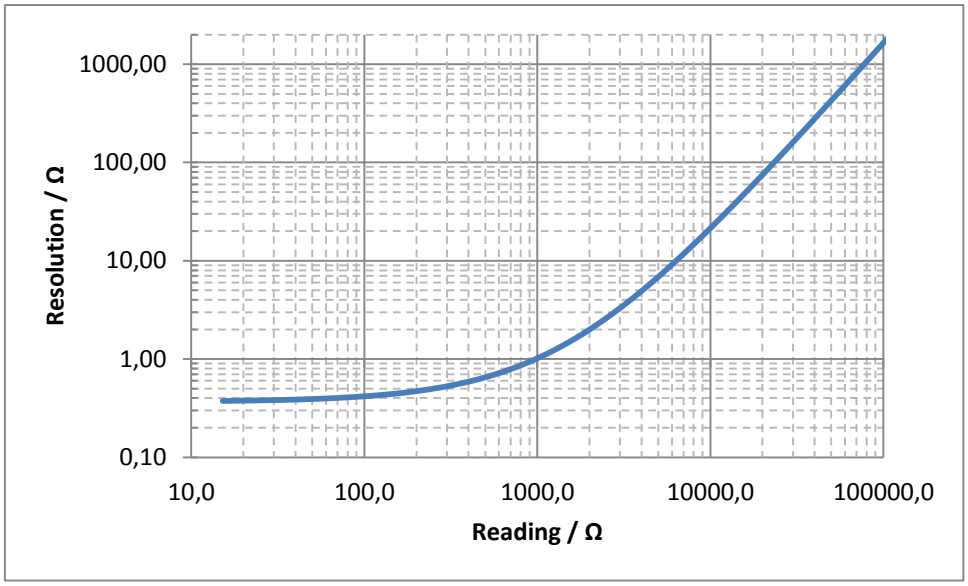


Figure 11 – $AI_{1k5\Omega.1}$ measurement resolution

Table 30 - Analog input functional specification

Item	Value	Notes
Sampling interval	6.4 kHz	Unfiltered samples can be streamed to application at full sample rate (RAW sample rate)
Input refresh rate	800Hz	Digitally filtered (FAST sample rate).
Diagnostic evaluation interval	100Hz	
Digital filter cutoff frequency f_{-3dB}	320Hz	Digital filter implemented in system software
Digital filter stop-band attenuation	Typical 20dB at f > 800Hz	
Input configuration	Selected during device initialization	
Overcurrent handling in AI_{20mA} mode	Fault reporting: • Current exceeds measurement range • Overcurrent protection is active Automatic disabling of current measurement on overcurrent after 30ms. Automatic re-enabling of current measurement after 1 second cool-down period (SUSPENDED state). After 10 retry sequences, input is permanently disabled (SHUTDOWN state) until power off-on cycle is performed.	Application can reconfigure the channel to voltage measurement mode to prevent the fault condition from repeating.
Diagnostics AI_{20mA}	OVERLOAD	

Table 31 - AI signals

Signal	Dir	Description
AI	In	Configurable analog input
GND_{AI}		AI reference ground

6.2.8 Input, Precision analog input, 0-10V, [$AI_{10V.2}$ / $AI_{10V.3}$]

For example following sensors can be connected to input.

- Potentiometer (3-wire)
- Temperature transducers
- Pressure sensors
- Voltage output sensors

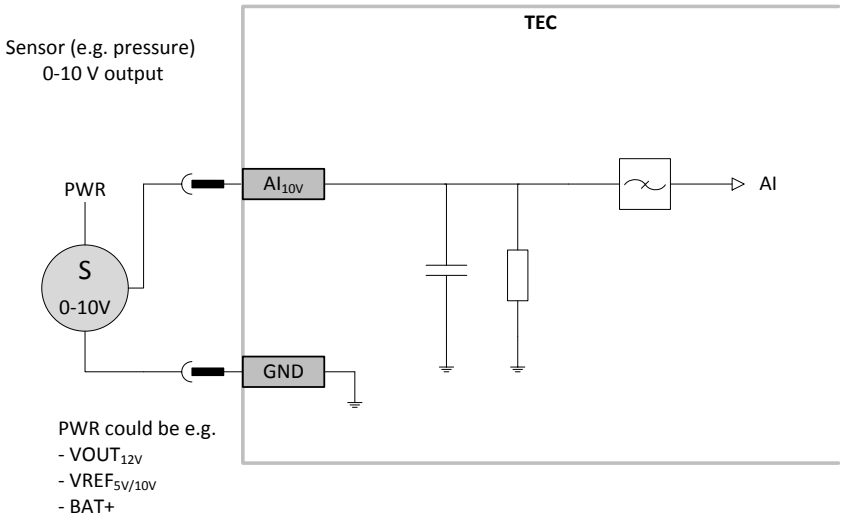


Figure 12 – $AI_{10V.2}$ / $AI_{10V.3}$ usage

Table 32 - Analog input electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Resolution			12		bits		
Protection		SC_G, SC_B					
Type	**$AI_{10V.2}$ 0-10V Voltage input**						
Input voltage range	U_{in}	0		10	V	Voltage input	
Over voltage				32	V		
Accuracy % FS				±3	%FS		
Accuracy, typical			2+0.5		%	± (% of reading + % FS)	
Input resistance			3		kΩ	U_{in} ≤ 10 V	
Input capacitance			4.7		nF		
Input cut-off frequency	f_{-3dB}		50		Hz	HW filter	

Table 33 - Analog input electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Resolution			12		bits		
Protection		SC_G, SC_B					
Type	**$AI_{10V.3}$ 0-10V Voltage input**						
Input voltage range		0		10	V	Voltage input	
Over voltage				32	V		
Accuracy % FS				±3	%FS		
Accuracy, typical			2+0.5		%	± (% of reading + % FS)	
Input resistance			11		kΩ	U_{in} ≤ 10 V	
Input capacitance			4.7		nF		
Input cut-off frequency	f_{-3dB}		50		Hz	HW filter	

Table 34 - Analog input functional specification

Item	Value	Notes
Sampling interval	800 Hz	Unfiltered samples can be streamed to application at full sample rate (RAW sample rate)
Input refresh rate	100Hz	Digitally filtered (NORMAL sample rate).
Digital filter cutoff frequency f_{-3dB}	40Hz	Digital filter implemented in system software
Digital filter stop-band attenuation	Typical 20dB at f > 100Hz	
Input configuration	Selected during device initialization	

Table 35 - AI signals

Signal	Dir	Description
AI	In	Configurable analog input
GND_{AI}		AI reference ground

6.2.9 Input, Precision analog input, 0-32V, [$AI_{32V.5}$]

For example following sensors can be connected to input.

- Temperature transducers
- Pressure sensors
- Voltage output sensors

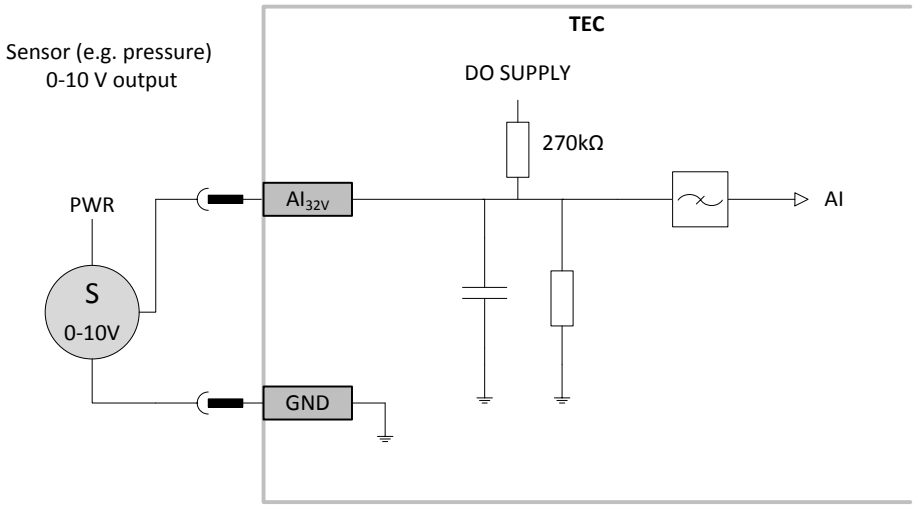


Figure 13 – $AI_{10V.5}$ usage

Table 36 - Analog input electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Resolution			12		bits		
Protection		SC_G, SC_B					
Type	**$AI_{10V.5}$ 0-32V Voltage input**						
Input voltage range	U_{in}	0		32	V		
Over voltage				32	V		
Accuracy % FS				±1	%FS		
Accuracy, typical			0.6+0.3		%	± (% of reading + % FS)	
Input resistance			3.4		kΩ		
Input capacitance			27		nF		
Input cut-off frequency	f_{-3dB}		100		Hz	HW filter	

Table 37 - Analog input functional specification

Item	Value	Notes
Sampling interval	800 Hz	Unfiltered samples can be streamed to application at full sample rate (RAW sample rate)
Input refresh rate	100Hz	Digitally filtered (NORMAL sample rate).
Digital filter cutoff frequency f_{-3dB}	40Hz	Digital filter implemented in system software
Digital filter stop-band attenuation	Typical 20dB at f > 100Hz	
Input configuration	Selected during device initialization	

Table 38 - AI signals

Signal	Dir	Description
AI	In	Configurable analog input
GND_{AI}		AI reference ground

6.2.10 Output, Sensor supply voltage 12 V [$VOUT_{12V.1}$]

Supply voltage for external sensors that are not tolerant to automotive power system.

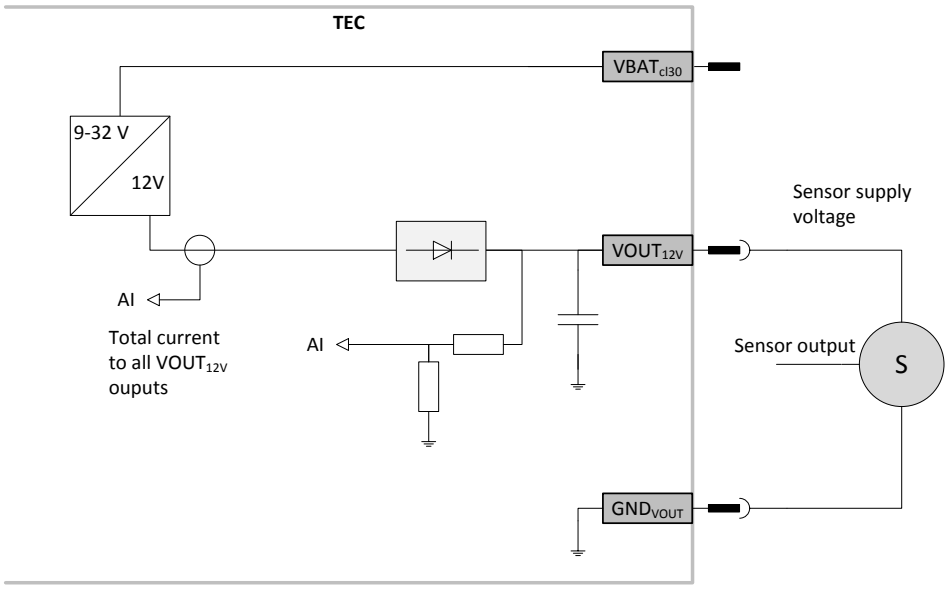


Figure 14- $VOUT_{12V}$ usage

Table 39 – $VOUT_{12V}$ Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	**$VOUT_{12V.1}$ 12 V ± 15% Sensor supply output**						
Default state		OFF					
Output voltage	U_{out}	10.2	11.5	13.5	V		
Output over voltage				32	V	Output short circuit to battery	
Output current				250	mA		
Maximum capacitive load				50	µF		
Turn-on delay				40	ms		
Protection		SC_G, SC_B, OC					
Output voltage measurement range		0		13.8	V		
Output voltage measurement accuracy % FS				±3	%FS		

Table 40 - Functional specification

Item	Value	Notes
Supply state	Software controllable as digital state ('0' = supply off, '1'=supply on)	
Diagnostics	VOLTAGE_ABOVE_NORMAL	E.g. short to battery
	VOLTAGE_BELOW_NORMAL	E.g. short to ground
Overcurrent / short to ground handling	Automatic disabling of supply on fault detection. After 1 second of cool-down period (SUSPENDED state), application can turn the supply on again. After 100 repeated faults, the supply is permanently disabled (SHUTDOWN state).	
Short circuit to Battery handling	Fault reporting: Output voltage above threshold value.	

Table 41 – $VOUT_{12V}$ signals

Signal	Dir	Description
$VOUT_{12V}$	Out	Sensor supply voltage output
GND_{VOUT}		AI reference ground

6.2.11 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.

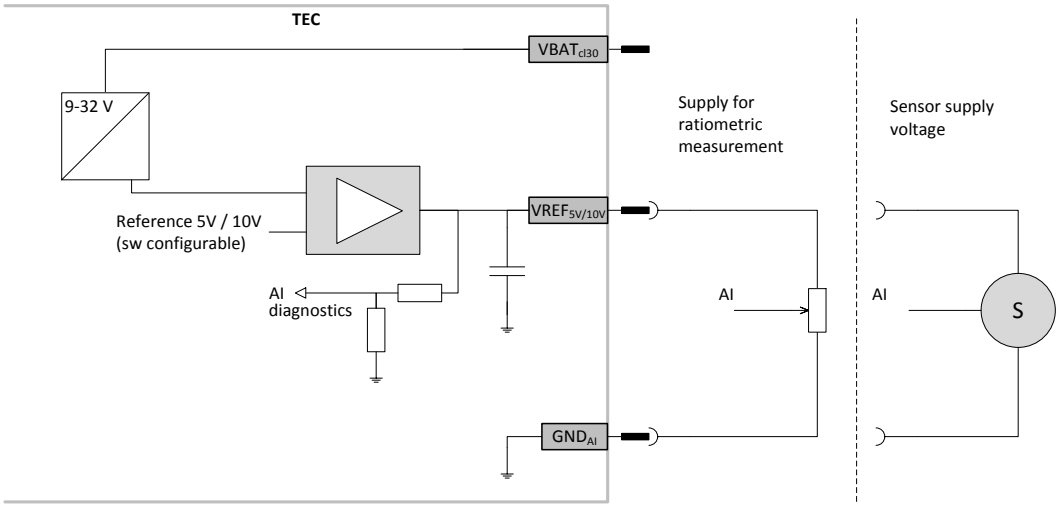


Figure 15- VREF usage

Table 42 – 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	Software selectable	
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, OC					

Parameter		Min	Nom	Max	Unit	Description	ID
Output voltage feedback measurement range		0		10.5	V		
Output voltage feedback measurement accuracy % FS				±1	%FS		

Table 43 - Functional specification

Item	Value	Notes
Supply state	Software controllable as digital state (‘0’ = supply off, ‘1’=supply on)	
Diagnostics	VOLTAGE_ABOVE_NORMAL	E.g. short to battery
	VOLTAGE_BELOW_NORMAL	E.g. short to ground
Short circuit to Battery handling	Fault reporting: Output voltage above threshold value.	

Table 44 – $VREF_{5V/10V}$ signals

Signal	Dir	Description
$VREF_{5V/10V}$	Out	Voltage reference output
GND_{AI}		AI reference ground

6.2.12 Output, high side PWM or ON/OFF with current feedback [$DO_{H2A5.1}$ / $DO_{L\_RET1A/2A.1}$]

TEC152 high-side outputs can be used either in open-loop PWM or current controller closed-loop mode. PWM output has integrated free-wheeling diode. Proportional valves with current controlled mode need both DO_{H2A5} and DO_{L_RET} outputs.

TEC152 high-side output load examples:

- Proportional valve (current controlled)
- ON/OFF valve
- Solenoid
- Bulb lamp
- Led lamp
- Heaters (and other resistive loads)
- Relay

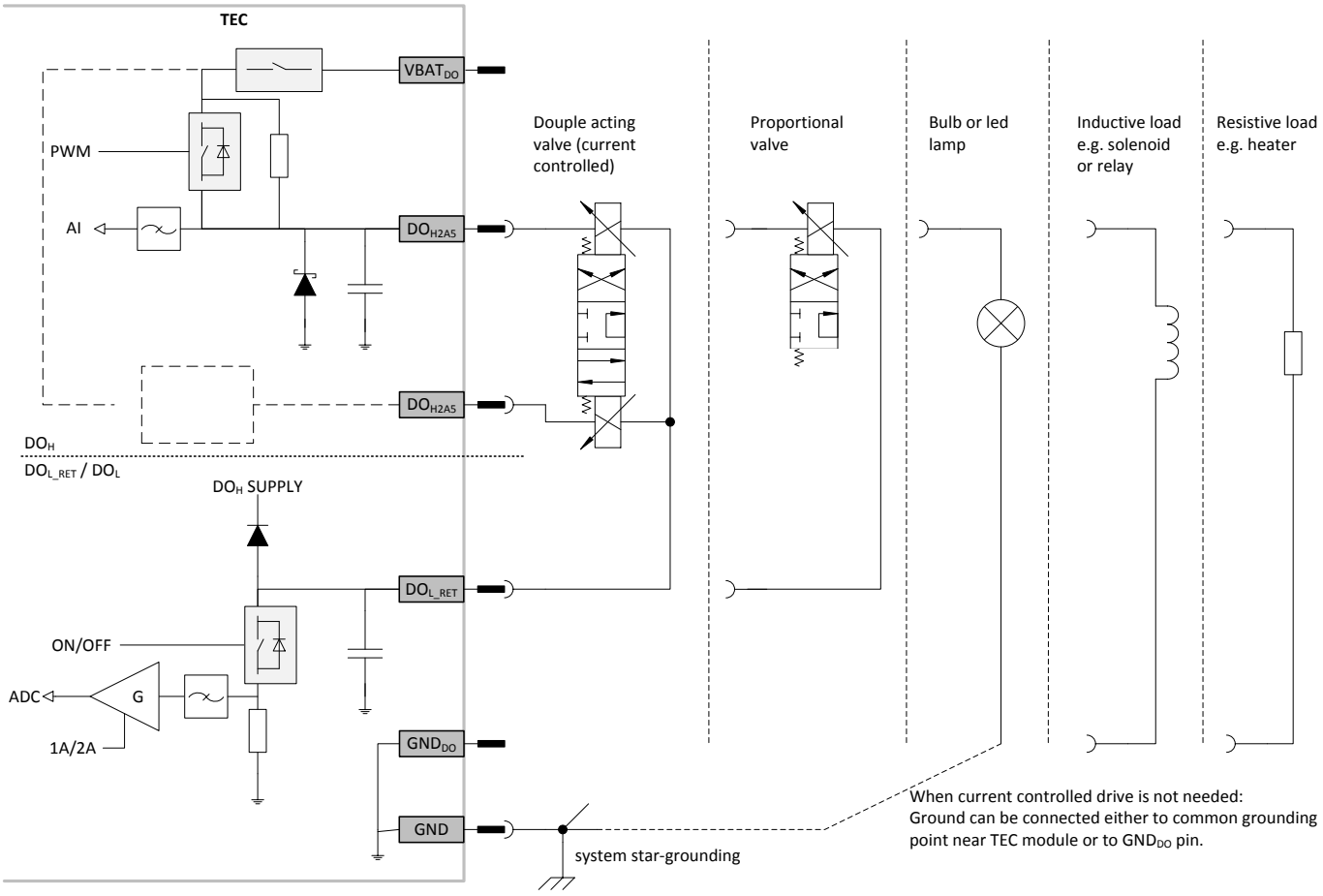


Figure 16 – DO_{H2A5} usage

Table 45- DO_{H2A5} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		**$DO_{H2A5.1}$** High-side output					
Default state		OFF					
Voltage range		9		32	V		
Over voltage				48	V	Output is switched automatically OFF when voltage exceeds 39-45.5V. Operation is resumed automatically after voltage is below this limit.	
Output current				2.5	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 2.5 A				 0.1 0.3	 V V	$U(VBAT_{DO}) – U(DO_H)$	
Output current				2.5	A		
Freewheeling diode current				1	A	Average current	
Short circuit current limit				6.5	A		
Leakage current in off state		-2		*0.4*	mA	Leakage current from DO_H (positive value outgoing from DO_H), $VBAT_{DO} < 32V$	
Pull-up resistance	R_{PU}		100		kΩ		
PWM frequency	f_{PWM}	10		1000	Hz	PWM period must be multiple of 100 µs	
PWM duty cycle resolution		0.1			%		
Dither frequency	f_{DITH}			500	Hz	Dither frequency can be set to $f_{DITH} = f_{PWM} / DIV$, where DIV={2,4,6,8,…}	
Dither amplitude				50	%	PWM duty modulation depth. '*PWM duty*' ± '*Modulation depth*' must always be 0%...100%	
Protection	SC_G, SC_B, OC					Output voltage (during SC_B) shall not exceed $VBAT_{DO}$ supply voltage in any conditions	

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 ($VBAT_{DO}/DO_H$) reverse current will flow through module. This current will flow through output FET parasitic diode and there now way to prevent this to happen (see Figure 17). 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 $VBAT_{DO}$)
- DO_H supply voltage cannot anymore be switched OFF using main switch

Reverse feed will damage the TEC152 module permanently and may cause unexpected device behavior.

Short circuit to battery can be detected from DO_H diagnostic functions (*VOLTAGE_ABOVE_NORMAL*). Diagnostic function is available in condition described in Table 48. After DOH output short circuit is detected **APPLICATION** program shall:

1) Switch OFF <u>all</u> DO_H channels (to protect TEC152 against damage)
2) <u>and</u> switch OFF DO_H MAIN SWITCH (to prevent reverse current flow to other devices in system)

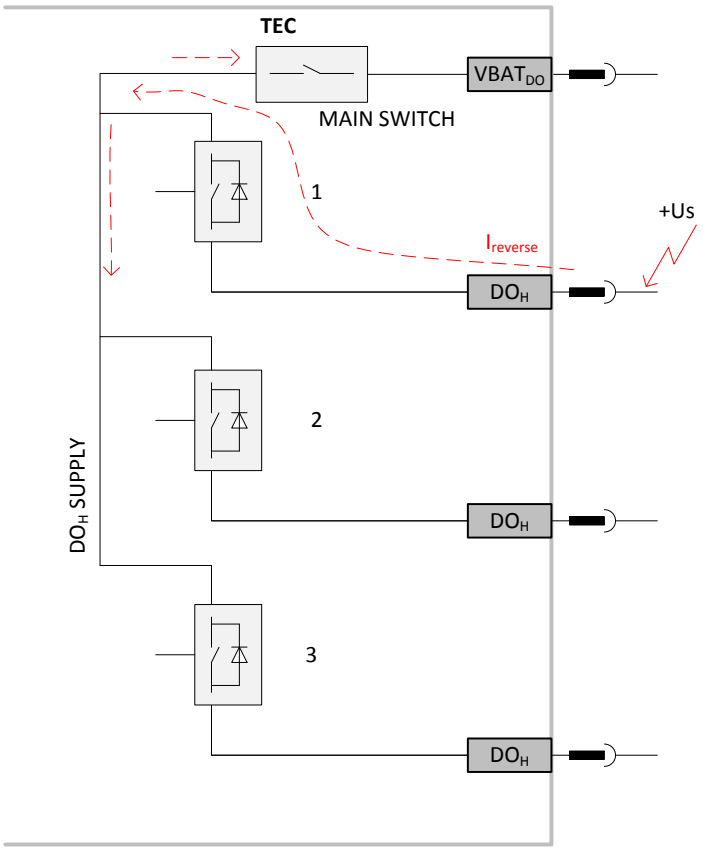


Figure 17 – DO_H output short to battery

6.2.12.1 Low-side output with current measurement [$DO_{L\_RET1A.1}$ / $DO_{L\_RET2A.1}$]

Low-side output with current measurement is used to closed loop current control for proportional hydraulic valves. Current measurement is used in conjunction with high-side PWM output (DO_{H2A5}). Two high-side outputs can be connected to same current measurement (DO_{L_RET}) channel if not used simultaneously (i.e for double acting valve). Current measurement range is software configurable to 0 – 1 A or 0 – 2 A. See Figure 16 for typical connections.

Table 46- DO_{L_RET1A} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		$DO_{L\_RET1A.1}$ return current measurement 0 – 1 A (for DO_{H2A5})					
Default state		OFF					
Voltage drop load 1 A				0.3	V	DO_{L_RET} – GND	
Output current				1	A		
Freewheeling diode current				0.5	A	Average current	
Short circuit current limit			1.2	1.3	A	$t_{measure}$ = 100 ms	
Current measurement range		0		1	A		
Current measurement accuracy				±1	% FS		
Current measurement accuracy, typical			0.6 + 0.2		%	± (% of reading + % FS)	
Current measurement resolution			1		mA		
Input cut-off frequency	f_{-3dB}		1		kHz	HW filter	
Protection	SC_G, SC_B, OC						

Table 47- DO_{L_RET2A} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		$DO_{L\_RET2A.1}$ return current measurement 0 – 2 A (for DO_{H2A5})					
Default state		OFF					
Voltage drop load 2 A				0.6	V	DO_{L_RET} – GND	
Output current				2	A		
Freewheeling diode current				0.5	A	Average current	
Short circuit current limit			2.4	2.5	A	$t_{measure}$ = 100 ms	
Current measurement range		0		2	A		
Current measurement accuracy				±1	% FS		
Current measurement accuracy, typical			0.6 + 0.2		%	± (% of reading + % FS)	
Current measurement resolution			1		mA		
Input cut-off frequency	f_{-3dB}		1		kHz	HW filter	
Protection	SC_G, SC_B, OC						

6.2.12.2 Functional specification

Table 48 – Functional specification

Item	Value	Notes
Dither modes	1) Direct PWM, PWM output without current control (i.e. open-loop control). 2) Current controlled output	1) PWM duty is modulated by dither depth value. 2) Current controller's target value is modulated by dither depth value
Direct PWM dither (amplitude and resolution)	Dither amplitude in PWM duty cycle deviation amount. Dither resolution 0.1%	
Current controlled dither (amplitude and resolution)	Dither amplitude is fraction of full scale feedback current. Dither resolution is mA	
Turn-on/off ramp (soft-start) modes	1) Direct PWM 2) Current controlled output	
Turn-on/off ramp (soft-start)	Minimum ramp step time: One PWM period Ramp type: linear or S-curve Dynamic ramp control: Linear ramp parameters can be controlled during ramp (see Figure 18)	
PID current control	Current controller loop time: One PWM period	
Double acting valve control	Single control value for two complementary channels.	
DO_H Over current / short circuit protection	Different overcurrent profiles for inductive and lamp loads Quick autoretry (< 100ms until output value is automatically restored after turn-off due to fault detection) After 10 autoretries, 1 second cool-down period (SUSPENDED state, output is disabled) after which application is allowed to turn on the output After 100 faults in total, output is disabled permanently (SHUTDOWN state) until power off-on cycle is performed	
DO_{L_RET} Over current / short circuit protection	Output is disabled for cool-down period of 1 s typical (SUSPENDED state) after overcurrent or short circuit, after which user application is allowed to turn on the output.	
Number of different PWM frequencies	Each channel can be configured independently.	
PWM frequency resolution	Period time of PWM must be multiple of 100µs	
DO_{L_RET} current measurement Input refresh rate & sampling interval	10kHz	
DO_{L_RET} current measurement filter – CC mode	Moving average filter	Sample window length one PWM cycle. Note: if PWM amplitude dither is enabled actual current and measurement varies
DO_{L_RET} current measurement filter – normal mode	Exponentially weighted moving average filter	Sample weight 0.125
Diagnostics DO_H	CURRENT_ABOVE_NORMAL	E.g. short to ground

Item	Value	Notes
	VOLTAGE_ABOVE_NORMAL	E.g short to battery. This detection is available only for output duty cycles 0-85%
Diagnostics DO_{L_RET}	CURRENT_ABOVE_NORMAL	E.g short to battery
	OVERLOAD	E.g short to battery
	SATURATING	Measurement range is exceed → too high current is driven to valve

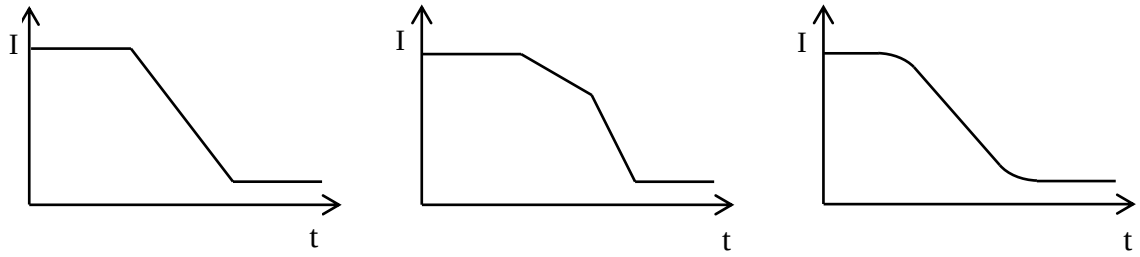


Figure 18 - Linear ramp control (left), dynamic control of linear ramp (middle) and S-curve (right)

Table 49 – DO_H & DO_{L_RET} signals

Signal	Dir	Description
DO_H	Out	High-side output
DO_{L_RET}	In	Feedback current measurement
$GND_{DO/DI}$		DO reference ground

6.2.12.3 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 TEC152 module may be damaged. When outputs are connected parallel maximum output current is doubled. However freewheeling current remains same as for **one** output and must not be exceeded.

Channels that can be connected parallel are presented in the Table 50. 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 TEC152 connector) to balance current sharing between channels (parallel wiring minimizes the effect of possible contact resistance differences on TEC152 connector). Otherwise TEC152 may be damaged.

Table 50 – DO_H Parallel connections

#	CH A	CH B	Notes
1	B97	B117	DO_{H2A5}
2	B120	B119	DO_{H2A5}
3	B112	B111	DO_{H2A5}
4	B110	B109	DO_{H2A5}
5	B105	B113	DO_{H2A5}
6	B108	B107	DO_{H2A5}
7	B118	B115	DO_{H2A5}
8	B116	B121	DO_{H2A5}

6.2.13 Output, low side ON/OFF

TEC152 low side output load examples

- Relays
- ON/OFF valves
- Resistive loads

Maximum output current is 1 A.

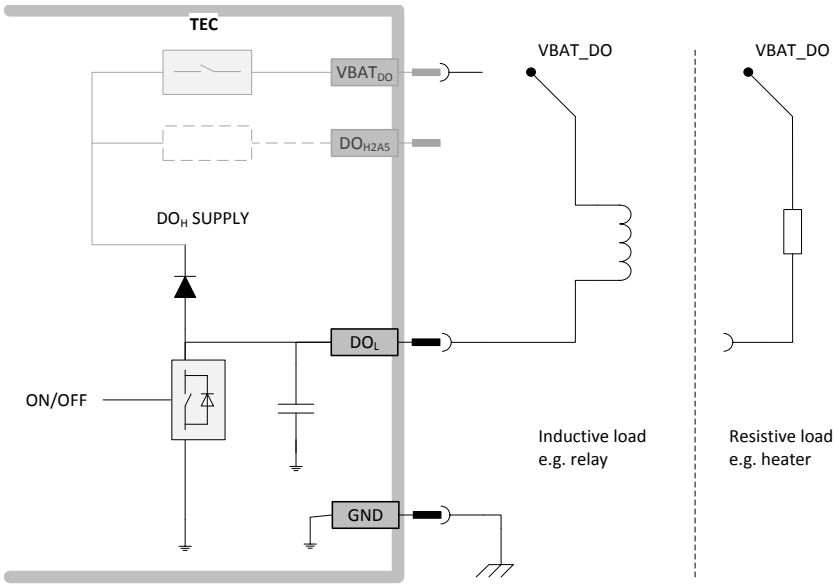


Figure 19 - DO_L usage

Table 51 - Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		$DO_{L.1}$ Low-side output 1 A					
Default state		OFF					
Voltage range		9		32	V		
Over voltage				48	V		
Voltage drop load 1 A				0.3	V		
Output current				1	A		
Freewheeling diode current				*0.5*	A	Average current	
Short circuit current limit			1.2	1.3	A	$t_{measure}$ = 100 ms	
Leakage current in off state			10	100	µA		
Protection	SC_G, SC_B, OC						

Internal freewheeling diode & reverse polarity

Note 1!
TEC152 DO_L has internal freewheeling diode connected to DO_H SUPPLY voltage. If voltage at DO_L pin is higher than in $VBAT_{DO}$ pin reverse current will flow inside the TEC152. Reverse current can damage TEC152. And DO_H supply main switch (Figure 2) is not functional because current will bypass the main switch. DO_L controlled loads shall be powered either

1) directly from module $VBAT_{DO}$ 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 TEC152 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 52 - Functional specification

Item		Value	Notes
Signal change rate		< 10Hz	
Diagnostics		CURRENT_ABOVE_NORMAL	E.g. short to battery
Diagnostic evaluation interval		100Hz	
Overcurrent / short circuit to battery handling		Output is disabled for cool-down period of 1 s typical (SUSPENDED state) after overcurrent or short circuit, after which user application is allowed to turn on the output.	

Table 53 – Digital output, low side interface signals

Signal	Dir	Description
DO_L	Out	Digital output low side

6.2.14 Output, Sauer-Danfoss valve control [$HB_{SDV.1}$]

TEC152 Sauer-Danfoss valve control output is intended to be used with voltage controlled hydraulic valves (Sauer-Danfoss valves with PVE actuator e.g. PVG 32, PVG 100 and PVG 120). Dedicated half-bridge output produces high frequency and symmetric push-pull PWM output (HB_{SDV}). HB_{SDV} output is connected to valve signal input (U_S) to generate ratiometric control voltage (0,25…0,75)*U_{DC}. HB_{SDV} output must be used together with DO_H output. DO_H output provides supply voltage to PVE actuator. Valve signals U_S and U_{DC} must connected to specific TEC152 I/O pins. TEC152 connection to PVE actuator is defined in Table 56.

TEC152 has internal monitoring to HB_{SDV} output voltage. If **application** software detects misbehavior at the HB_{SDV} output voltage DO_H shall be switched OFF to stop hydraulic valve. HB_{SDV} outputs have common overcurrent diagnostics. If overcurrent or short to ground is diagnosed at any HB_{SDV} output all channels are disable i.e. DO_H should be turned off (see Table 55).

TEC152 HB_{SDV} usage:

- Voltage controlled U_S = (0,25…0,75)*U_{DC} hydraulic valves.

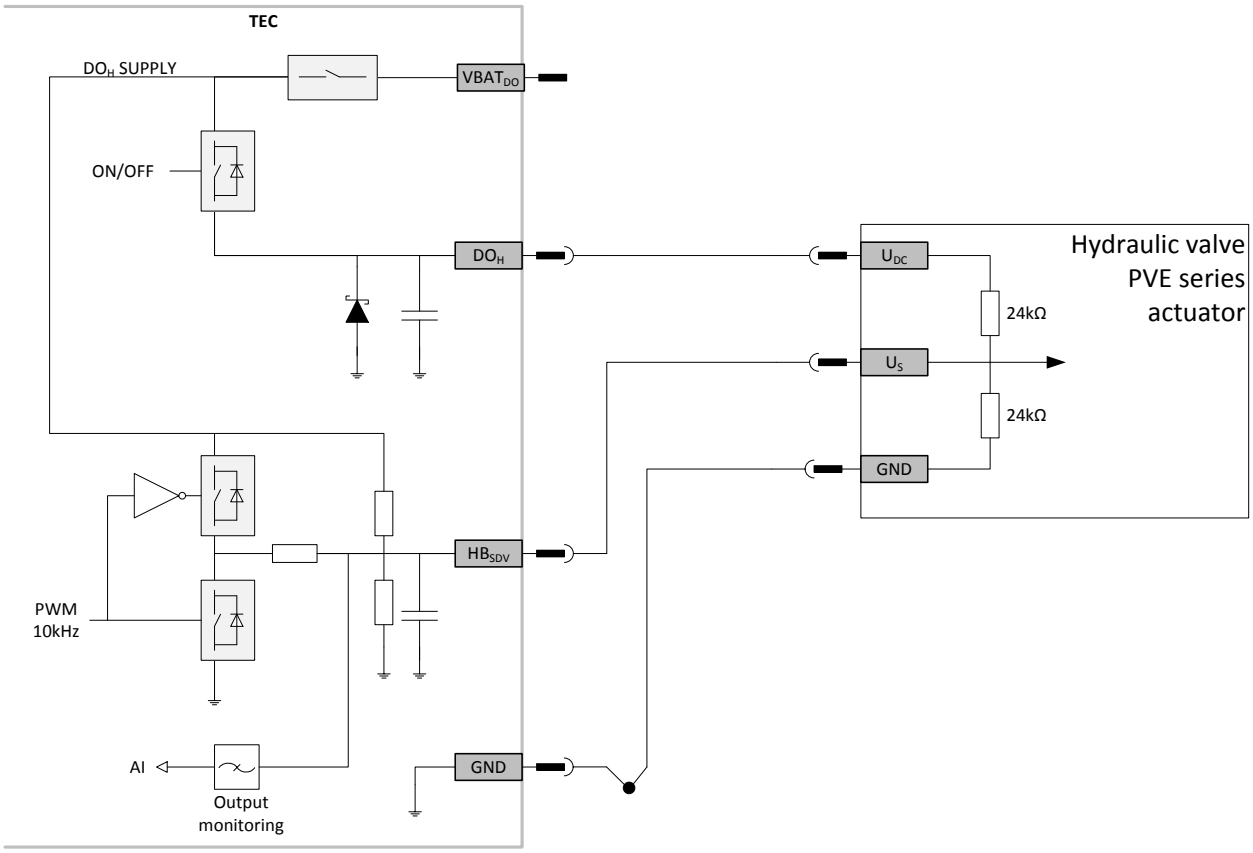


Figure 20 - HB_{SDV} usage

Table 54- HB_{SDV} Electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type		$HB_{SDV.1}$ Half-bridge output for 12 kΩ resistive load (24 kΩ Pull-up/-down)					
Default state		Pull-down 3.4 kΩ (Output driver Hi-Z)				HB_{SDV} is not activated	
Voltage range		9		32	V		
Over voltage				36	V		
Voltage drop load 0.001 A			1.2		V	DO_H SUPPLY – HB_{SDV}	
Output current				0.03	A	$VBAT_{DO}$=32V, HB_{SDV} = GND	
PWM frequency			10		kHz		
PWM duty cycle resolution		0.1			%		
HB_{SDV} output range		10		90	% U_{DC}		
PVE valve pull-up/-down input resistance			24		kΩ	i.e Valve input impedance in relation to 0.5*U_{DC} = 12 kΩ. HB_{SDV} output does not give correct output for other loads	
Series output resistance	R_{SER}		1.2		kΩ	Voltage drop in series resistance is automatically compensated. PVE valve input resistance pull-up/-down resistance must be 24 kΩ (i.e input impedance in relation to 0.5*U_{DC} = 12 kΩ)	
Protection	SC_G, SC_B, OC						

Table 55 - Functional specification

Item	Value	Notes
Diagnostics	CURRENT_ABOVE_NORMAL	E.g. Over current at output
	VOLTAGE_BELOW_NORMAL	HB_{SDV} turned OFF (Hi-z) due to undervoltage.
Diagnostic evaluation interval	100Hz	
Fault handling	DO_H channel providing supply to HB_{SDV} channel is turned off to prevent erratic control	Driver hardware has internal protection. Fault protection is shared by HB_{SDV} channels 1-4 (port 1) and 5-8 (port 2) – fault in one channel shuts down all HB_{SDV} port channels

Table 56 – Sauer-Danfoss valve control interface signals

#	TEC152 Signal	Dir	TEC152 Pin	PVE	Description
1	DO_H	Out	B108	U_{DC}	Supply voltage to PVE actuator
1	HB_{SDV}	Out	B100	U_S	Signal voltage to actuator
1	GND		B114	GND	Ground
2	DO_H	Out	B109	U_{DC}	Supply voltage to PVE actuator
2	HB_{SDV}	Out	B101	U_S	Signal voltage to actuator
2	GND		B114	GND	Ground
3	DO_H	Out	B110	U_{DC}	Supply voltage to PVE actuator
3	HB_{SDV}	Out	B102	U_S	Signal voltage to actuator
3	GND		B114	GND	Ground
4	DO_H	Out	B107	U_{DC}	Supply voltage to PVE actuator
4	HB_{SDV}	Out	B99	U_S	Signal voltage to actuator
4	GND		B114	GND	Ground
5	DO_H	Out	B112	U_{DC}	Supply voltage to PVE actuator
5	HB_{SDV}	Out	B93	U_S	Signal voltage to actuator
5	GND		B114	GND	Ground
6	DO_H	Out	B113	U_{DC}	Supply voltage to PVE actuator
6	HB_{SDV}	Out	B94	U_S	Signal voltage to actuator
6	GND		B114	GND	Ground
7	DO_H	Out	B111	U_{DC}	Supply voltage to PVE actuator
7	HB_{SDV}	Out	B84	U_S	Signal voltage to actuator
7	GND		B114	GND	Ground
8	DO_H	Out	B105	U_{DC}	Supply voltage to PVE actuator
8	HB_{SDV}	Out	B85	U_S	Signal voltage to actuator
8	GND		B114	GND	Ground

6.2.15 IO GND (actuator / sensor return signal)

TEC152 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 at system level. For example the use of dedicated analog ground signal prevents measurements errors caused by ground currents. Sensors and loads shall be grounded (IO GND pin or star-grounding near module GND pin) only in module side to prevent ground loops.

Table 57 – IO GND electrical specification

Parameter		Min	Nom	Max	Unit	Description	ID
Type	GND_{FI}, GND_{AI}, GND_{VOUT}, $GND_{DO/DI}$, GND_{RS232} Ground signal for sensors and actuators						
Input current				3	A	MQS pins	
				10	A	JPT pins	

6.2.16 System status LEDs

There are two LEDs that are visible to the user. LEDs are located on cover near main connector (see Figure 23). First (green) led indicates module operational or fault state other (yellow) is user application programmable. Module status LED (green) functionality is according to Table 58.

Table 58 - Status led operation

LED (green) state	Description
Constant ON	Power ON – system software not running
2 blinks	Application SW running
3 blinks	System SW running – application not started
4 blinks	Application / system SW reprogramming
5 blinks	HW fault
6 blinks	SW operation fault
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 four CAN 2.0 A/B communication interfaces (CANA-CAND, CANA is dedicated to CODESYS development interface CANB-CAND can be used freely in IEC application). CAN physical layer is according to ISO 11898-2. CAN interface supports CANopen and other protocols implementable over CAN2.0 A/B. CAN bus can be terminated in the module using short wire loop (max 80 mm) between pins CAN_H_TERM and CAN_L_TERM.

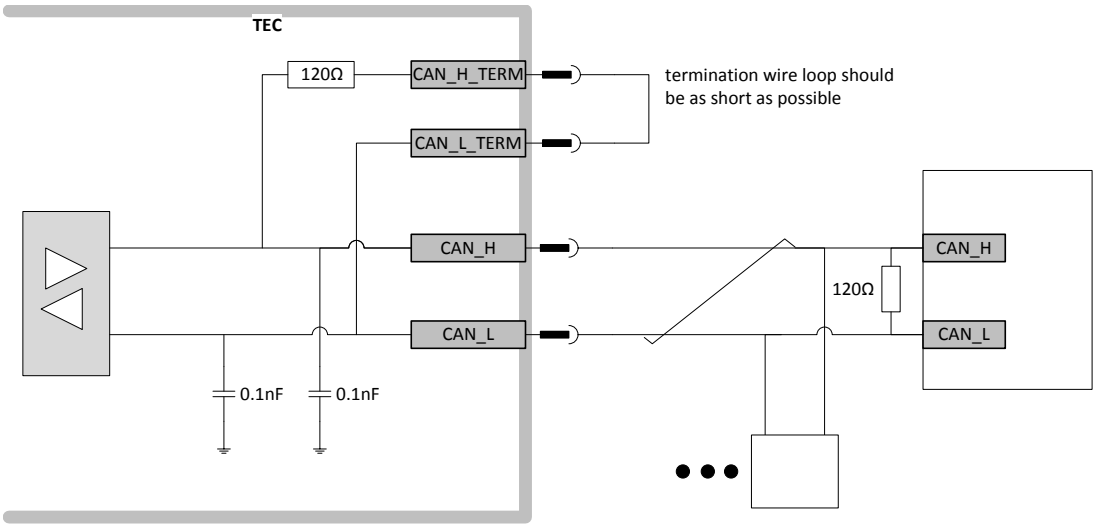


Figure 21- CAN usage

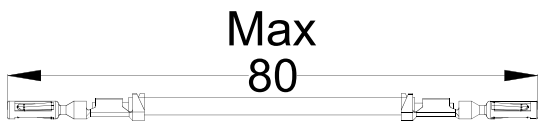


Figure 22- CAN termination wire loop maximum length

Table 59- CAN Electrical specification

Parameter		Value	Description
Physical layer		ISO 11898-2	High speed CAN
Termination resistor		120 Ω ± 5%	Termination resistor is connected using wire loop in connector
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 60 - CAN interface signals

Signal	Dir	Description
CAN_H	In / Out	CAN transmit / receive high
CAN_L	In / Out	CAN transmit / receive high
CAN_TERM_L	-	Termination resistor connection (internally connected to CAN_L)
CAN_TERM_R	-	Termination resistor connection (internally connected to termination resistor)

Twisted-pair cable shall be used.

6.3.2 RS-232

RS-232 interface can be used to communicate with external devices.

Table 61- RS-232 Electrical specification

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

Table 62 – RS-232 interface signals

Signal	Dir	Description
TXD	Out	RS-232 Transmit data
RXD	In	RS-232 Receive data
GND_{RS232}		Reference ground signal

6.4 Fault handling

Individual IO channels implement fault containment mechanisms which protect the hardware from breaking down. Recovery from situation can be attempted, unless allowed number of retries has been exhausted due to repeated failure. When no more retries are allowed, the affected IO channel is non-operational until a power off-on cycle is performed.
The recovery is performed in two stages:

- When the fault is initially detected, the output channel may enter RECOVERING state (implemented on some IO-types). The channel output is momentarily disabled, but will be automatically re-enabled with the value last set by application. If the fault is still present, recovery is attempted again.
- When a set limit of fault events for one IO channel has been reached, the channel is disabled for a longer cool-down time. This is SUSPENDED state. After cool-down time expires, normal operation is allowed. Note however, that the output will remain turned off unless application explicitly writes a control value for the output after exit from SUSPENDED state.
- When faults have repeated long enough, the channel is put to SHUTDOWN state. In this state, the channel is disabled and cannot return to normal operation until power off-on cycle is performed.

The application can read the diagnostic information from all outputs using the functions provided in the Technion IO library.

Table 63 - IO channel fault handling parameters

Parameter	Value	Notes
Number of fault events until IO channel is set to SUSPENDED state	10 1	DO_H outputs (fast auto-recovery through RECOVERING state) Other IO types
Number of entries into SUSPENDED state after which IO channel is set to SHUTDOWN state	10	All IO types
Minimum cool-down time in SUSPENDED state	1s	

Faults that affect the whole module, such as power supply issues, are reported to application using CODESYS system events mechanism. Where appropriate, the operation of the user application is forced to stop unless fault is removed.

7 Environmental specification

7.1 General

Electrical and environmental requirements are based on standard ISO 16750.

7.2 Ambient temperature

TEC152 is to be designed to operate mounted directly in vehicle body or inside the cabin.

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

7.3 Functional safety

TEC152 is not a safety component according to the machine directive 2006/42/EC. TEC152 is not SIL classified.

8 Connector pin mapping

8.1 Connector locations

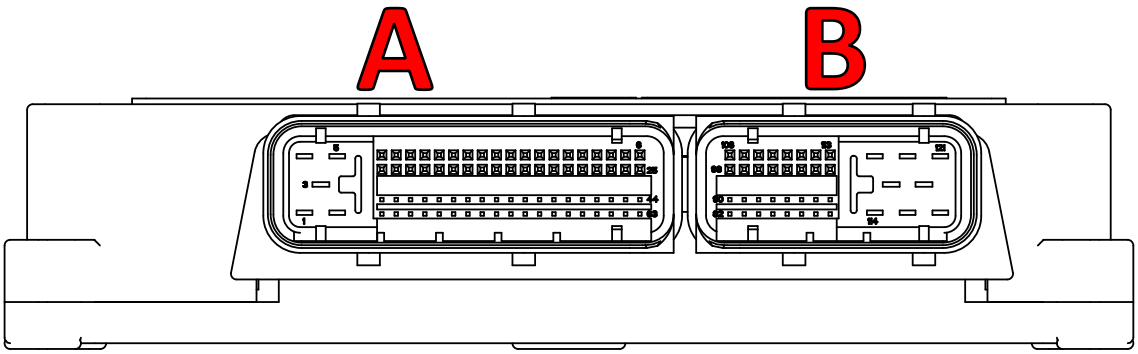


Figure 23 - Connector locations

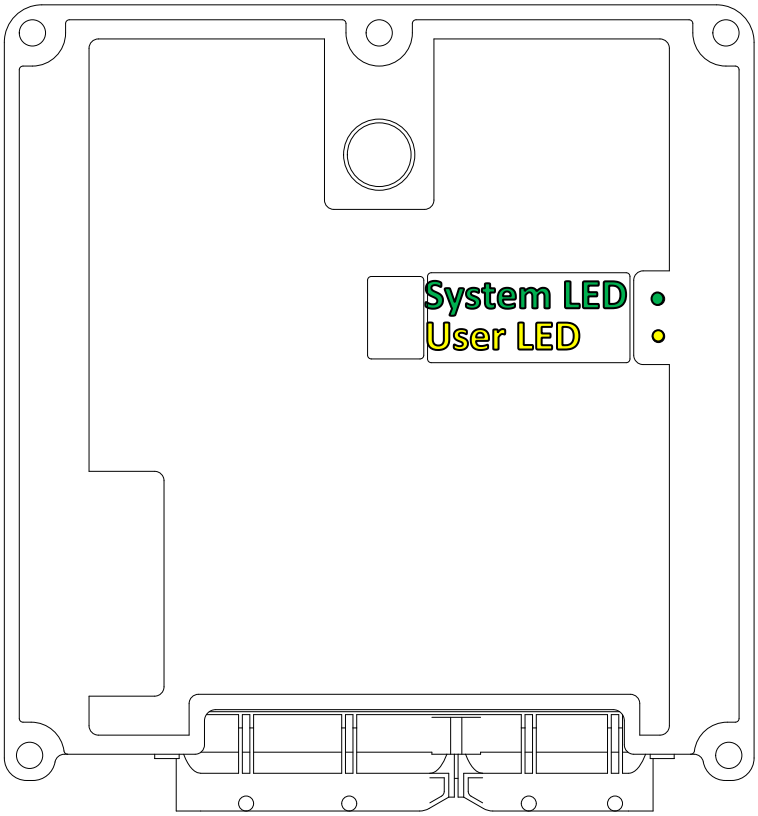


Figure 24 - LED locations

8.2 Main connectors pin map (TEC152-001)

Main connector is divided to two parts A & B. Connector pinout is presented below. Connector has two type of contacts JPT and MQS. Contact current rating has to be taken account in power and ground pins. Maximum current for single JPT pin is 10 A and for MQS 3 A. Ground pin current rating is presented in notes column.

Table 64 – Connector A pinout (TEC152-001)

Connector A – TYCO 1241434-1, TEC152					
Pin		**Dir**	**Function(s)**	**I/O Group**	**Notes**
A	1	PWR(1	$VBAT_{DO}$		Power supply for outputs (MAX 10 A)
A	2	PWR(1	$VBAT_{DO}$		Power supply for outputs (MAX 10 A)
A	3	GND(2	GND(2		Power Supply Ground (MAX 10 A)
A	4	PWR	$VBAT_{CL30}$		Power supply for logic and sensors
A	5	GND(2	GND(2		Power Supply Ground (MAX 10 A)
A	6	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
A	7		$GND_{DO/DI}$		Ground for digital outputs / inputs (MAX 3 A)
A	8	I	$DI_{H/L.2}$, $AI_{10V.2}$	I_#8	
A	9	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{1k5.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	10	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{1k5.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	11	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{1k5.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	12	O	$VOUT_{12V.1}$	O_#6	+12V output
A	13	O	$VOUT_{12V.1}$	O_#6	+12V output
A	14	I	$FI1_{H.1}$, $AI_{10V.3}$, $DI_{H.3}$	I_#7	Frequency/pulse, analog or digital input
A	15	I	$FI2_{H.1}$, $AI_{10V.3}$, $DI_{H.3}$	I_#7	Frequency/pulse, analog or digital input
A	16	I	$FI3_{H.1}$, $AI_{10V.3}$, $DI_{H.3}$	I_#7	Frequency/pulse, analog or digital input
A	17	I	$FI4_{H.1}$, $AI_{10V.3}$, $DI_{H.3}$	I_#7	Frequency/pulse, analog or digital input
A	18	I	$FI5_{H.1}$, $AI_{10V.3}$, $DI_{H.3}$	I_#7	Frequency/pulse, analog or digital input
A	19	I	$FI6_{H.1}$, $AI_{10V.3}$, $DI_{H.3}$	I_#7	Frequency/pulse, analog or digital input
A	20	I	$FI7_{VR.1}$+	I_#7	Frequency/pulse input+
A	21	I	$FI8_{VR.1}$+	I_#7	Frequency/pulse input+
A	22	IO	CANA_H		CAN interface A dominant high line
A	23	IO	CANA_L		CAN interface A dominant low line
A	24	I	$VBAT_{CL15}$		Control input for logic power supply
A	25	I	$DI_{H/L.2}$, $AI_{10V.2}$	I_#8	
A	26	I	$DI_{H/L.2}$, $AI_{10V.2}$	I_#8	
A	27	I	$DI_{H/L.2}$, $AI_{10V.2}$	I_#8	
A	28		GND_{AI}		Ground signal for AI (MAX 3 A)
A	29		GND_{AI}		Ground signal for AI (MAX 3 A)
A	30		GND_{AI}		Ground signal for AI (MAX 3 A)
A	31		GND_{VOUT}		Ground signal for VOUT (MAX 3 A)
A	32		GND_{VOUT}		Ground signal for VOUT (MAX 3 A)
A	33		GND_{FI}	-	Ground signal for FI_H (MAX 3 A)
A	34		GND_{FI}	-	Ground signal for FI_H (MAX 3 A)
A	35		GND_{FI}	-	Ground signal for FI_H (MAX 3 A)
A	36		GND_{FI}	-	Ground signal for FI_H (MAX 3 A)
A	37		GND_{FI}	-	Ground signal for FI_H (MAX 3 A)
A	38		GND_{FI}	-	Ground signal for FI_H (MAX 3 A)
A	39	I	$FI7_{VR.1}$-	I_#7	Frequency/pulse input-
A	40	I	$FI8_{VR.1}$-	I_#7	Frequency/pulse input-
A	41	I	CANA_H_TERM		CAN interface A bus termination (connect to A42)
A	42	I	CANA_L_TERM		CAN interface A bus termination (connect to A41)
A	43		GND		
A	44		$GND_{DO/DI}$		Digital output/input ground (MAX 3 A)
A	45	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{1k5.1}$, $DI_{H.1}$	I_#4	High precision analog input

Connector A – TYCO 1241434-1, TEC152					
Pin		**Dir**	**Function(s)**	**I/O Group**	**Notes**
A	46	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{20mA.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	47	O	$VREF_{5V.1}$, $VREF_{10V.1}$	O_#5	5V/10V reference output
A	48	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{20mA.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	49	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{20mA.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	50	O	$VREF_{5V.1}$, $VREF_{10V.1}$	O_#5	5V/10V reference output
A	51	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{20mA.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	52	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{20mA.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	53	I	$AI_{5V.1}$, $AI_{10V.1}$, $AI_{20mA.1}$, $DI_{H.1}$	I_#4	High precision analog input
A	54	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
A	55	O	TDX		RS-232 transmit signal
A	56	IO	CAND_H		CAN interface D dominant high line
A	57	IO	CAND_L		CAN interface D dominant low line
A	58	IO	CANC_H		CAN interface C dominant high line
A	59	IO	CANC_L		CAN interface C dominant low line
A	60	IO	CANB_H		CAN interface B dominant high line
A	61	IO	CANB_L		CAN interface B dominant low line
A	62	I	MOD_{ADDR+}		Module address resistor
A	63	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
A	64		GND_{AI}		Ground signal for AI (MAX 3 A)
A	65		GND_{AI}		Ground signal for AI (MAX 3 A)
A	66	O	$VREF_{5V.1}$, $VREF_{10V.1}$	O_#5	5V/10V reference output
A	67		GND_{AI}		Ground signal for AI (MAX 3 A)
A	68		GND_{AI}		Ground signal for AI (MAX 3 A)
A	69	O	$VREF_{5V.1}$, $VREF_{10V.1}$	O_#5	5V/10V reference output
A	70		GND_{AI}		Ground signal for AI (MAX 3 A)
A	71		GND_{AI}		Ground signal for AI (MAX 3 A)
A	72		GND_{AI}		Ground signal for AI (MAX 3 A)
A	73		GND_{RS23}		Ground reference for RS232
A	74	I	RXD		RS-232 receive signal
A	75	I	CAND_H_TERM		CAN interface D bus termination (connect to A76)
A	76	I	CAND_L_TERM		CAN interface D bus termination (connect to A75)
A	77	I	CANC_H_TERM		CAN interface C bus termination (connect to A78)
A	78	I	CANC_L_TERM		CAN interface C bus termination (connect to A77)
A	79	I	CANB_H_TERM		CAN interface B bus termination (connect to A80)
A	80	I	CANB_L_TERM		CAN interface B bus termination (connect to A79)
A	81	I	MOD_{ADDR-}		Module address resistor

[1] *Several parallel pins are needed for output current rating, all pins must be connected*

[2] *Several parallel pins are needed for output current rating, all pins must be connected*

Table 65 – Connector B pinout (TEC152-001)

Connector B – TYCO 1241434-1, TEC152					
Pin		Dir	Function(s)	I/O Group	Notes
B	82	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
B	83	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
B	84	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3b	
B	85	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3b	
B	86		$GND_{DO/DI}$		Digital output/input ground (MAX 3 A)
B	87	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	88	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	89	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	90	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
B	91	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
B	92	I	$DI_{H.2}$, $AI_{10V.2}$	I_#8	
B	93	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3b	
B	94	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3b	
B	95		$GND_{DO/DI}$		Digital output/input ground (MAX 3 A)
B	96	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	97	O	$DO_{H2A5.1}$	O_#1	
B	98	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	99	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3a	
B	100	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3a	
B	101	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3a	
B	102	IO	$HB_{SDV.1}$, $AI_{32V.5}$, $DI_{H.5}$	IO_#3a	
B	103	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	104	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	105	O	$DO_{H2A5.1}$	O	
B	106	IO	$DO_{L\_RET1A/2A.1}$, $DO_{L.1}$	IO_#2	
B	107	O	$DO_{H2A5.1}$	O_#1	
B	108	O	$DO_{H2A5.1}$	O_#1	
B	109	O	$DO_{H2A5.1}$	O_#1	
B	110	O	$DO_{H2A5.1}$	O_#1	
B	111	O	$DO_{H2A5.1}$	O_#1	
B	112	O	$DO_{H2A5.1}$	O_#1	
B	113	O	$DO_{H2A5.1}$	O_#1	
B	114		$GND_{DO/DI}$		Digital output/input ground or Ground reference for HB_{SDV} (MAX 10 A)
B	115	O	$DO_{H2A5.1}$	O_#1	
B	116	O	$DO_{H2A5.1}$	O_#1	
B	117	O	$DO_{H2A5.1}$	O_#1	
B	118	O	$DO_{H2A5.1}$	O_#1	
B	119	O	$DO_{H2A5.1}$	O_#1	
B	120	O	$DO_{H2A5.1}$	O_#1	
B	121	O	$DO_{H2A5.1}$	O_#1	

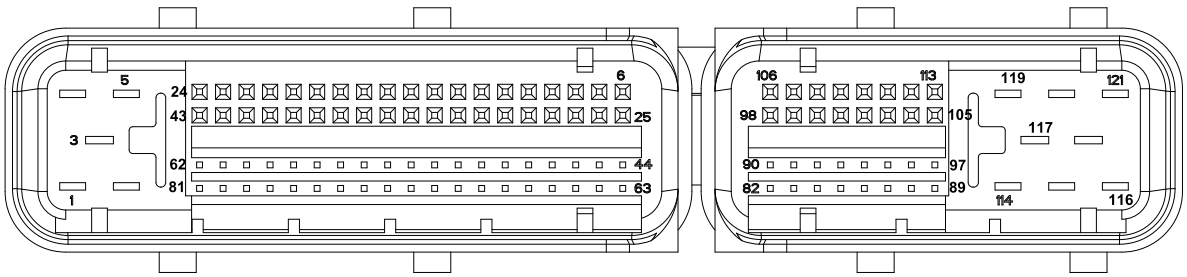
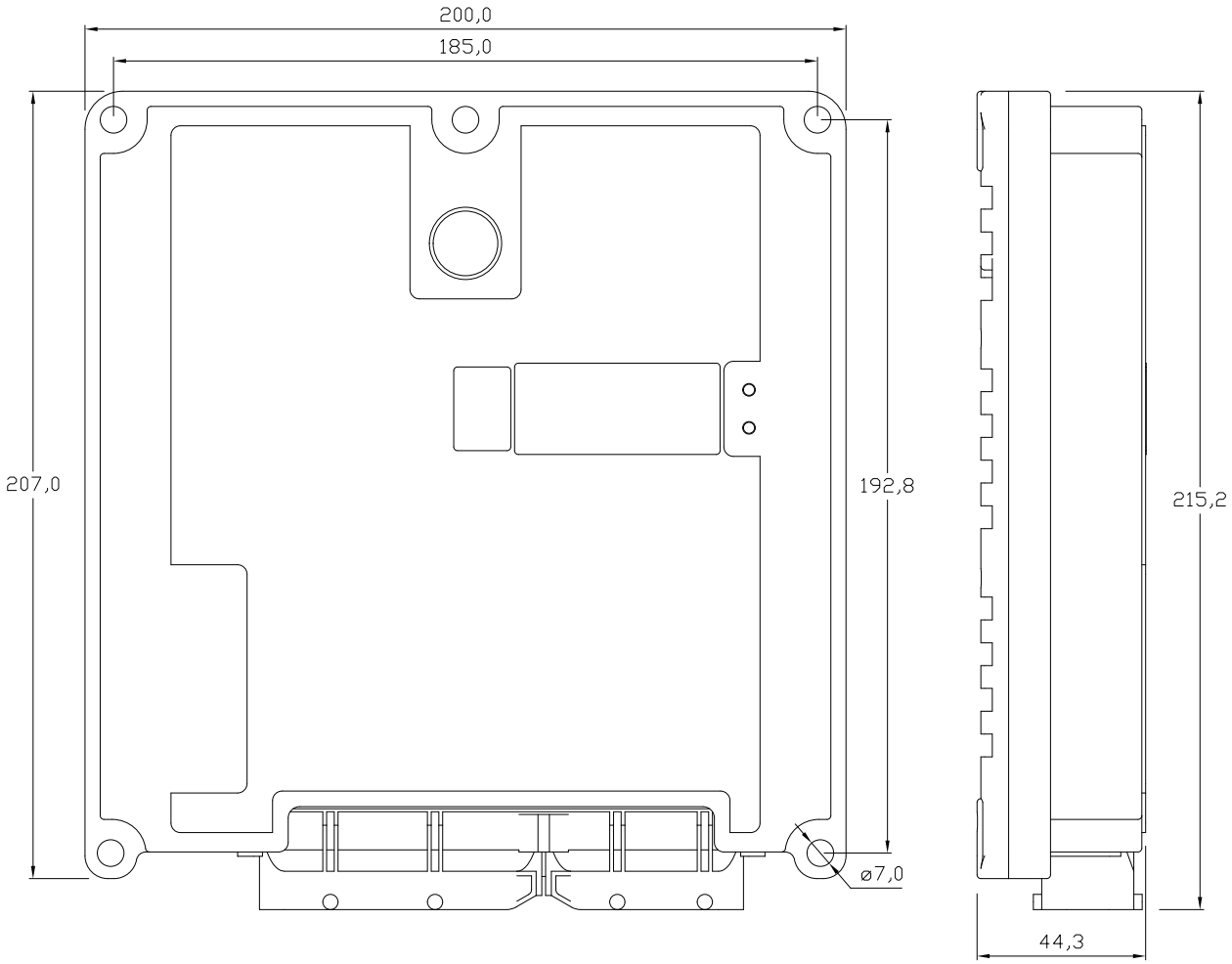
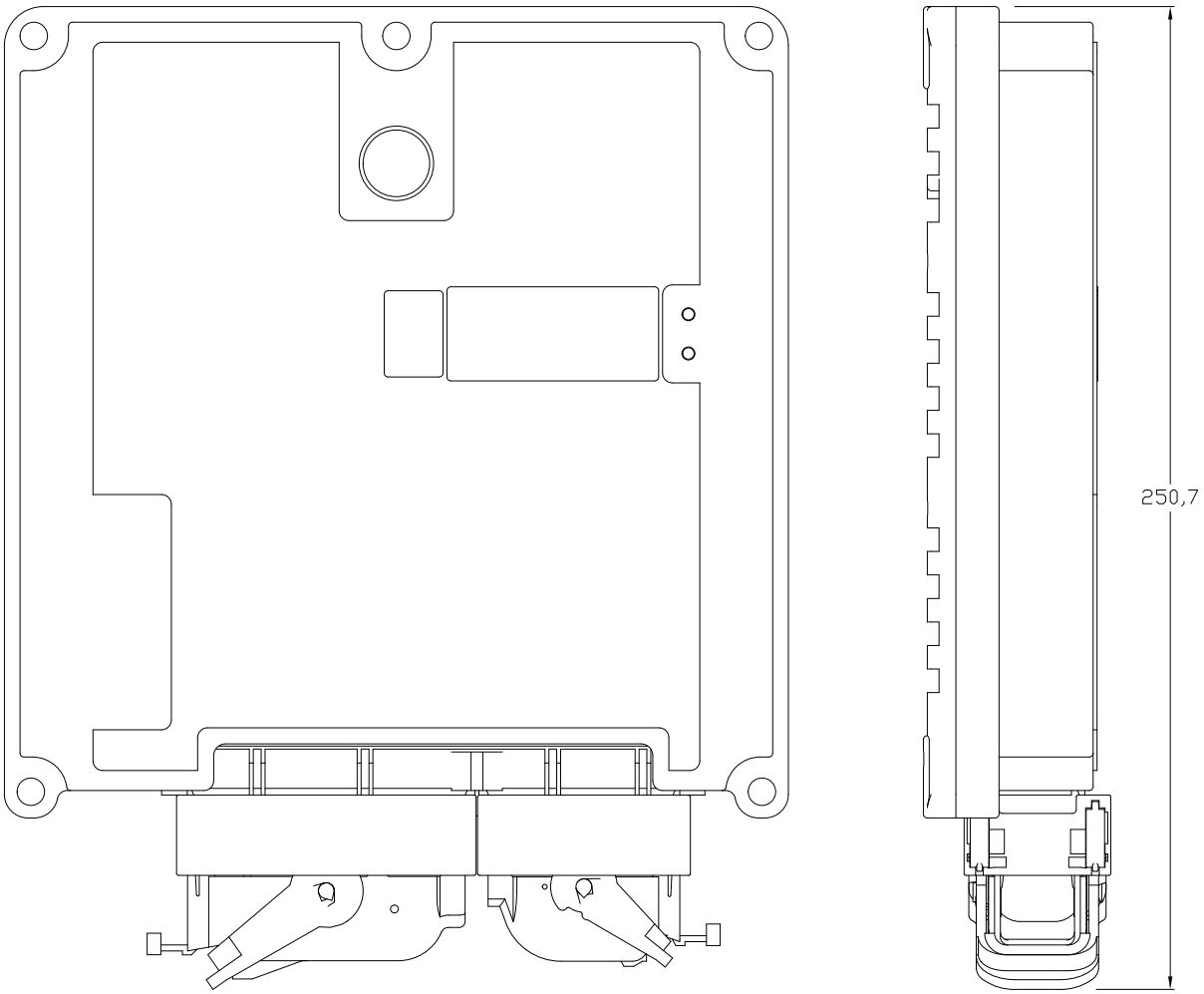


Figure 25- Connector A & B pin numbering

9 Mechanical drawings

All measurements in millimeters (mm).




250,7

10 Software environment

User applications for TEC152 are developed as IEC 61131-3 applications, using CODESYS V3 programming environment. By default, CANA is used as development port for communication between the module and the development PC. The CODESYS tool is compatible with USB-to-CAN interfaces provided by Kvaser and PEAK-System Technik. The firmware of TEC152 supporting development of user applications consists of the Boot loader and the System software.

10.1 Boot loader

The boot loader is the first program running after power-up of the device, and it provides facilities for updating the system software and user application over CAN using CANopen-based download protocol. Technion offers a software tool for Windows-based PCs for performing the download. The software tool is compatible with USB-to-CAN interfaces provided by Kvaser and PEAK-System Technik.

10.2 System software

The system software of TEC152 manages the I/O features of the module, and implements CODESYS V3 Runtime System, necessary for creating user applications with CODESYS. Main features provided by the runtime system for application development are:

- On-line monitoring and writing of application variables
- Software break points
- Pre-emptive multitasking scheduler for application tasks
- Exception processing for handling application programming errors
- Support for CAN interfaces
- Support for file access on data flash
- Support for RS232 interface
- Retain variables support
- Support for configuring all analog and digital I/O interfaces of TEC152

Documentation on how to access these features can be found in built-in help system of CODESYS.

11 Reference documents

Item	Document name	Description	Rev
[1]	Technical Report: The Tin Commandments: 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: Guidelines For The Use Of Gold On Connector Contacts, AMP Incorporated	http://www.te.com/documentation/whitepapers/pdf/aurulrep.pdf	7/29/96
[3]	Instruction sheet 411-78008, Sealed MQS/JPT 81/40pos connector, Tyco Electronics	http://www.te.com/commerce/DocumentDelivery/DDEController?Action=showdoc&DocId=Specification+Or+Standard%7F411-78008%7FA%7Fpdf%7FJapanese%7FJPN_SS_411-78008_A.pdf%7F1241434-1	4/6/09

12 Version History

Version	Date	Description	Author	Approval
1.0	02.02.2015	Technical manual initial public release	TA,TS	AP
1.1	19.04.2016	Updates in following chapters: Ch. 5.3 $VBAT_{cl30}$ fuse rating added Ch. 5.3.1 $VBAT_{DO}$ reverse current protection description Ch. 6.3.1 Minimum communication speed updated Ch. 6.2.1 & 6.2.7 Input types $D_{IH.1}$, $AI_{5V.1}$, $AI_{10V.1}$ & $AI_{20mA.1}$ do not withstand reverse polarity Ch. 6.2.2 & 6.2.9 Reverse feed and polarity restrictions removed Ch. 6.2.4 Removed limitation on $FI6_H$ encoder modes, alternative mode added to input capture. Minimum pulse width & jitter spec added Ch. 6.2.5 FI_{VR} cutoff frequency updated Ch. 6.2.7 $AI_{1k5\Omega.1}$ accuracy specification clarified Ch. 6.2.12 DO_H reverse feed note added Ch. 6.2.12.3 Added guidelines for parallel connection Ch. 6.2.13 DO_L connection guidelines added Ch. 6.2.14 HB_{SDV} electrical specification updated Ch. 6.2.x Diagnostic specification clarified in all sub-chapters Ch. 9 Mechanical drawing updated	TA	AP
1.2	27.04.2017	Updates in following chapters: Ch. 4.1.1 Chapter added Ch. 4.2 Connection guidelines added Ch. 4.2 Reference to TE instruction sheet added Ch. 5.3.2 Chapter added Ch. 6.2.12 Description for operation during over voltage added, current measurement filter characteristics added Ch. 8.2 CAN bus naming convention updated	TA	AP