PT1G with PTBM

Rotational Speed Sensor for Turbochargers

PT1G with PTBM datasheet

Revision: 7

Release Date: 2024-08-09

Document Status: Production

PICOTURN is a system for measuring the rotational speed of turbochargers. It's functional principle is one-megahertz pulse induction and eddy current discrimination, done with a solenoid sensor mounted in the compressor housing through a bore. The sensor detects and counts compressor vanes one by one. When compared to optical detection, this inductive method benefits from its lack of sensitivity to dirt, oil and dust. When compared to the magnetized nut method, the PICOTURN system is safer as there is no concern with nuts coming loose and destroying the charger and the engine.

The PT1G series (1st generation) is made of a sensor with 1.5m cable, a PTBM V6.2 signal-conditioning box and a cable for output and power supply. It is capable of speed measurement up to 400,000 rpm. The minimum speed is 200 rpm. The high sensitivity allows a large distance between sensor and the rotating vanes in the range of 1 mm at 0.6mm vane thickness.

Various sensors are available. They differentiate by the length and thread of the sensor head. The PTSM-H series in addition is optimized for high sensitivity, targeting titanium wheel and other critical applications.

Key Features & Benefits

Eddy-current damping based rotational speed sensors

Rotational speed 200 rpm to 400,000 rpm

Dedicated for compressor wheels made of **aluminum or titanium**

PTBM V6.2 signal conditioning box with digital and analog outputs

Wide operating ranges:
- Electronics: -40 to +85°C
- Sensor tip: -40 to +230°C (250°C peak 5 min.)
- Sensor tip -H type: -40 to +250°C (270°C peak 5 min.)
- VDD: 8 to 30 V

Applications

- Turbocharges on engine test benches
- Turbocharges in test cars

Content Guide

1 PTBM V6.2

The PICOTURN signal conditioning box drives the sensor, converts the sensor signal to rotational speed and provides this information as a digital pulse output or an analog output voltage. The PTBM V6.2 is optimized with respect to similar sensitivity for different kinds of sensors. The number of vanes is programmable between 1 - 15 / 16 – 31. The box offers two kinds of interfaces:

- Digital pulse interface
- Analog interface 0.5 V – 4.5 V

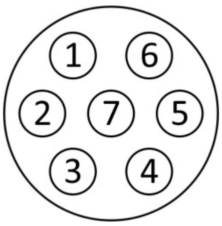
A measurement system requires at least a PTBM V6.2 box and a sensor from our PTSM series. The sensor is connected to the box by a coaxial cable with two inner conductors, about 1.5 m (59‘) long (max. 3 m (118‘)). The connector is SMB type. The box comes with aluminum housing.

Figure 1: PTBM front

Figure 2: PTBM back

1.1 PTBM V6.2L

Sciosense offers a special version of PTBM V6.2 with a Lemo connector instead of the 4 mm banana jacks for power supply. In addition to the power line, digital and analog output signals are also available on the Lemo connector. The Lemo order number for the fitting male connector is EXG.1B.307.HLN. The pin assignment is as follows:



Pin 1 – Digital OUT
Pin 2 – Signal GND
Pin 3 – Analog OUT
Pin 4 – +8…+30 V
Pin 5 – V GND
Pin 6 – n.c.
Pin 7 – n.c.

Figure 3: PTBM back

2 Technical Data

Model	PTBM V6.2, PTBM V6.2L	
Sensors suitable	PTSM 5.3, PTSM 5.5, PTSM 5.6, PTSM 5F.2, PTSM 5F.3, PTSM 5F.5,	PTSM-H 5.3, PTSM-H 5.5, PTSM-H 5.6, PTSM-H 5F.2, PTSM-H 5F.3, PTSM-H 5F.5
Target material	Aluminum	Aluminum, titanium
T_{op} sensor tip	-40°C to 230°C, max. +250°C for 5 minutes	-40°C to 250°C, max. +270°C for 5 minutes
T_{op} sensor cable	-40°C to 180°C	
T_{op} PTBM	-40°C to 85°C	
Distance sensor tip to blade for Al	1 to 2 mm for passenger cars, 2 to 3 mm for trucks. The maximum distance depends strongly on the turbocharger geometry, the vane thickness at the sensor tip and the alloy of the wheel. So only an indication can be given.	
Cable length sensor	1.5 m, no extension cable to be used	
Speed range	200 rpm to 400,000 rpm	
Number of vanes[1]	Digital out: 1 to 15, or 16 to 31, Analog out: 4 to 15, or 16 to 31,	
Digital output	Pulsed CMOS, 5V / 10 mA, 50% duty cycle, frequency precision 0.009% of full scale. One impulse per N vanes, N = 1 to 31	
Analog output	Range 0.5 V to 4.5 V, 0.5 V = stand still, slope 80,000 rpm/V (subject to correct vane number setting) Voltage precision 0.5 % of full scale at 25°C Measurement rate approximately 260 Hz, resolution 390 rpm when set to 10 vanes. Update rate at vane number N =	
Power supply	8 to 30V DC / typ. 45 mA	
Housing	105 x 30 x 85 mm³ (4.1‘*1.18‘*3.35‘)	

Update rate at vane number N (Analog output):

4	104 Hz	7	182 Hz	10	260 Hz	13	339 Hz
5	130 Hz	8	208 Hz	11	286 Hz	14	365 Hz
6	156 Hz	9	234 Hz	12	313 Hz	15	391 Hz

[1] If the analog output is used, the number of vanes is selectable between 4 to 31.

3 Ordering Information

Table 1: Product list

Part No.	Product	Description			
202300004	PTBM V6.2	Signal conditioning box with standard interface			
202300007	PTBM V6.2L	Signal conditioning box with LEMO interface connector			
220170004	PTCT	Calibration system			
220140001	PTCT signal cord	Signal cord for calibration system			
Sensors					
New		Sensor length/ thread length	Diameter	Cable length	Temperature range sensor head
220150008	PTSM 5.3	60 mm/54 mm	M5 x 0.8	0.95 m	-40 °C to +230 °C
220150006	PTSM 5.5	46 mm/40 mm	M5 x 0.8	0.95 m	-40 °C to +230 °C
220150012	PTSM 5.6	75 mm/69 mm	M5 x 0.8	0.95 m	-40 °C to +230 °C
220150004	PTSM 5F.2	41 mm/25 mm	M5 x 0.5	0.95 m	-40 °C to +230 °C
220150014	PTSM 5F.3	56 mm/40 mm	M5 x 0.5	0.95 m	-40 °C to +230 °C
220150016	PTSM 5F.5	76 mm/60 mm	M5 x 0.5	0.95 m	-40 °C to +230 °C
H-types for higher temperature and higher sensitivity					
220180003	PTSM-H 5.3	60 mm/54 mm	M5 x 0.8	0.95 m	-40 °C to +250 °C
220180004	PTSM-H 5.5	46 mm/40 mm	M5 x 0.8	0.95 m	-40 °C to +250 °C
220180005	PTSM-H 5.6	75 mm/69 mm	M5 x 0.8	0.95 m	-40 °C to +250 °C
220180003	PTSM-H 5F.2	41 mm/25 mm	M5 x 0.5	0.95 m	-40 °C to +250 °C
220180004	PTSM-H 5F.3	56 mm/40 mm	M5 x 0.5	0.95 m	-40 °C to +250 °C
220180008	PTSM-H 5F.5	76 mm/60 mm	M5 x 0.5	0.95 m	-40 °C to +250 °C
	H-types: 270°C peak temperature for 5 min, higher sensitivity, for use in critical applications				
220120001	Extension cable 1.5 m, SMB to SMB				

4 Mechanical Data

4.1 PTBM Dimensions

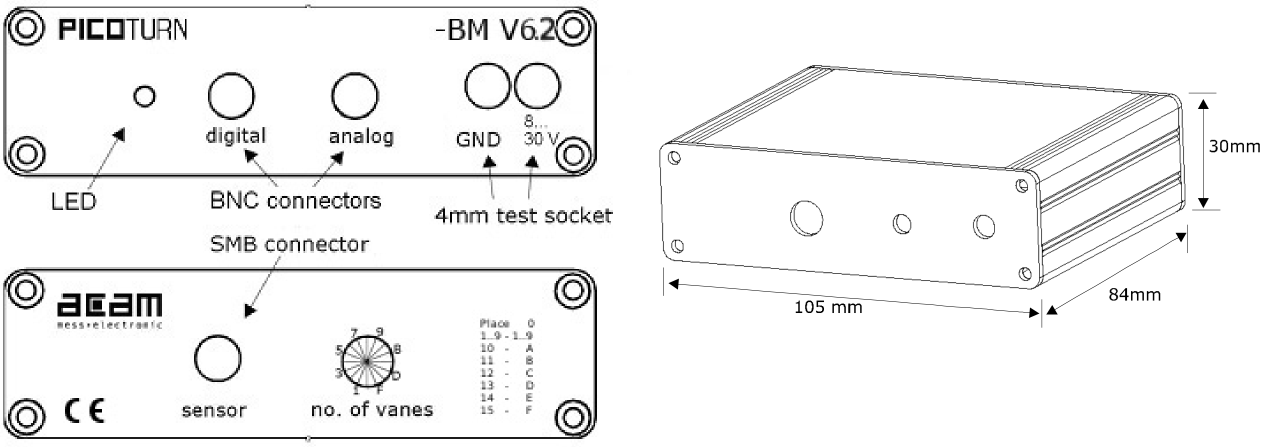
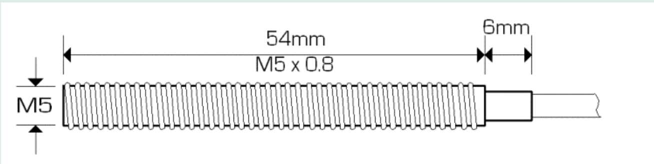
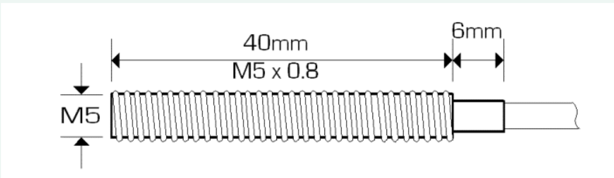
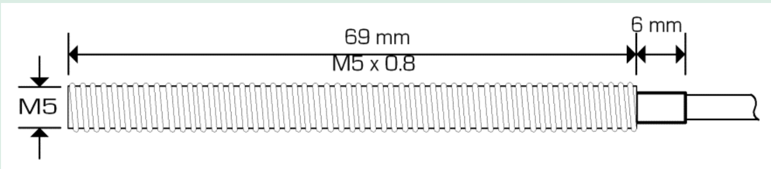
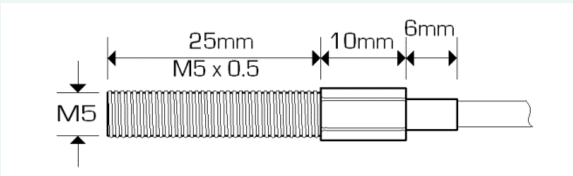
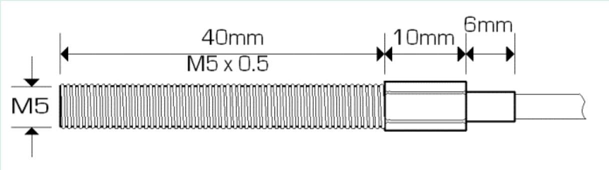
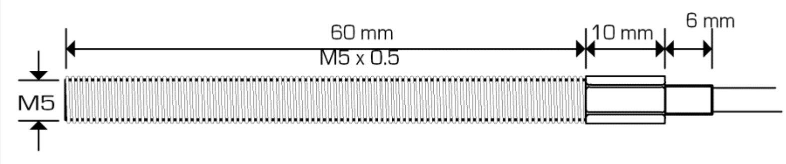


Figure 4: PTBM Outline

4.2 Sensor Tip Dimension

Table 2: Dimensions

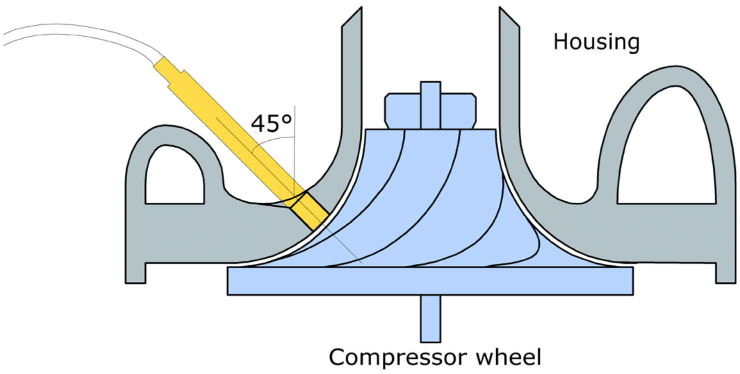
Sensor	Drawing
PTSM 5.3 PTSM-H 5.3	
PTSM 5.5 PTSM-H 5.5	
PTSM 5.6 PTSM-H 5.6	
PTSM 5F.2 PTSM-H 5F.2	

PTSM 5F.3 PTSM-H 5F.3	
PTSM 5F.5 PTSM-H 5F.5	

5 Sensor Application

CAUTION: Prior to the PICOTURN product installation, be sure that the turbocharger is cool.

The sensor body should be mounted in principle as indicated (see Figure 5). The compressor housing needs to be removed. Drill a hole into the case and cut a thread, according to the chosen sensor housing. Select the position of the hole so that every vane, both big and small, will be sensed. Place the sensor directly in front of the small vanes (“splitter vanes”), avoiding the vicinity of their upper edge (which could induce error into the system).



The correct mounting position and method depends on the individual geometry and characteristics of the turbocharger in use. Contact the manufacturer of the turbocharger for information about details on possible positions and correct mounting instructions.

Figure 5: Sensor Application

IMPORTANT: Make sure the tip of the sensor is approximately flush with the inside contour of the housing. Otherwise, it may hit and damage the compressor wheel.

Notice: Lock torque: The sensor body is not a 5-millimeter bolt, but merely a sleeve with some 0.3 mm thick walls. Apply only a fraction of the torque you would with a solid bolt: 0.3 Nm maximum (finger force, not fist force).

Environment: The sensor element with respect to its electronics and “Superseal” connector has been designed for under-hood operation and is considered engine compartment tolerant.

6 Analog Interface

The analog output voltage covers 0.5 V to 4.5 V. The slope is 80,000 rpm/V, corresponding to 0 rpm at 0.5 V and 320,000 rpm at 4.5 V output voltages, respectively. The above values are valid only if the number of vanes is correctly encoded. The analog output works correctly for vane numbers of 4 to 31, it is not applicable for settings of 1, 2 and 3.

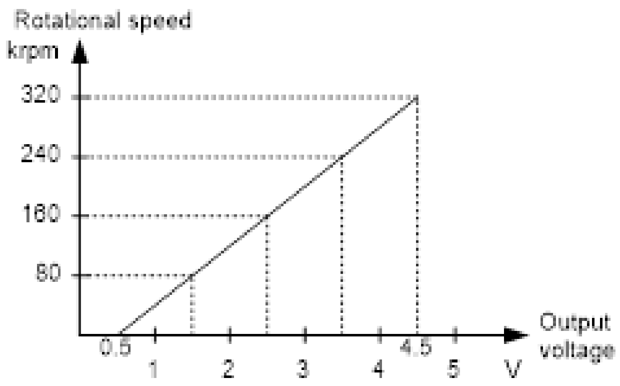


Figure 6: Speed vs. Voltage

Hint: If the vane number setting differs from the number of vanes on the wheel, the voltage slope and maximum speed at the analog output changes. This can be used to measure a rotational speed above 320,000 rpm at the analog output (setting a higher number, see example 1), or to increase resolution (setting a lower number, see example 2).

Example 1:		Example 2:	
Real vane number:	8	Real vane number:	10
Set number:	12	Set number:	5
-> Slope	1.5 * 80,000 rpm /V	-> Slope	0.5 * 80,000 rpm /V
	= 120,000 rpm /V		= 40,000 rpm /V
Maximum speed:	480,000 rpm	Maximum speed:	160,000 rpm

7 LED Display functionality

7.1 Diagnostics

Table 3: LED functionality

Mode	LED behavior	Circumstance	Consequences
A	LED stays dark		No power supply: the supply voltage is missing or below 8 V. Please check the power supply
B	LED on Continuously (green)	Turbo standing still	The rotational speed is zero. The controller is ok and in wait state.
		Turbo rotates	The sensor head is too far away from the wheel. To check the controller, remove the sensor and check that the LED is blinking.
C	LED on Continuously (red)	Turbo rotates	The system is operating normally.
D.1	LED shines red with short green breaks	Turbo rotates	The sensor signal is correctly captured most of the time and the controller can measure. But the signal strength is quite low. If possible, bring the sensor head 0.1 to 0.2 mm closer to the wheel.
D.2	LED shines green with short red breaks	Turbo standing still	There are electromagnetic disturbances. On engine test stations this might be due to ground loops. Add an additional GND wire from the controller box to the engine. Otherwise the signal might be disturbed, especially at low rotational speeds.
		Turbo rotates	The sensor signal is too weak. If possible bring the sensor head closer to the wheel.
E	LED blinking fast with about 8 Hz (red/green)	Sensor not connected	Please connect the sensor.
		Sensor disconnected for	Device test. The controller is ok and the supply voltage sufficient.
		device test	The sensor, the sensor cable or the sensor connector is defective or the power supply voltage is too small (below 8V).

7.2 Analog Signal for optimal Sensor Positioning

The measurement signal can also be tested quantitatively. This is helpful during application but may also be of interest during operation. It helps to achieve a higher signal-to-noise ratio of the measurement chain.

The number of vanes has to be set to 0 (code switch set to '0' and internal DIP switch DIVPULS off). A voltmeter has to be connected to the analog output, being set to the right measurement range (e.g. 5V). In contrast to all other settings, the output voltage is below 0.2V when the turbo is standing. Any other setting of the number of vanes results in an output voltage of 0.5V at standing turbo.

When the turbo wheel rotates, the indicated voltages can be interpreted according to the following table, assuming that the noise level is low (engine off):

Table 4: Signals for sensor positioning

Voltage	LED Light	Interpretation
Less than 0.20V	LED shines green permanently or with short red breaks	The sensor is too far away, bring it closer to the wheel. The LED is also permanently green if the wheel is standing still or too slow (below 200rpm).
Between 0.20V and 0.25V	LED shines red with short green breaks	Bring the sensor 0.1 mm closer to the wheel.
More than 0.25V but less than 4V	LED shines red permanently	Good signal. For gasoline engines it should be more than 1.5V to have enough margin against noise.
More than 4V	LED shines red permanently	Be careful. The sensor is very close to the wheel and might touch it.

7.3 Practical Hints

a) On engine test stands add an additional GND wire from the GND input of the PTBM (black connector) to the engine. This is not necessary in cars.

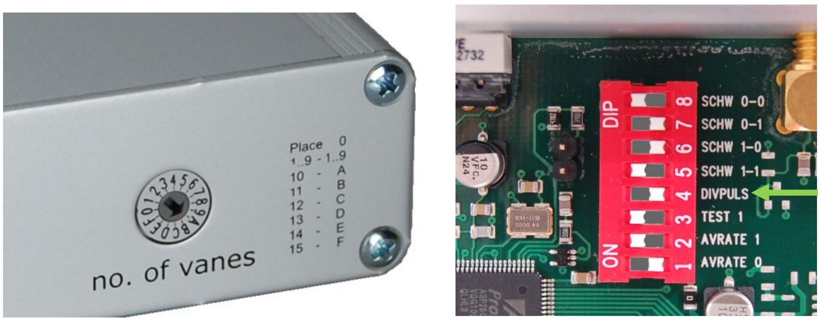
b) The cable length should be only as long as necessary. The shorter the cable, the better the sensor signal quality will be. On engine test stands, the 1.5 m sensor cable length should be sufficient. The maximum total cable length is 3 m.

c) Prefer the digital output if both output signals can be used. It shows higher dynamics and better precision. The analog output might need a recalibration from time to time to fix voltage offset and slope. For recalibration we offer the PTCT calibration device.

d) When you want to open the controller box, release the 4 upper screws. In case the screws are too tight, use a screwdriver and strike it with a brief but strong force. This will loosen the screw.

7.4 Number of Vanes - Code Switch

The number of vanes of the turbo wheel is set by a rotational code switch placed on the backside of the PTBM V6.2 box case. The standard range is 1 to 15 vanes, which can be changed to 16 to 31 vanes by setting an inside DIP switch. To set the DIP switch the case must be opened (default=off). The position of the DIP switch “DIVPULS” can be seen in the photo below, marked by an arrow.



No.4: DIVPULS: Division Factor 1 to 15 or 16 to 31

Figure 7: PTBM switches for vane number

Table 5: Switch settings

Code switch	0	1	2	3	4	...	9	A	...	F
DIVPULS16_31 = off	1[2,3]	1[1]	2[1]	3[1]	4	...	9	A	...	F
DIFFPULS16_31 = on	16	17	18	19	20	...	25	26	...	31

7.5 Measurement at high signal levels

The default setting of PTCM is for medium and weak signals. The internal DIP switches for filter settings will be set as follows:

- TEST1 = On
- AVRATE1 = 0n
- AVRATE0 = Off

If the sensor provides a very high signal level (analog output voltage > 4 V at vane number = 0, see section 3.5), then you should make changes stepwise in the following order, until the signal voltage falls below 4V:

[2] Not applicable to analog output
[3] Sensor positioning signal at analog output.

1. Screw back the sensor a little bit
2. Set AVRATE1 = AVRATE2 = Off
3. Set TEST1 = Off.

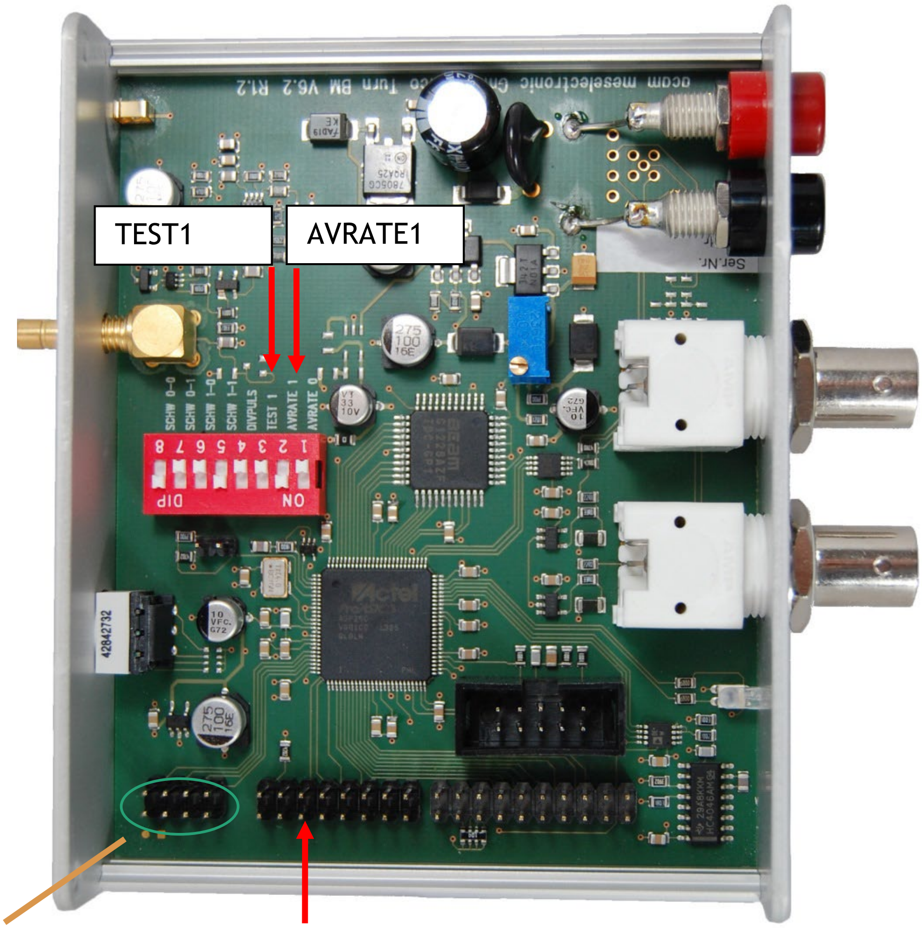


Figure 8: PTBM Internal settings

All other jumpers are for testing and should be open.

7.6 Measuring very high Rotational Speeds

The default settings of the PTBM are optimized for rotational speed measurement up to 280,000 rpm. For measuring higher rotary speed, it could be helpful to adjust the internal filter settings to avoid interferences. In case of problems at high speed, the following can be tried:

1. If possible, the usage of an extension cable between the sensor and the PTBM V6.2 evaluation box should be avoided. Connecting the sensor directly to the box gives the highest sensitivity.

All other steps require opening the box. Remove the upper four screws from the aluminum case and lift-off the housing cover. Then try one of the following:

2. Set DIP switch ‘AVRATE_1’ to OFF (see picture above). This adjustment tunes the internal filter for a wider range and improves the system for measuring higher speed frequency.
3. It can also be helpful to put a jumper on the edge connector to activate signal ‘FORCE_PULSOUT’ (see picture above). This switches off the double peak suppression and thereby increases the system’s reaction speed.

With these measures the system supports a safe detection up to 100,000 vanes per second. Please consider the increased sensitive of the system towards external disturbances due to the extended sensitivity range of the internal filter. Therefore we recommend to apply measures 2 or 3 only as far as required for a stable high speed measurement.

8 Calibration

8.1 PTCT

This device is for testing and calibrating the PTBM boxes. It simulates the behavior of a sensor mounted to a turbocharger. A selectable vane frequency / revolution speed is reproduced very precisely and allows the verification and calibration of the analog and digital output signals over the entire measurement range.

You select the number of vanes on a virtual compressor wheel and its simulated revolution speed by pushbutton code switches.

- Up to 32 vanes
- Revolution speeds between 0 and 360,000 rpm in steps of 40,000

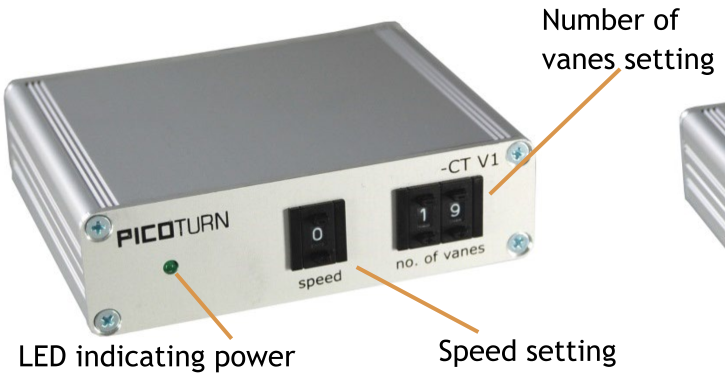


Figure 9: PTCT front

Figure 10: PTCT back

8.2 Technical Data

Table 6: Technical data

Supply voltage (box)	9 to 16 V	
Consumption (box)	20 mA @12 V	
Temperature (box)	-40˚C to +85˚C (-40˚F to +185˚F)	
Dimensions (box)	105 mm x 85 mm x 30 mm	
Length of PTCT signal cord, connecting CT and PTBM	From SMB to SMB	Approximately 0.15 meters

8.3 Setup

In a calibration process the offset and slope of the analog output get corrected. The sensor is simulated by calibration device PTCT.

In order to get started the following steps are necessary:

- Connect PTBM device under test to a 12 V DC power supply (battery, stationary power supply). Connect the PTCT to the same power supply.
- Connect the PTBM by means of the short PTCT cable to the PTCT.
- Connect the analog output of the PTCM to a calibrated, precision multi-meter to measure the output voltage.
- Connect the digital output to a calibrated, precision frequency counter.

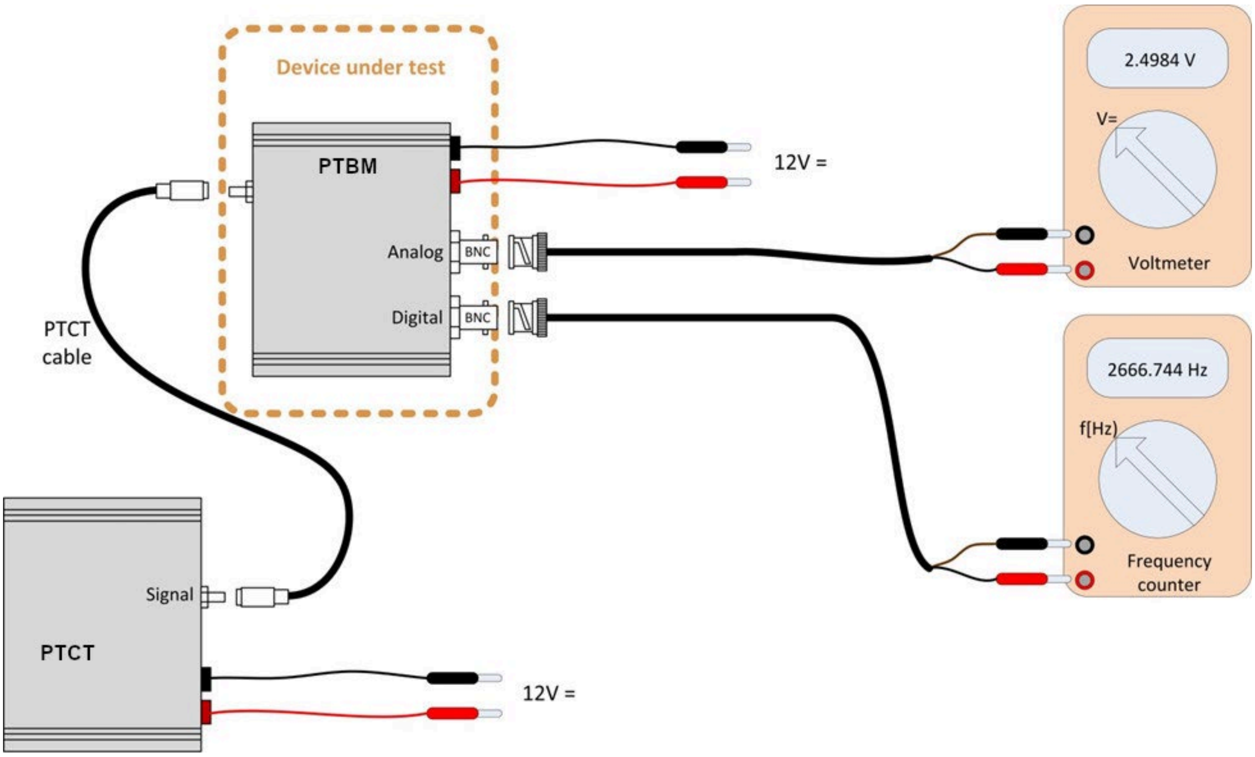


Figure 11: Calibration setup

8.4 Calibration process

For calibration, please open the housing. Find the fourfold switches and the potentiometer, marked by red circles in Figure 12: Calibration points:

The four switches adjust the offset in steps and the potentiometer adjusts the maximum value (slope). The switches add 5 mV, 10 mV, 20 mV or 40 mV in offset.

1. Configure the PTBM and PTCT for the same vane number, e.g. 7 .
2. Set the PTCT to speed “7” = 280,000 rpm. The analog output voltage of the PTBM should be 4.0 V. Adjust the potentiometer for an output voltage of 4.0 V, as precisely as feasible.
3. Now set the speed at PTCT to 0 = 0 rpm. The analog output voltage should be 0.5 V. Correct the lower value by means of the jumpers to come as close as possible to 0.5V.

4. Now check the upper value by setting the speed at PTCT to “7” again. If now the upper output voltage shows an increased deviation from 4.0 V, repeat steps 2-4 until no further improvement is achieved.

Figure 12: Calibration points

8.5 Verification

The verification is done in two steps. First, the number of vanes is set to a fixed value and only the speed setting is changed. Second, the speed is set to a fixed value and the vane number is changed.

- Verification with fixed vane number

The number of vanes is set to a fixed value, namely 10, on both PTBM and PTCT. On the PTBM rotational encoder, “A” stands for 10.

In the following, the setting for speed is increased from 0 to 8 by means of the pushbuttons, and the values for output voltage and frequency are recorded. A sample report is available as a ready-made Excel sheet from ScioSense at no charge.

The tolerable deviation is:

Voltage	+/- 0.5% of full scale
Frequency	+/- 0.009% of full scale

Table 7: Verification

Sweed switch setting	Nominal speed [1/min]	Nominal voltage [V]	Nominal frequency [Hz]
0	0	0.5000	0.000
1	40000	1.0000	666.667
2	80000	1.5000	1333.333
3	120000	2.0000	2000.000
4	160000	2.5000	2666.667
5	200000	3.0000	3333.333
6	240000	3.5000	4000.000
7	280000	4.0000	4667.445
8	320000	4.5000	5333.333

- Verification with fixed nominal speed

On the PTCT the number of vanes has to be set to 4 and the speed has to be set to 7. This corresponds to a pulse frequency of 18,665.42 Hz.

The number of vane setting on the PTBM is changed from 4 to 15 (10 = A,… 15 = F), and again the values for output voltage and frequency are recorded.

Table 8: Verification with fixed speed

No. of vanes setting	Nominal speed [1/min]	Nominal voltage [V]	Nominal frequency [Hz]
4	279981	4.000	4666.355
5	223985	3.300	3733.084
6	186654	2.833	3110.903
7	159989	2.500	2666.489
8	139991	2.250	2333.178
9	124436	2.055	2073.936
10	111993	1.900	1866.542

11	101811	1.773	1696.856
12	93327	1.667	1555.452
13	86148	1.577	1435.802
14	79995	1.500	1333.244
15	74662	1.433	1244.361

Settings 1, 2 and 3 produce a correct frequency at the digital output, but the analog output is not designed for these settings and sets the output to 5 V.

Note: The maximum vane frequency (vanes per second) is 100 kHz. If this frequency is exceeded due to the speed and No. of vanes setting, the calibration device automatically goes back to standstill. Choosing parameters out of range (e.g. No. of vanes < 4 or > 32) also causes standstill simulation.

9 RoHS Compliance & ScioSense Green Statement

RoHS: The term RoHS compliant means that Sciosense B.V. products fully comply with current RoHS directives. Our semiconductor products do not contain any chemicals for all 6 substance categories, including the requirement that lead does not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, RoHS compliant products are suitable for use in specified lead-free processes.

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10.1 Important Safety Information

10.1.1 Product Use

PICOTURN products are designed for industrial use. The intended use of the product is the measurement of speed of a turbocharger in a test bench environment or in driving tests. For proper installation and usage please follow the mounting instructions in this document. During operation of the test bench (including the motor and turbocharger), no persons must be present in the test room. For use in driving tests, in which persons may be present, use the product in such a way that in case of malfunctions or error, personnel and equipment are not endangered. Any use other than the one described above is considered as non-intended use and ScioSense declines any liability with respect to such non-intended use.

10.1.2 Installation

The speed sensor should be installed by a qualified automotive technician. Please carefully read and follow the instructions given in this manual for proper installation and use of the product. Furthermore, please pay attention to any installation instructions given by the turbocharger manufacturer, especially for the mounting of the sensor at the turbocharger and its safe operation. If you have any question or doubts regarding the installation or operation please contact the distributor from whom you purchased the sensor or alternatively contact ScioSense directly.

10.1.3 Signal words and symbols used

The following symbols and signal words are used in this data sheet.

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury

NOTICE is used to address practices not related to physical injury

10.1.4 Safety messages

The following list provides an overview of potential damages that can occur if the turbocharger sensor system is not operated as outlined in this manual.

CAUTION Connect an adequate power supply (meeting the specifications for supply voltage and current) in accordance with safety regulations for electrical equipment. Otherwise there is risk of injury and/or damage to or destruction of the sensor and controller box.

NOTICE Mount the sensor according to the installation instruction in this data sheet and/or the installation instructions of the turbocharger manufacturer. If the sensor is mounted incorrectly, the sensor itself; the turbocharger housing; or the turbo charger wheel (blades) can be damaged. Particularly in the case where the sensor goes too far into the turbocharger cavity, the wheel blades may be touched and thus the turbo wheel damaged. As a consequence, single blades of the turbo wheel could be detached and go into the motor and cause further damage there.

11 Revision Information

Table 9: Revision history

Revision	Date	Comment	Page
1	17 Jan 2017	Initial version	
2	15 Dec 2023	Transfer to Sciosense format, combination PTCM with sensors Minor rearrangement of sections	All
3	11 Mar 2025	Correction of wrong article number 220120001	6

Note(s) and/or Footnote(s):

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

Product PTBM complies with EMC standard 89/336/EEC and standard DIN EN 61326, for laboratory equipment (for use in the electromagnetic environment).

Interference immunity standard 2 (EN 61000-4-4: 0.5KV, -4-6: 1V), In the event of strong electromagnetic interference, the output signal may deviate, but only for the duration of the interference.

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