Test bench requirements to connect a Discom system

2024-09-16

Electrical Setup and Wiring for Discom Measurement System

Electrical Requirements

1. Separate sensor cables from power cables and keep them isolated.

- This rule applies to accelerometer and speed encoder cables.
- Never have them together in the same cable tray with power lines feeding the motors or robots or lines running high frequency and high power.
- Best route the *sensor cables in a separate metal cable tray*. Distance to power lines helps. Metal cable trays are made of galvanized iron sheet metal which has a much higher magnetic permeability than just a copper shield mesh. They therefore can shield better against magnetic crosstalk from power lines.
- Magnetic fields: *Distance is the best friend* to minimize the cross talk. In practical test stand design, 30 cm distance should be achievable.
- Within the sensor cable channels, do not use any BNC extensions, adapters or any other metal parts from the sensor cables. Also ensure that the sensor cable ends are mounted fully isolated from each other or any other metal parts of the test stand.

2. Avoid any cables going into the measurement PC to run in parallel to power cables.

A 10 m USB and monitor cable connected to the Discom PC running in the same cable tray for 5 m as the power cables picked up enough high frequency noise to feed this noise into the TAS measurement box. That the cables are shielded does not help as the high frequency will be induced into the shield and from the shield into the PC.

Electrical Requirements, Continued

3. Power the Tas Box from a cleaner UPS socket

If there is a UPS installed, use a connector to break out one of the outputs into a connector for the TAS power supply.

4. Grounding of Tas Box, Power Supply:

First connect Tas Box to ground then connect signals.
For TAS28 or TAS48 with more then 2 TAD cards, external power supply is required.

5. Choose appropriate type of accelerometer (ICP type or charge type)

ICP accelerometers are recommended for all medium to high power applications, because they have a much higher immunity to EMI-induced noise, which is proportional to the test stand's voltage and power levels.
Charge type accelerometers with external amplifier are recommended for low noise and low power applications. The combination of charge type sensor and ICP amplifier has lower noise and higher output voltage than ICP type sensors.
Because of the long distance between the high-impedance Piezo sensor and the external amplifier, this combination is more sensitive to EMI-induced noise, most often caused by high voltage and / or high-power inverters.

Electrical Requirements, Continued further

6. Use Differential Speed Signals

If the speed source is single ended, have a converter from single-ended to differential installed in close vicinity (30 cm) of the single-ended output (see next page and additional documentation).

7. Connecting other analog signals to Tas Box in differential mode only

When connecting non-Discom sensors which are not isolated, connect them in differential more only. (Tas Box input channel has to be set to differential mode *before* connecting the sensor.)
Make sure that there is no higher ground / potential difference than 10 V between the Tas Box ground (Tas Box case) and the signal ground.

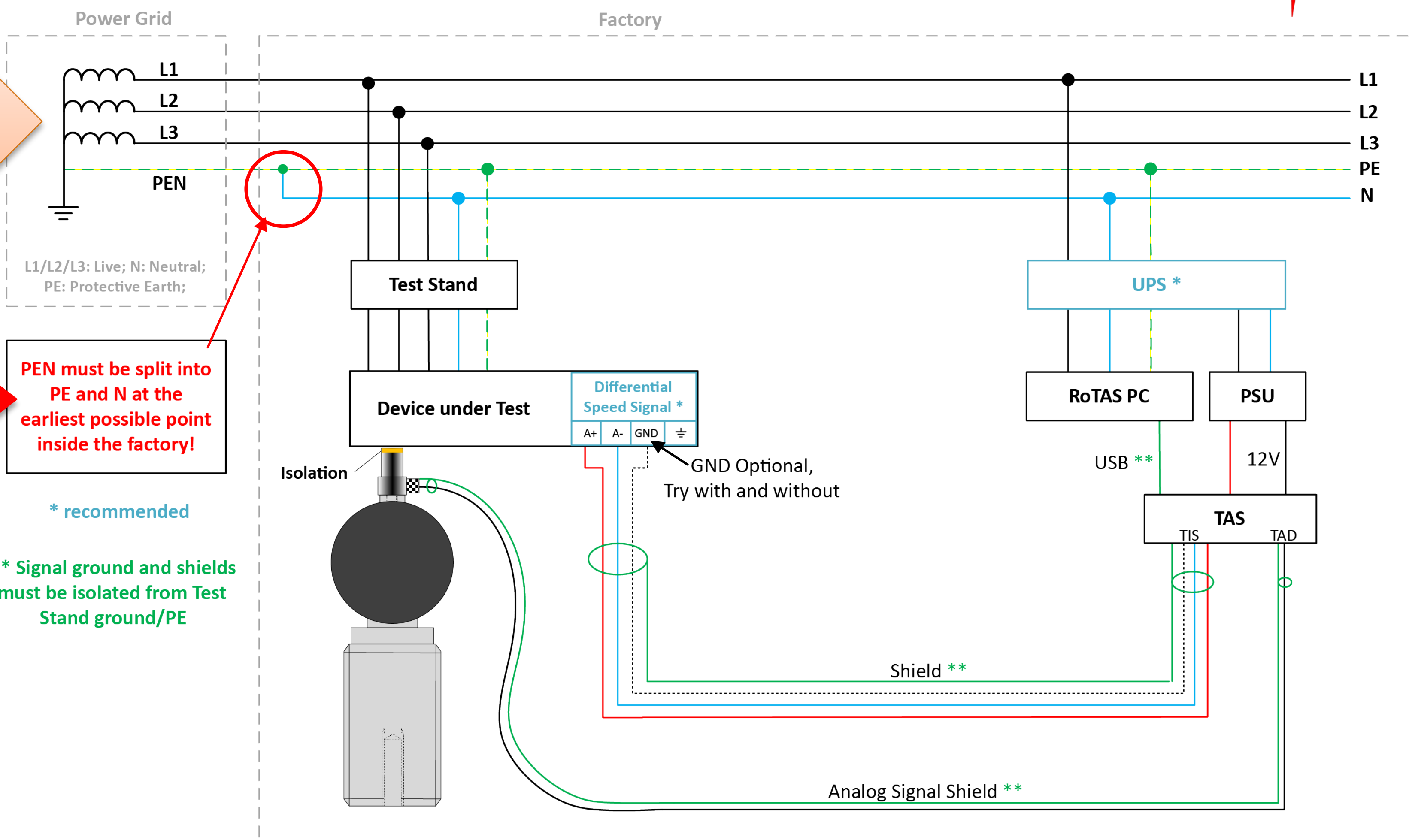
8. Check Block Diagram

Each Discom measurement PC comes with a block diagram showing the correct connections between PC, Tas Box, sensors and other external devices.
It can be found in the paper folder which accompanies the PC and on the PC in the folder D:\Discom-Documentation\SystemSpecific. Refer to it when in doubt how and where to connect a sensor or other device.

Power Grid Connection and Grounding

DISCOM

Connection to power grid



PEN must be split into PE and N at the earliest possible point inside the factory!

* recommended

** Signal ground and shields must be isolated from Test Stand ground/PE

To avoid EMC problems, the Discom system is not allowed to be connected to a 4-conductor-environment (L1/L2/L3/PEN).
Discom will not take over any responsibility for such a setup.

Avoiding Ground Loops

Tas Box – Analog Inputs

The **analog inputs** (TAD28, TAD48, TAD48+) are **NOT isolated**.

The ground (GND) of these inputs in *single-ended mode* equals the TAS system GND, which again equals the TAS case potential, which again is the same as the USB-connection's GND, which again equals the host PC's GND:

$$GND_{TAD} = GND_{TAS} = GND_{TAS\text{-}CASE} = GND_{USB} = GND_{PC}$$

This leads to the following rules for connecting analog signals to the TAD inputs:

- Do not connect any analog signal from the test stand to a TAD input in single-ended mode. If an analog signal must be connected directly to a TAD input, use **differential** mode only:
  - turn on differential mode ***before*** connecting the signal
  - make sure that the potential difference between TAS GND and the used test stand signal GND (from source output) is **< 10 V**
- Make sure that no accelerometer sensor grounds (usually on the sensor's case and outer BNC connections) have any connection to any test stand metal or other conducting material. Also prevent GND connections within / to cable trays.
- Keep apart even the GND connections of any analog TAS signals, this prevents creating a "loop antenna".
- Prevent cable loops in general, these also might create loop antennas. If possible, trim cables to the needed length.

TIS – RPM Inputs

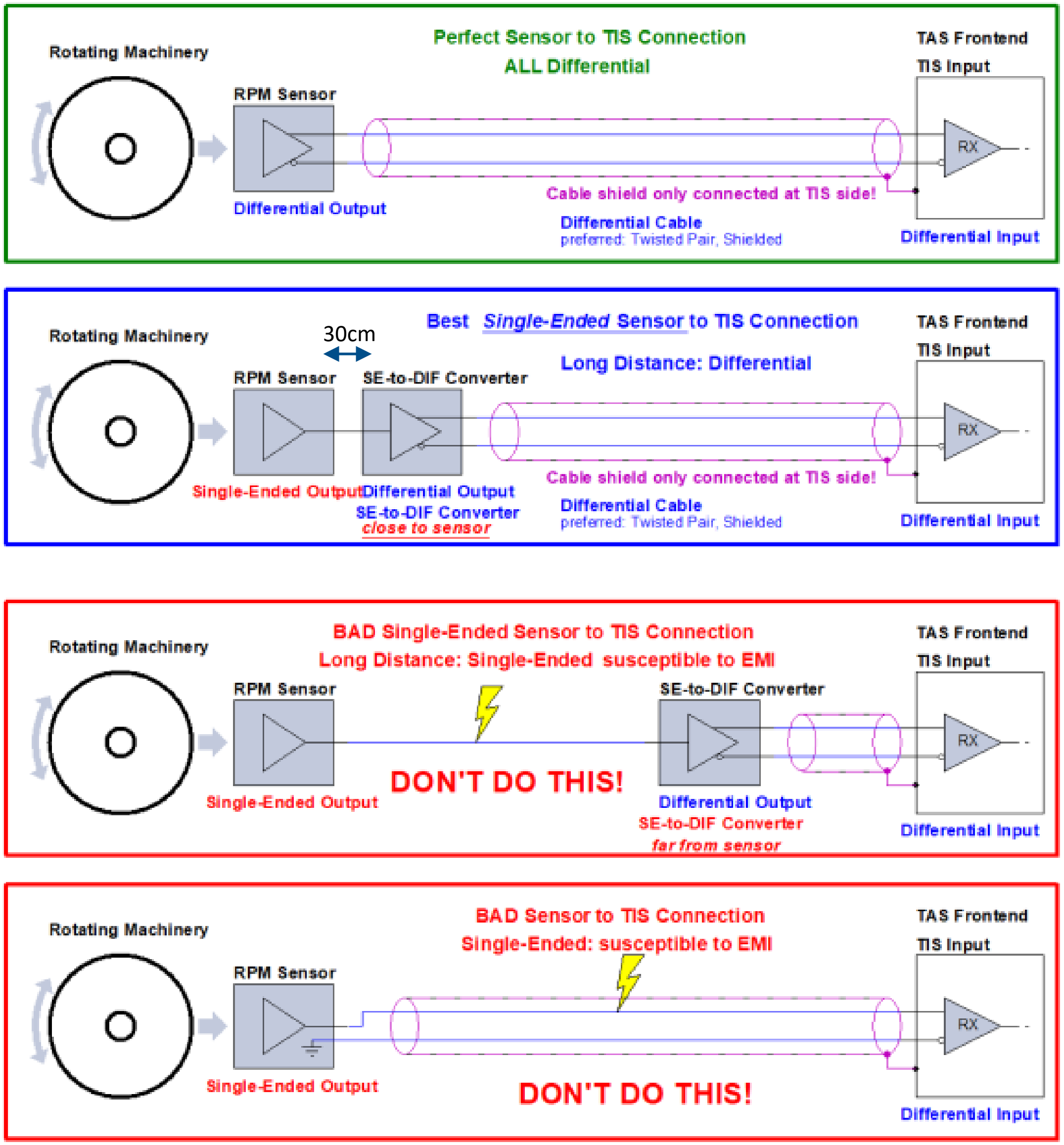
The TIS input lines are isolated to the Tas Box – but not to each other within one and the same TIS card.

Further, the TIS connector's shield, and so the cable shield, is usually connected to the TAS-case, so make sure that the TIS cable shield is connected only on one side (TAS side preferred).

And again: the TIS inputs prefer differential signals. If the original source is single-ended, use a converter to differential *close to the source*. The single-ended signals are much more sensitive to noise induced by electromagnetic fields, which might make the signals unusable.

Speed Pulse Signal Connection

Picture below: TIS to sensor connection scenarios, top to bottom = best to worst (don't!)



See also separate extended documentation on this topic!

Download extra documentation here:
https://download.discom.de/Documentation/TestStand_Speeds

Communication between test stand and NVH system

1. The test stand must as a minimum communicate transmission model, serial number, and test step information to the NVH test system. Communication uses text commands so that the communication can be logged and supervised. See separate command protocol documentation for details.
2. The test stand shall be capable to repeat any test step (gear, ramp) in case of an acoustic anomalies, automatically or when the operator presses a button. The number of allowable repeats can be specified.
3. The test stand can signal own errors and test results to the acoustic system. In case that the test stand software also stores results it is desirable that the test stand sends a time stamp to the NVH system to keep both results aligned.

Download communication protocol manual from
https://download.discom.de/Documentation/TestStand_Communication

TEST STAND DESIGN

General Test Stand Design Recommendations

1. Avoid run out of driving shafts, especially for high-speed inputs. Alignment should be as perfect as possible.

2. Strive for low runout, imbalance and misalignment. As a guideline, the misalignment of the input shaft shall be less than 0.1 mm for speeds up to 3000 rpm. For higher speeds, the runout needs to be smaller. The vibration of the test stand drive shafts consists usually of low orders. The vibration level of these low orders should be 10 dB or lower than the transmission vibration at these orders. Interesting transmission orders can be as low as 0.01 m/s^2 at orders 4 and above.

3. Use rigid clamping of the test unit, not soft mounting. Clamp the unit such that it does not move under torque change.

4. Keep close attention to torque fluctuations. Discom can add a torque spectrogram channel in both order and fixed frequency domain to aid the analysis of observed torque fluctuations.

Test Stand Mechanics

6. Create a mechanically rigid design with minimal linear and torsional resonances.

7. Data from a torque cell at least for the input shaft or one output shaft of a transmission is required. The torque (voltage output of torque cell) must be wired to the Tas Box. (Using the PLC control signal is not suitable.)

8. Gear sets used in the test stand itself shall have order amplitudes that are 10 dB less than transmission orders. The design shall ensure that this noise quality is maintained over time.

9. Toothed belt and chain drives should be avoided or must be guaranteed to exhibit less than 10 dB order noise compared to the transmission at these orders.

All test stands of a line should be from the same manufacturer and with identical design.

Sensors

1. **Vibration**: The Discom BKS vibration sensor are pressed onto the transmission surface. Check sensor data sheets for press-on force or press-in distance. Make sure to keep the required press-on force/distance constant.
2. **Speed**: speed encoders shall provide a pulse train with at least 60 pulses per revolution, 5V TTL. (Pulse rates of 4096 pulses per revolution and more are possible.) The speed sensor must be coupled to the according shaft such that no slip or flexibility exists. Speed pulse signals must be delivered as RS422 differential signals (see separate documentation).
3. **Speed sources**: for E-Drives and DHT/DCT transmissions, speed signals from both output shafts are required; for DCT/DHT transmission, also the input shaft speed is necessary. For manual transmissions or E-Drive gear sets without e-motor, either input or output speed(s) is sufficient.
4. **Torque**: The voltage signal from at least one torque sensor (input shaft or output shaft) is required. The voltage signal from this sensor needs to be an analog signal in the range of ±10V.
5. **Torsional Acceleration**: for E-Drives and axles with planetary gear sets, it is recommended to use a torsional acceleration (TAC) sensor in addition to the vibration sensors for achieving better vehicle correlation of the test results. Torque fluctuation can be used but has a lower frequency bandwidth than a TAC sensor.

IT Infrastructure

1. If more than one test stand is installed in a line, a server for storing the acoustic data, results, and parameterization is necessary. This can be a physical server computer or a virtual machine. See separate document for server requirements.
2. The test stands and the server need to be constantly connected via network.
3. A remote access to the server for support is highly recommended.

Test Cycle, Torques, Speeds

1. The test stand needs to be able to run speed ramps at constant torques. The torque variation during the speed ramp shall be less than 5% of the selected torque. The bandwidth for torque measurements shall be 50 Hz.

2. In addition, torque ramps at constant speeds may be used.

3. The torque and speed range shall be adequate to find vehicle related noise issues.

4. For manual, automatic and DHT transmissions: in gears 3 and up the test stand shall be capable of delivering 40% of the rated torque of the transmission. In gears R, 1 and 2 this requirement can be reduced for less expensive output motors. As a guideline, 30 Nm shall be possible in these gears.

   A low torque condition of 15-20 Nm shall be possible in gears 2, 3 and 4.

5. The test cycle must be configurable in terms of speeds, ramp times and torques independently for each gear / test condition.

6. Manual transmissions: it must be possible to test a manual transmission in up-shifting and in down-shifting (going from gear 1 to 6 or from gear 6 to 1).

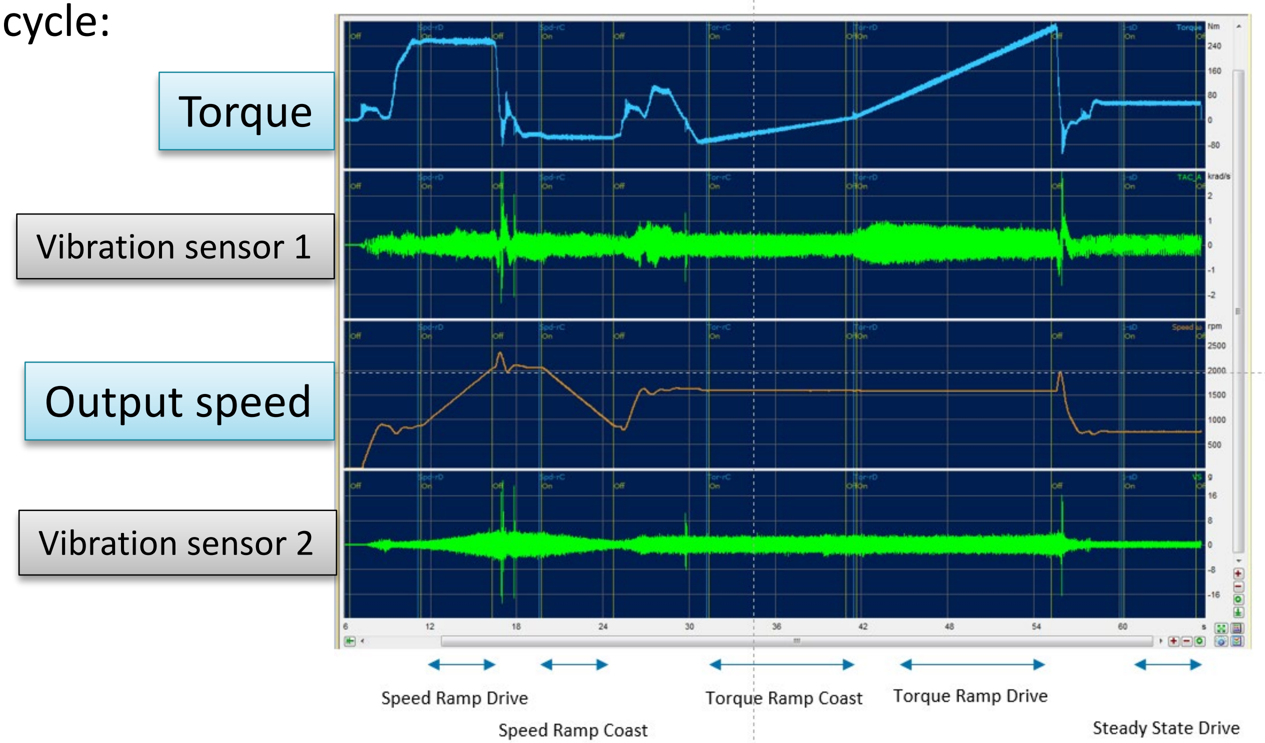
Test Cycle for E-Drives and E-Motors

E-Drives and E-Motors have either just one or only two gears (operating conditions).

The test cycle should consist of speed ramps, torque ramps and possibly constant speed sections.

The recommended ramp speed acceleration is such that the whole ramp is done in 10 s each up and down, resulting in *output speed* accelerations of 100 -130 RPM/s, the torque ramps should cover 10-15 s for the full range.

Example of such a test cycle:



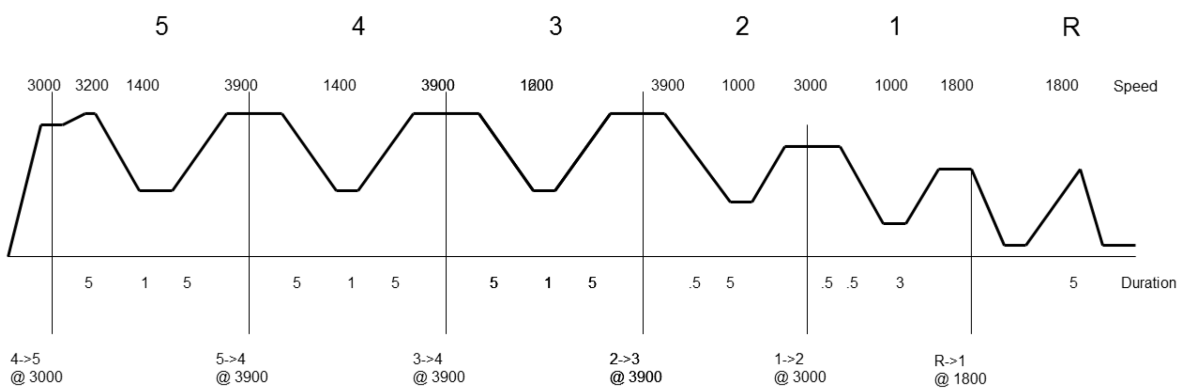
Test Cycle for Transmissions

The speed ranges for transmissions shall minimally be:

Gear	Low RPM	High RPM
R,1	1200	2500
2,3	1200	3200
4,5	1400	3500
6,7	1600	3000

The recommended ramp speed acceleration is 400 RPM/s. The ramp speed shall not exceed 600 RPM/s. The test time on a ramp shall be at least 3 s.

Example of a test cycle for transmissions:

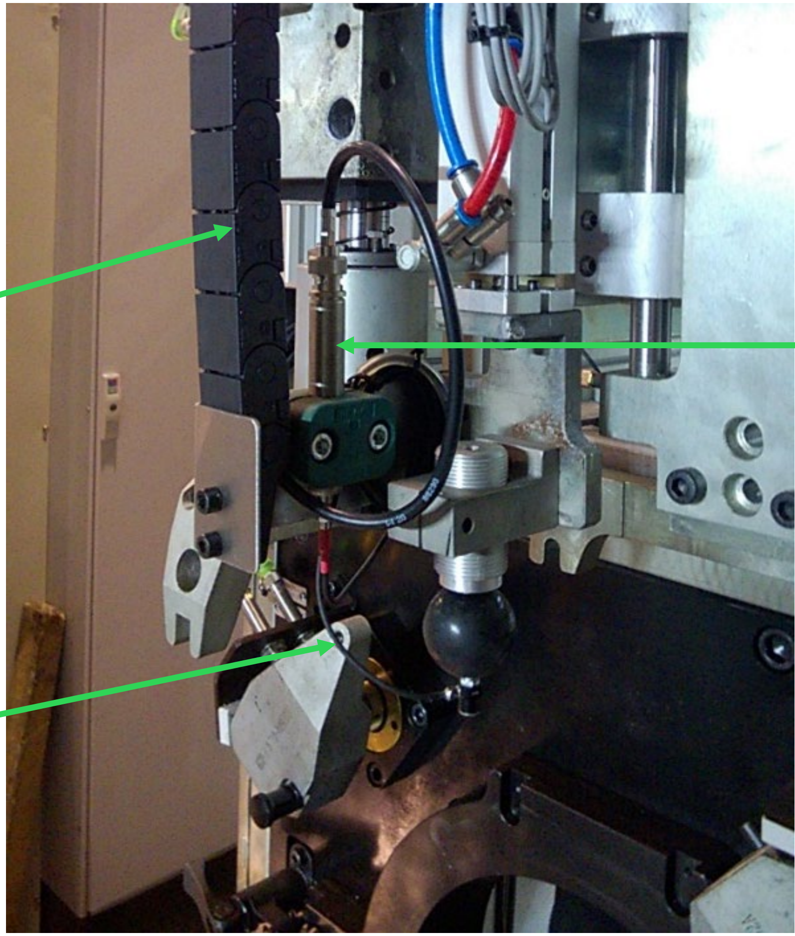


BKS03 SENSOR USAGE

BKS03 Sensor Cable Routing Good Practices

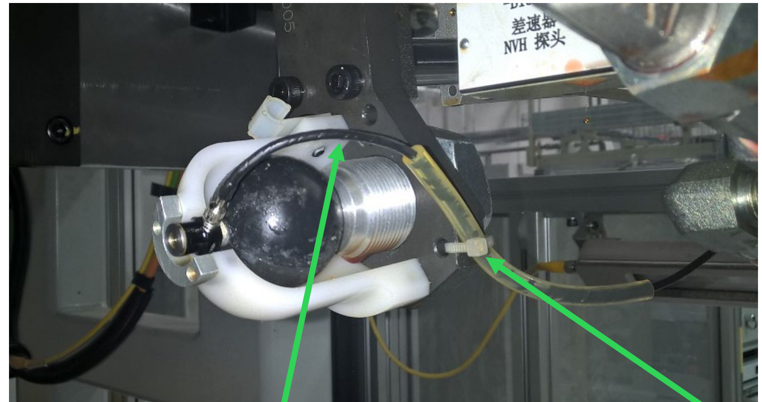
Cable guide for large movement of sensor position

5 cm free slack of the sensor cable



Isolation for ICP Amplifier
Easy access to terminals to check the tightness of the connectors

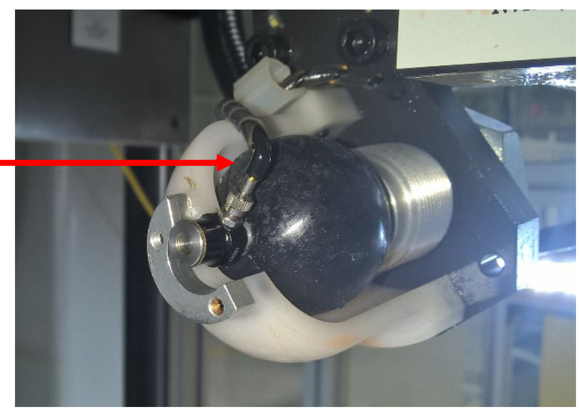
BKS03 Sensor cable routing



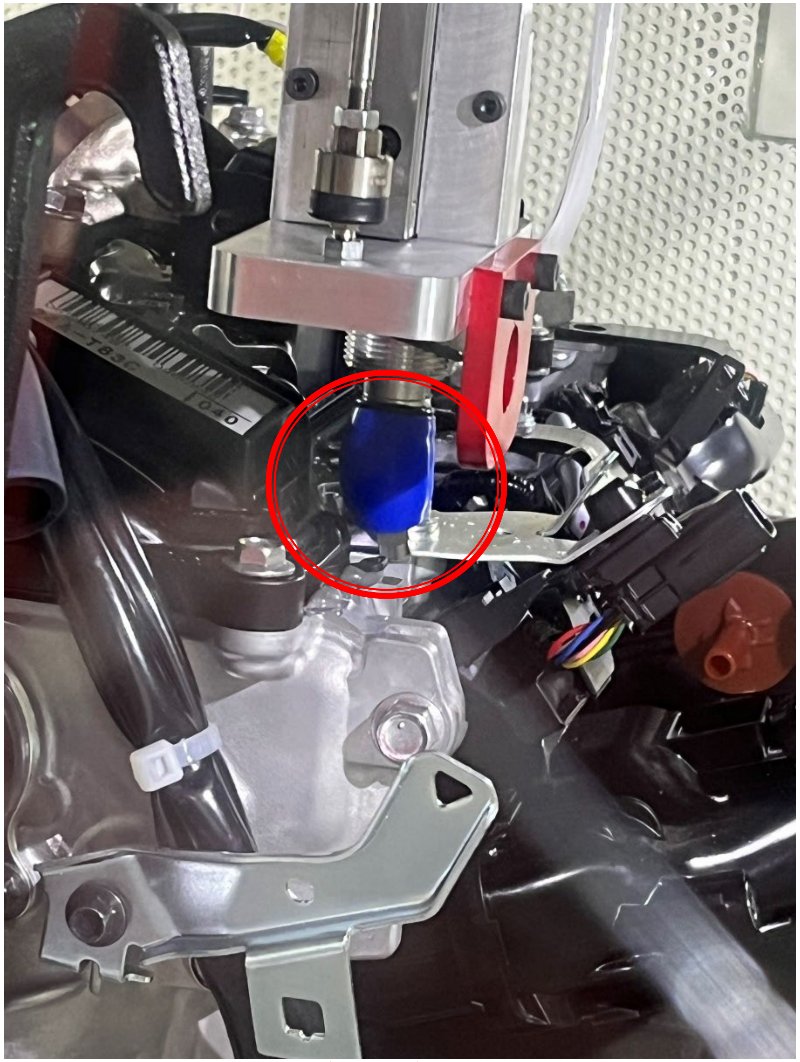
Good: free movement of sensor cable

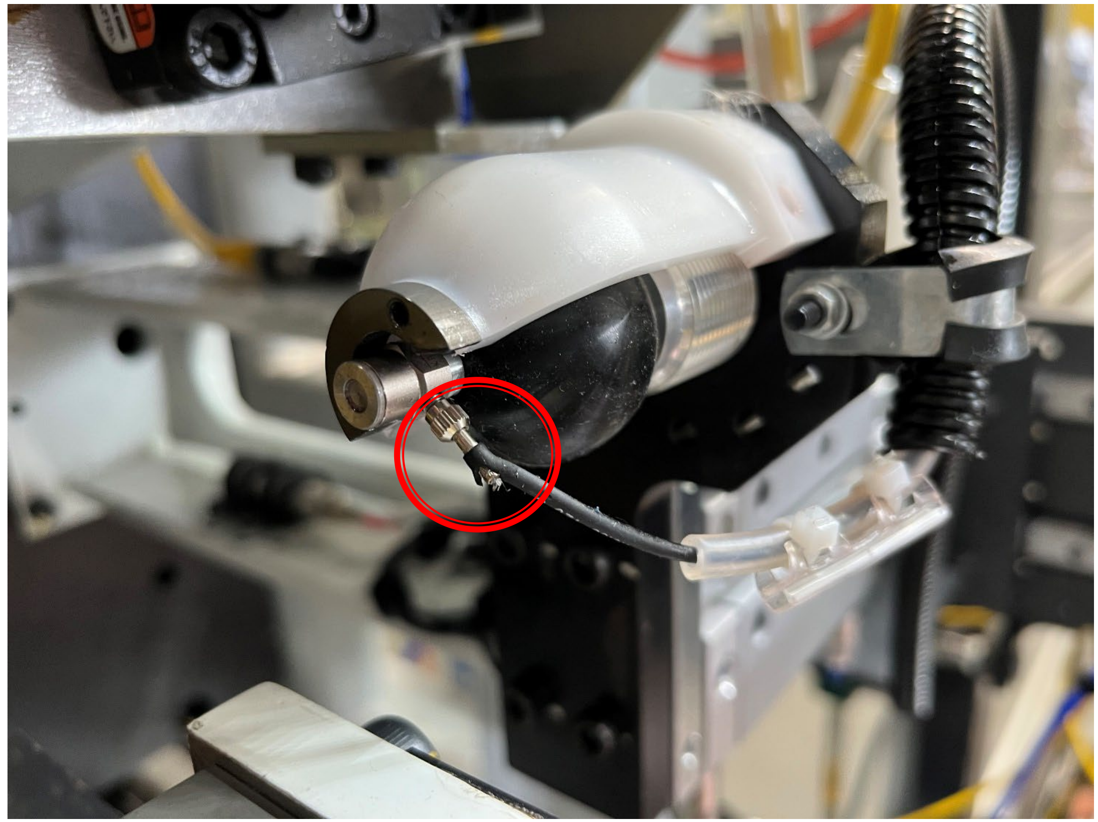
The silicon tube protects the cable against cable ties

Bad: High strain on cable and connector. The cable will break soon

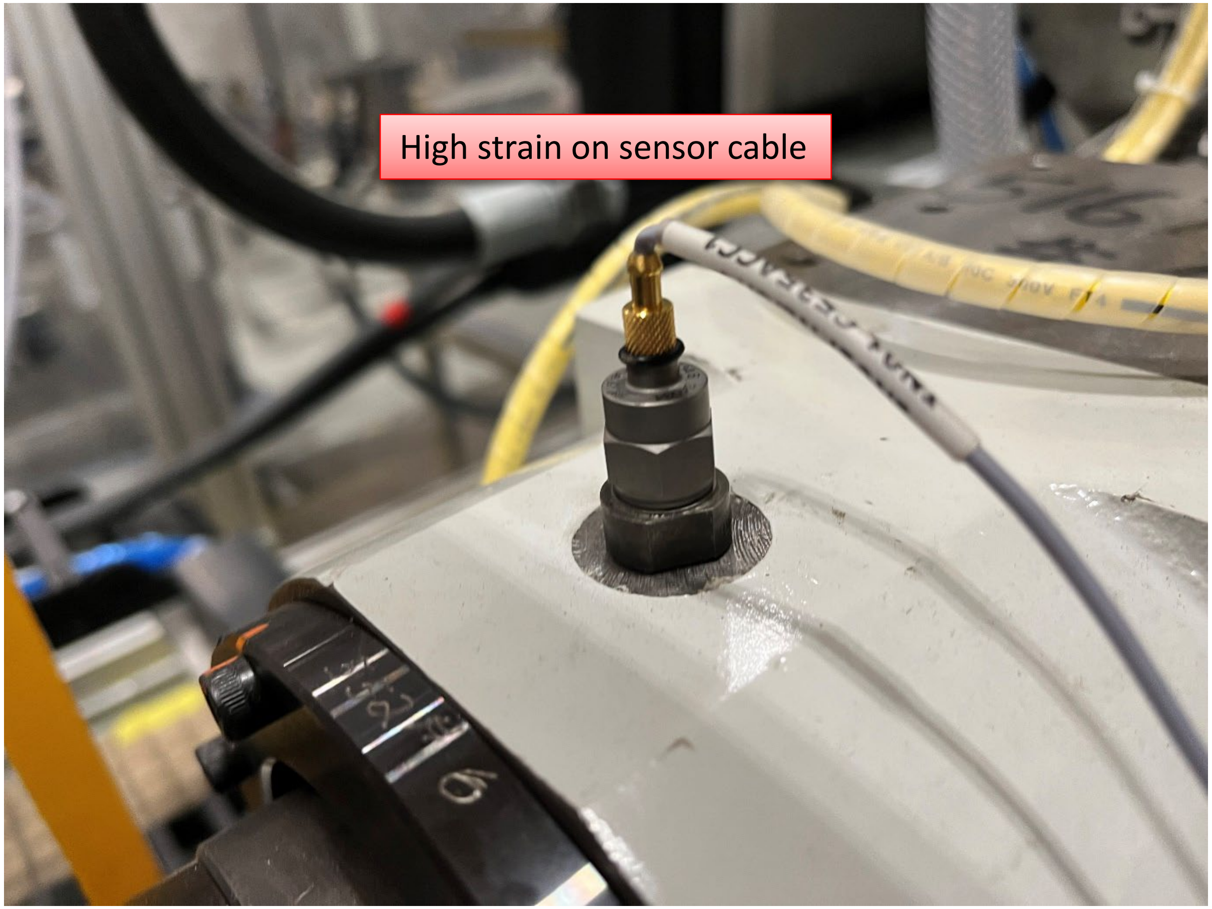


Whoops! Examples





Whoops! Examples

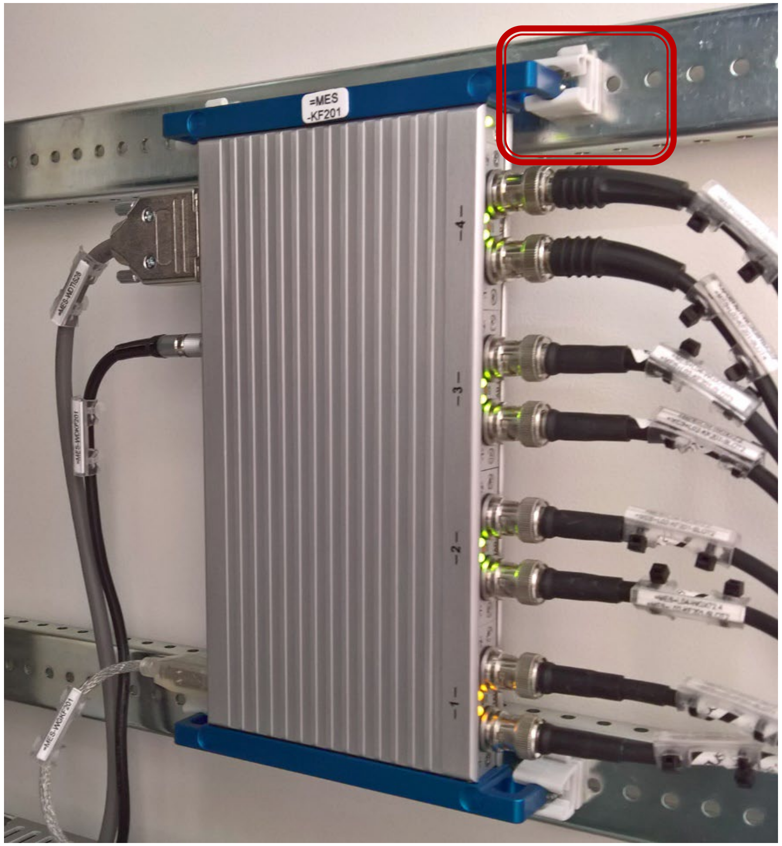


TAS BOX MOUNTING

Tas Box Mounting in Cabinet

The Tas Box **must be mounted electrically isolated** from cabinet metal parts.

If mounted to rails, use the white plastic clamps provided with the Tas Box.



If placed horizontally, the rubber feet of the Tas box will provide isolation.

Tas Box and PC placement

- Access to the back side of the PC is necessary for maintenance. Plan a door and leave enough room to get to the rear of the PC!

- Tas Box should get power from 220V/110V power supply plug. Do not rely on the USB power!

- Keep Tas Box close to PC. USB cable length is limited to 3m.
  (If a separation of Tas Box and PC is unavoidable, use active USB-over-Ethernet extensions. Ask Discom for specifications.)

CALIBRATION AND VERIFICATION

Calibration and Verification of the Test Result

1. Calibration equipment shall be available for the vibration sensor (shaker) and for the torque cell. Vibration sensor calibration is done within the Discom software.
2. A master part shall be available that can be tested to verify that the test results for this master part are constant. A schedule for the test of this master part shall be implemented (once per day, week,..)
3. Optionally, additional vibration sensors can be mounted on the test stand for condition monitoring. These sensors can be cheked by the NVH system for deviations.
4. The NVH system will store original sensor data of the measurement for detailed analysis and to understand speed/torque correctness of the test.
5. For verification of the test stand capabilities the following procedure is recommended: Repeat a part ten times under same conditions. That includes temperature. Either wait for the part to cool off or use the last ten runs of 25 runs. The gear mesh H1 amplitude should have max. 1.5dB standard deviation for the gear mesh in speed ranges where it is 10 dB above background. See separate documentation for details.