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**Practical Guide:
Measures in case of long cables**

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Measures in case of long cables

Topic:

- What is the maximum possible cable length?
- What have to be considered in case of “long” cables?

Situation:

Standard cables in use by motors and sensors often just have a length of 30 cm up to 3 m. Sometimes this is not long enough especially if controllers are installed in a cabinet of a machine which might be placed some meters away or even in another room.

Solution:

Maximum length of encoder or hall sensor cables?
There is no general answer concerning the maximum cable length. A cable length of up to 10 m can be handled without any problems if some special measures are taken into account. Even cable lengths up to 100 m have been successfully in use if anything is installed in a perfect way and the voltage drop of supply and motor lines is kept low based on sufficient wire gauges. The effectiveness of all measures have to be checked during initial commissioning.

Special measures to think about in case of long cable lengths
Quite often the first spontaneous thought might be that the signal’s voltage drop on long wires might be the critical point and root cause of problems. In fact this is quite often not the truth because digital sensor signals (e.g. of hall sensors or encoders) typically just have to fulfill the TTL specification which accepts a logical “High” signal already at a voltage level above 2.1V. The required signal level is specified in the “Hardware Reference” of the maxon controllers in the chapters about the encoder and hall sensor inputs.

Please find different measures to be taken into account on the following pages.

1) **Encoder 's / Sensor's supply voltage**

Encoders typically have a tight tolerance concerning the supply voltage. In case of a 5V +/-5% specification this means that at least 4.75V has to be present at the encoder's supply voltage input to ensure its operation. The voltage drop of the supply by a long cable can be the actual critical factor then. If the supply voltage is not sufficient, the sensor signals will not be present, wrong, or sometimes missing. The root cause of wrong position information might not be the signal quality but is a too low supply voltage which blocks the encoders sporadically to generate the consecutive pulse stream during a movement.

One of the main important points and precondition for a reliable operation of digital sensors (e.g. encoders) is an adequate supply voltage level directly at the connector of the sensor (and not just at the controller). The actually present supply voltage should be checked by a mulitmeter or oscilloscope at the sensor during operation.

The voltage drop and the influence of high or changing supply loads can be improved by using thicker wire gauges inside the cable. Actually such thicker wires are just required for the supply voltage and GND wire. The voltage drop of the digital sensor signal wires is not so critical (like already mentioned above).

The drawback of generally thicker wires is that these make cables less flexible, heavier, and more expensive. Cables with mixed wire gauges are very special designs and even more expensive. There is a simple solution to overcome these drawbacks:

- **Use more than one wire for the supply and GND**
  - Use a cable extension with more wires than actually required, e.g. a cable with 10 or 12 wires instead of just 8 wires typically required by an encoder.
  - Use 2 – 3 wires each for the supply and GND.

  Such cables with a higher number of wires are still standard, most cost-efficient, have a better bending property and are more flexible than cables with thicker wire gauges.

2) **Encoder's signal type**

There is the general recommendation (independent of the cable length) to use encoders with differential signal lines (A, A\, B, B\) only. This improves noise immunity and reduces the effects of noise interference in between motor power lines and sensor signal lines which can result in bad control results, error messages, and wrong positioning. The mandatory requirement in case of long cables is …

- **Use only encoders with differential signal lines (A, A\, B, B\)!**

Hall sensors quite often do not offer differential signal lines but are not so critical concerning the effect of a single wrong pulse. Anyway the risk of signal noise and negative effects in case of failing hall sensor signals also have to be judged and depending on that other mentioned measures might have to be taken into account too. If there is a risk of a malfunction or an error state by the controller due to disturbed hall sensor signals, think about using shielded cables for the hall sensors or install a line driver close to the motor and a line receiver close to the controller for the hall sensor signal lines.

3) **Bus interfaces**
If there is a need for extended bus communication lines (> 3m) in between the controller and the master system (e.g. PLC or PC), you should clearly avoid using USB. USB is the most critical interface running into failing or interrupted communication in case of EMI. USB is not designed for extended cable lengths especially not in a harsh industrial environment. RS232 is less critical than USB but the clear recommendation is to use one of the industrial network bus interfaces:

- **Use CAN or EtherCAT interface for communication**
  in case of long interface cables or an harsh industrial environment (e.g. inside a machine)
  - ➢ Take care of a proper bus topology and bus termination in case of CAN and adapt the maximum CAN bit rate in use according to the total bus length.
- **Use just CAN or EtherCAT network cables which are approved for industrial usage.**

4) **Reduce EMI influence**
The risk of an EMI disturbance caused by inductive loads is strongly increased in case of long signal lines. Quite often it is even not fully obvious where all the cables are actually placed inside cable channels and machines. The usage of shielded power cables for all inductive loads like motors, relays, mains contactors, pumps, fans, but also starters of neon tubes (just to mention some) is mandatory then.

- **Do not mix signal and motor power lines inside one cable!**
  Use one common cable for the hall sensors and one separate cable for the motor windings.
- **Try to avoid long flat cables!**
  Flat cables are more critical concerning EMI and offer less chance for any shielding.
- **Use shielded cables for power and motor lines!**
  Particularly shield the power and motor cables because these are often the root cause of EMI.
- **Attach the shielding to Earth using earthing clamps at both ends of the long cable!**
  Just a shield having an extensive Earth contact can discharge EMI.

- **Try to separate motor cables and signal or sensor cables!**
  Do not put power and sensor cables on top of each other (if possible).

If you take care of all these measures and finally check and verify signal quality during initial commissioning, the drawbacks and risks of long cables can be managed.