SICK AG WHITEPAPER

CABLE AND CONNECTOR FOR HIPERFACE DSL® MOTOR DRIVE APPLICATIONS

INFORMATION FOR CABLE MANUFACTURERS NOTE-2_03

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Information for cable manufacturers

The HIPERFACE DSL® technology as a digital protocol offers a single cable connection between motor and drive controller. By reason of the protocol robustness it is possible to route the motor feedback wires within the motor energy cable. This simplifies the motor connection and saves costs.

The great advantage of a single cable connection creates some requirements for the communication at the same time when routing the communication wires within the same environment where also the power supply wires for the motor are located. In this case impacts from the power cables can create a signal disturbing crosstalk.

Within this application note SICK Stegmann GmbH provides information and general recommendations for cable and connector design to achieve a stable and reliable HIPERFACE DSL® connection. It is related to the signal lines only. The information provided in here are subject to change based on ongoing tests and continuous improvements. The cable manufacturer is responsible for the overall motor cable design including the motor power supply and the requirements for different utilizations.

Communication

HIPERFACE DSL® is a common digital interface based on RS485 transceivers with a transmission rate of 9,375 MBaud, based on a transmission frequency of about 10 MHz. Pre-emphasizing on the signal edge can reach frequencies well beyond 100 MHz (up to 500 MHz). Cycle times for position reading down to 12,1 µs become possibly.

The data transmission is realized with differential signal from an inverted and non-inverted voltage level. For the communication interface high-speed RS485 transceivers are used with switching times of 106 ns.

Crosstalk & shielding

Crosstalk means a noise signal coupling during exposure to EM interferences, finally caused by a changing electrical (to higher frequencies) and magnetic (to lower frequencies) field.
Inductive crosstalk means, the cable operates like an AC- or pulse transformer from the energy wires to the DSL wires. Capacitive crosstalk is related to the distance between the wires as well as the dielectric properties of the material in-between. (see also Fig. 1)

The propagation of the noise signal happens in both directions – forward & backward. The forward crosstalk of capacitive and inductive coupling has an opposite sign and is compensating up to a certain extent. [1], [2]
This compensating effect can also be obtained at twisted pair wires. Based on the twist the wires have different positions within the field, which causes different signs of the coupled noise signal. This also leads to a certain compensation of the different noise contents. [2]

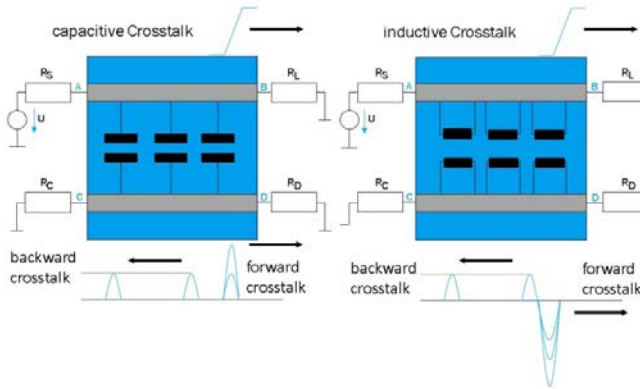

Fig. 1 – Cable model for capacitive and inductive crosstalk and signal propagation (forward and backward) [1]

The coupling factor can be decreased by an increased wire distance and a decreasing dielectric thickness in-between. With this the line capacity to the shielding is increased what reduces the coupling into the neighborhood wire. [1]
Finally proper wire insulation and shielding are the most important measures against crosstalk and communication signal disturbance.

General electrical requirements

With the numbers provided within this chapter information shall be given for basic requirements based on the current test and field experiences. The overall design target is a stable communication between encoder and drive controller via the signal lines. The residual signal margin as difference of transmission margin and line attenuation needs to be high enough for a reliable signal processing ($\Delta V_{DSL} \leq \pm 0{,}2$ V). For suitable differential signal transmission both the communication lines shall be within equal environmental conditions.
In reference to the previous chapter the overall goal of the cable design is the most possible reduction of crosstalk impacts from the motor power lines to the signal cable to reduce or avoid disturbances of the signal transmission. Based on the rated motor power and utilization (fix or moving) the required measures can be different.
Not all individual and special application requirements can be foreseen. In this case additional tests and verifications of the numbers are recommended.

Number of wires:	2 (for encoder supply & communication)
Recomm. wire diameter:	0,34 mm² (e.g. AWG22); flex wires, copper
	typically 19 x 0,15 mm
Style:	shielded twisted pair
Shielding:	coverage >85 %
	Type of shielding (braided and foil) based on the cable rated utilization
Max poss. cable length:	up to 100 m (for HIPERFACE-DSL®)

The above listed wire cross section of 0,34 mm² is related to a max. possible communication distance of 100 m. As long as the other requirements for the communication are met it can be reduced for shorter distances (<25 m). Tests are recommended prior to final decision.

Based on today's knowledge recommendations for electrical performance are as followed:

DC-line resistance:	< 100 Ω/km (for each wire)
Line impedance:	110 ±10 Ω
Propagation delay:	≤ 4,8 ns/m
Velocity rate:	> 0,66 c
Line attenuation:	< 5 dB/100 m @ 10 MHz
Test voltage:	e.g. 600 V or 1000 V

The numbers shown below are some references based on initial tests and field application experiences with running DSL-utilizations. These values are neither fix design goal nor valid for all kinds of application. The purpose is to provide some basic information of currently running systems.

Capacitance:	<100 nF/km @ 1000 Hz (wire to shielding)
	<50 nF/km @ 1000 Hz (wire to wire)
Dielectric coefficient:	<2,3
Crosstalk attenuation:	<-50 dB (up to 100 MHz; power line to data line))
DC-shield resistance:	<65 m Ω/m (shielding motor cable)
DC-shield resistance:	<150 m Ω/m (shielding DSL cable)

There is a wide range of different motor utilization conditions, which will require tailored cable designs to meet the requirements for the data communication as well as for the particular environmental conditions, defined also in various standards and guidelines. Throughout all different applications the most important target is a stable and reliable wire positions to each other within the cable, the quality of the shielding and the insulation material. Further information and recommendations for installations are provided within [4].

Recommendations for cable and connector design

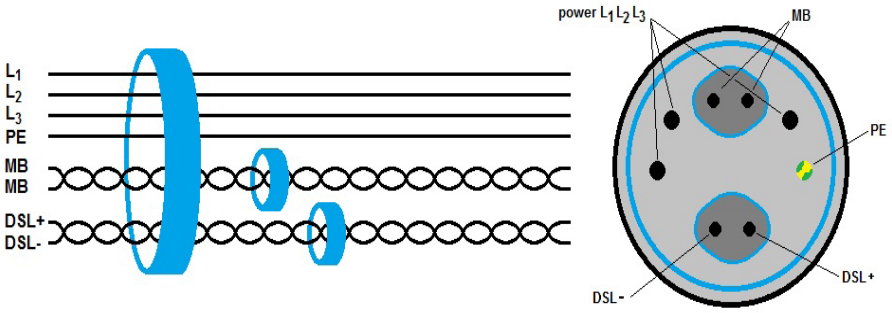

Fig. 2 – general configuration of a motor cable and principle location of the pins within a connector; a separate DSL-shield–connection is required for coupling connectors within the line

Fig. 2 shows the general structure of a 3 phase motor supply cable with integrated DSL-lines and their separate shielding and Fig. 3 an example of a real hybrid cable. The proper and undamaged outer and DSL-shielding of the cable as well as its good contact at the connector is very important to avoid or reduce impacts of the power lines to the DSL-lines.
Within the cable the location of the motor power wires shall be as far as possible away from the DSL-wires. Furthermore they shall be in a symmetric position to them. (see also Fig. 2/right & Fig. 3)
For stable and equal conditions along the whole length the DSL-line shall be done as shielded twisted pair wires. Depending on the rated application the shielding needs to withstand frequent cable bending or twisting within cable tracks at moving systems (robots or x-y-handling systems). Cable design and manufacturing shall be done in such a way, that the internal conditions (wire positions to each other or to the shielding or the coverage of the shielding) do not change over the time of utilization.

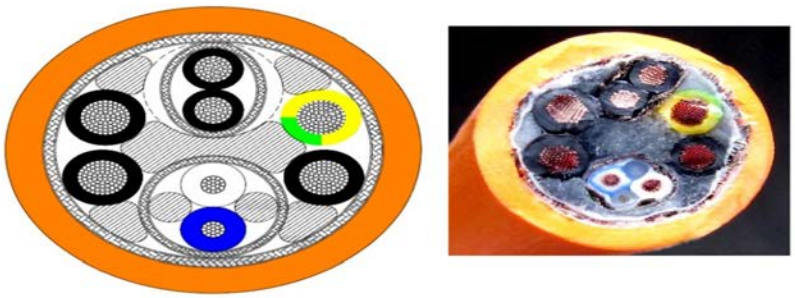

Fig. 3 – example of a real type hybrid cable with integrated motor brake and data wire (below, white/blue); left: specification drawing, right: real cable cut-off; source: Tecnikabel/Italy

A symmetric arrangement shall be continued within the connector as well. A good electrical contact of the signal line shielding through the connector is very important. Multiple contacts for its connection can support this. The outer motor cable shielding and the signal wire shielding need to be separate from each other throughout the line between motor and drive controller.
Based on tests and current experiences for the connector design the following general design recommendations can be made:

- Physical largest possible distance between DSL-line and power-line cable pins
- Symmetric arrangement of the different wires as well as the pins within the connector.
- Separate and electrical isolated contacts for the signal line shield and the outer motor cable shield for coupling connector within the line
- Pigtail style shielding connections need to be avoided within the connector
- Support a good low-ohmic contact of the shielding at the connectors
- Keep free wires as short as possible (<50 mm) and twisted as long as possible within the connectors

Disclaimer

Information presented in here are for typical known applications. The max possible cable length (communication related) of a particular installation depends on signal propagation delay, line attenuation and the level of disturbances at a location as well as the general utilization (fix or moving).
Not all specific conditions of each individual application or installation site can be tested and investigated upfront within our laboratory, e.g. different cable lengths and routings or different ground levels at the motor and drive controller locations. By reason of the interaction of cable properties, installation conditions and controller interface performance additional tests are recommended for special applications.
In a case of concerns or problems please contact SICK Stegmann GmbH with a detailed description of the situation for further support.

REFERENCES

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[4] – Cabels and connectors for HIPERFACE DSL® motor drive applications
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