HARTING *TOP INFO*

EMC

Electromagnetic
Compatibility
of Industrial Interfaces

- This technical documentation focuses on the problem of electro-magnetic compatibility of interfaces in industrial connector technology.

- This brochure is provided for the user of connectors. Not only users who face an EMC issue for the first time, but also users who have precise demands on the connectors they use.

- In the first chapter some basics are examined which are the basic preconditions for a better understanding of the different EMC phenomena in order to find solutions for the problems that occur in practice. On the following pages you will see several diagrams that point out the technical features of HARTING Han – hoods and housings, different types of cables as well as pre-assembled cables.

- There are increasingly more problems arising due to the realization of interfaces in the industrial arena which are susceptible to Electro magnetic interference. One must also take into consideration the radiated interferences in the high frequency spectrum which are often difficult to interpret.

- **The aim is to develop an EMC strategy, that allows the user to choose, the relevant HARTING hoods \ housings according to his requirements that ensure a homogeneous and high quality shielding in combination with the cables.**

In order to reach this aim, HARTING will always be at your disposal as a competent and future practice oriented partner.

EMC
and HARTING connectors

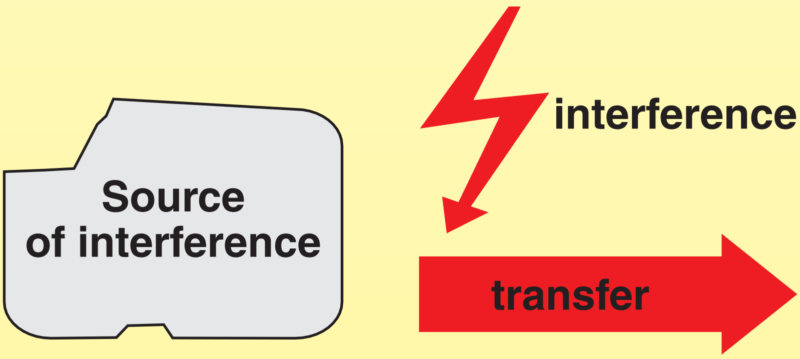
- Electromechanical components are not included in the EU legislation concerning EMC, although almost all HARTING customers need CE-EMC certification for their machines, installations and control devices.
- The connector itself is a mechanical product, which is used in electrical and electronic applications.

The significance of EMC

The electromagnetic compatibility (EMC) is defined as the

> **“Ability of an electrical unit to function satisfactorily in its electromagnetic environment without influencing this environment - to which other units may belong – in an undue way”.** (DIN VDE 0870)

Thus an electrical installation is compatible, when it has tolerable emissions (being a source of interference) and (being a receptor) shows a tolerable immunity against interference which means it has a sufficient shielding capacity.



The interior of the connector or rather the conductor which passes through the connector inserts represents the interference sink. The interference threshold* depends on the hood and housing, cable gland as well as on the cable installation.

It is a criteria for the interference immunity
and the shielding effectiveness respectively

* The interference threshold is the threshold value that has to be exceeded to cause an interference.

Critical points in applications

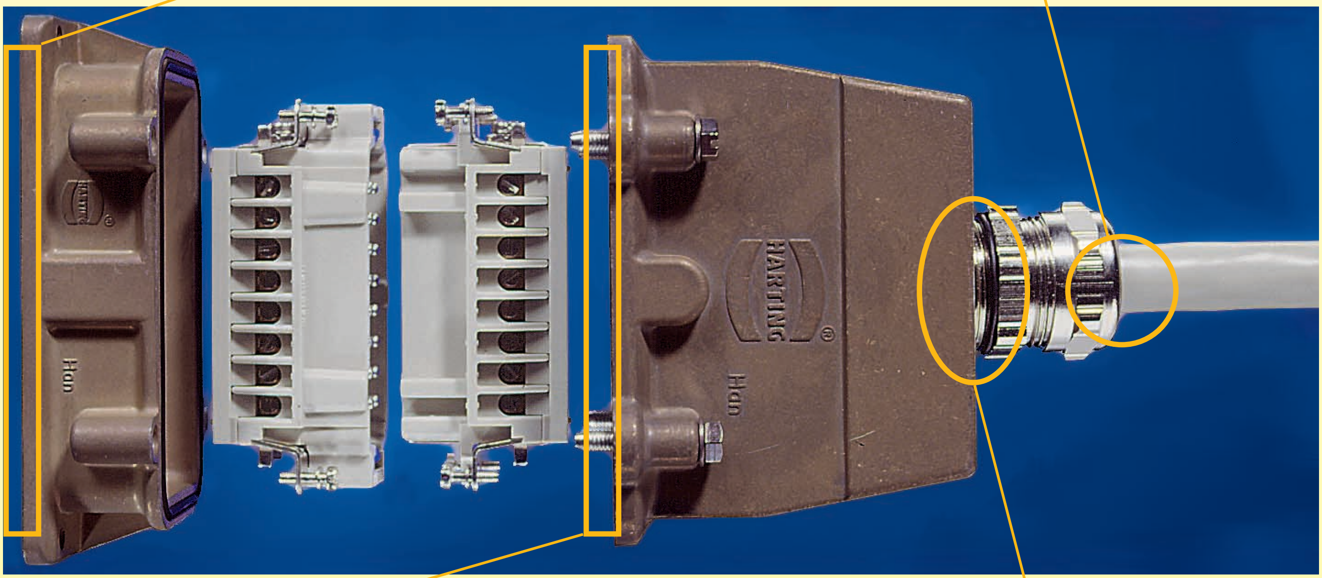
In screened components a continuous and homogeneous shielding is basically desirable.

However, with regard to the weak points of pre-assembled cables, which are determined by the system itself, this cannot always be realized.

The critical points for screening in an industrial connector are detailed below:

Contact point: bulkhead mounted housing and switch cabinet panel

Contact point: Iris spring and cable screen



Gap between housing and hood

Contact point: cable gland and hood

At interfaces where the homogeneous shielding is interrupted, interferences may occur in the system.

- The degree of interference immunity or the potential shielding effectiveness of a (pre-assembled) connector has to be so high, that the electromagnetic fields surrounding it cannot interfere with the transmitted signals inside the connector.
- The active interference potential of a connector has to be so small, that there is no interference with other installations or components in its environment.

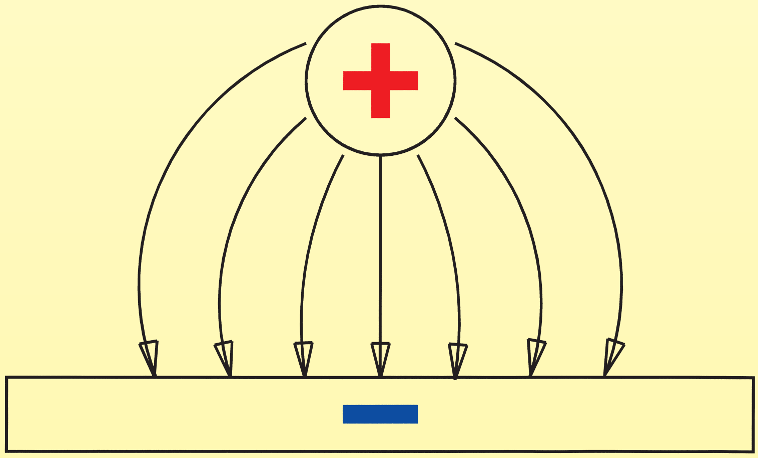
Definition: electromagnetic interference

An electromagnetic interference includes all electromagnetic phenomena, that have an impact on the performance of a component, a device or an installation.

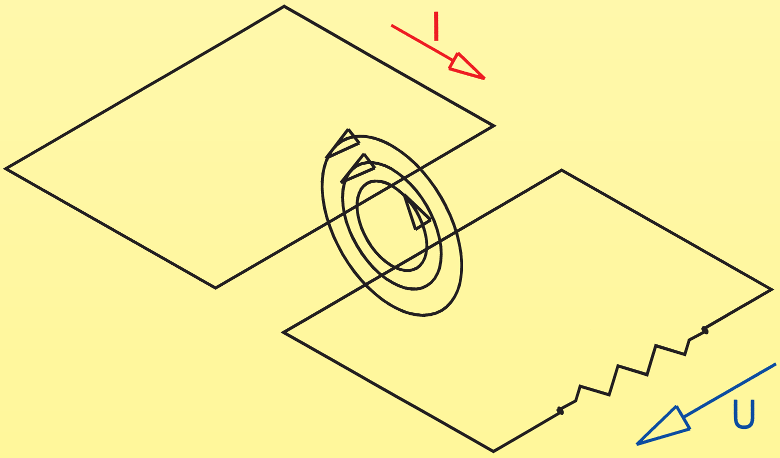
An electromagnetic interference includes electromagnetic impulses, drop-ins, or a spontaneous increase of the propagation mode. They are all electrical signals that overlay and interfere with the usable signal.

Electromagnetic interference consists of the electrical field component E as well as the magnetic field component H.

➩ The electrical field is generated by a potential difference.



➩ The magnetic field is generated by a current in an electrical conductor.



Sources of electromagnetic interferences

The whole spectrum of frequencies ranging from low frequency (Hz) up to high frequency (GHz) is potentially a source of electromagnetic interferences.

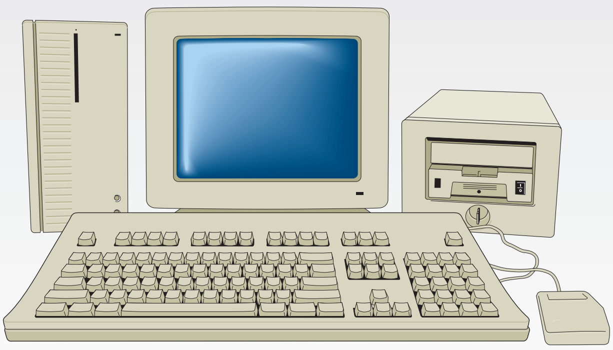
Functional and non-functional sources (intentional and non-intentional transmission of interferences) can be defined as shown below.

Functional Sources

- Communication transmitter
- Generators for industrial or medical applications
- Mobile Phones
- Radar source
- Manufacturing processes
- Microwave ovens etc.

Non-functional Sources

- Automobile ignition
- Fluorescent lamps
- Welding equipment
- **Contacts in connectors**
- Relays and contactor coils
- Electrostatic discharges (ESD)
- Static converters
- Switching actions in high voltage networks
- Devices with clock frequency generators (PC, SPS, etc.)
- Abrupt changes in voltage and current



Classification of sources of electromagnetic interferences

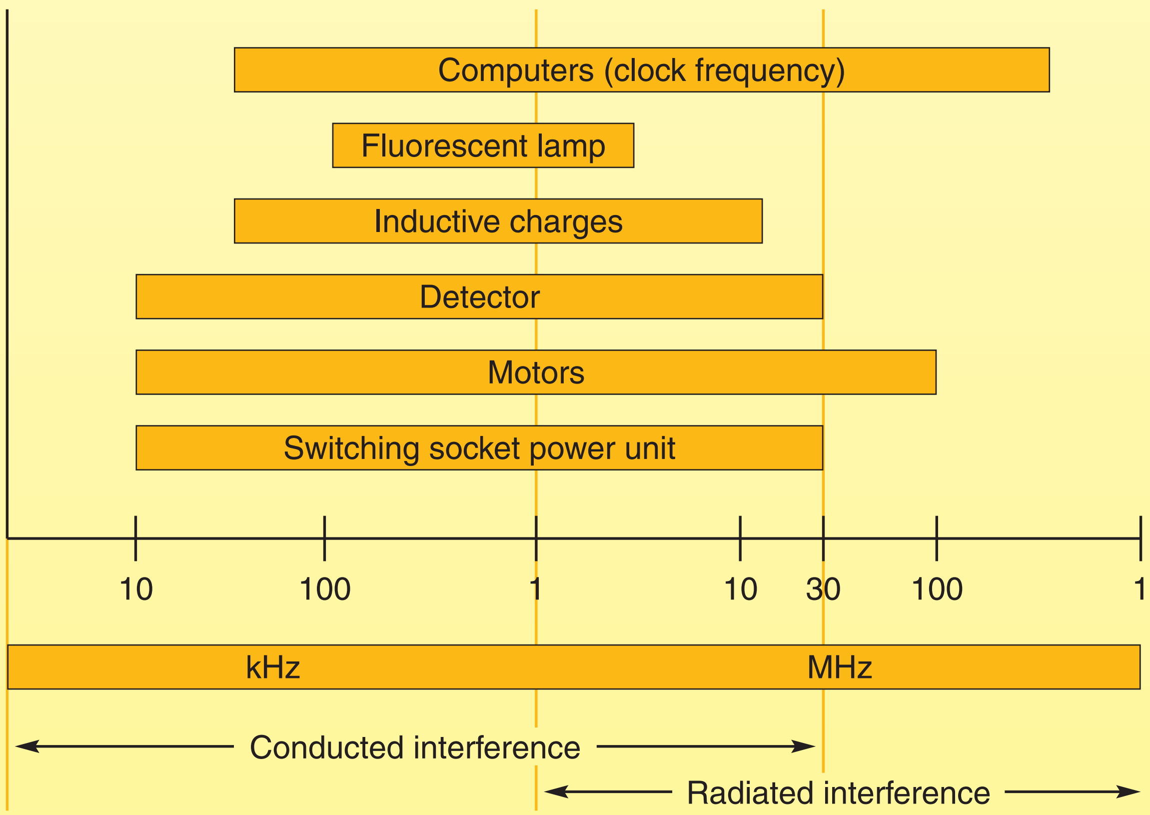
Sources of electromagnetic energy are classified generally according to their order in frequency range (i. e. their emitted spectrum).

Interferences in the low-frequency spectrum occur mainly in the conducted state (via cables, etc.)

- Frequency range: 0 … 30 MHz
- Energy: high energy capacity possible
- Consequences: functional disturbances up to the destruction of equipment

Interferences in the high-frequency spectrum occur mainly in the radiated state

- Frequency range: 30 MHz up to the GHz-range
- Energy: generally low
- Consequences: functional disturbances of equipment



Paths of signal-propagation

Coupling mechanisms in connectors:

Coupling describes the impact of electromagnetic interferences on (assembled) connectors.

We differentiate between 4 types of coupling:

• Galvanic Coupling

In connectors galvanic coupling occurs mainly in the earth circuit. In pre-assembled cables all earth-wires are connected via common electrical conductors to the earth potential and consequently to the PE. The electrical conductor can be for example the switchcabinet panel. This is the way in which interferences occurring in these conductors may be transmitted to the connector.

• Inductive Coupling

A variable current that flows over the housing, the cable gland as well as over the cable screening generates a magnetic field. This magnetic field is variable and generates an induced interference voltage. One example is a motor with a frequency converter. Here very often high currents are generated travelling along the shield.

• Capacitive Coupling

Between cable conductors as well as the connector housing there exists a permanent certain capacity, as there are two conductive elements with a variable potential difference, an electrical current may be induced via the insulation medium of air, thus a disturbance capacity is generated

• Radiated Coupling

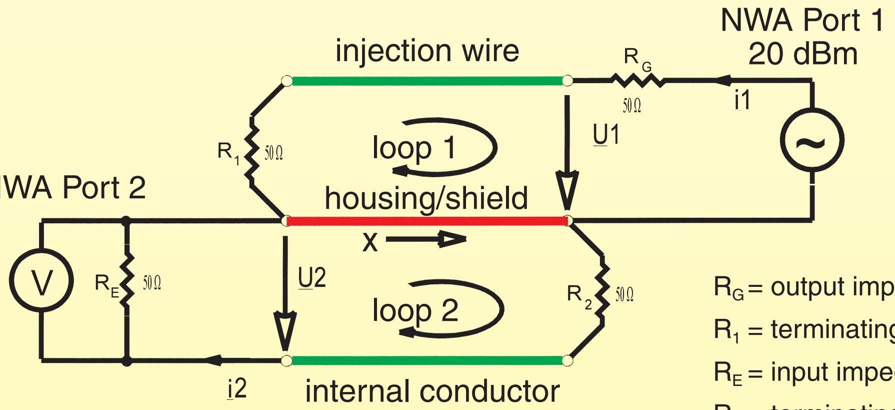
Because of high transmission frequencies and “long” cable runs electromagnetic waves may emanate from the conductor (antenna principle). A suitable receiving medium can “catch” these electromagnetic waves and thus generate an interference voltage or an interference current, that overlays the transmitted signals. However, the energy level is normally quite low.

Determining the coupling parameters

Coupling parameters can be measured by means of the

Line-injection method (parallel wire method) according to VG 95214

This is a standardized measuring method, that determines correct, reproducible and thus comparable results of screened components with respect to the transfer impedance.

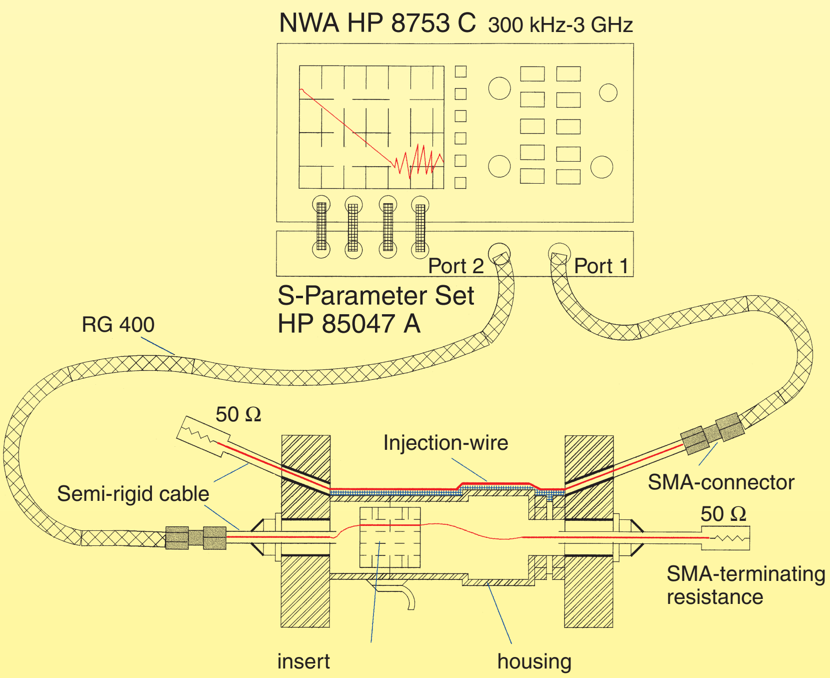


Three-wire-system of the **line-injection** method

R_G = output impedance of the signal generator
R_1 = terminating resistor of the generator circuit
R_E = input impedance of the signal receiver
R_2 = terminating resistor of the receptor circuit

The connector is designed as a three-wire-system, where the internal conductor, the screening and the environment each represent one conductor.

Schematic description of the line-injection test set-up



➩ The efficiency of the screening is defined as the relationship of the induced disturbance voltage to the interference current

Definitions:

The shielding efficiency of a housing can be represented by the values of shielding effectiveness a_S and the transfer impedance R_K.

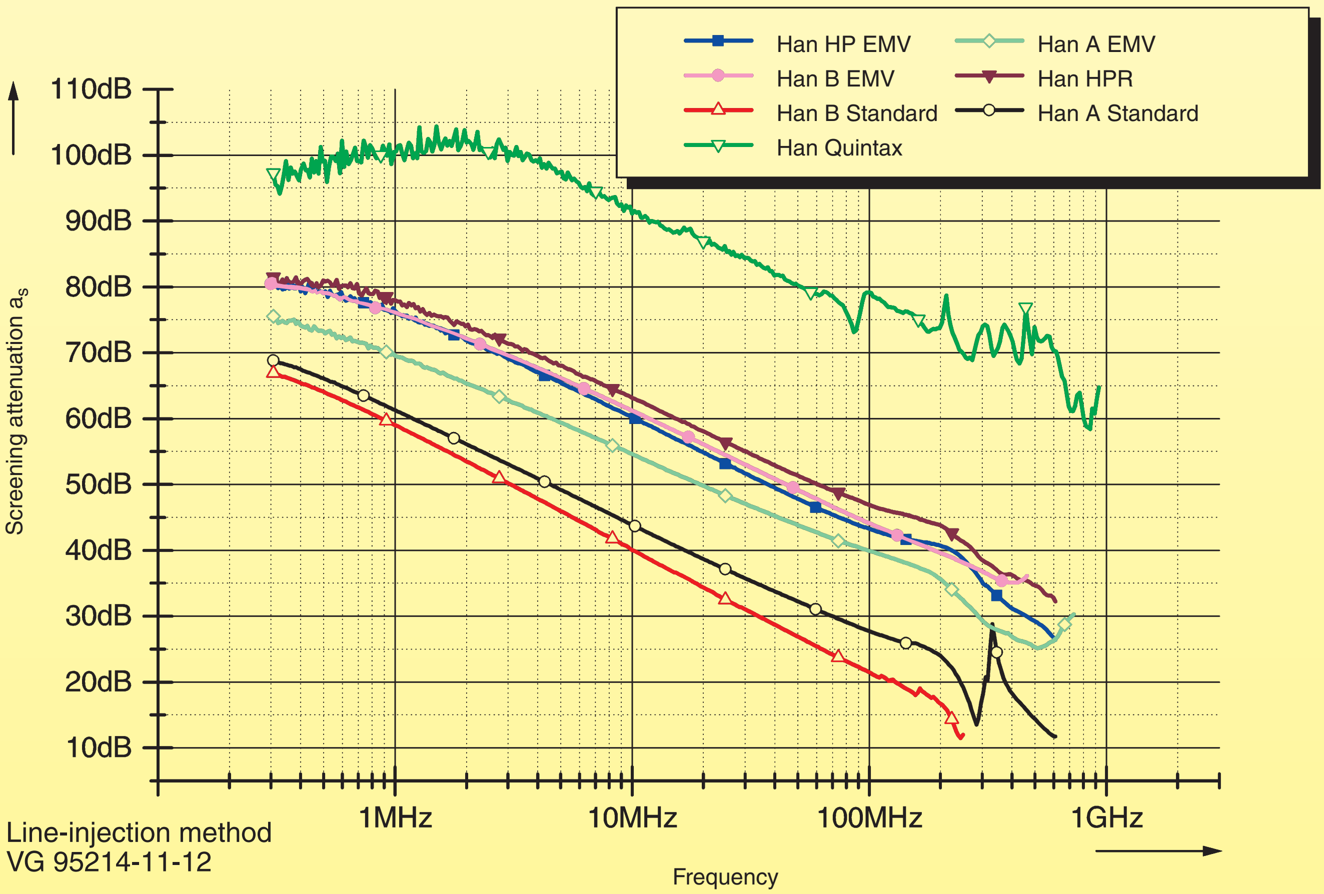
Shielding effectiveness

The Shielding effectiveness of a component is defined as the ratio of a power radiated within the component to the maximum resulting interference power outside the component in the environment. Vice versa, this definition also applies to the interference power within the component due to external interference sources. It is specified as a logarithmic ratio and as such referred to as the Shielding effectiveness ratio. (Standard: VG 95214)

Transfer impedance

The transfer impedance is the ratio of the induced interference voltage between outer conductor and housings to the interference current applied to the screen. The transfer impedance is a component screening parameter. (Standard: VG 95214)

Shielding effectiveness of HARTING connectors



Line-injection method
VG 95214-11-12

Han HP EMC 6/10/40/64
Han A EMC 15/25

The EMC hoods and housings range

Han® HPR

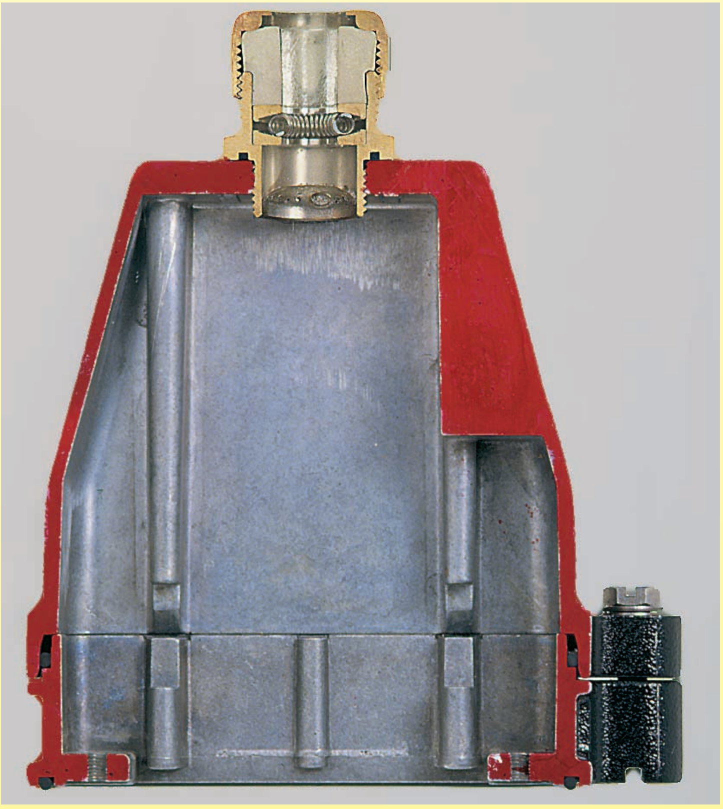
Han® HP

Han® B EMV

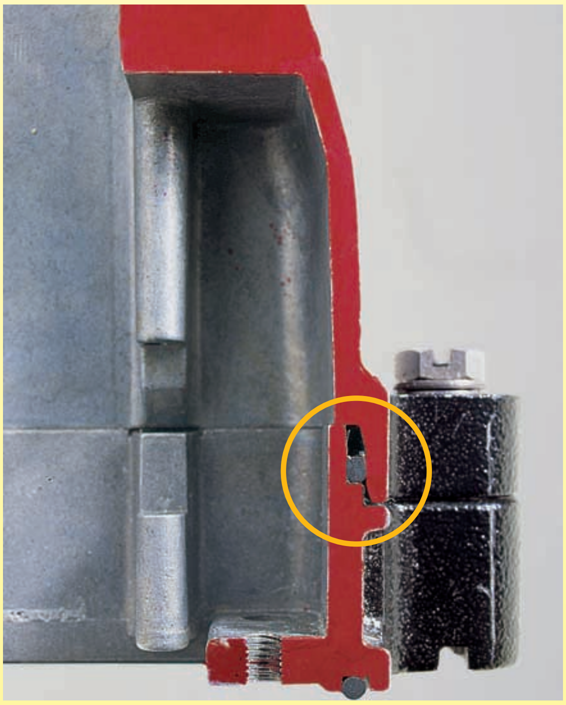
Han® A EMV

have been designed especially for EMC applications.

These EMC hoods and housings have high screening values due to two facts: First, the well-developed labyrinth structure and secondly, the extensive contact between hood and housing (overlapping).



Labyrinth-Structure



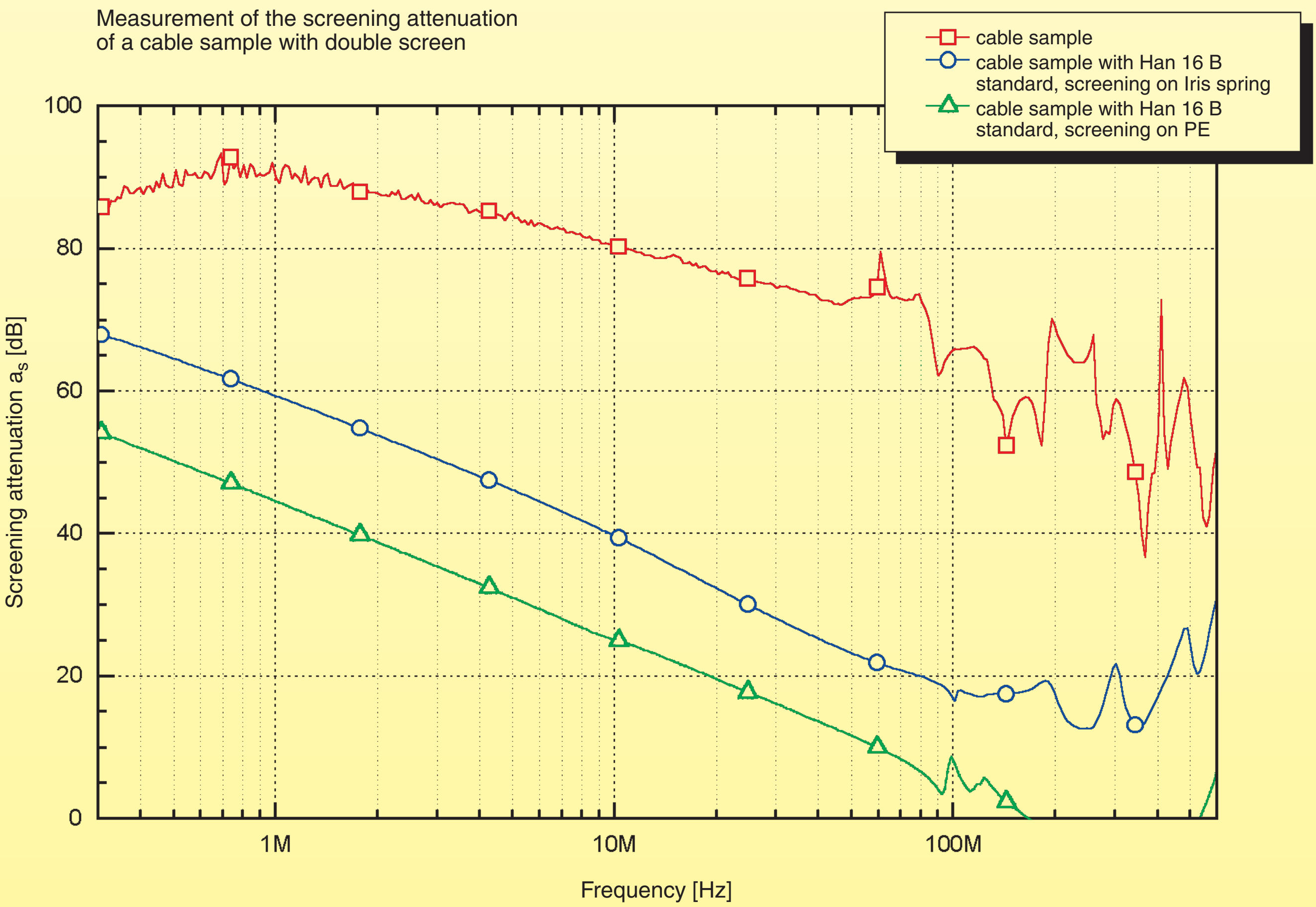
Han® standard hoods and housings ensure a screening attenuation of **40 dB** at a frequency of **10 MHz**!
Han® EMC hoods and housings ensure **60 dB.**

Shielding effectiveness

of HARTING hoods and housings
– cable glands – cable combinations

➩ In practice we assume the use of pre-assembled cables

➩ Important fact: the different ways of connecting the screening must be considered
- EMC cable gland
- Screening connection via PE-contact of the insert



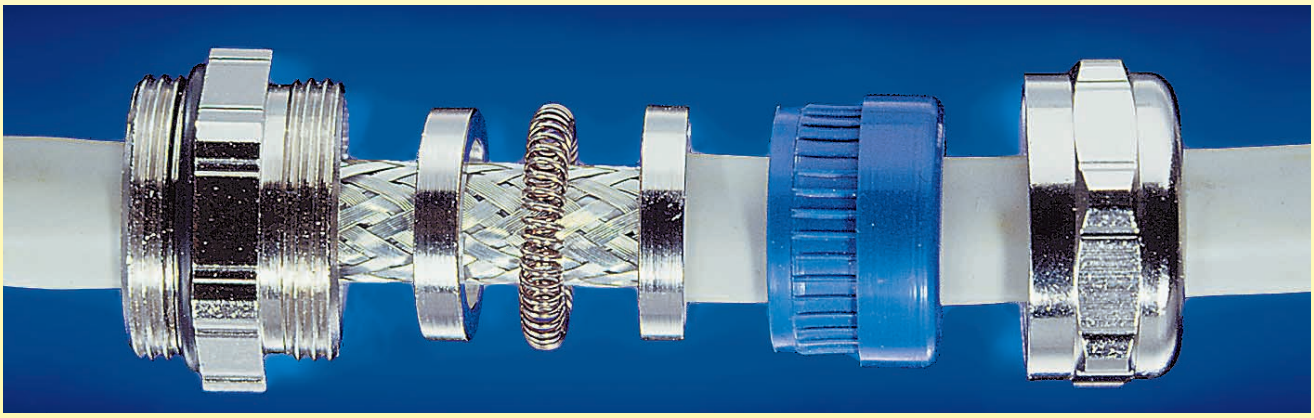
➩ The shielding effectiveness of a pre-assembled cable depends not only on the shield of the connector

EMC cable gland or PE contact?

EMC cable gland:

If the contact between cable screening and connector hood is realized by an EMC cable gland, there is a higher screening attenuation (approximately 6 - 15 dB) compared to connection to a PE contact.

Reason:
- Iris spring allows complete 360°-contact
- Low transfer resistance allows optimal flow or unwanted surface-currents e.g. on cable braids
- Interference currents are not led into the connector



EMC cable gland with complete 360°-contact of the cable screen due to Iris spring

PE Contact:

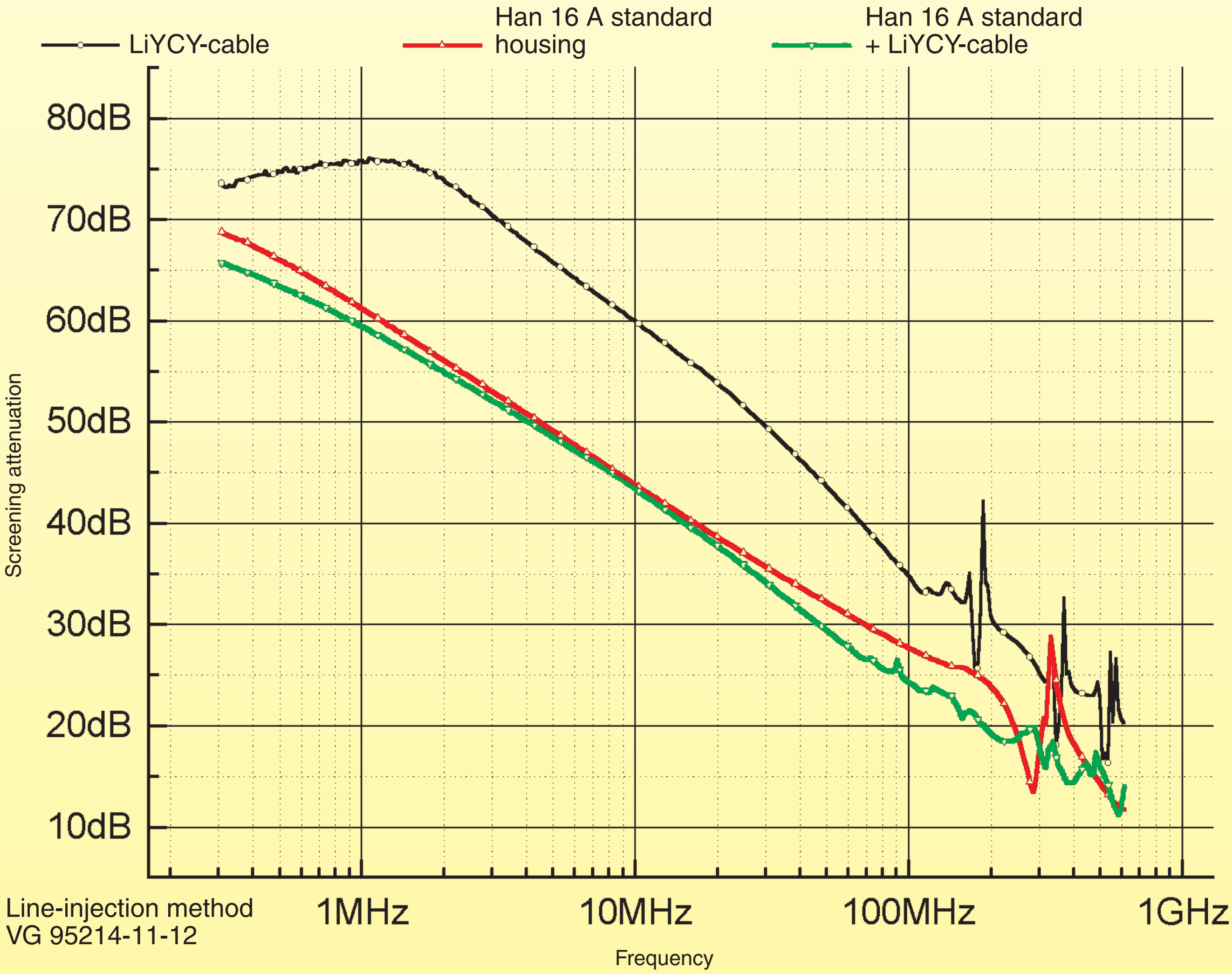
However, the connection of the cable shielding to a PE contact leads to a reduction of the shielding effectiveness.

Reason:
- The shield braiding has to be opened which weakens its effectiveness
- Interference currents which may be present on the shield are led into the connector

⇨ higher impact on the signal integrity

"Optimal System"

There is one main precondition for an "optimal system": All the single components should have the same shielding effectiveness. Thus over engineering is avoided and total system costs are kept to a minimum.



Line-injection method
VG 95214-11-12

➩ In this case the measured results of the pre-assembled cable depend on the shielding effectiveness of the connector

The shielding effectiveness of a pre-assembled cable is only as good as the shielding effectiveness of the “weakest component”.

- Compared to a standard connector some cables have a better shielding effectiveness, however, one has to take into consideration that this is only valid for a cable length of **1 m**.

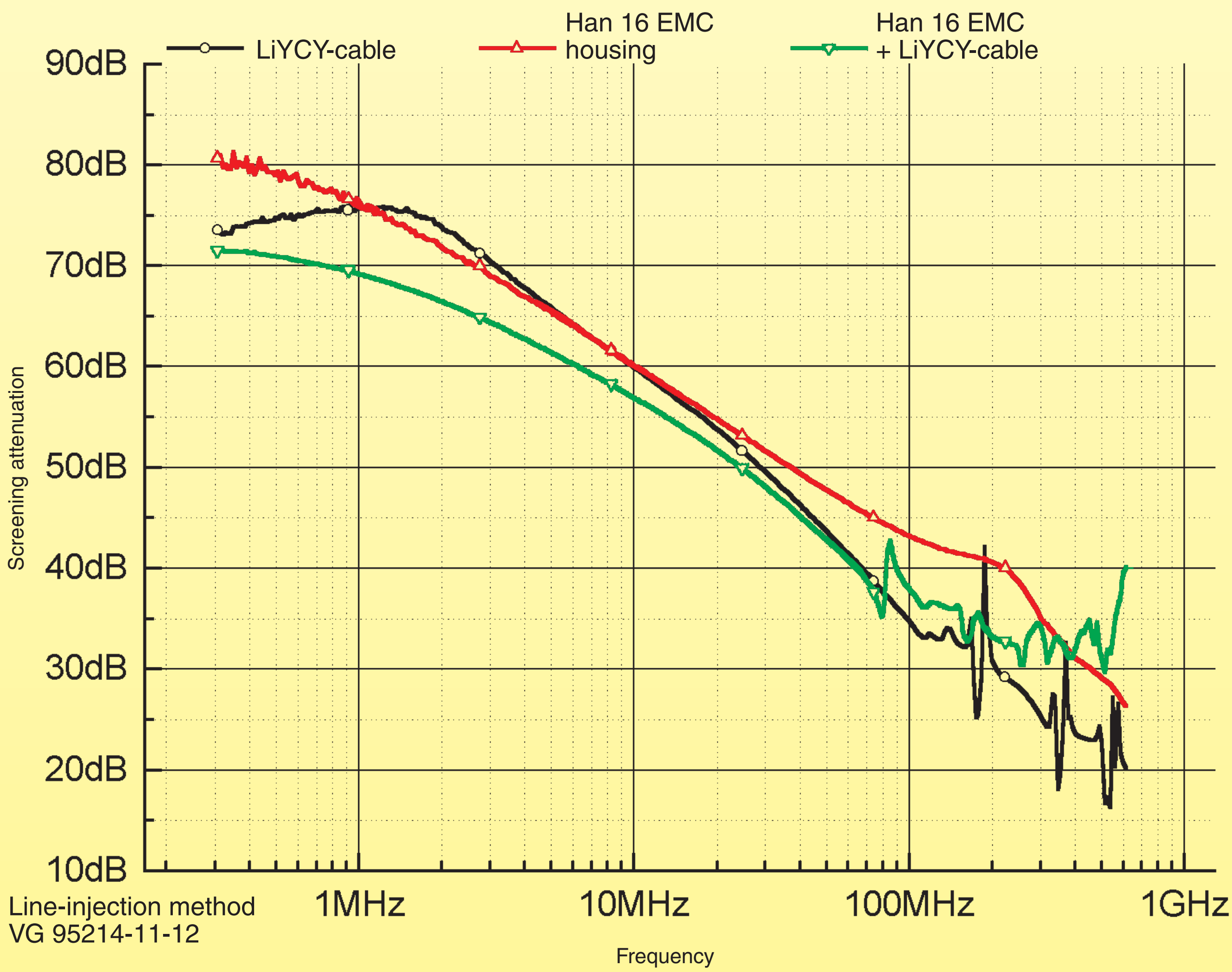
➯ If the length of the cable increases to **10 m**, the shielding effectiveness decreases considerably.

➯ This allows the conclusion that the curve of the cable approaches the connector’s curve. Which means that both components are equivalent concerning their shielding effectiveness.

Thus we have an equivalent system of high quality

Precondition: The connection of the screening between cable shield and housing shield is optimal

Another possibility to reach an equivalent system is to use equivalent components:



Line-injection method
VG 95214-11-12

Alternative measuring method to determine the shielding effectiveness

A source of interference which is very common in practice is the discharge from an electrostatically charged person that touches an electronic component. Such an ESD-impulse (**e**lectro-**s**tatic-**d**ischarge) with a voltage of 8000 V was discharged on **HARTING** connectors in order to test their shielding effectiveness.

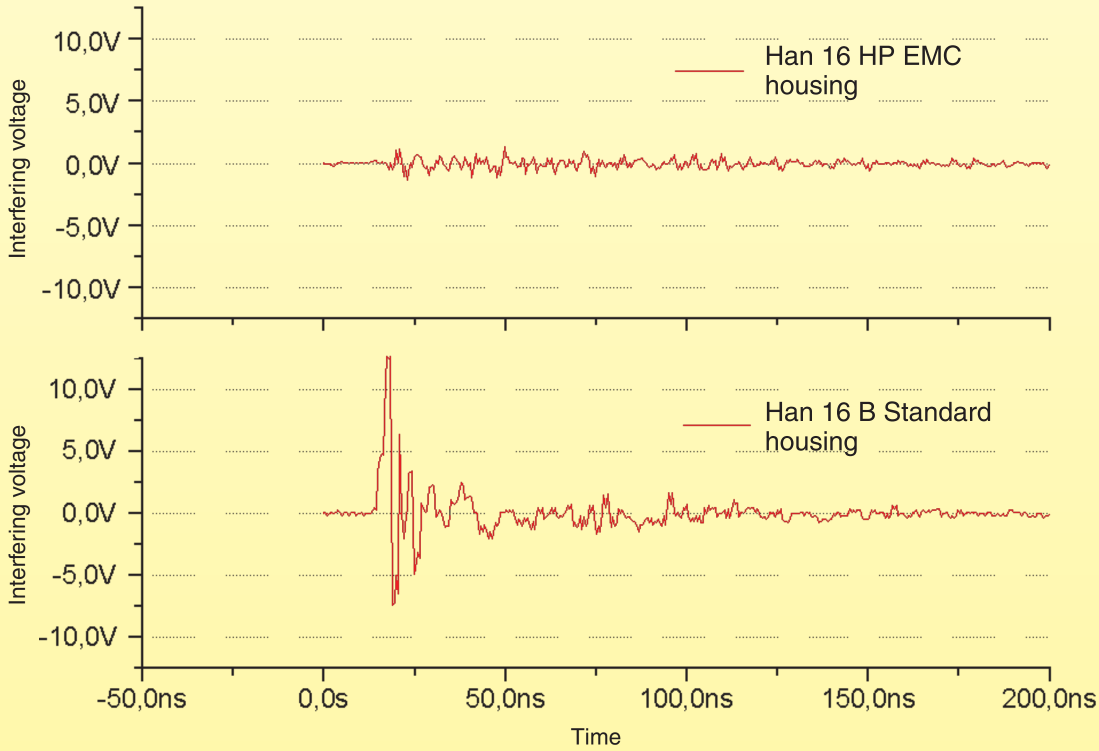
Interference voltage in the connector at the discharge of 8000 V*

1.4 V

Han
HP EMC

12.5 V

Han
B Standard



➩ High shielding effectiveness of EMC connectors reduces the interference voltage over a transmission distance!

The shielding effectiveness values of the Line-injection-method are the same as the results of the ESD-method.

* If the system is incorrectly terminated the measurement results can increase by max. 6 dB.

In practice

Using an EMC connector in combination with a cable with a lower screening quality, does not necessarily mean an improvement of the total shielding effectiveness.

The following facts have an important influence on the shielding effectiveness:

- Cable gland
- Correct installation
- Corrosive effects in the gland and in the screw thread

Consequence:

Reduction of the shielding effectiveness potential of the entire system!

Remember:

The weakest part in the chain determines the shielding effectiveness of the entire system!

The correct use and application of HARTING EMC-connectors can improve the situation considerably.

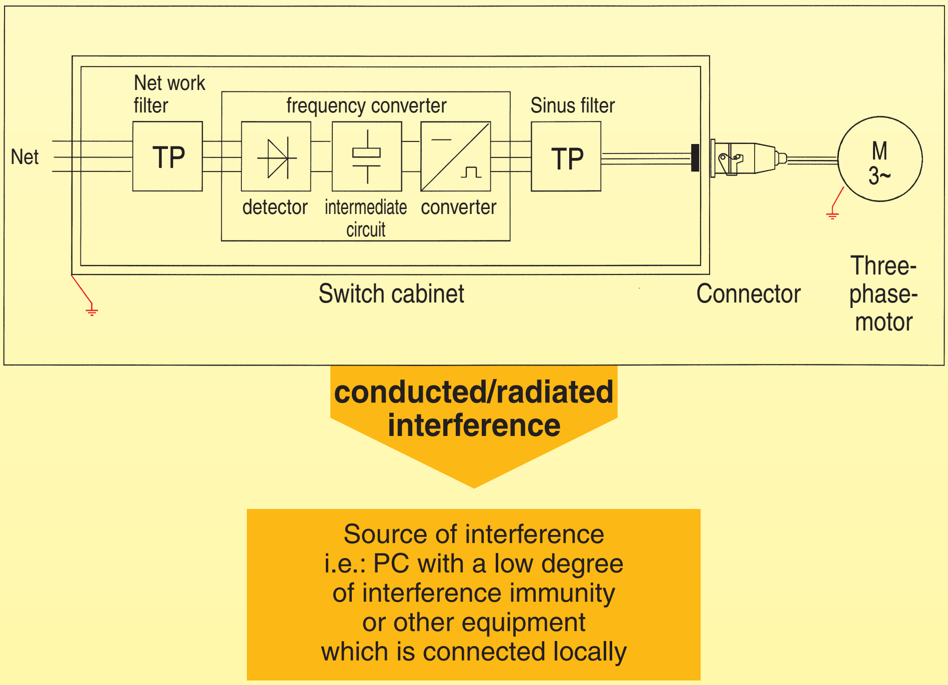
In practice: Frequency Converter Application

What influence does the use of HARTING connectors have on the EMC features of a frequency converter?

- Frequency converters are known to be a source of electromagnetic interference (in conducted as well as in radiated form).

- Manufacturers of frequency converters recommend not to break the wiring by installing a connector. However, it is exactly this feature that the customers require.
  There is a legitimate fear that connectors have a negative influence on the electromagnetic compatibility of frequency converters due to their insufficient shielding effectiveness. This motivated HARTING to conduct a series of tests with the aim of quantifying the electromagnetic compatibility of connectors.

Frequency Converter Application



EMC questions concerning a frequency converter application:

- The working principle of a frequency converter and the resulting sources of interference.
  - ❏ **Problem:** The reproduction of sinusoidal currents in rectangular signal form.
    - ➪ Short rise times of rectangular signals are a cause of high frequency disturbance signals

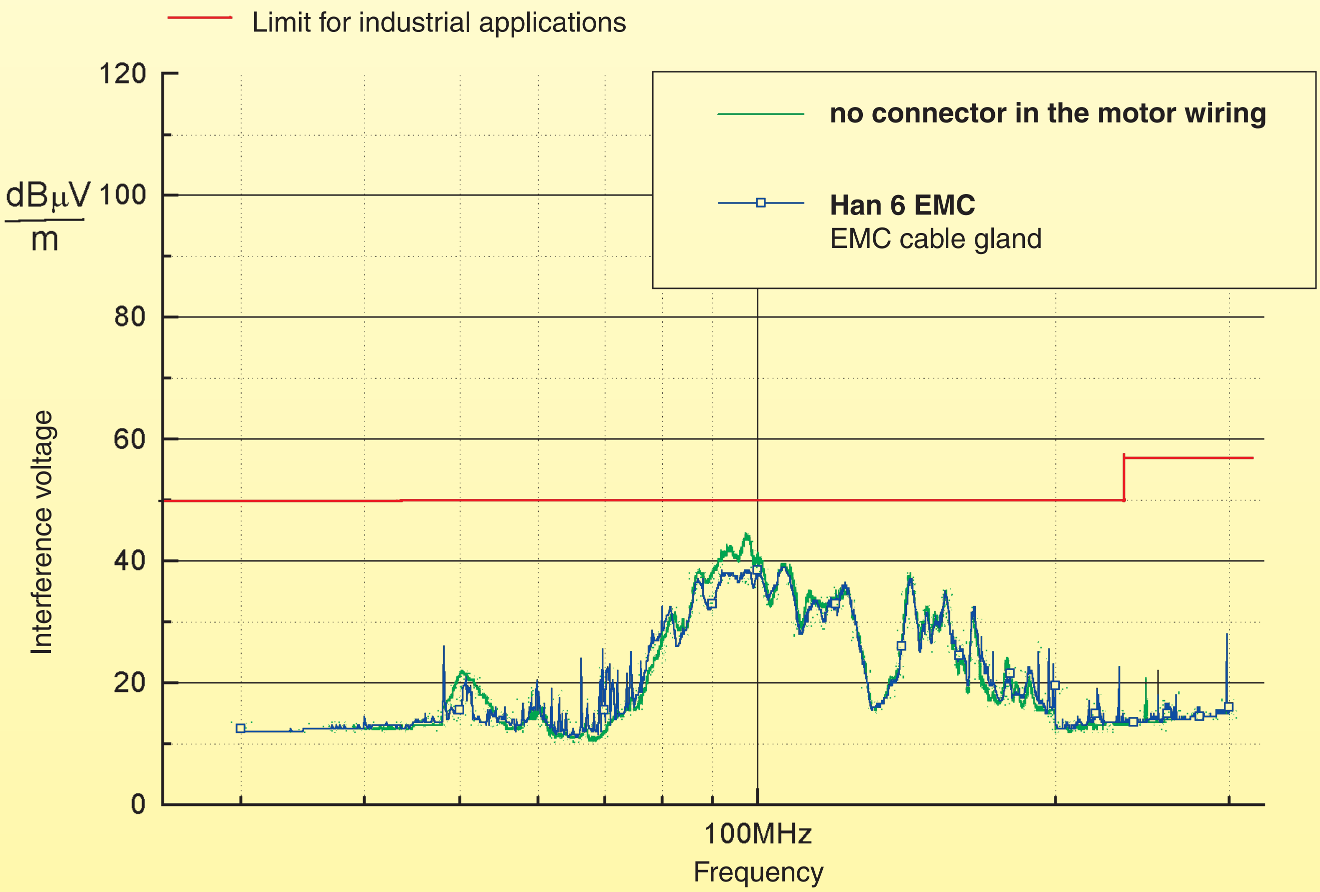
- The influence of industrial connectors on the EMC features of frequency converter applications.

Determination of interference transfer

The radio interference transfer is measured according to the European Standard EN 55022 / EN 55011.

➩ **Examination of the whole system, whether the interference transfer (in conducted or radiated form) is influenced in a negative way by HARTING connectors.**

Interference transfer of a frequency converter application

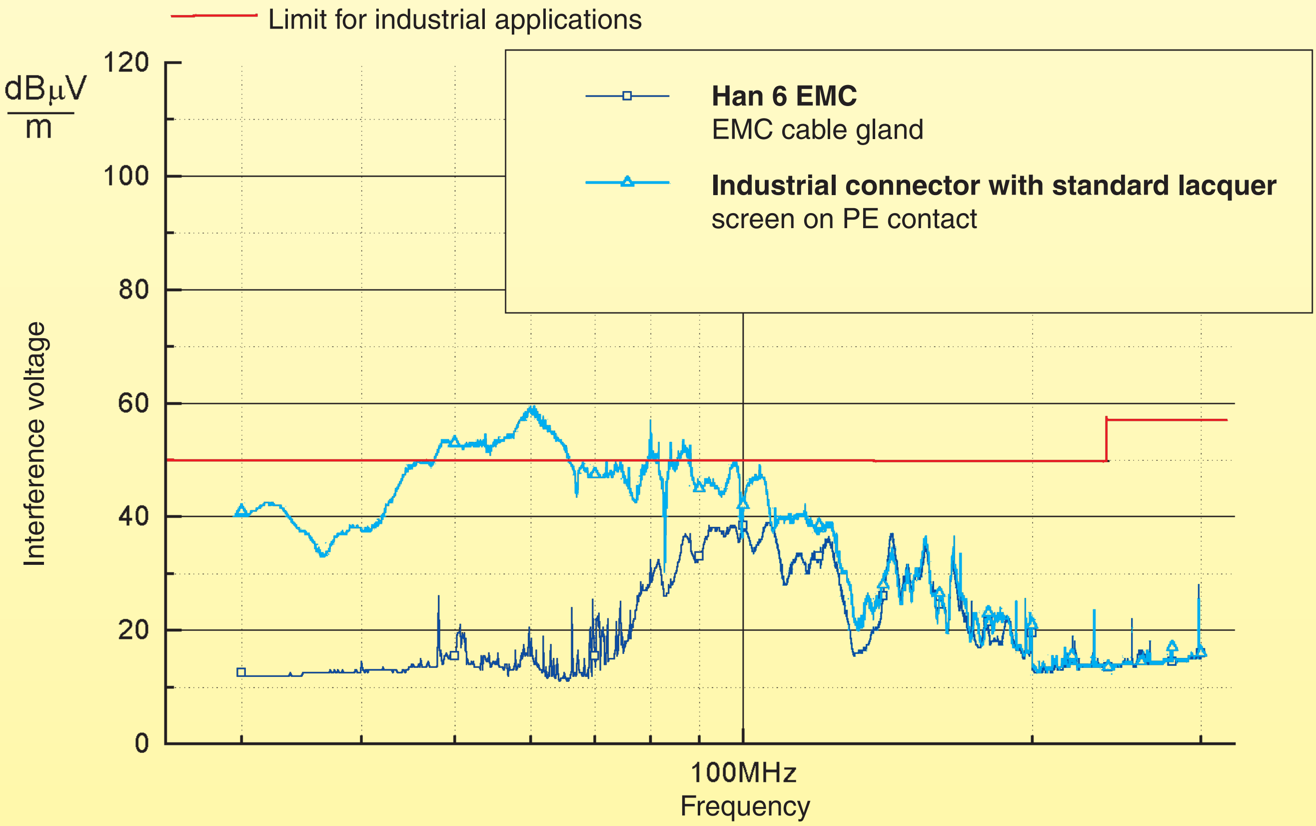


The comparison shows that the radio interference transfer of the whole system is not influenced, if the EMC connector is mounted with respect to electro-magnetic compatibility.

➩ HARTING EMC housings feature a chromated and corrosion resistant surface. Using these housings in combination with an EMC cable gland with Iris spring ensures very good, low contact resistance values. This ensures a low resistance connection of the cable braid of the motor wiring to the reference ground.

“Worst Case Scenario”

- The “Worst Case scenario” when using a connector in a frequency converter application occurs, if a standard connector with a painted insulating surface is installed.
- f the screening current can not flow off the housing unhindered (i.e. because of corrosion, insufficient constructive features) the surface currents are interrupted.
- Avoiding an all-around screening connection in favour of a screening connection via a PE contact of the connector has disadvantages.



Remember:

An insulating mounting surface and metal screws that insulate the reference ground allow a very high impedance connection of the connector to the reference ground.

However, even in this “worst case” the limit for industrial applications is only slightly crossed in the range from 45 MHz to 65 MHz.

External Influences

- In an aggressive industrial environment with gases such as SO_2, H_2S, NO_x or CL_2 corrosion can occur. In the worst case these corrosive layers can lead to an electrical insulation of the connector mounting screws. Hence, the connection of the shielding braid of the motor wire to the earth potential has high contact resistance.

In order to ensure the internal and external electro-magnetic compatibility it is recommended to use HARTING EMC connectors in frequency converter applications because:

- the EMC connectors guarantee an extensive and very conductive connection to ground (PE)
- the connection of the motor wires shielding braid with the reference ground is done with very low impedance
- the corrosive resistant surface avoids negative influences due to corrosive effects
- assembly faults (with respect to EMC) are minimized

HARTING EMC connectors make frequency converters pluggable !

If the installation is done with regard to EMC, the screened motor wire of a frequency converter can be established via a connector without influencing the conducted or radiated interference transfer in a negative way.

Conclusion

Based on the determined shielding effectiveness values we would like to give the following recommendations to our customers:

- The collected results show clearly very high shielding effectiveness values for each type of HARTING connector.
- As the shielding effectiveness always depends on the entire system, good shielding effectiveness values can often also be reached with standard connectors (i.e.: Shielding effectiveness at 1 MHz = ca. 60 dB)
- EMC cable glands allow a considerable increase in shielding effectiveness values, even when used with standard housings.
- Due to their high shielding effectiveness values (at 1 MHz ca. 78 dB) EMC hoods and housings allow further optimisation of the total system.

Due to the great variety of HARTING's product range the user can reach a quick and reliable harmonization of the entire system.

The testing laboratory of the HARTING KGaA has been awarded its accreditation on the basis of DIN EN 45001. It is the formal confirmation that the requirements in terms of materials and personnel as well as for the procedures have been met. The laboratory is fully independent and neutral. The tests are comprehensive and retraceable.

The test reports have the same format as certifications.

Deutscher Akkreditierungs Rat

DAR

For further information, please do not hesitate to contact our EMC-experts.

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