System solution EMClots®

Installation instructions and notes on implementation of an inter-meshed equipotential bonding system with EMClots®

Project:

Project key:

Project management:

Responsible for the lot:

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Draft 0.1	24.05.2017	Steinmetzger	Creating the document
Draft 1.0	10.08.2017	Wagner	Adjusting details
Draft 1.4	18.12.2017	Wagner	Adjusting labelling

Contents

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The goal of this document is to present the optimal implementation of an intermeshed equipotential bonding system for functional-equipotential bonding and protective-equipotential bonding. The advantage of such a system is the low-impedance dissipation of interference currents and the related high quality for reliability and function of the electric system.

1. Standards and guidelines

VDE 0100-540 / DIN EN 61140 – Leakage currents

PE conductors should not be used as a conductive path for operating currents in normal operation. If the PE current is equal to or greater than 10 mA under normal operating conditions when the device is turned on, one of the following constructive measures has to be implemented:

- PE conductor has to have at least 10 mm² along the entire length
- Second protective conductor of equal cross-section has to be provided at a separate terminal on the device

Machinery Directive DIN EN 60204-1 – Excerpt for implementing a CBN

"Functional equipotential bonding is usually achieved by means of a connection with the PE conductor system (CBN). However, if the level of electrical disturbances in the PE conductor system is not sufficiently low so as to ensure the proper function of the electrical equipment, it may be necessary to connect the functional-equipotential bonding system to a separate connector for functional grounding ..."

Since CBN is being installed mostly, a low level of disturbances is required.

DIN VDE 0100-444 and DIN EN 50310 – Structure of equipotential bonding systems

Star-shaped equipotential bonding structures are not suitable in particular when using signal cables and information technology equipment (e.g. PROFINET). The equipotential bonding should be set up intermeshed as small as possible and thus with low impedance (<0.3 ohm).

Draft of the PI Directive – "Recommendations for the functional earth and shielding of PROFIBUS and PROFINET"

The recommendation of good practices of the PI, which currently is being drafted, specifically describes the measures that need to be ensured when employing PROFIBUS and PROFINET. Under requirement H3 it says: *"Design the equipotential bonding system as finely intermeshed as possible (MESH-BN)"*

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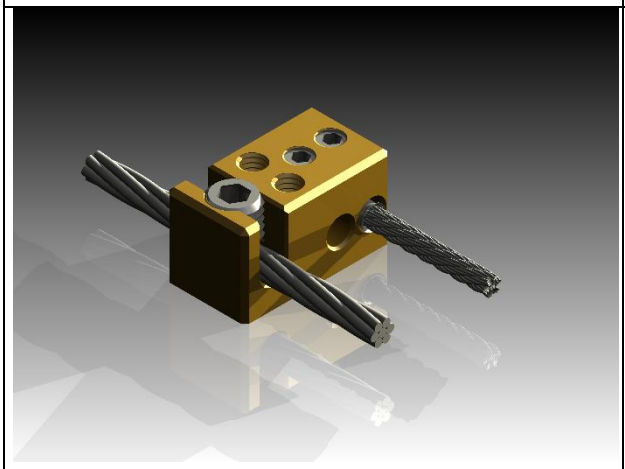
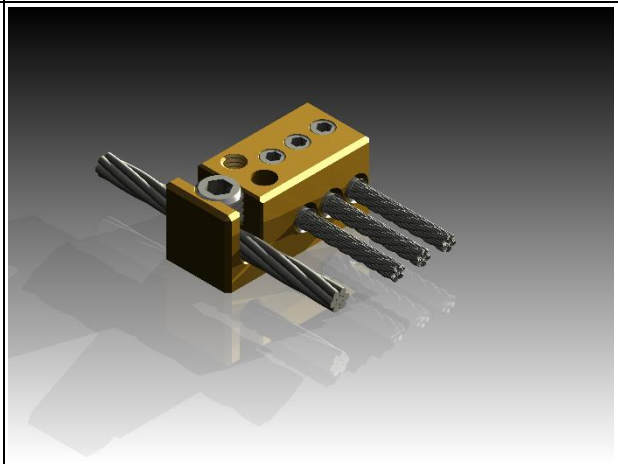
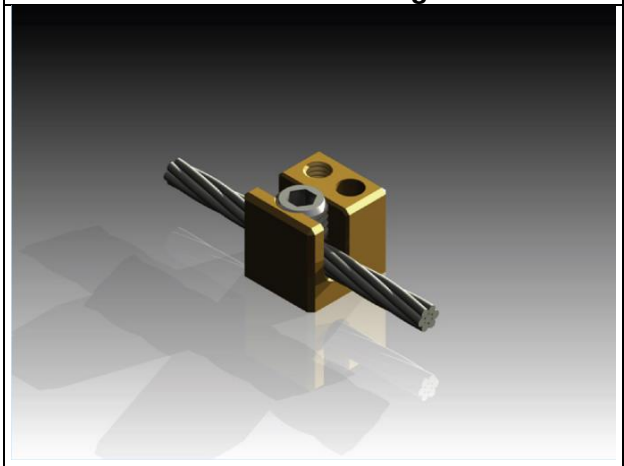
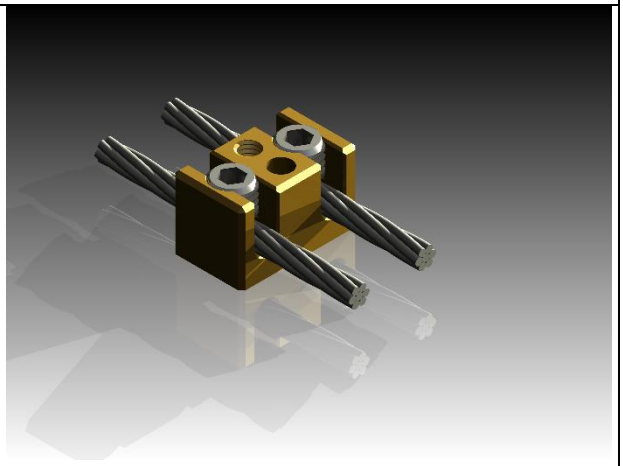
2. Fastening elements EMClots®

The use of **EMClots®** significantly facilitates the implementation of a distributed intermeshed equipotential bonding system. The components can be used for connecting, fastening and branching of conductor cables of extra-fine wire and stranded type. Undefined interference currents are thus prevented and uniform equipotential bonding is implemented even in long production lines. They are ideal for the implementation according to the finely meshed and low-impedance execution of the equipotential bonding system in machines and systems as required by EN 50310.

EMClots® Junction V2	**EMClots® Junction V2 3-fold**
	
The EMClots® Junction serves to fixate conductor cable (trunk) and to create two branches (spurs) for connection to the BN.	The EMClots® Junction serves to fixate conductor cable (trunk) and to create three branches (spurs) for connection to the BN.

EMClots® Fastening V2	**EMClots® Connector V2**
	
The EMClots® Fastening serves to fixate conductor cables (trunk).	The EMClots® Connector serves to fixate and connect to conductor cables (trunk).

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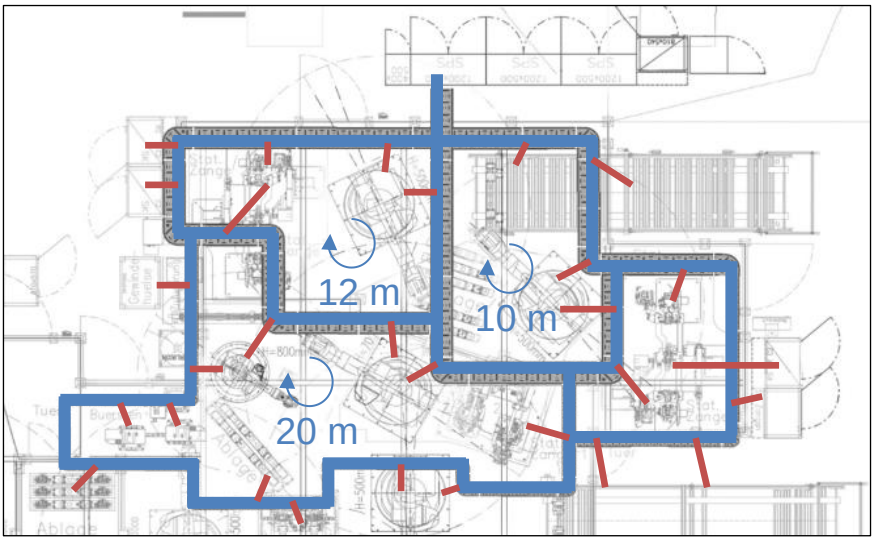
3. Basic rules for the system

The system is built up by trunks (ring-shaped backbone) and spurs (connections). In the following illustration, this is shown based on a classic cell structure.



= Trunk of the MESH-BN

= Spurs of the MESH-BN

Creating a trunk (backbone):

- Using the cable trays as part of the equipotential bonding system
- Creating a ring structure with **up to 20 metre long loops** to ensure reliably maintaining the required loop impedance of 0.3 ohm.
- As many and small meshes as possible to reduce the impedance and to provide the current with as many and short distances as possible.
- Install fastening elements EMClots® at **intervals of 1 metre**.
- A **16 mm² conductor cable** is usually used for the trunk.
- Conductor cables should be **tin-plated** and **non-insulated** so that all necessary system parts can be flexibly integrated.
  For example: **conductor cable class 2, tin-plated, non-insulated**
  Alternatively: conductor cable class 7, tin-plated, non-insulated
  Alternatively: multi-frequency combination conductor cable

Connection of the components by spur:

- Connection of electronic devices, robots, protective bonding etc.
- Connection by short and flexible conductor cables: **max. 2 m**
- Connection to the robot's foot within 2 m
- A device or system component which requires **protective-equipotential bonding** (BN) is connected by a 10 mm² spur conductor cable (DIN EN 61140).
- A device or system component which requires **functional-equipotential bonding** (FE) is connected by a 6 mm² spur conductor cable.
- Conductor cable in **tin-plated** and **flexible design**, insulated in drag chains.
  E.g. **conductor cable class 7, tin-plated, insulated (green/yellow) or non-insulated**
  Alternatively: multi-frequency combination conductor cable
  For robots: conductor cable class 8, tin-plated, insulated, torsion capable

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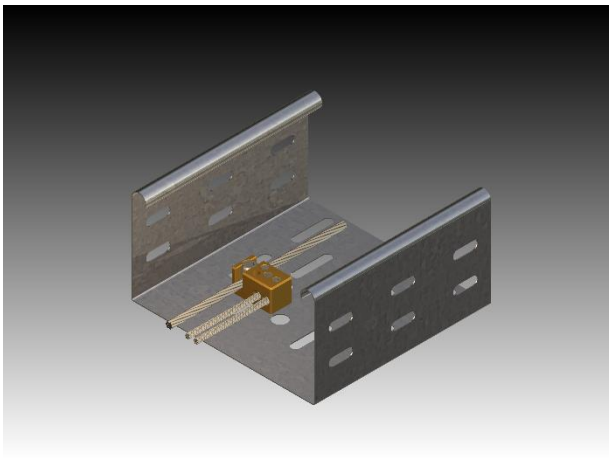
Using the cable trays as part of the equipotential bonding:

The fastening of the EMClots® can be done within or outside of cable trays. Mounting should be carried out here using a type M6x9 screw. In special application cases, the fastening is possible with a second screw from above. Principally it is recommendable to connect conductive system components, in particular cable trays, to the equipotential bonding (BN) in order to achieve a greatest possible intermeshing. Likewise, conductive system components provide a good discharge capacity for low and high frequency currents due to their large cross-section and the large surface.

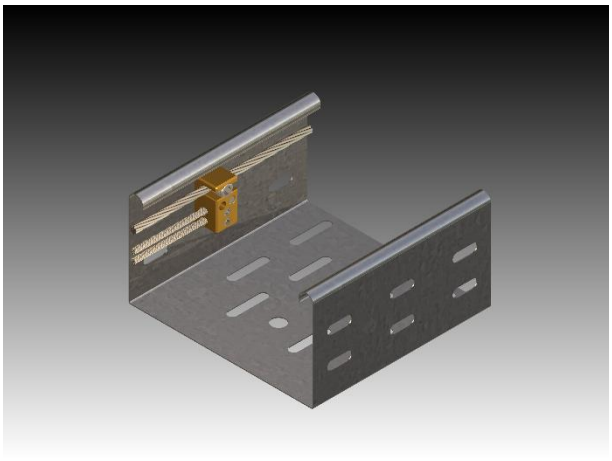
- Separate conductor cables for the equipotential bonding where possible from the lines with electric power (e.g. by spacers).
- Routing the equipotential bonding together with the 24-volt or the information technology does not pose a problem.
- The individual currents are minimal due to the intermeshed system.

The following variants are possible:



Installation inside the cable tray at the bottom.

Requires space and installation access from below.



Installation laterally inside the cable tray.

Protection by the duct and space saving.

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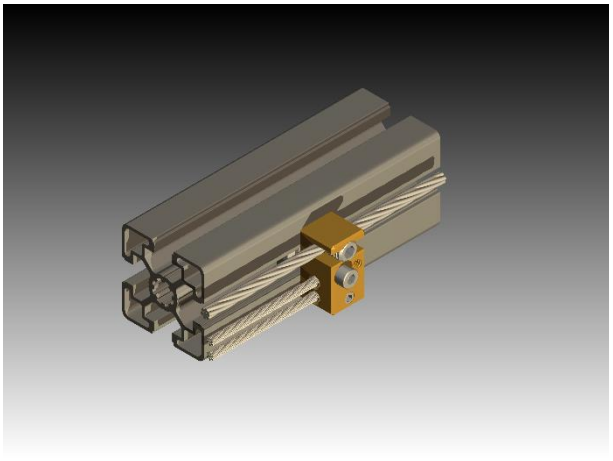
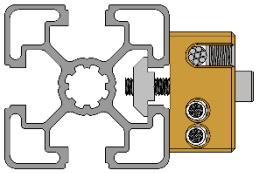
Installation outside of the cable tray.

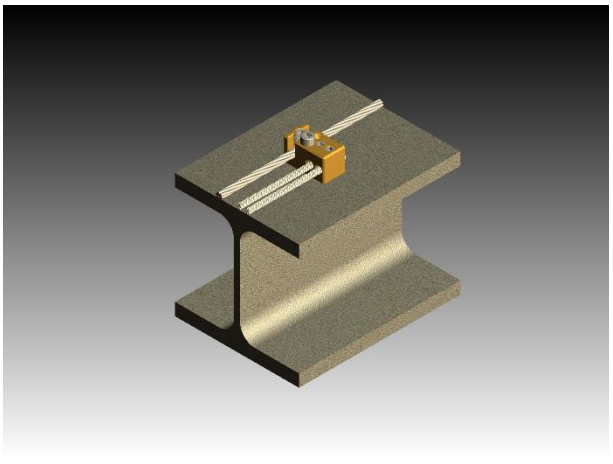
Requires no space within the duct and offers flexible installation possibilities by accessibility and visibility.



Installation on profile.

Flexible installation possibilities by accessibility and visibility. Attention: coating of profiles prevents connection to bonding network.





Installation on other parts.

Flexible installation possibilities by accessibility and visibility. Attention: coating of parts prevents connection to bonding network.

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4. Installation sequence

Step 1:

- Installation of all cable trays

Step 2:

- Planning the connection points (functional- and protective-equipotential bonding)
- Installation of the EMClots® Junction in the cable duct near the connection points

Step 3:

- Installation of the trunk
- Attaching the conductor cable to the already installed EMClots® Junction
- Optional: Installation of further EMClots® for affixing the conductor and for maintaining the basic rules of the overall system (mesh size, maximum distance of the fastening elements etc.)

Step 4:

- Connecting the flexible spur conductor cables to the EMClots® Junction. Use corresponding wire end ferrules for this.
- Route the conductor cables to the connection points - taking the maximum pass length of 2 m into account.
- Fastening the conductor at the connection point, including labelling of the conductor.

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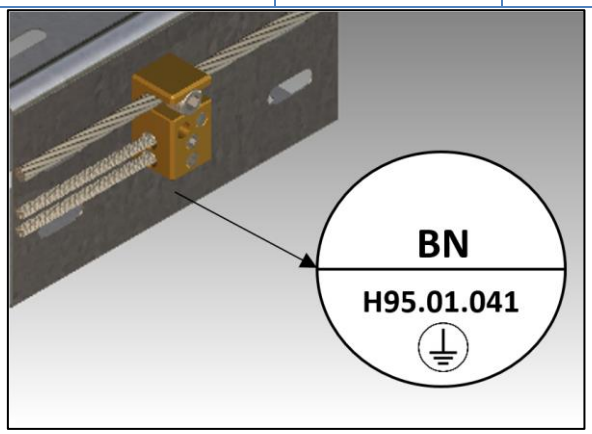
5. Labelling of the connection points

- Labels should be applied directly at the fastening element
- The labelling should be clear
- The connection point should be labelled with the abbreviation "BN" for **Bonding Network.**
- A clear association to the system, the machine and a unique number of the fastening element.
- The following nomenclature is feasible:

	Position 1	Position 2	Position 3
Bonding Network	XXX.	XX.	X
	Abbreviation for the system	Abbreviation for the mesh	Unique number of the fastening element
BN	H95.	01.	041



Identification of the system:

In Section 6.3.2 of the DIN EN 60445 (VDE 0197): 2011-10, the following is regulated:
"In case bare conductors that are used as PE conductors are marked by colours, they must be green-yellow, either along the entire length of the conductor or in every part or every unit or every accessible point. If adhesive tape is used, then bicoloured tape must be used."

Furthermore it states:
"NOTE 3: In case the PE conductor is easily identifiable by is shape, its construction or its location, e.g. the concentric conductor, the colour marking over the entire length is not necessary, however, the ***ends or accessible points*** *ought to be clearly marked by the graphic symbol ⏚ or the* ***bicolour combination green-yellow*** *or the alpha-numeric identification* ***PE****."*

Based on these statements, the following recommendation can be derived:

- A marking of the conductors should be made at the connection points as well as at accessible points.
- The marking can consist of:
  - The graphic symbol: „⏚ “
  - The bicolour combination green-yellow in the form of a cable lug or shrink sleeve
  - The alpha-numeric mark "PE"

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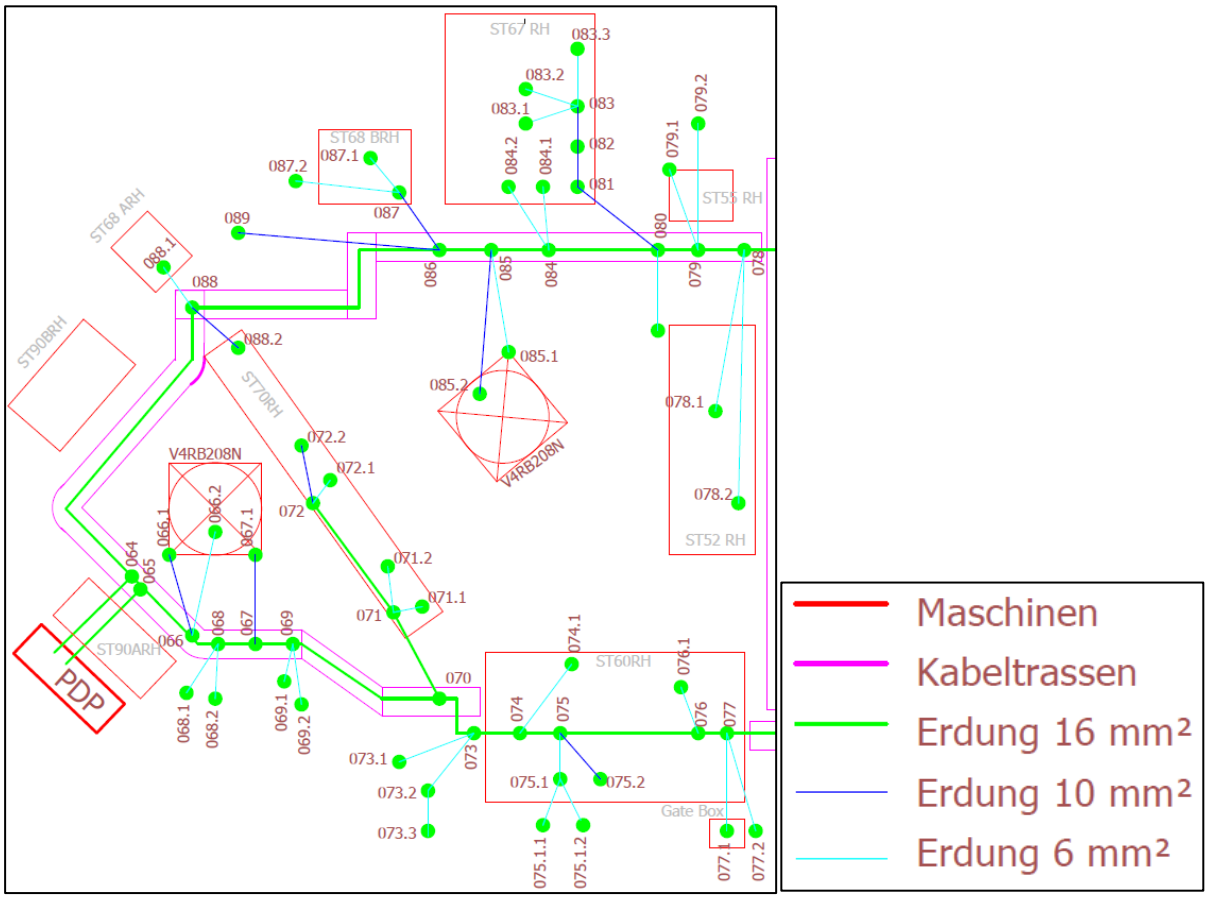
6. Documentation of the system

- A comprehensive documentation is to be created.
- In addition to the fastening elements, the installation site must be recorded.
- The documentation must include a description of the type of the conductor cable used, including the cross-section used.

Example:



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7. Instrumental examination

An examination of the system needs to be carried out to certify the functionality. This test should be conducted at important points while the system is in operation. Basically two points are observed during the examination:

Quality of the system	Load of the system
Measurement during standstill (even before commissioning) is possible	Measurement must be made under conditions that closely simulate production At selected points, the peak values need to be monitored over a longer period
Size of the mesh (impedance of the loop)	Height of the currents on the PE and CBN conductors
Functionality of the shielding of the data and motor lines (impedance of the loop)	Height of the shield currents of the data and motor lines

Quality values:
To certify a sufficiently intermeshed equipotential bonding system, the following values need to be maintained for the loop impedance:

Protective conductor (PE): **max. 0.3 ohm (at 2.083 kHz)**

Protective- or functional-equipotential bonding (CBN): **max. 0.3 ohm (at 2.083 kHz)**

To ensure a sufficiently active effect of the shields, the following values need to be maintained for shields:

Motor cable shielding: **max. 0.3 ohm (at 2.083 kHz)**

Signal cable shielding: **max. 0.6 ohm (at 2.083 kHz)**

The load of the system can be determined by the current. Thus the following limits should be maintained:

Protective conductor (PE): **max. 5% of the phase current**

Protective- or functional-equipotential bonding (CBN): **max. 300 mA (DGUV V3)**

To protect the devices against too much current, the following limits are recommended for the load of the shields:

Motor cable shielding: **max. 300 mA**

Signal cable shielding: **max. 40 mA**

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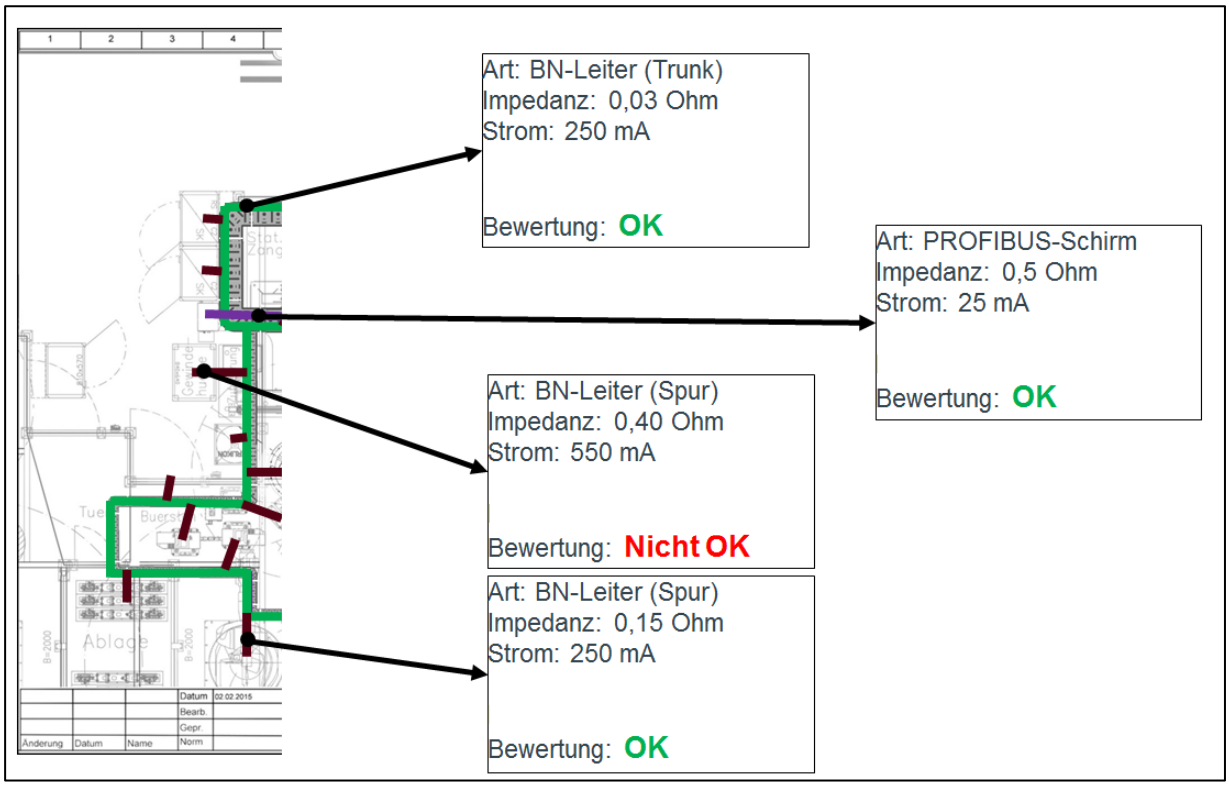
Example evaluation of the readings:



Measuring instruments:

Application purpose	Designation
To determine the quality of the system (impedance at 2.083 kHz)	Loop impedance measuring clamp MWMZ II – Indu-Sol GmbH
To determine the load Simple current measurement	Leakage current measuring clamp LSMZ I – Indu-Sol GmbH
To determine the load Intelligent current measurement	Intelligent current measuring clamp ISMZ I – Indu-Sol GmbH
To determine the load Intelligent current measurement on up to 4 channels	Permanent current analysis EMV-INspektor® V2 – Indu-Sol GmbH

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8. Ordering specifications

EMClots®:

Ordering specifications	Trunk connection	Spur connection	Item no.
EMClots® Junction V2	10-16 mm²	4-10 mm²	122180100
EMClots® Junction V2	25-35 mm²	6-16 mm²	122180101
EMClots® Junction V2 3-fach	10-16 mm²	4-10 mm²	122180110
EMClots® Junction V2 3-fach	25-35 mm²	6-16 mm²	122180111
EMClots® Connector V2	10-16 mm²	-	122180200
EMClots® Connector V2	25-35 mm²	-	122180201
EMClots® Fastening V2	10-16 mm²	-	122180300
EMClots® Fastening V2	25-35 mm²	-	122180301

Conductor cables:

Ordering specifications	Cross-section	Diameter	Insulation	Item no.
Multifrequency conductor	6 mm²	4,5 mm	bare	122040901
Multifrequency conductor	10 mm²	5,5 mm	bare	122040903
Multifrequency conductor	16 mm²	7,0 mm	bare	122040904
Conductor cable class 2	16 mm²	5.1 mm	bare	122040501
Conductor cable class 7	6 mm²	3.9 mm	bare	122040601
Conductor cable class 7	10 mm²	5.1 mm	bare	122040603
Conductor cable class 7	16 mm²	6.3 mm	bare	122040604
Conductor cable class 7 gn/ye	6 mm²	6.0 mm	PVC (gn/ye)	122040721
Conductor cable class 7 gn/ye	10 mm²	7.3 mm	PVC (gn/ye)	122040723
Conductor cable class 7 gn/ye	16 mm²	8.8 mm	PVC (gn/ye)	122040724
Conductor cable class 8	10 mm²	8.0 mm	PUR (gn/ye)	122041103

Attachments:

Ordering specifications	Cross-section	Length	Item no.
Wire end splices Cu-tin-plated	10 mm²	18 mm	122080177

Measurement instruments:

Ordering specifications	Item no.
EMCheck® LSMZ I	122010005
EMCheck® MWMZ II	122010010
EMCheck® ISMZ I	122010020
EMC-INspektor® V2	122010001
EMCheck® measuring clamp case	122010006
EMCheck® measuring clamp case XL	122010007

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