CHARGING AND COMMUNICATION SYSTEM FOR A MOTOR VEHICLE

Description

[0001] The present invention pertains to a charging and communication system for a motor vehicle, especially for a hybrid or electric motor vehicle.

Prior Art

[0002] Many different data communications technologies are used for home network applications. It is becoming apparent that methods which have been defined by standardization committees and industrial associations such as IEEE (P1901), the Homeplug Alliance (HP AV, HP AV2, HP Green PHY), and the ITU (e.g., G.hn (G.9960) and G.hnem, HPNA (G.9954)) will be widely accepted in the future for data transmission based on electrical lines, such as transmission over two-wire lines of copper or other material. All of these methods are to be designated in their totality herein as HP/G.hn. These transmission methods are based on OFDM/DMT (Orthogonal Frequency Division Multiplexing / Discrete Multitone) or its modifications, wherein the number of carriers and their spacing are varied to suit different bandwidths and transmission media.

[0003] The applications are not limited to home networks alone; that is, the expression "home network" is considered here as a generalization for any possible concrete application of the technologies in question in buildings, offices, single-family dwellings, industrial facilities, etc. The methods involved here consist exclusively of those which have been developed for electrical transmission media, i.e., power lines, telephone cables, coaxial cable, data cables such as twisted-pair cable, etc.

[0004] The development of electric vehicles has accelerated in recent years. Various concepts for charging the batteries in electric vehicles, for example, are being discussed. Regardless of the types of charging stations and the charging voltages which are adopted to realize the charging function (AC voltage at, for example, 110 V, 220-240 V, or 380 V for slow charging, or DC voltage for fast charging), all of the approaches share the common feature that an electrical charging cable is used as a connection between the charging station and the electric vehicle.

[0005] It is also known that the communication between the charging station and the electric vehicle occurs using the same electrical charging cable, wherein various data communication methods can be used for this purpose. The above-mentioned methods also defined for home network applications are being discussed for this purpose. When an electric vehicle is connected to a charging station by a charging cable, the information transmitted over the communications channel does not have to consist solely of data on the charging status of the battery and authentication data; on the contrary, there is also is the opportunity to transmit infotainment data between the home network and the infotainment devices (e.g., music or video downloads, updating the navigation system data, and the like) or service information (e.g., diagnostic defects, fault memory contents, etc.). Also, the status of the vehicle (charging status, servicing schedule, engine-independent heating/cooling, or the like) can be called up "from the living room" and influenced.

[0006] Many different bus systems are in use for data transmission in vehicles. For the transmission of infotainment data (multimedia data with associated monitoring and control information) and also in driver assistance systems, the so-called MOST (Media Oriented Systems Transport) bus system is used. MOST is an optical system, which uses optical waveguides such as polymer-based optical fiber (POF). The use of POF in vehicles of the upper-mid and higher classes represents the state of the art today (in 2010, the MOST Forum announced that there were already more than 100 vehicles models equipped with MOST).

[0007] In addition, the methods described by HP/G.hn can also be used in principle for data communications over copper wires within vehicles. In ITU-T Recommendation G.9960 (06/2010), Figure VI-4/G.9960 shows an example of the use of G.hn in an electric vehicle. Figure 1 shows this example, in which the infotainment data can be transmitted by means of the G.hn technology in an electric vehicle. In Recommendation G.9960, G.hn is described exclusively as a copper-based transmission method, i.e., as a transmission method based on electrical lines.

[0008] The typical structure of a known electrical HP/G.hn transceiver, i.e., interface element, for gigabit ethernet (GbE-) transmission is shown in Figure 2.

[0009] An electrical HP/G.hn transceiver consists of the following hardware components:

-- GbE PHY: a GbE PHYsical layer interface component (MAC -- Media Access Controller);

-- DFE: Digital Front End;

-- AFE: Analog Front End (DAC -- Digital-Analog Converter; ADC -- Analog-Digital Converter); and

-- LIF: electrical Line Interface (also called 4-wire/2-wire converter or hybrid).

The software running on the DFE and AFE depends on the concrete, copper-based transmission medium. In the case of the above-mentioned hardware components, what is involved in each case is (with the exception of the LIF) a highly complex system-on-a-chip component.

[0010] A known optical HP/G.hn transceiver is illustrated schematically in Figure 3.

[0011] Most of the hardware components of the optical HP/G.hn transceiver of Figure 3 are identical to those of the electrical HP/G.hn transceiver shown in Figure 2. In place of an LIF, however, an optical transceiver consisting of an analog optical transmitter and an analog optical receiver are used. The software of the DFE and AFE can be identical to that of an electrical HP/G.hn transceiver, but it does not necessarily have to be; that is, it can be adapted or optimized for the special features of the optical transmission medium (e.g., number of carriers, spacing between carriers, cyclic prefix, etc.). The tie-in to the optical transmission medium (here: one POF per transmission direction) occurs in this example by way of plug connectors (SV), but it can also be implemented without these (in so-called "connectorless" fashion).

[0012] The use of such an HP/G.hn transceiver 1 in a motor vehicle charging station is illustrated in Figure 4. Here a vehicle (KFZ) is connected to a home network or charging station by means of HP/G.hn over an electrical charging cable 2. In the home network, an electrical HP/G.hn transceiver 1 takes care of establishing the interface connection to the electrical data network in the house. In the KFZ, a corresponding HP/G.hn-to-MOST converter 3 (also called a "gateway") is required. This converter 3 contains many of the same components also found in the above-described electrical HP/G.hn transceiver 1 (DFE, AFE, and LIF) as well as all of the components necessary to realize a MOST interface (e.g., MOST Network Interface Controller); it therefore has a relatively complicated structure. In the KFZ, transmission proceeds over POF, for example. The copper-based cable infrastructure is used in the home network/charging station, and the charging cable 2 uses the electrical lines in the charging cable to realize a communications channel.

Disadvantages of the Prior Art

[0013] When the data is transmitted between the home network and charging station via the charging cable by an HP/G.hn method, an additional converter for converting from HP/G.hn (electrical) to MOST (optical) is required in the electric vehicle. This additional converter, required for the protocol conversion, must be implemented separately and thus generates cost. In addition, it increases the complexity of the infotainment system and has a negative effect on its susceptibility to malfunction.

[0014] If, however, electrical lines were to be used for communication in the electric vehicle by the HP/G.hn method, all of the advantages which POF offers in vehicles (see http//www.dspof.com/en/support-pgdetail-88.html), i.e., the very advantages responsible for its widespread adoption in motor vehicles, would be lost.

Object of the Invention

[0015] It is therefore the object of the present invention to provide a charging and communications system for a motor vehicle which overcomes the above-mentioned disadvantages of the prior art, is of relatively simple design, reduces the costs and the complexity of the overall system, and requires no additional components. Simultaneously, high data transmission rates between the home network and the motor vehicle and the continued use of optical transmission media in the motor vehicle are to be made possible.

[0016] This object is achieved by the subject matter having the features of claim 1. Advantageous embodiments are described in the dependent claims.

[0017] Homogeneous data communication between a charging station or home network and the motor vehicle is thus guaranteed, namely, communication which does not require complicated hardware or software to convert from one transmission method to another. This leads to a considerable reduction of effort and thus of cost. The likelihood of a malfunction and the amount of maintenance effort are consequently reduced as well. The uniform, i.e., continuous, transmission method encompassing all components of the charging and communications system according to the invention thus achieves the goal that the POF infrastructure, proven to be highly advantageous for use in motor vehicles, can continue to be used. Thus the advantages of the use of POF can be exploited without limitation, and faster bit rates can also be offered. Because of the uniformity of the interfaces, no "protocol converters", i.e., additional hardware or software components, are required in the vehicle. This results in savings with respect to cost, power consumption, and weight.

[0018] A standardization or harmonization of the data transmission method between the home network and the motor vehicle is proposed; that is, the transmission method used in the home network is used to transmit data over the charging cable, and the same method is also used to transmit data in the vehicle. It doesn't matter whether the home network, the charging section, and the data network in the motor vehicle are configured as electrical media, i.e., based on an ethernet cable, or as an optical media. For the data transmission in the motor vehicle, therefore, the proven advantages of POF (polymer fiber-optic conductor) can continue to be exploited.

[0019] The invention is explained in greater detail below with reference to the exemplary embodiments illustrated in the drawings:

-- Figure 1 shows a schematic diagram of the known use of the transmission standard G.hn in an electric vehicle;

-- Figure 2 shows a schematic diagram of the structure of a known electric HP/G.hn transceiver;

-- Figure 3 shows a schematic diagram of the structure of a known optical HP/G.hn transceiver;

-- Figure 4 shows a schematic diagram of the optical HP/G.hn transceiver of Figure 3 in a known motor vehicle charging station;

-- Figure 5 shows a schematic diagram of a preferred embodiment of the charging and communication system according to the invention;

-- Figure 6 shows a schematic diagram of another embodiment of the charging and communication system according to the invention;

-- Figure 7 shows a schematic diagram of another embodiment of the charging and communication system according to the invention;

-- Figure 8 shows a schematic diagram of another embodiment of the charging and communications system according to the invention; and

-- Figure 9 shows a schematic diagram of another embodiment of the charging and communication system according to the invention.

[0020] In the following, several exemplary embodiments of the present invention will be explained in detail on the basis of the schematic diagrams of Figures 5-9.

[0021] Figure 5 shows how the present invention differs from the prior art; the HP/G.hn-MOST converter 3 of Figure 4 in the KFZ is no longer required here, because the transmission method used in the KFZ is identical to the transmission method used in the home network/charging station. In the KFZ, the transmission is carried out over POF. In the home network/charging station, the copper-based cable infrastructure is used, and the charging cable 2 (connection between the home network/charging station and the KFZ) uses the copper lines in the charging cable to realize a communications channel. The first interface element is an electrical HP/G.hn transceiver 1, as already described above.

[0022] The second interface element 4 in the KFZ is a media converter, which represents a "back-to-back" circuit of an electrical and an optical HP/G.hn transceiver, wherein the GbE-PHYs and/or most of the MAC functionally can be omitted.

[0023] By means of this type of circuitry in the interface element 4, the electrical signal from the charging cable 2 is converted into an optical signal for further processing in the POF data processing network of the KFZ. In analogous fashion, the media converter also acts in the opposite direction, i.e., for the conversion of the optical signal from the KFZ into an electrical signal for transmission via the charging cable 2.

[0024] With reference to ITU-T Recommendation G.9960 (edition of 6/2010), a media converter can also be understood as an "inter-domain bridge" (IDB) (see (Figure 5-5/G.9960 and §5.1.6 of ITU-T Recommendation G.9960) when the electrical copper-based part is considered a first domain and the optical POF network in the KFZ a second domain. An IDB consists of two HP/G.hn DFEs, two HP/G.hn AFEs (or one double HP/G.hn AFE), one HP/G.hn LIF, and one optical transceiver. This guarantees that the data from the first domain are transmitted to the second domain and the data from the second domain are transmitted to the first domain.

[0025] The cabling between the HP/G.hn nodes 5 in the KFZ is indicated symbolically in each of the figures; that is, the cabling structure can be of any desired type. It can have, for example, a ring, star, double-ring, bus, daisy-chain, point-to-point, or point-to-multipoint structure.

[0026] In an elaboration of the exemplary embodiment of Figure 5, Figure 6 shows another embodiment of the invention, according to which the home network/charging station does not necessarily have to have only an electrical, copper-based infrastructure; on the contrary, it is also possible to use the POF there as well as a supplementary transmission medium. For the use of the POF, the first interface element 9 must also comprise an optical transceiver, which takes care of converting the electrical signal (charging cable 2 and electrical home network) into an optical signal for the POF infrastructure. This media converter 9 corresponds in terms of its function and structure to the media converter of the second interface element 4. Here, too, the cabling structure in the home network is indicated only in symbolic fashion; that is, any type of cabling structure can be present, such as a ring, star, double-ring, bus, daisy-chain, point-to-point, or point-to-multipoint structure.

[0027] Embodiments are also possible in which the transmission by means of HP/G.hn methods between the home network/charging station and the KFZ and/or within the home network can be optical (FSO -- Free Space Optics; VLC -- Visible Light Communication; OWC -- Optical Wireless Communications) (see Figure 7). In this case, the communication channel is not realized over the charging cable but rather over an optical free-space connection. The optical transceivers for FSO or VLC or OWC differ from those for the POF (see above) in that there is no plug for connecting to the POF. Instead of plugs, optical sending-and-receiving systems consisting of lenses are used (see, for example, http://www.freespaceoptics.org). Thus communications can be established without the need to plug in the charging cable.

[0028] The basic structure of a VLC system is described in A. Paraskevopoulos, J. Vucic, K. Kottke, L. Fernandez, H. Habel, and K.-D. Langer: "Optical Wireless Network Built on White-Light LEDs Reaches 800 MB/s: http://spie.org/x84327.xml?ArticleD=x84237.

[0029] In this case, the two interface elements are provided with additional transceivers 6 to convert the electrical or optical signal from the home network into an optical signal suitable for the optical free-space connection; this must be done because the optical wavelength or frequency used for the POF is usually different from that of the free-space connection. In analogous fashion, an additional transceiver 6 in the second interface element of the KFZ converts the optical signal of the free-space connection for further processing.

[0030] Figure 8 shows an elaboration of the exemplary embodiment of Figure 7. Here an HP/G.hn-based electrical communications channel between the home network/charging station and the KFZ is realized in parallel to the optical free-space connection. This makes it possible to increase both the reliability of the connection between the home network/charging station and the KFZ and the bit rate (channel bundling or Multiple Input Multiple Output, MIMO).

[0031] For applications with high bit rates, one or more POFs can be integrated into the charging cable in the future. Thus an interference-proof communications channel with very high transmission capacity between the home network and the vehicle can be realized. This exemplary embodiment with additional optical charging section 7 is illustrated in Figure 9. The first interface element comprises an optical inter-domain bridge 10 or a plug connector (similar to 8). The second interface element comprises here a purely optical plug connector 8.

[0032] With the present invention, a charging and communications system for a motor vehicle has been provided, which is relatively simple in structure, reduces costs and complexity, and eliminates the need for additional complicated components while continuing to make use of the advantages of POF in the KFZ.

CLAIMS

1. Charging and communications system for a motor vehicle (KFZ) having

- a charging station which is attached to a home network and which is connected by a first interface element (1, 6, 9, 10) to one end of a charging section (2, 7) wherein the home network uses a first transmission method for data communication,
- and a second interface element (3, 4, 6, 8) between the other end of the charging section (2, 7) and a data network of the motor vehicle (KFZ), wherein the data network of the motor vehicle (KFZ) uses a second transmission method for data communication,
- wherein the charging section comprises a charging cable with an electric line (2) for charging an energy store of the motor vehicle,
- wherein at least one transmission channel designed for data communication is formed in both directions via the first interface element (1, 6, 9, 10), the charging section (2, 7) and the second interface element (3, 4, 6, 8), wherein the first transmission method is identical with the second transmission method,

characterised in that

- at least one element of the group which is comprised of the home network, the charging section (2, 7) and the data network of the motor vehicle comprises an optical transmission section, and
- the first and the second transmission method is a transmission method based on OFDM, orthogonal frequency division multiplexing, and DMT, discrete multitone, or modifications thereof, defined by one of the following standards: IEEE P1901, HP HomePlug Alliance, AV, HP AV2, HP Green PHY, ITU G.hn, ITU G9960, ITU G.hnem, ITU G.9954, ITU HPNA.

2. Charging and communications system according to claim 1 characterised in that the optical transmission section is formed as a glass fibre or polymer optical fibre (POF).

3. Charging and communications system according to claim 1 characterised in that the transmission channel for data communication is formed wireless as optical transmission section by means of free space optics, FSO, or OWC, optical wireless communications, or data transmission by means of visible light, visible light communication, VLC.

4. Charging and communications system according to one of the preceding claims characterised in that the first interface element comprises an optical transceiver (6) which is suitable for converting electrical signals into optical signals.

5. Charging and communications system according to one of the preceding claims characterised in that the first interface element comprises an optical transceiver (9) which is suitable for converting optical signals into electrical signals.

6. Charging and communications system according to one of the preceding claims characterised in that the second interface element comprises an optical transceiver (4) which is suitable for converting electrical signals into optical signals.

7. Charging and communications system according to one of the preceding claims characterised in that the first or second interface element has an optical converter (8, 10) which is suitable for converting optical signals.

8. Charging and communications system according to one of the preceding claims characterised in that the second interface element comprises an optical transceiver (6) which is suitable for converting optical signals into electrical signals.

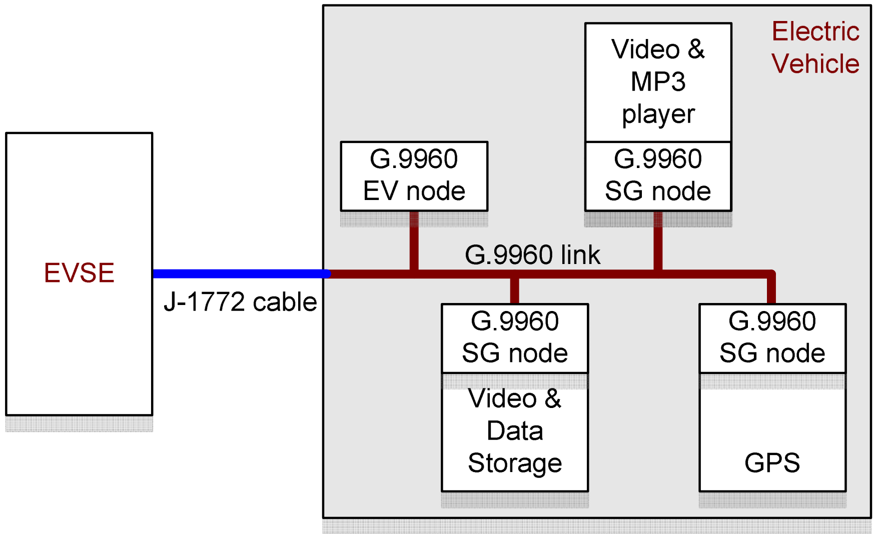

Fig. 1 (Prior Art)

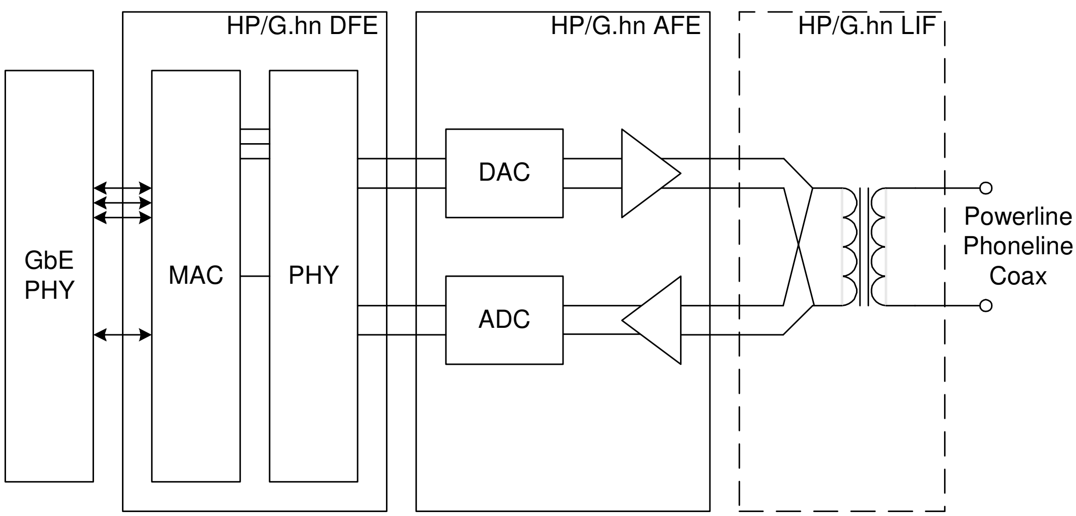

Fig. 2 (Prior Art)

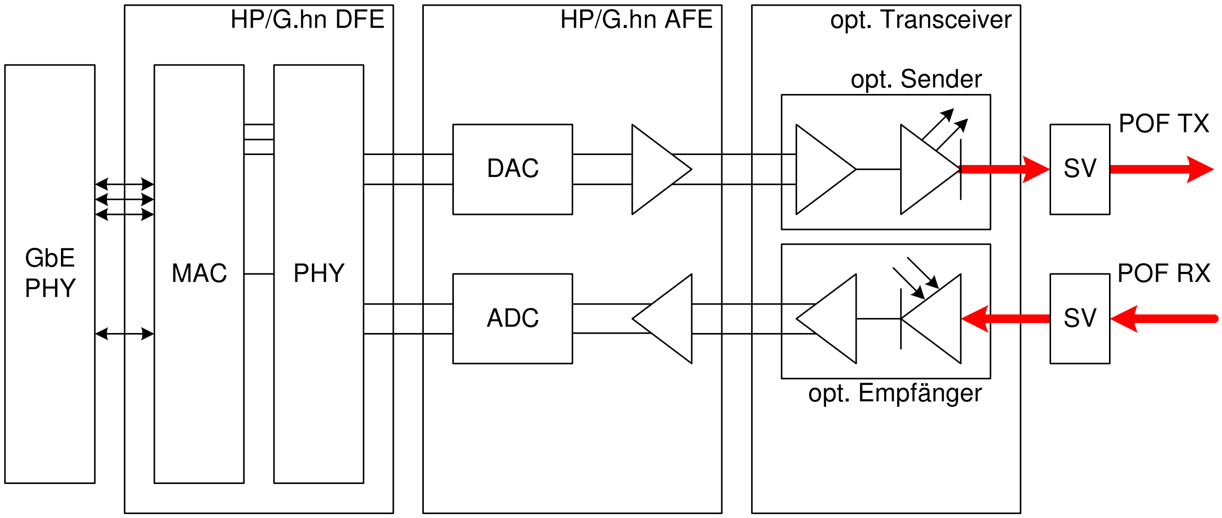

Fig. 3 (Prior Art)

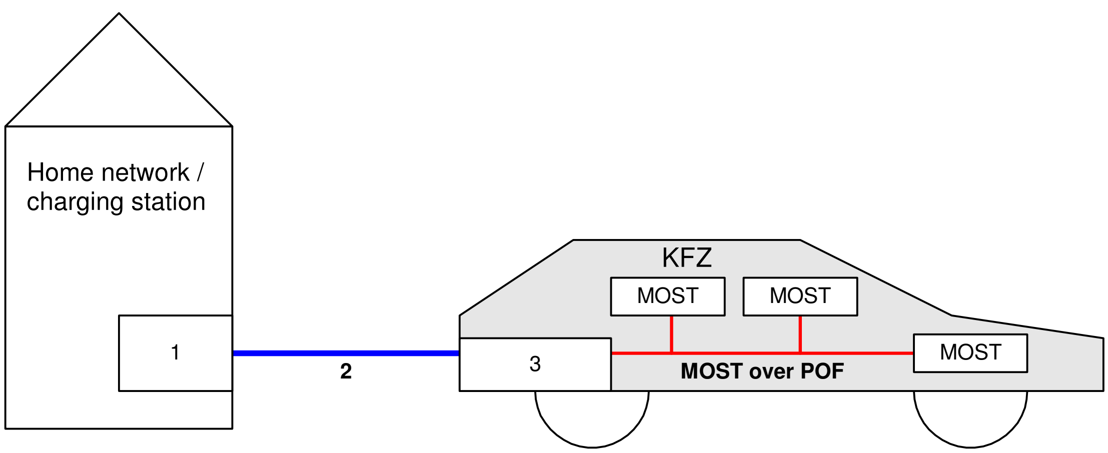

Fig. 4 (Prior Art)

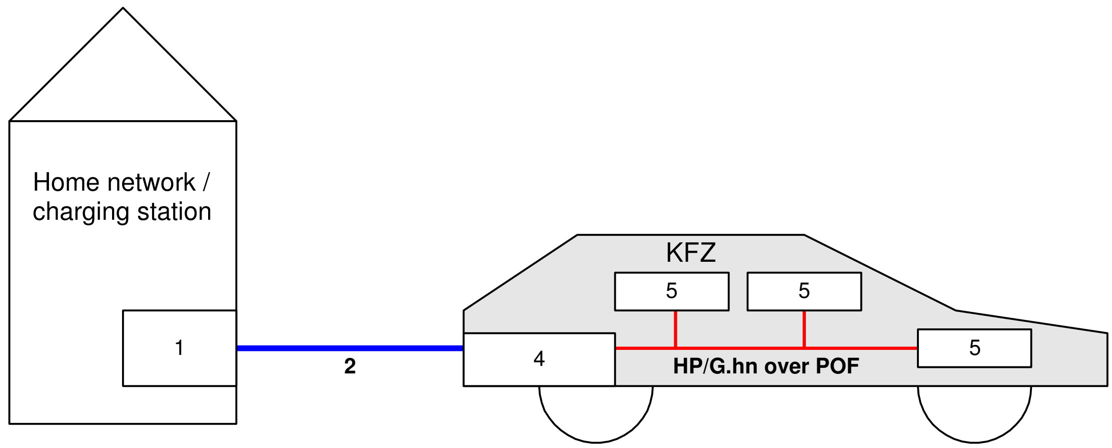
Home network /
charging station
1
2
KFZ
5
5
4
HP/G.hn over POF
5

Fig. 5

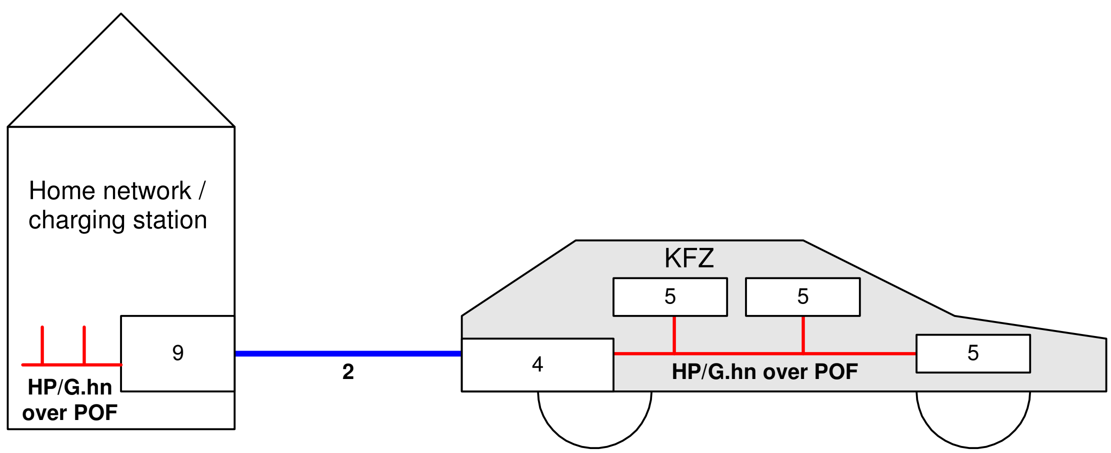
Home network /
charging station
9
HP/G.hn
over POF
2
KFZ
5
5
4
HP/G.hn over POF
5

Fig. 6

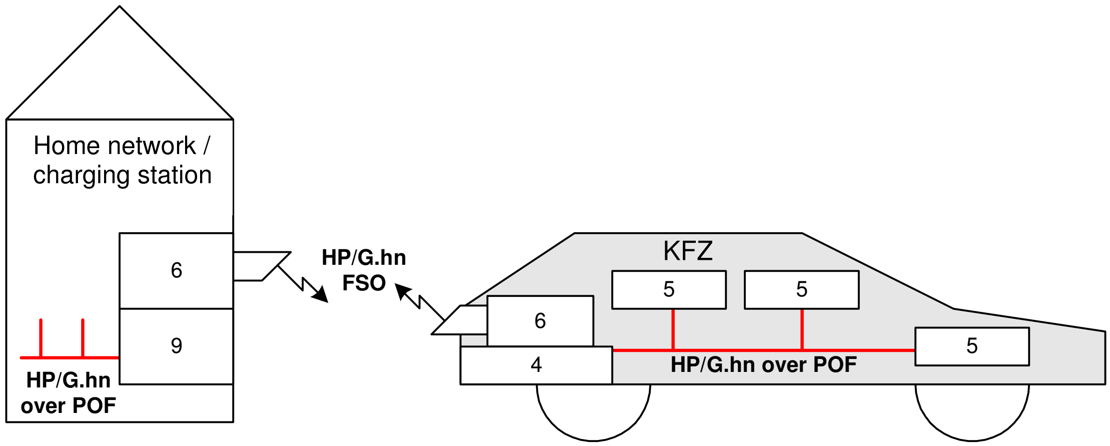
Home network / charging station
6
9
HP/G.hn over POF
HP/G.hn FSO
KFZ
6
4
5
5
5
HP/G.hn over POF

Fig. 7

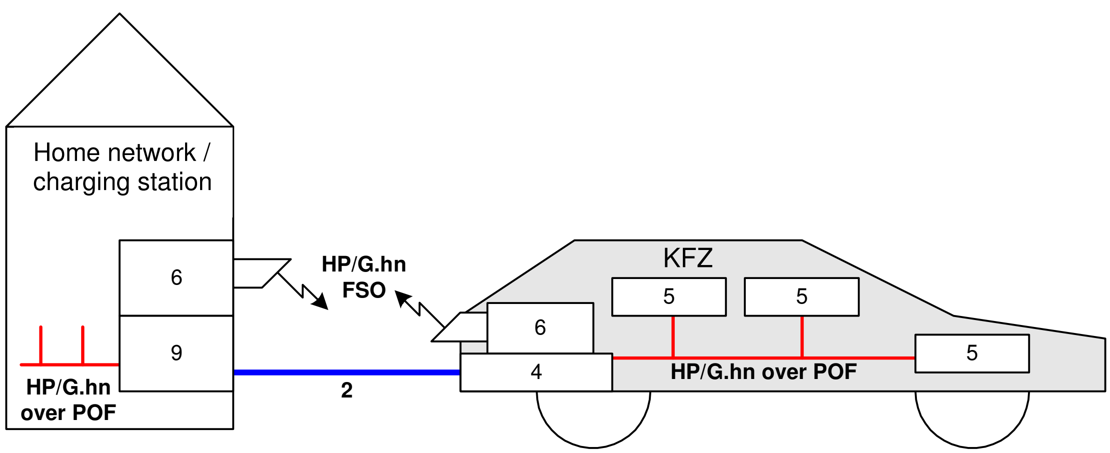
Home network / charging station
6
9
HP/G.hn over POF
HP/G.hn FSO
2
KFZ
6
4
5
5
5
HP/G.hn over POF

Fig. 8

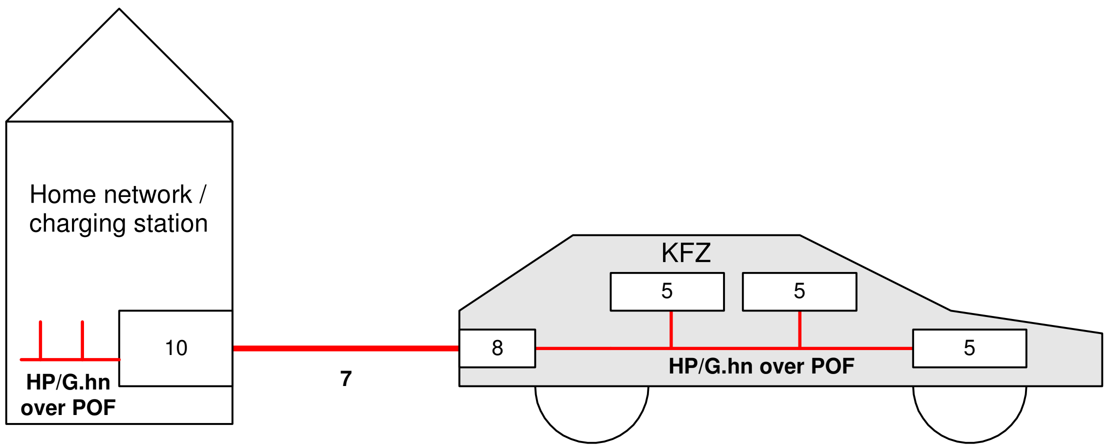

Fig. 9

List of Reference Numbers:

1	Electric HP/G.hn transceiver
2	Charging cable
3	HP/G.hn-MOST converter (gateway)
4	Media converter or inter-domain bridge
5	Optical HP/G.hn transceiver for POF
6	Optical HP/G.hn transceiver for FSO/OWC/VLC
7	Charging cable with integrated POF
8	Plug connector
9	Media converter or inter-domain bridge
10	Optical inter-domain bridge