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(54) **Connection apparatus for connecting at least two signal lines with at least two further signal lines, signal processing apparatus and modular active antenna system thereof**

(57) The embodiments of the invention relate to a connection apparatus (MC) for connecting at least two signal lines (SL1, ..., SL5, SLG) to at least two further signal lines. The connection apparatus (MC) contains the at least two signal lines (SL1, ..., SL5, SLG), a first plug device (PD1) connected to a first one of the at least two signal lines (SL1, ..., SL5, SLG), at least a second plug device (PD2, ..., PD11) connected to a second one of the at least two signal lines (SL1, ..., SL5, SLG), and a

movably mounted support system (MMSS) for a movable support of the first plug device (PD1) and the at least second plug device (PD2, ..., PD11). The embodiments of the invention further relate to a signal processing apparatus for electrical signals and/or optical signals, which contains the connection apparatus and to a modular active antenna system, which contains the signal processing apparatus.

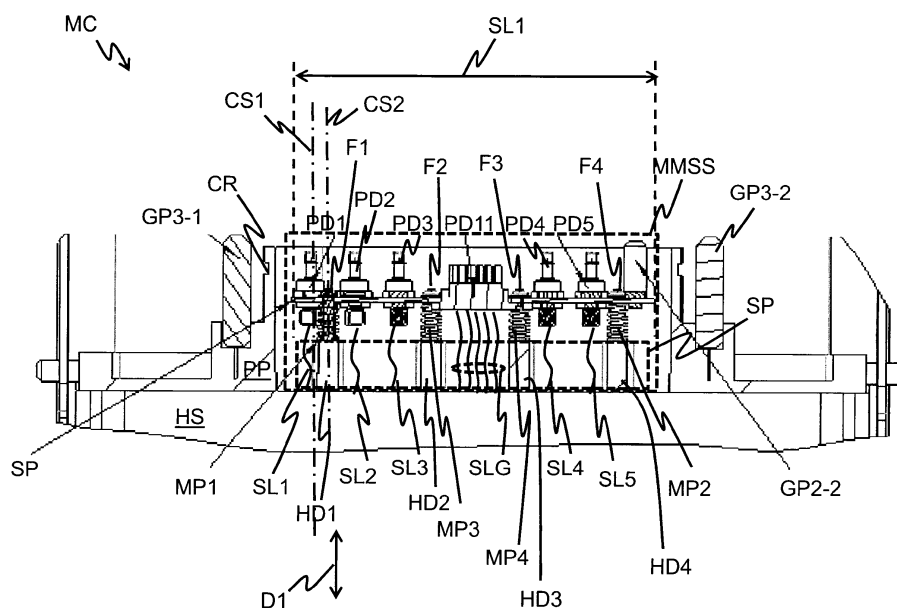


FIG. 1

Description

FIELD OF THE INVENTION

[0001] Embodiments of the invention relate to connectors and, more particularly but not exclusively, to connectors for modular active antenna systems.

BACKGROUND

[0002] In mobile communication networks existing so far, an active antenna unit is installed as a single AA unit (AA = Active Antenna). A total weight of the single AA unit usually exceeds a so-called "one man lift" weight limit, which is usually in a range between 20 to 30 kg depending on a country or region. Therefore, two or more persons or even a crane are required to replace a defective AA unit or to upgrade the AA unit by a new AA unit with new technical features.

[0003] When a single device of the AA unit is defective or does not work anymore with a sufficient performance, a replacement of the whole AA unit is necessary, because interconnects within the AA unit have to be broken and have to be remade, when a new device has to be installed. This can only be done in a repair center or service station because the renewal of the interconnects requires highly skilled installation teams and specific functional tests for a validation of the new interconnect such as PIM tests (PIM = Passive Inter Modulation) for detecting and eliminating passive inter-modulation products caused by a non-linearity of a device or element and which are detectable as interference signals. Furthermore, each replacement usually requires a calibration of an antenna pointing direction.

[0004] Instead of the AA unit an RRH unit (RRH = Remote Radio Head) with a connected antenna may be used to provide wireless coverage in a mobile communication network. When the RRH unit needs to be replaced at an antenna mast, antennas need to be disconnected from the old RRH unit and need to be reconnected to the new RRH unit. RF Coaxial Connectors (RF = Radio Frequency) such as 7/16 DIN connectors for RF cables between the RRH unit and the antennas usually require a torque controlled mount. Even if the 7/16 connector fulfils the IP68 specification with a solid particle protection, that provides no ingress of dust and a complete protection against contact and with a liquid ingress protection, that provides protection for an immersion into water beyond a depth of 1 m by a hermetical sealing, water may enter a feeder cable, if the new connection is not assembled by a highly skilled person.

SUMMARY

[0005] A replacement of current AA units or RRH units requires highly skilled service technicians and/or a considerable amount of work and/or lifting equipment and therefore produces large replacement costs. Thus, it is

an object of the invention to facilitate the replacement, to reduce an error rate of the replacement process and to reduce replacement costs in a radio communication network.

[0006] The object is achieved by a connection apparatus for connecting at least two signal lines to at least two further signal lines. The connection apparatus contains the at least two signal lines, a first plug device connected to a first one of the at least two signal lines, at least a second plug device connected to a second one of the at least two signal lines, and a movably mounted support system for a movable support of the first plug device and the at least second plug device.

[0007] The object is further achieved by a signal processing apparatus for electrical signal and/or for optical signals, which contains the connection apparatus for connecting the at least two signal lines to the at least two further signal lines. The signal processing apparatus may be for example part of a transmitter, receiver or transceiver for optical signals, radio frequency signals or electrical signals other than radio frequency signals such as digital data on an Ethernet link. Alternatively, the signal processing apparatus may be any other signal processing apparatus, which contains an input interface for electrical and/or optical input signals and/or an output interface for electrical and/or optical output signals and the connection apparatus, which is adapted to connect at least two signal lines to at least two further signal lines of a further signal processing apparatus or a transmission device such as a cable, may be the input interface and/or the output interface. In a preferred embodiment, the connection apparatus for connecting the at least two signal lines may be part of a housing of the signal processing apparatus and thereby allows for a weight reduction of the signal processing apparatus.

[0008] The object is even further achieved by a modular active antenna system, which contains the signal processing apparatus and a further signal processing apparatus. The signal processing apparatus may contain for example at least one power amplifier in a transmit path of the modular active antenna system and the further signal processing apparatus may contain for example at least one low noise amplifier in a receive path of the modular active antenna system.

[0009] In an alternative, the object may be also achieved by a transmission device for electrical signal and/or for optical signals, which contains the connection apparatus for connecting the at least two signal lines to the at least two further signal lines. The transmission device may be for example a cable with two or more leads such as a data cable or a so-called hybrid cable or may be any other transmission device, which may be adapted to transfer at least two radio frequency signals, electrical signals, optical signals or a mixture of at least two of a group of radio frequency signals, electrical signals, and optical signals.

[0010] Preferably, the connection apparatus for connecting the at least two signal lines may have an outer

shape of a male connector such as a plug. Correspondingly the counterpart connection apparatus may have an outer shape of a female connector such as a socket. According to an alternative, the connection apparatus for connecting the at least two signal lines may have an outer shape of a female connector and the counterpart connection apparatus may have an outer shape of a male connector.

[0011] The at least two signal lines may be for example wires such as copper wires or optical fibres or a mixture of wires and optical fibres.

[0012] The first plug device and the at least second plug device may be male connectors or female connectors or a mixture of male connectors and female connectors.

[0013] The embodiments of the invention provide a first benefit of facilitating a connection between the connection apparatus for connecting the at least two signal lines with or to the at least two further signal lines of a counterpart connection apparatus. The movably mounted support system avoids that the first plug device, the at least second plug device or both plug devices get jammed, when the connection apparatus gets in contact with the counterpart connection apparatus. Thereby, the connection can be done in a shorter time and a possibility of contact faults can be reduced.

[0014] The embodiments of the invention provide a second benefit of not requiring highly skilled people for being able to connect a transmission device to a signal processing apparatus or to connect a first signal processing apparatus to a second signal processing apparatus.

[0015] Based on the first benefit and the second benefit, the embodiments of the invention provide a third benefit of reducing installation costs or replacement costs.

[0016] According to a preferred embodiment, the movably mounted support system may contain a stationary part, at least one movable part and a supporting part. The first plug device and the at least second plug device may be mounted to the supporting part. The at least one movable part provides a mobility of the supporting part in reference to the stationary part. Preferably, the at least one movable part may be mounted between the stationary part and the supporting part.

[0017] The stationary part may be for example part of a housing of the signal processing apparatus or of a housing of a connector casing. The at least one movable part may be any mechanically part such as a spring or a rubber component, which provides a change in a linear extension of the mechanically part. The supporting part may be for example a supporting plate such as a metal plate made from aluminum or steel, a plastic plate made from a material such as CELSTRAN PA66 GF30, which is a heat stabilized polyamide 66 with 30 percent long glass fibers, or any other material, which provides stiffness comparable to metal.

[0018] The preferred embodiment provides a first benefit of collectively adjusting the plug devices of the connection apparatus with respect to a location of counter-

part plug devices of the counterpart connection apparatus for facilitating an interlocking between the connection apparatus and the counterpart connection apparatus. According to a second benefit, the at least one movable part allows the supporting plate to move towards and backwards with respect to the counterpart connection apparatus and may be also allow the supporting plate to move sideways in a limited way by a few tenth millimeter in a plane parallel to an end face of the counterpart connection apparatus. This mobility allows some tolerances with respect to lateral displacements as well as to off-axis displacements, when the connection apparatus and the counterpart connection apparatus are going to be connected to each other.

[0019] In an even further preferred embodiment, the at least one movable part may be at least one spring such as a metal spring. The supporting part may contain at least one first opening such as a perforation or transfixion. The movably mounted support system may further contain at least one first guiding pin, which may be located within the at least one spring. The at least one first opening may be applied for guiding a movement of the at least one spring and the supporting part. The at least one first guiding pin may be mounted to the stationary part for example by a screw fitting. The even further preferred embodiment provides a first advantage, that the spring offers a durable mobility of the movably mounted support system and of a cost-efficient mobility solution. The at least one first opening of the supporting part and the at least one guiding pin provide a second advantage of a reliable and limited path of motion, which avoids any damages at the plug devices during the establishing of a connection by the connection apparatus. The springs provide a further advantage of enabling an easy control of tolerances of parts (e.g. mainly positions and dimensions of the plug devices and counterpart plug devices) of the connector apparatus and the counterpart connector apparatus, which affects good contacting between the plug devices and the counterpart plug devices.

[0020] Preferably, the movably mounted support system may further contain at least one fastener and the at least one first guiding pin may contain at least one second opening in an end face of the at least one guiding pin. The at least one fastener is inserted into the at least one first opening and the at least one second opening and is mounted to the at least one guiding pin by compressing the spring. The at least one fastener may be for example at least one screw and the at least one second opening may be for example a blind hole with a female screw thread. By using such arrangement, the plug devices of the connection apparatus are continuously pressed against the counterpart plug devices of the counterpart connection apparatus, which provides the benefit of a reliable electrical contact between the plug devices and the counterpart plug devices.

[0021] In a further preferred embodiment, the movably mounted support system may further contain at least two further movable parts. In such a case, the at least one

movable part and a first one of the at least two further movable parts may be arranged in a plane perpendicular to a plug-in direction of the first plug device and the at least second plug device and at opposing ends of a largest longitudinal extension of the supporting part and a second one of the at least two further movable parts may be further arranged in the plane and in a direction perpendicular to the largest longitudinal extension. This provides the advantage of limiting a movement of the movably mounted support system for avoiding too large rotations or too large displacements from a starting position or a relaxed position of the movably mounted support system, when the connector apparatus is not in mechanical contact with the counterpart connector apparatus. A too large movement would prevent a sticking of the plug devices of the connection apparatus into the corresponding counterpart plug devices of the counterpart connection apparatus. An application of at least three movable parts provides the further advantage of increasing a pressure for pressing the plug devices of the connection apparatus continuously against the counterpart plug devices of the counterpart connection apparatus. A predefined contact pressure provided by a spring or several springs needs to be adapted to a size of the connector apparatus and the counterpart connector apparatus and a number of signal lines going to be connected by the connector apparatus and the counterpart connector apparatus. The predefined contact pressure may be provided by a single spring with a corresponding size. But for reducing a size of the connector apparatus, preferably two or more than two springs may be applied in the connector apparatus. In addition, an application of more than one spring limits a risk of large tilts of the supporting part and a risk of damaging the plug devices and/or the counterpart plug devices.

[0022] In an even further preferred embodiment, the supporting part may contain at least one second guiding pin adapted to be inserted into at least one third opening of the counterpart connection apparatus. In addition, a periphery part of the connection apparatus surrounding the movably mounted support system may contain at least one third guiding pin adapted to be inserted into at least one fourth opening of the counterpart connection apparatus. The even further preferred embodiment provides a first advantage of guiding the movably mounted support system by means of the at least one first guiding pin and of guiding the connection apparatus by means of the at least one second guiding pin, when the connection apparatus is going to be connected to the counterpart connection apparatus. Thereby, it can be avoided, that the connection apparatus and the counterpart connection apparatus may get jammed and may impede the connection apparatus's freedom of movement. The even further preferred embodiment provides a second advantage of stiffening the movably mounted support system by means of the at least one second guiding pin and of stiffening the connection apparatus by means of the at least one third guiding pin, when the connection appa-

tus is connected to the counterpart connection apparatus. Any vibrations or impacting forces may be mainly absorbed by the guiding pins and thereby safeguard the plug devices and the counterpart plug devices against any possible damages.

[0023] Further advantageous features of the embodiments of the invention are defined and are described in the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

[0024] The embodiments of the invention will become apparent in the following detailed description and will be illustrated by accompanying figures given by way of non-limiting illustrations.

Figure 1 shows schematically a connection apparatus for connecting at least two signal lines in a cross sectional view of guiding pins of the connection apparatus and a side view of the connection apparatus according to an embodiment of the invention.

Figure 2 shows schematically an extension of a part of the connection apparatus in a cross sectional view of a movable part of a movably mounted support system of the connection apparatus and a further side view of the connection apparatus, when the connection apparatus is connected to a counterpart connection apparatus.

Figure 3 shows schematically a further extension of a further part of the connection apparatus in a cross sectional view of a guiding pin of the movably mounted support system and an even further side view of the connection apparatus, when the connection apparatus is connected to the counterpart connection apparatus.

Figure 4 shows schematically a top view of the connection apparatus and a top view of the counterpart connection apparatus according to the embodiment of the invention.

Figure 5 shows schematically the connection apparatus and the counterpart connection apparatus in a further cross sectional view of the guiding pins of the connection apparatus, when a signal processing apparatus containing the connection apparatus is positioned for connecting to a further signal processing apparatus containing the counterpart connection apparatus.

Figure 6 shows schematically the connection apparatus and the counterpart connection apparatus in an even further cross sectional view of the guiding pins of the connection apparatus, when the signal processing apparatus containing the connection apparatus is connected to the further signal processing

apparatus containing the counterpart connection apparatus.

Figure 7 shows three lateral views of a modular active antenna system, which contains the signal processing apparatus and the further signal processing apparatus, according to an embodiment of the invention.

Figure 8 shows a block diagram of electrical components of the signal processing apparatus and the further signal processing apparatus of the modular active antenna system, signal connections between the electrical components within the signal processing apparatus and within the further signal processing apparatus and further signal connections between electrical components of the signal processing apparatus and further electrical components of the further signal processing apparatus by the use of the connector apparatus and the counterpart connector apparatus according to the embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0025] Various example embodiments will now be described more fully with reference to the accompanying drawing in which an example embodiment is illustrated. In the figure, the thicknesses of lines, layers and/or regions may be exaggerated for clarity.

[0026] Accordingly, while example embodiments are capable of various modifications and alternative forms, embodiments thereof are shown by way of example in the figure and will herein be described in detail. Especially numerical quantity values described in the following are only given as example values. It should be understood, however, that there is no intent to limit example embodiments to the particular forms disclosed, but on the contrary, example embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of the invention. Like numbers refer to like or similar elements throughout the description of the figure.

[0027] It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.).

[0028] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context

clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

[0029] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It will be further understood that terms, e.g., those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0030] Figure 1 shows schematically in a cross sectional view CS0 across guiding pins GP3-1, GP3-2 (see also Figure 4a) and a side view a connection apparatus MC for connecting two or more signal lines. The connection apparatus MC may have an outer shape of a male connector such as a plug as shown in Figure 1. Correspondingly a counterpart connection apparatus FC with corresponding signal lines may have an outer shape of a female connector such as a socket as shown for example in Figure 5. According to an alternative, the connection apparatus MC may have an outer shape of a female connector and the counterpart connection apparatus FC may have an outer shape of a male connector.

[0031] The connection apparatus MC exemplarily contains ten single signal lines, from which five signal lines SL1, SL2, SL3, SL4, SL5 are shown in Figure 1, and further contains a group of signal lines SLG, which contains for example up to 10 further signal lines. In further alternatives, the connection apparatus MC may contain between two and nine single signal lines or more than ten single signal lines with or without the group of signal lines SLG or with more than one group of signal lines. The group of signal lines SLG may be for example a ribbon cable or a wire harness.

[0032] The signal lines SL1, SL2, SL3, SL4, SL5, SLG may be for example wires such as copper wires for transmitting electrical signals such as radio frequency signals or electrical signals such as data signals based on the Ethernet protocol. In further alternatives, the signal lines SL1, SL2, SL3, SL4, SL5, SLG may be optical fibres for transmitting optical signals or a mixture of wires and optical fibres.

[0033] The connection apparatus MC further exemplarily contains eleven plug devices (see Figure 4 a), from which six plug devices PD1, PD2, PD3, PD4, PD5, PD11 are shown in Figure 1.

[0034] A first plug device PD1 is connected to a first signal line SL1, a second plug device PD2 is connected to a second signal line SL2, a third plug device PD3 is connected to a third signal line SL3, a fourth plug device

PD4 is connected to a fourth signal line SL4, a fifth plug device PD5 is connected to a fifth signal line SL5 etc. The plug devices PD1, PD2, PD3, PD4, PD5 may be for male connectors such as P-SMP connectors from the company Rosenberger as shown in Figure 1. In further alternatives, the plug devices PD1, PD2, PD3, PD4, PD5 may be female connectors or a mixture of male connectors and female connectors.

[0035] An eleventh plug device PD11 may be connected to the group of signal lines SLG. The eleventh plug device PD11 may be for example a male connector such as a Micro-Fit 3.0™ connector from the company Molex as shown in Figure 1.

[0036] The connection apparatus MC further contain a movably mounted support system MMSS for a movable support of the plug devices PD1, PD2, PD3, PD4, PD5, PD11. Components or parts of a preferred embodiment of the movably mounted support system MMSS are surrounded by the dashed line shown in Figure 1. The movably mounted support system MMSS contains a supporting part SP, seven movable parts, from which four movable parts MP1, MP2, MP3, MP4 are shown in Figure 1 (each one of further three movable parts is hidden by one of the four movable parts MP1, MP2, MP3, MP4 shown in Figure 1) and a stationary part SP. Preferably, the movably mounted support system MMSS further contains the plug devices PD1, PD2, PD3, PD4, PD5, PD11,

[0037] In further alternatives, the movably mounted support system MMSS may contain only a single movable part, between two and five movable parts, or more than seven movable parts.

[0038] The supporting part SP may be preferably a supporting plate such as a flat supporting plate with a predefined stiffness. The predefined stiffness may be provided for example by a thickness of for example 1.5 mm of a metal material such as aluminum or steel. The predefined stiffness depends for example on dimensions and numbers of the plug devices PD1, PD2, PD3, PD4, PD5, PD11. In an alternative embodiment, the predefined stiffness may be provided by a plastic material such as CELSTRAN PA66 GF30 with a thickness, which is preferably adapted to mechanical forces impacting on the supporting plate during generating the connection between the connection apparatus MC and the counterpart connection apparatus FC and during maintaining and operating the connection between the connection apparatus MC and the counterpart connection apparatus FC.

[0039] The movable parts MP1, MP2, MP3, MP4 may be arranged according to the supporting part SP preferably in a following way: A first movable part MP1 and a second movable part MP2 may be arranged and located at opposing ends of a first straight line SL1, which may be given by a largest longitudinal extension of the supporting part SP. At least a third one of the movable parts may be laterally arranged and located in a direction SL2 perpendicular to the first straight line SL1 (see Figure 3).

[0040] With respect to Figure 3, which shows a first cross section CS1 across the first plug device PD1 (see

Figure 1), a third movable part MP3 and a fourth movable part MP4 (covered by the third movable part MP3) are laterally arranged and located in a direction SL2, which is perpendicular to the first straight line SL1. In addition, a fifth movable part MP5 and a further movable part (covered by the fifth movable part MP5) are laterally arranged and located according the first straight line SL2 and in opposite direction to the direction SL2. A distribution of the movable parts MP1, MP2, MP3, MP4, MP5 across a surface of the supporting part SP can be deduced from Figure 4a), which shows in a top view six fasteners F1, F2, F3, F4, F5, F6. Below each of the fasteners F1, F2, F3, F4, F5, F6 and the supporting part SP one of the movable parts MP1, MP2, MP3, MP4, MP5 is arranged.

[0041] The movable parts MP1, MP2, MP3, MP4, MP5 may be preferably springs such as metal springs as shown in Figure 1 and Figure 2. In further alternatives, the springs may be replaced by hollow cylinders, which are made from a durable rubber material such as silicon rubber or may be replaced by any other movable parts, which exist of a compressible and extendable material.

[0042] The movable parts MP1, MP2, MP3, MP4, MP5 are movable in first directions D1, which are a plug direction to connect the connection apparatus MC to the counterpart connection apparatus FC and an opposite direction to the plug direction to disconnect the connection apparatus MC from the counterpart connection apparatus FC. Preferably the first directions D1 are parallel to plug directions and unplug directions of the plug devices PD1, PD2, PD3, PD4, PD5, PD11.

[0043] The movable parts MP1, MP2, MP3, MP4, MP5 are preferably further movable in second directions D2 and third directions D3, which are perpendicular to the first directions D1 and which are perpendicular to each other to constitute a plane, which is perpendicular to the first directions D1. Such vertical mobility with respect to the first directions D1 may be achieved for example by an arrangement as depicted in the Figure 3, which shows a second cross section CS2 across the first movable part MP1 (see Figure 1). A first guiding pin GP1-1 is mounted to the stationary part SP for example by a screw fitting SF. The first guiding pin GP1-1 may have for example a form of a solid cylinder and may contain at a first end face a male screw thread. The stationary part SP may contain a blind hole with a female screw thread adapted to the male screw thread of the first guiding pin GP1-1. An end piece of the first guiding pin GP1-1 with the first end face and with an exemplarily length of 6 mm may have a smaller diameter of for example 2.5 mm as the remaining part of the first guiding pin GP1-1 with an outer diameter of for example 4.8 mm and with an exemplarily length of 15.5 mm. In an alternative, the first guiding pin GP1-1 may be mounted by a welded joint.

[0044] A spring SG with an inner diameter of for example 5.5 mm may be imposed on the first guiding pin GP1-1 and may surround the first guiding pin GP1-1. The supporting part SP may contain a first opening OP1-1, which may be preferably a perforation with an inner diameter

of for example 5.2 mm. The difference between the inner diameter of the first opening OP1-1 and the outer diameter of the first guiding pin GP1-1 allows for a transverse mobility of the supporting part SP with respect to the first directions D1 in a length range between 0 and 0.3 mm.

[0045] The supporting part SP is mounted to the first guiding pin GP1-1 by applying a first fastener F1. The first fastener F1 may be for example a screw, which is inserted in the first opening OP1-1 of the supporting part SP and which is mounted to a second opening OP2-1 of a second end face of the first guiding pin GP1-1. The second opening OP2-1 may be a blind hole with a female screw thread. In a preferred embodiment, a washer WS may be applied between a screw head of the screw and a surface of the supporting part SP. In an alternative, the first fastener F1 may be a split pin or a rivet.

[0046] By mounting the supporting part SP to the first guiding pin GP1-1 the spring SG get compressed for example from a stress-free length of 13.5 mm to a compressed length of 11.5 mm.

[0047] The above described overall arrangement of the stationary part SP, the first movable part MP1 and the supporting part SP allows, that the first movable part MP1 provides a mobility of the supporting part SP with respect to the stationary part SP. An identical arrangement may be applied preferably with respect to the other movable parts MP2, MP3, MP4, MP5 of the movably mounted support system MMSS.

[0048] The stationary part SP of the movably mounted support system MMSS may be part of a housing HS of the connection apparatus MC and the housing HS of the connection apparatus MC may be part of a housing of a signal processing apparatus PP1 (see Figure 7) for radio frequency signals, for electrical signals such as data signals of an Ethernet transmission, for optical signals such as WDM signals (WDM = wavelength-division multiplexing) or a mixture of at least two of these signal types. The stationary part SP with respect to the embodiment shown in Figures 1, 3, 5 and 6 consists preferably of four so-called partition walls or so-called thwarts with air gaps in between for reducing an overall weight of the connection apparatus MC. An upper part of the stationary part SP facing towards the plug devices PD1, PD2, PD3, PD4, PD5, PD11 is in contact with the movable parts MP1, MP2, MP3, MP4, MP5 and a lower part of the stationary part SP in a contrary direction passes into the housing HS of for example the signal processing apparatus PP1 shown in Figure 1.

[0049] The supporting part SP preferably further contains one or more second guiding pins GP2-1, GP2-2, which are adapted to be inserted into corresponding third openings OP3-1, OP3-2 of the counterpart connection apparatus FC of the connection apparatus MC (see Figures 4a and 4b). The one or more second guiding pins GP2-1, GP2-2 are preferably sharpened and may contain a taper at an end part, which faces towards the corresponding third openings OP3-1, OP3-2 of the counterpart connection apparatus FC.

[0050] Figure 4a shows in a top view two second guiding pins GP2-1, GP2-2, which are located at the opposing ends of the largest longitudinal extension of the supporting part SP and which are preferably located in diagonal corners of the supporting part SP. The second guiding pins GP2-1, GP2-2 and the plug devices PD1, PD2, PD3, PD4, PD5, PD11 are located on a same side of the supporting part SP and are preferably orientated in a same direction. The second guiding pins GP2-1, GP2-2 are for example solid cylinders with a conical end that faces towards the counterpart connection apparatus FC (see Figure 2). The second guiding pins GP2-1, GP2-2 may be mounted to the supporting part SP for example by a screwing or a welded joint. A height level of the second guiding pins GP2-1, GP2-2 with respect to an outer surface of the supporting part SP of for example 22 mm may be preferably for example at least 3 mm larger than a largest height level of the plug devices PD1, PD2, PD3, PD4, PD5, PD11 with respect to the outer surface of the supporting part SP.

[0051] A periphery part PP of the connection apparatus MC, which surrounds the movably mounted support system MMSS preferably contains one or several third guiding pins GP3-1, GP3-2, which may be adapted to be inserted into corresponding fourth openings OP4-1, OP4-2 of the counterpart connection apparatus FC (see Figures 4a and 4b). Figure 4a shows in a top view two third guiding pins GP3-1, GP3-2, which are located at opposing ends of the periphery part PP. Thereby, the two third guiding pins GP3-1, GP3-2 are located in an extension of the largest longitudinal extension of the supporting part SP. The third guiding pins GP3-1, GP3-2 are preferably orientated in a same direction as the second guiding pins GP2-1, GP2-2. The third guiding pins GP3-1, GP3-2 are for example solid cylinders with a conical end that faces towards the counterpart connection apparatus FC (see Figure 5). The third guiding pins GP3-1, GP3-2 may be mounted to the periphery part PP for example by a grouted connection to the periphery part PP generated by a swaging process. A height of the third guiding pins GP3-1, GP3-2 with respect to an outer surface of the supporting part SP may be preferably for example at least 3.5 mm larger than the height of the second guiding pins GP2-1, GP2-2 with respect to the outer surface of the supporting part SP.

[0052] An upper part of the periphery part PP facing towards the counterpart connection apparatus FC may contain at an outer surface a circumferential chamfer CR for inserting an insulating material such as an o-ring (see Figures 1, 2 and 3). A shape of the upper part of the periphery part PP is adapted to be inserted in an opening OP-CP of the counterpart connection apparatus FC (see Figures 2, 3, 5 and 6). Thereby, the insulating material is pressed between the outer surface of the upper part of the periphery part PP and an inner surface of the opening OP-CP of the counterpart connection apparatus FC for providing a hermetical insulation against environmental influences provided for example by fluids or gases.

[0053] Figure 4b) shows a top view of the counterpart connection apparatus FC. The counterpart connection apparatus FC contains eleven plug devices CPD1, CPD2, CPD3, CPD4, CPD5, CPD6, CPD7, CPD8, CPD9, CPD10, CPD11, which are adapted to be connected to the corresponding plug devices PD1, PD2, PD3, PD4, PD5, PD11 of the connection apparatus MC. The counterpart connection apparatus FC further contains the third opening OP3-1, OP3-2 and the fourth opening OP4-1, OP4-2.

[0054] Figure 5 shows a cut-out CO and a cross sectional view across the third guiding pins GP3-1, GP3-2 of a modular active antenna system MAAS (see Figure 7a) as an example of a communication apparatus, which applies the connection apparatus MC and the counterpart connection apparatus FC for an internal connection between the signal processing apparatus PP1 and a further signal processing apparatus PP2.

[0055] The third guiding pins GP3-1, GP3-2 are preferably sharpened and may contain a taper at an end part, which faces towards the corresponding fourth openings OP4-1, OP4-2 of the counterpart connection apparatus FC.

[0056] The internal connection is shown for the case, that the signal processing apparatus PP1 and the further signal processing apparatus PP2 are positioned for connecting the signal processing apparatus PP1 with the further signal processing apparatus PP2 by applying the connection apparatus MC at the signal processing apparatus PP1 and by applying the counterpart connection apparatus FC at the further signal processing apparatus PP2. In an alternative, the connection apparatus MC and the counterpart connection apparatus FC may be exchanged with respect to the signal processing apparatus PP1 and the further signal processing apparatus PP2. This means, the connection apparatus MC may be part of the signal processing apparatus PP1 and the counterpart connection apparatus FC may be part of the further signal processing apparatus PP2.

[0057] The second guiding pins GP2-1, GP2-2 are aligned with respect to the third openings OP3-1, OP3-2, which are indicated in Figure 5 by dashed lines. In a same way, the third guiding pins GP3-1, GP3-2 are aligned with respect to the fourth openings OP4-1, OP4-2. Figure 5 further shows the o-ring OR, which is inserted into the circumferential chamfer CR of the connection apparatus MC.

[0058] The connection apparatus MC is preferably part of a housing of the signal processing apparatus PP1 and the counterpart connection apparatus CS is preferably part of a housing of the further signal processing apparatus PP2. Thereby, additional sled walls can be avoided and total weights of the signal processing apparatus PP1 and the further signal processing apparatus PP2 can be reduced.

[0059] Figure 6 shows the internal connection for the case, that the connection apparatus MC of the signal processing apparatus PP1 is inserted into the counter-

part connection apparatus FC of the further signal processing apparatus PP2. A circular cross section of the o-ring OR is compressed for example into an elliptical shape by the inner surface of the opening OP-CP of the counterpart connection apparatus FC and by the outer surface of the upper part of the periphery part PP of the connection apparatus MC.

[0060] Figure 7 shows three lateral views of the modular active antenna system MAAS with the cut-out of the connection between the signal processing apparatus PP1 and the further signal processing apparatus PP2, which is shown in Figure 5 and Figure 6. Figure 7a) shows a back side of the modular active antenna system MAAS. Figure 7b) shows the modular active antenna system MAAS rotated by 90 degrees along a longitudinal axis LA with respect to Figure 7a). The first cross-sectional view CS1 and the second cross-sectional view CS2 shown in Figures 2 and 3 are cut-outs of this lateral view of the modular active antenna system MAAS. Figure 7c) shows the modular active antenna system MAAS rotated by further 90 degrees along a longitudinal axis LA with respect to Figure 7b). A housing HS1-2 protects antenna elements AE1, AE2, AE3, AE4 (indicated by dashed lines, see also Figure 8) of the modular active antenna system MAAS against environmental influences.

[0061] Figure 8 shows a block diagram of modular active antenna system MAAS for transmitting and receiving radio frequency signals via the antenna elements AE1 to AE4. The modular active antenna system MAAS is shown for an FDD transmission scheme (FDD = Frequency Division Duplex). In an alternative, by replacing duplex filters DF1, DF2 as shown in Figure 8 with single filters and switches as known in the prior art, the modular active antenna system MAAS may be modified to be used for a TDD transmission scheme (TDD = Time Division Duplex).

[0062] The embodiment is exemplarily shown for the case that the antenna elements AE1, AE2 are used for a transmission of radio frequency signals and all four antenna elements AE1 to AE4 are used for a reception of further radio frequency signals. In further alternatives, the modular active antenna system MAAS may be adapted for transmitting the radio frequency signals via a single antenna element, via four antenna elements by adding two additional transmit paths with corresponding devices or via more than four antenna elements by adding more than two additional transmit paths with corresponding devices. In an even further alternative, the modular active antenna system MAAS may be adapted for receiving the further radio frequency signals via a single antenna element, via two antenna elements or via more than four antenna elements by adding additional receive paths with corresponding devices.

[0063] The modular active antenna system MAAS is split into the signal processing apparatus PP1 as a first subsystem and the further signal processing apparatus PP2 as a second subsystem. The modular active antenna system MAAS contains the signal processing appa-

ratus PP1, the further signal processing apparatus PP2 and a detachable connection between the signal processing apparatus PP1 and the further signal processing apparatus PP2. The detachable connection is adapted to separate the signal processing apparatus PP1 from the further signal processing apparatus PP2 and to assemble the signal processing apparatus PP1 to the further signal processing apparatus PP2.

[0064] The signal processing apparatus PP1 contains the connection apparatus MC and the further signal processing apparatus PP2 contains the counterpart connection apparatus FC. The detachable connection is provided by the connection apparatus MC and the counterpart connection apparatus FC. The signal lines SL1, SL2, SL3, SL4, SL5 shown in Figure 1 correspond to electrical connections EC1 to EC10 between the signal processing apparatus PP1 and the further signal processing apparatus PP2. Electrical connections EC1, EC7, EC8 and EC9 are signal connections for the further radio frequency signals, which have been received at the antenna elements AE1, AE2, AE3, AE4. Electrical connections EC2 and EC6 are signal connections for the radio frequency signals, which are provided to the antenna elements AE1 and AE2. Electrical connections EC5, EC9 are signal connections for VSWR measurement signals (VSWR = voltage standing wave ratio), which are taken from a forward path and a reverse path of the directional couplers DC1, DC2. Electrical connections EC3, EC4 are signal connections for transmission monitor signals, which are taken from the forward path of the directional couplers DC1, DC2. The electrical connections EC1 to EC10 are allocated in an arbitrary way to one of the plug devices DP1 to PD10 and the counterpart plug devices CPD1 to CPD10. Further electrical connections for power supply of low noise power amplifier systems LNAG1, LNAG2, LNAG3, LNAG4 and switches SW1, SW2 and control signals for the switches SW1, SW2, which may be allocated to the plug device PD11 and the counterpart plug device CPC11, are not shown in Figure 8 for simplification.

[0065] Devices of transmit paths Tx1-SS1, Tx2-SS1 and receive paths Rx1-SS1, Rx2-SS1, Rx3-SS1, Rx4-SS1 of the further signal processing apparatus PP2 between the counterpart connection apparatus FC and antenna ports OP1-AE1, OP2-AE2, OP3-AE3, OP4-AE4 are preferably located within a housing HS1-1 such as a composite plastic and aluminium sheet metal housing. The antenna elements AE1 to AE4 are preferably located inside the housing HS1-2 such as a PVC housing (PVC = polyvinyl chloride) or a fiberglass housing. The signal processing apparatus PP1 is preferably located within housing HS2 such as an aluminium die cast housing. In a further preferred embodiment, the antenna elements AE1 to AE4 may be connected to the antenna ports OP1-AE1, OP2-AE2, OP3-AE3, OP4-AE4 of the further signal processing apparatus PP2 by non-detachable connections. Thereby no passive inter-modulation radio frequency signals may be generated. In case of detachable

connections, such passive inter-modulation radio frequency signals may be generated due to the connections becoming unfasten or untighten.

[0066] The further signal processing apparatus PP2 contains within a first transmit path Tx1-SS1 first means DF1 for filtering amplified first radio frequency signals in the first transmit path Tx1-SS1. Thereby, unwanted radio frequency signals which may be generated for example by a non-perfect contacting for electrical connection EC2 between the connection apparatus MC and the counterpart connection apparatus FC of the detachable connection due to passive intermodulation are attenuated or suppressed. The first means DF1 for filtering the amplified first radio frequency signals may be for example a first duplex filter DF1 such as shown in Figure 8, which separates a single electrical connection for transmit signals and receive signals between the first duplex filter DF1 and a first antenna element AE1 into the first transmit path Tx1-SS1 and a first receive path Rx1-SS1. The first duplex filter DF1 may contain a band-pass filter, which lets passing the transmit signals within a frequency band licensed by an operator of a radio communication system and which attenuates or blocks the transmit signals outside the frequency band. Instead of the first duplex filter DF1 a single filter may be applied, if the first antenna element AE1 may be only used for transmitting radio frequency signals. In case of a TDD application, the first duplex filter DF1 may be replaced by a single filter such as a single bandpass filter.

[0067] Equally, the further signal processing apparatus PP2 further contains within a second transmit path Tx2-SS1 second means DF2 for filtering further amplified first radio frequency signals in the second transmit path Tx2-SS1. Thereby, further unwanted radio frequency signals, which may be generated for example by a non-perfect contacting for electrical connection EC6 between the connection apparatus MC and the counterpart connection apparatus FC of the detachable connection due to passive intermodulation are attenuated or suppressed. The second means DF2 for filtering the further amplified first radio frequency signals may be for example a second duplex filter DF2 such as shown in Figure 8, which separates a single electrical connection for transmit signals and receive signals between the second duplex filter DF2 and a second antenna element AE2 into the second transmit path Tx2-SS1 and a second receive path Rx2-SS1. The second duplex filter DF2 may contain a band-pass filter, which lets passing the transmit signals within the frequency band licensed by the operator and which attenuates or blocks the transmit signals outside the frequency band. Instead of the second duplex filter DF2 a single filter may be applied, if the second antenna element AE2 may be only used for transmitting radio frequency signals. In case of a TDD application, the second duplex filter DF2 may be replaced by a further single filter such as a single bandpass filter.

[0068] The first transmit path Tx1-SS1 contains an electrical connection between a first input port IP1-SS1

located at the counterpart connection apparatus FC and the first duplexer DF1, the first duplexer DF1, an electrical connection between the first duplexer DF1 and a first directional coupler DC1, the first directional coupler DC1, an electrical connection between the first directional coupler DC1 and a first antenna port OP1-AE1 for the first antenna element AE1. Preferably, an electrical connection between the first antenna port OP1-AE1 and the first antenna element AE1 may be a fixed non-detachable connection. This means, the first antenna element AE1 may be a part of the further signal processing apparatus PP2.

[0069] The first receive path Rx1-SS1 contains the electrical connection between the first antenna port OP1-AE1 and the first directional coupler DC1, the first directional coupler DC1, the electrical connection between the first directional coupler DC1 and the first duplex filter DF1, the first duplex filter DF1, preferably an electrical connection between the first duplex filter DF1 and a first low noise power amplifier system LNA1, preferably the first low noise power amplifier system LNA1, preferably an electrical connection between the first low noise power amplifier system LNA1 and a first output port OP1-SS1. The first low noise power amplifier system LNA1 may contain two low noise power amplifiers connected in series such as shown in Figure 8. Alternatively, a single low noise power amplifier or a low noise power amplifier system with more than two low noise power amplifiers may be applied.

[0070] The second transmit path Tx2-SS1 contains an electrical connection between a second input port IP2-SS1 located at the counterpart connection apparatus FC and the second duplexer DF2, the second duplexer DF2, an electrical connection between the second duplexer DF2 and a second directional coupler DC2, the second directional coupler DC2, an electrical connection between the second directional coupler DC2 and a second antenna port OP2-AE2 for the second antenna element AE2. Preferably, an electrical connection between the second antenna port OP2-AE2 and the second antenna element AE2 may be a fixed non-detachable connection. This means, the second antenna element AE2 may be a part of the first subsystem SS1.

[0071] The second receive path Rx2-SS1 contains the electrical connection between the second antenna port OP2-AE2 and the second directional coupler DC2, the second directional coupler DC2, the electrical connection between the second directional coupler DC2 and the second duplex filter DF2, the second duplex filter DF2, preferably an electrical connection between the second duplex filter DF2 and a second low noise power amplifier system LNA2, preferably the second low noise power amplifier system LNA2, and preferably an electrical connection between the second low noise power amplifier system LNA2 and a second output port OP2-SS1. The second low noise power amplifier system LNA2 may contain two low noise power amplifiers connected in series such as shown in Figure 8. Alternatively, a single

low noise power amplifier or a low noise power amplifier system with more than two low noise power amplifiers may be applied.

[0072] Preferably, the further signal processing apparatus PP2 contains means for providing at the at the first output port OP1-SS1 and the second output port OP2-SS1 of the receive paths Rx1-SS1 and Rx2-SS1 a power level of the received second radio frequency signals within a predefined range to a power level of the amplified first radio frequency signals at the first input port IP1-SS1 and the second input port IP2-SS1 of the transmit paths Tx1-SS1 and Tx2-SS1. Preferably, the predefined range is between -130 dB and -100 dB. Preferably, the first low noise amplifier system LNA1 and the second low noise amplifier system LNA2 are applied for this purpose of providing at the at the first output port OP1-SS1 and the second output port OP2-SS1 of the receive paths Rx1-SS1 and Rx2-SS1 the power level of the received second radio frequency signals within the predefined range.

[0073] The further signal processing apparatus PP2 as exemplarily shown in Figure 8 further contains a third receive path Rx3-SS1 and a fourth receive path Rx4-SS1. The third and the fourth receive path Rx3-SS1, Rx4-SS1 contain electrical connections between antenna ports OP3-AE3, OP4-AE4, directional couplers DC3, DC4, electrical connections between the directional coupler DC3, DC4 and filters F3, F4, the filters F3, F4, preferably electrical connections between the filters F3, F4 and low noise power amplifier systems LNA3, LNA4, preferably the low noise power amplifier systems LNA3, LNA4, and preferably electrical connections between the low noise power amplifier systems LNA3, LNA4 and output ports OP3-SS1, OP4-SS1. The low noise power amplifier systems LNA3, LNA4 may contain two low noise power amplifiers connected in series such as shown in Figure 8. Alternatively, single low noise power amplifiers or low noise power amplifier systems with more than two low noise power amplifiers may be applied. The filters F3, F4 are single bandpass filters or a combination of multiple bandpass filters.

[0074] The further signal processing apparatus PP2 further contains a first switch SW1 enabling access to the radio frequency signals of the two pairs of directional couplers DC1, DC2 being attached to the filters DF1 and DF2, a second switch SW2 for enables access to the two pairs of directional couplers DC3, DC4 being attached to the filters F3 and F4, a first integrated circuit or a first microcontroller IC1 with a first computer program product and a second integrated circuit or a second microcontroller IC2 with a second computer program product. The first computer program product and the second computer program product may be used for controlling the switches SW1, SW2 and for providing inventory data for the further signal processing apparatus PP2. The first and the second switch SW1, SW2 may be for example FETs (FET = Field Effect Transistor).

[0075] Preferably, all devices of the further signal processing apparatus PP2 fulfill a predefined minimum

reliability. The predefined minimum reliability may be for example a maximum failure rate per year, a maximum mean time between failures or a minimum year over year return rate. The maximum failure rate per year may be for example 1 percent of installed first subsystems per year. Exemplarily, the devices of the further signal processing apparatus PP2 fulfill following reliabilities: The low noise power amplifier systems LNAG1 to LNAG4 fulfill a reliability of 0.003 % per year. The duplex filters DF1, DF2 fulfill a reliability of 0.2% per year. The filter F3, F4 fulfill a reliability of 0.1 % per year. The directional couplers DC1 to DC4 fulfill a reliability of 0.01 % per year. The switches SW1, SW2 fulfill a reliability of 0.003 % percent per year. The integrated circuits or microcontrollers IC1, IC2 fulfill a reliability of 0.01 % per year. The first and the second computer program product fulfill a reliability of 1 min outage per year. The reliability of the first and the second computer program products mainly depend on a complexity of instruction of the computer program product and an effort, which has been spent for debugging to test almost all possible combinations of input parameters, which are used by the computer program product, to avoid a program crash for example in case of a division by zero.

[0076] Voltage supplies and connections for voltage supply of the devices of the further signal processing apparatus PP2 are not shown in Figure 8 for simplification. Preferably, the further signal processing apparatus PP2 does not contain any voltage supplies and voltage supply is provided by one or several voltage supplies of the signal processing apparatus PP1.

[0077] The signal processing apparatus PP1 contains a power amplifier system PAS in a first transmit path Tx1-SS2 and a second transmit path Tx2-SS2. The power amplifier system PAS contains a first power amplifier P1 and a directional coupler DC5 for the first transmit path Tx1-SS2 and a second power amplifier P2 for the second transmit path Tx2-SS2 and a directional coupler DC6 for the second transmit path Tx2-SS2. The directional couplers DC5, DC6 are used for a pre-distortion of the transmit signals. Instead of the power amplifier system PAS separate power amplifiers may be applied for the first transmit path Tx1-SS2 and the second transmit path Tx2-SS2. In further alternatives, two or more power amplifiers may be applied for the first transmit path Tx1-SS2 and the second transmit path Tx2-SS2. In even further alternatives, only a single power amplifier may be contained in the signal processing apparatus PP1, if the signal processing apparatus PP1 contains only a single transmit path.

[0078] The signal processing apparatus PP1 further may further contain a processing unit PU and two converters CV1, CV2, which are connected by electrical connections to the processing unit PU. The converter CV1, CV2 are part of a so-called CPRI (CPRI = Common Public Radio Interface) for transmitting I/Q samples in a form of electrical or optical signals. The optical fibers FB1, FB2 may be connected to the converters CV1, CV2. The con-

verters CV1, CV2 contain optical detectors for converting optical signals into electrical signals and contain optical emitters such as LEDs (LED = Light Emitting Diode) or small lasers for converting electrical signals into optical signals. The processing unit PU is primarily used for controlling an adaptation of the transmit signals for example by pre-distortion means and/or clipping means.

[0079] Digital transmit signals may be provided from the processing unit PU to a first transmitter unit TU1 of the first transmit path Tx1-SS2 and to a second transmitter unit TU2 of the second transmit path Tx2-SS2 (corresponding electrical connections are not shown in Figure 8 for simplification). The transmitter units TU1, TU2 convert the digital transmit signals into analogue transmit signals and perform an up mixing from a low frequency to a high frequency in a range of for example MHz or GHz. Digital receive signals may be provided from receiver units RU1, RU2, RU3, RU4 to the processing unit PU (corresponding electrical connections are also not shown in Figure 8 for simplification). The receiver units RU1, RU2, RU3, RU4 convert analogue receive signals into digital receive signals and perform a down mixing from the high frequency in the range of for example MHz or GHz to a low frequency as known from active antenna units in the prior art.

[0080] The signal processing apparatus PP1 further contains with respect to the first transmit path Tx1-SS2, the first transmitter unit TU1, an electrical connection from the first transmitter unit TU1 to the power amplifier system PAS, the power amplifier system PAS, and an electrical connection from the power amplifier system PAS to a first output port OP1-SS2.

[0081] Equally, the signal processing apparatus PP1 further contains with respect to the second transmit path Tx2-SS2, the second transmitter unit TU2, an electrical connection from the second transmitter unit TU2 to the power amplifier system PAS, the power amplifier system PAS, and an electrical connection from the power amplifier system PAS to a second output port OP2-SS2.

[0082] The signal processing apparatus PP1 further contains with respect to receive paths Rx-SS2, Rx2-SS2, Rx3-SS2, Rx4-SS2 electrical connections from input ports IP1-SS2, IP2-SS2, IP3-SS2, IP4-SS2 to attenuators AT1, AT2, AT3, AT4, the attenuators AT1, AT2, AT3, AT4, electrical connections from the attenuators AT1, AT2, AT3, AT4 to intermediate amplifiers IA1, IA2, IA3, IA4, the intermediate amplifiers IA1, IA2, IA3, IA4, electrical connections from the intermediate amplifiers IA1, IA2, IA3, IA4 to the receiver units RU1, RU2, RU3, RU4 and the receiver units RU1, RU2, RU3, RU4. The attenuators AT1, AT2, AT3, AT4 are used for enabling a power level adjustment of the receive signals at an input of the intermediate amplifiers IA1, IA2, IA3, IA4.

[0083] According to a first alternative, the attenuators AT1, AT2, AT3, AT4 may be located in the further signal processing apparatus PP2 instead of being located in the signal processing apparatus PP1. According to a second alternative, the attenuators AT1, AT2, AT3, AT4, the

electrical connections between the attenuators AT1, AT2, AT3, AT4 and the intermediate amplifiers IA1, IA2, IA3, IA4 and the intermediate amplifiers IA1, IA2, IA3, IA4 may be located in the further signal processing apparatus PP2 instead of being located in the signal processing apparatus PP1.

[0084] The signal processing apparatus PP1 as exemplarily shown in Figure 8 further contains a switch SW3, a generator TG for providing a test signal and a test receiver TR. The switch SW3, the generator TG and the test receiver TR are applied for predistortion, self-testing of the receive paths Rx1-SS1 to Rx4-SS1 and Rx1-SS2 to Rx4-SS2 and the transmit paths Tx1-SS1, Tx2-SS1, Tx1-SS2, Tx2-SS2 including the connection apparatus MC and the counterpart connection apparatus FC, and calibration of the receive paths Rx1-SS1 to Rx4-SS1 and Rx1-SS2 to Rx4-SS2 and the transmit paths Tx1-SS1, Tx2-SS1, Tx1-SS2, Tx2-SS2.

[0085] The first output port OP1-SS1 of the further signal processing apparatus PP2 is connected by the electrical connection EC1 with the first input port IP1-SS2 of the signal processing apparatus PP1. The first output port OP1-SS2 of the signal processing apparatus PP1 is connected by the electrical connection EC2 with the first input port IP1-SS1 of the further signal processing apparatus PP2. The second output port OP2-SS2 of the signal processing apparatus PP1 is connected by the electrical connection EC6 with the second input port IP2-SS1 of the further signal processing apparatus PP2. The second output port OP2-SS1 of the further signal processing apparatus PP2 is connected by the electrical connection EC7 with the second input port IP2-SS2 of the signal processing apparatus PP1. The third output port OP3-SS1 of the further signal processing apparatus PP2 is connected by the electrical connection EC8 with the third input port IP3-SS2 of the signal processing apparatus PP1. The fourth output port OP4-SS1 of the further signal processing apparatus PP2 is connected by the electrical connection EC10 with the fourth input port IP4-SS2 of the signal processing apparatus PP1.

[0086] The first switch SW1 of the further signal processing apparatus PP2 is connected by the electrical connection EC5 with the third switch SW3 of the signal processing apparatus PP1. The second switch SW2 of the further signal processing apparatus PP2 is connected by the electrical connection EC9 with the third switch SW3 of the signal processing apparatus PP1.

[0087] Electrical connections between the processing unit PU and the generator TG and between the processing unit PU and the test receiver TR are not shown in Figure 8 for simplification.

[0088] The signal processing apparatus PP1 further contains a single power supply or a single voltage transformer or several voltage supplies or several voltage transformers for the devices contained in the further signal processing apparatus PP2 and for the devices contained in the signal processing apparatus PP1. This means, that no power supplies or voltage transformer

are required within the further signal processing apparatus PP2. The devices of the further signal processing apparatus PP2 are supplied by the power supplies or voltage transformers of the signal processing apparatus PP1 via corresponding electrical connections via the connection apparatus MC and the counterpart connection apparatus FC. Such electrical connections are not shown in Figure 8 for simplification.

[0089] In addition an inlet filter with surge protection may protect the power supplies or voltage transformers of the signal processing apparatus PP1 and may reduce at a power inlet switching noise. Isolated DC/DC converters are combined in series with one or several non-isolated DC/DC converters. This means for example that the first power amplifier P1 and the second power amplifier P2 may be directly supplied by one isolated DC/DC converter -48V to 28V, the other devices of the further signal processing apparatus PP2 and the signal processing apparatus PP1 may be supplied by one isolated DC/DC converter -48V to 5V plus several non-isolated DC/DC converters providing lower voltages. The power supply of the low noise power amplifiers systems LNAG1 to LNAG2 of the further signal processing apparatus PP2 is derived from one of power rails of the signal processing apparatus PP1. The signal processing apparatus PP1 contains one or several devices for current limitation and supply voltage filtering supplying the first and the second low noise amplifier systems LNAG1, LNAG2 of the further signal processing apparatus PP2. Such well-known voltage components may have a high failure risk and are therefore preferably located only within the signal processing apparatus PP1.

[0090] The further signal processing apparatus PP2 may have a first weight, which exceeds a predefined maximum weight, which is also called a one man lift weight. The one man lift weight is usually given by legal requirements. The one man lift weight may be for example 20 kg or 30 kg. The signal processing apparatus PP1 preferably has a second weight, which is equal to or below the one man lift weight. The second weight may be adjusted by shifting functional units such as the attenuators AT1 to AT4 from the signal processing apparatus PP1 to the further signal processing apparatus PP2.

Claims

1. A connection apparatus (MC) for connecting at least two signal lines (SL1, ..., SL5, SLG) to at least two further signal lines, said connection apparatus (MC) comprising:
 - said at least two signal lines (SL1, ..., SL5, SLG),
 - a first plug device (PD1) connected to a first one of said at least two signal lines (SL1, ..., SL5, SLG),
 - at least a second plug device (PD2, ..., PD11)

- connected to a second one of said at least two signal lines (SL1, ..., SL5, SLG), and
 - a movably mounted support system (MMSS) for a movable support of said first plug device (PD1) and said at least second plug device (PD2, ..., PD11).
2. Connection apparatus (MC) according to claim 1, wherein said movably mounted support system (MMSS) comprises a stationary part (SP), at least one movable part (MP1) and a supporting part (SP), wherein said first plug device (PD1) and said at least second plug device (PD2, ..., PD11) are mounted to said supporting part (SP) and wherein said at least one movable part (MP1) provides a mobility of said supporting part (SP) in reference to said stationary part (SP).
 3. Connection apparatus (MC) according to claim 2, wherein said at least one movable part (MP1) is at least one spring, wherein said supporting part (SP) comprises at least one first opening (OP1-1), wherein said movably mounted support system (MMSS) further comprises at least one first guiding pin (GP1-1), and wherein said at least one first guiding pin (GP1-1) is located within said at least one spring and within said at least one first opening (OP1-1) for guiding a movement of said at least one spring and said supporting part (SP).
 4. Connection apparatus (MC) according to claim 3, wherein said movably mounted support system (MMSS) further comprises at least one fastener (F1, ..., F4), wherein said at least one first guiding pin (GP1-1) comprises at least one second opening (OP2-1), wherein said at least one fastener (F1, ..., F4) is inserted into said at least one first opening (OP1-1) and said at least one second opening (OP2-1) and is mounted to said at least one guiding pin (GP1-1) by compressing said spring.
 5. Connection apparatus (MC) according to claim 4, wherein said at least one fastener (F1, ..., F4) is at least one screw and wherein said at least one second opening (OP2-1) is a blind hole with a female screw thread.
 6. Connection apparatus (MC) according to any of the preceding claims 3, 4 and 5, wherein said at least one first guiding pin (GP1-1) is mounted to said stationary part (SP) by a screw fitting (SF).
 7. Connection apparatus (MC) according to any of the preceding claims 2 to 6, wherein said movably mounted support system (MMSS) further comprises at least two further movable parts (MP2, MP3, MP4), wherein said at least one movable part (MP1) and a first one of said at least two further movable parts (MP2, MP3, MP4) are arranged in a plane perpendicular to a plug-in direction (D1) of said first plug device (PD1) and said at least second plug device (PD2, ..., PD11) and at opposing ends of a largest longitudinal extension (SL1) of said supporting part (SP) and wherein a second one of said at least two further movable parts (MP2, MP3, MP4) is further arranged in said plane and in a direction (SL2) perpendicular to said largest longitudinal extension (SL1).
 8. Connection apparatus (MC) according to any of the preceding claims 2 to 7, wherein said supporting part (SP) is a supporting plate.
 9. Connection apparatus (MC) according to any of the preceding claims 2 to 8, wherein said supporting part (SP) comprises at least one second guiding pin (GP2-1, GP2-2) adapted to be inserted into a third opening (OP3-1, OP3-2) of a counterpart connection apparatus (FC) of said connection apparatus (MC), and wherein a periphery part (PP) of the connection apparatus (MC) surrounding said movably mounted support system (MMSS) comprises at least one third guiding pin (GP3-1, GP3-2) adapted to be inserted into a fourth opening (OP4-1, OP4-2) of said counterpart connection apparatus (FC).
 10. Connection apparatus (MC) according to any of the preceding claims, wherein said connection apparatus (MC) has an outer shape of a male connector.
 11. A signal processing apparatus (PP1) for radio frequency signals, electrical signals and/or optical signals comprising a connection apparatus (MC) according to any of the preceding claims.
 12. Signal processing apparatus (PP1) according to claim 11, wherein said connection apparatus (MC) is part of a housing (HS) of said signal processing apparatus (PP1).
 13. Signal processing apparatus (PP1) according to any of the preceding claims 11 and 12, wherein said signal processing apparatus (PP1) is a part of a modular active antenna system (MAAS) and wherein said part of said modular active antenna system (MAAS) comprises at least one power amplifier (P1, P2) in a transmit path of said modular active antenna system (MAAS).
 14. A modular active antenna system (MAAS) comprising a signal processing apparatus (PP1) according to claim 13 and a further signal processing apparatus (PP2) that comprises at least one low noise amplifier (LNAG1, LNAG2, LNAG3, LNAG4) in a receive path of said modular active antenna system (MAAS).

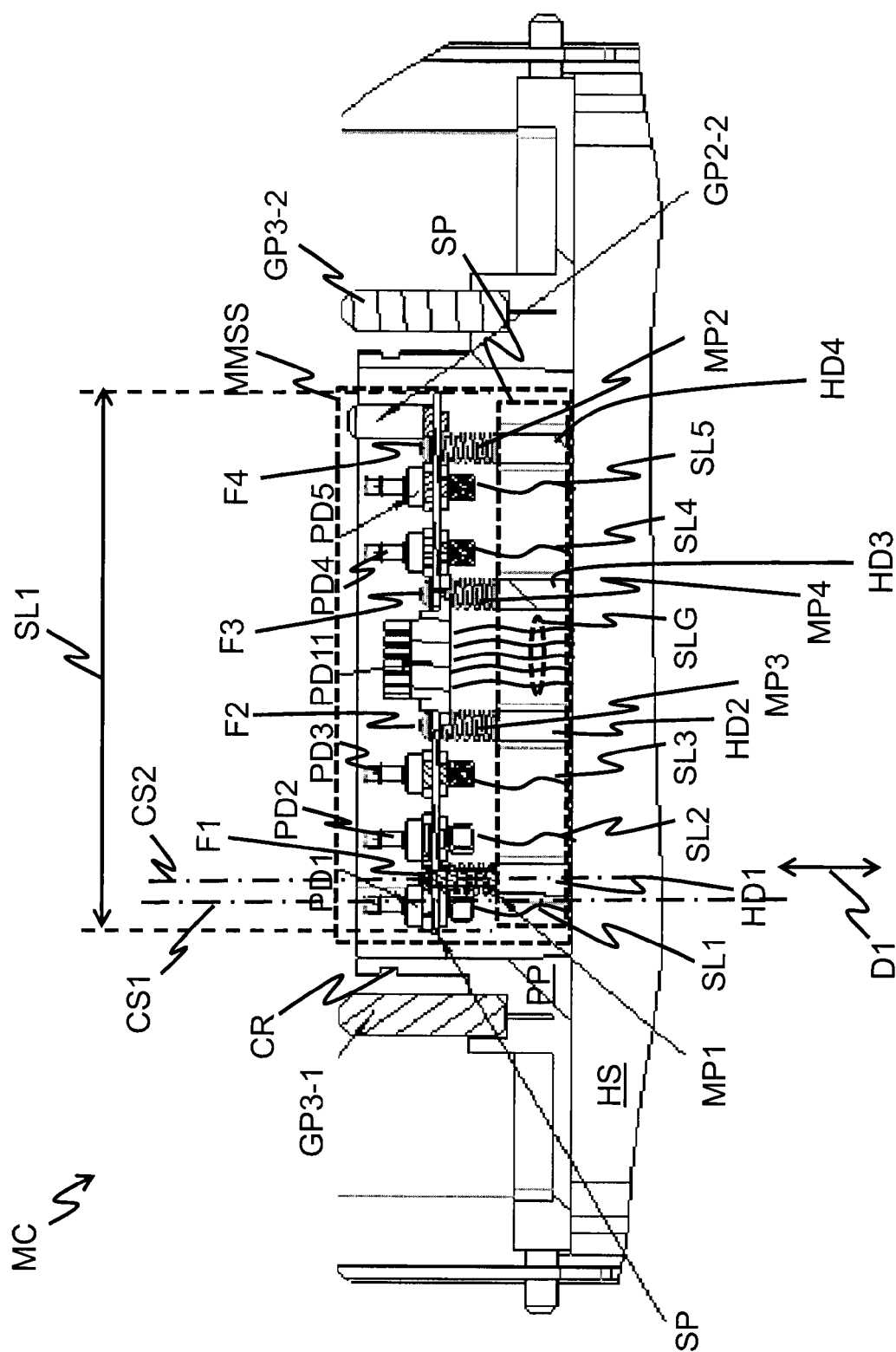
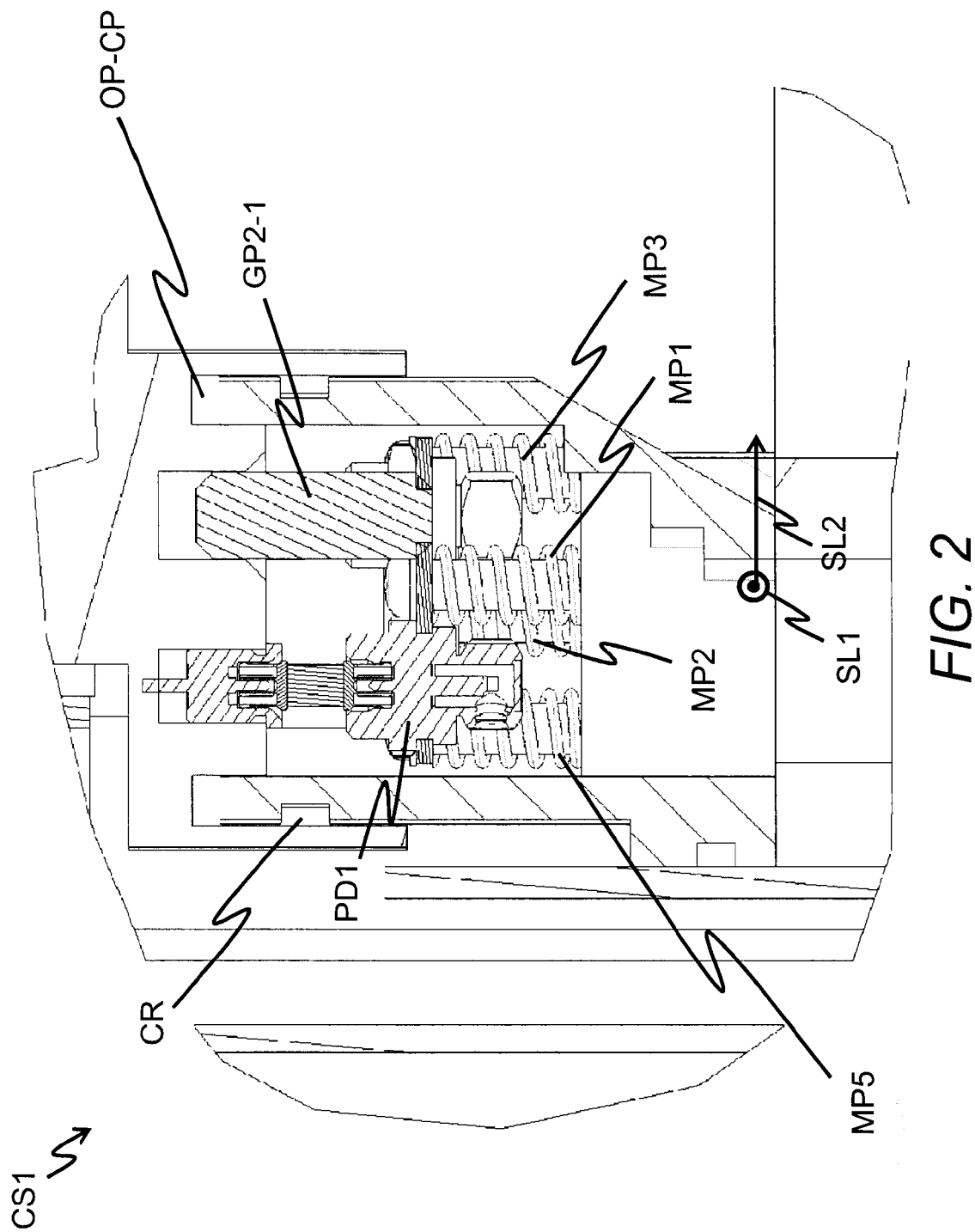
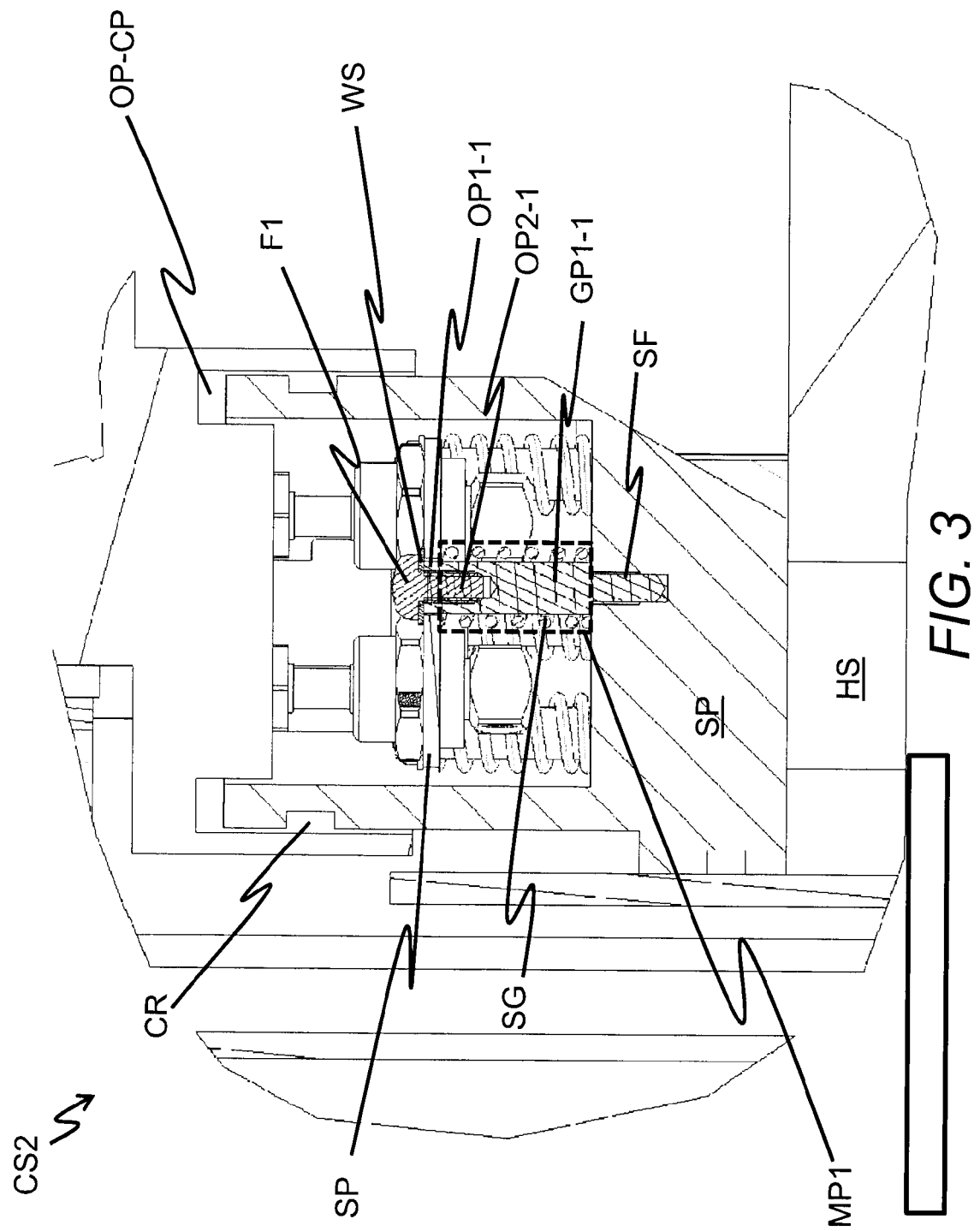


FIG. 1





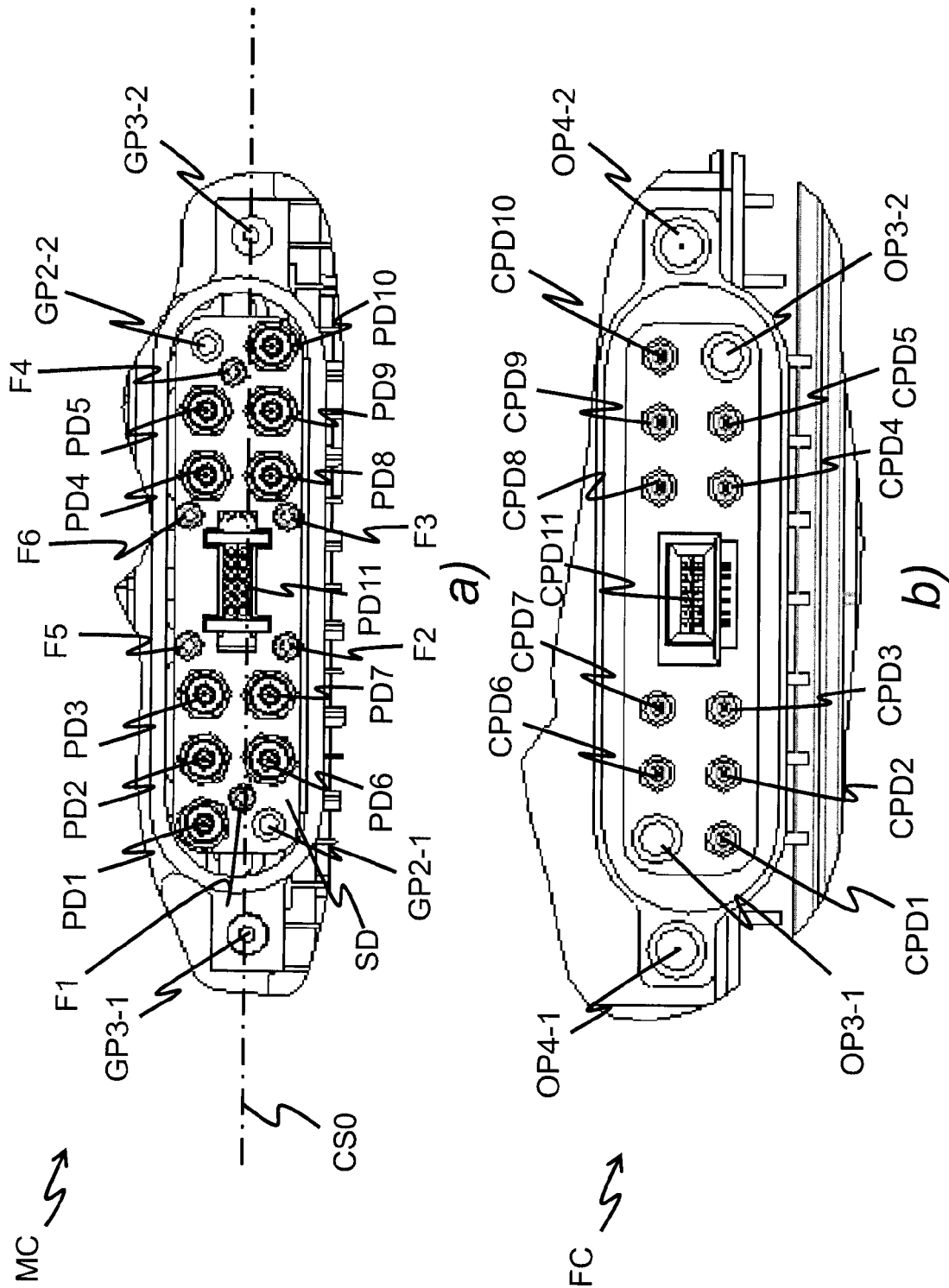


FIG. 4

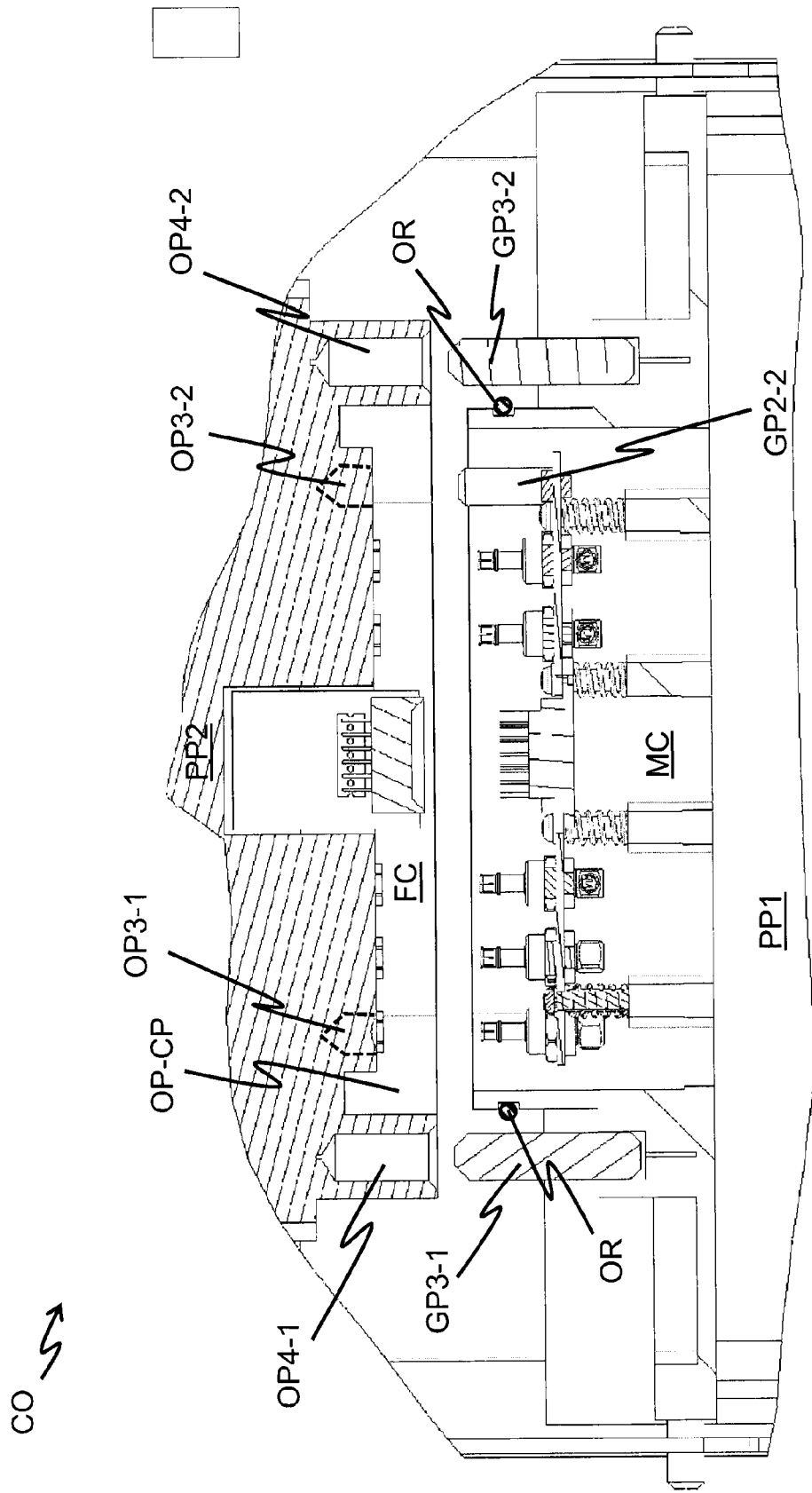


FIG. 5

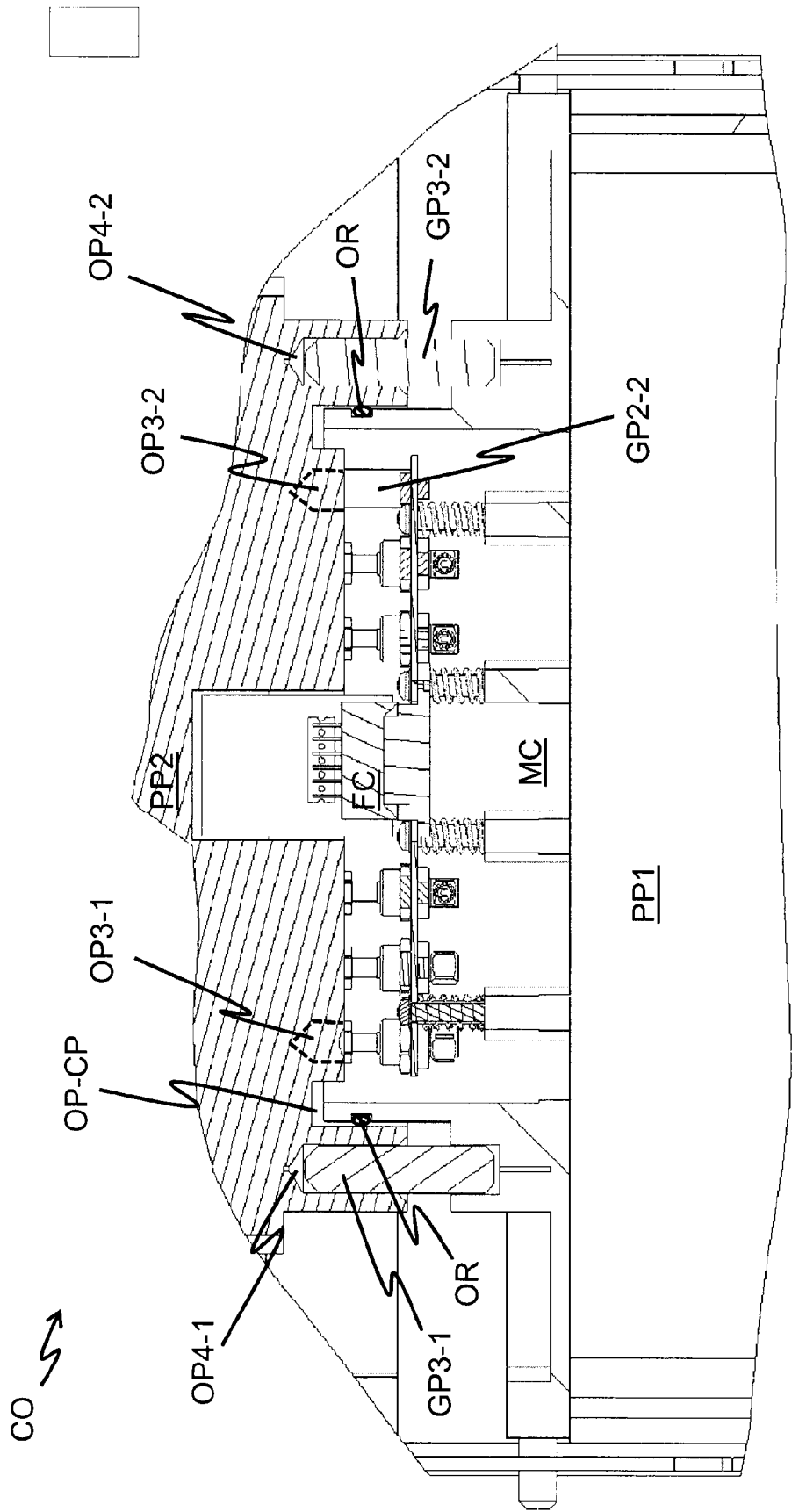


FIG. 6

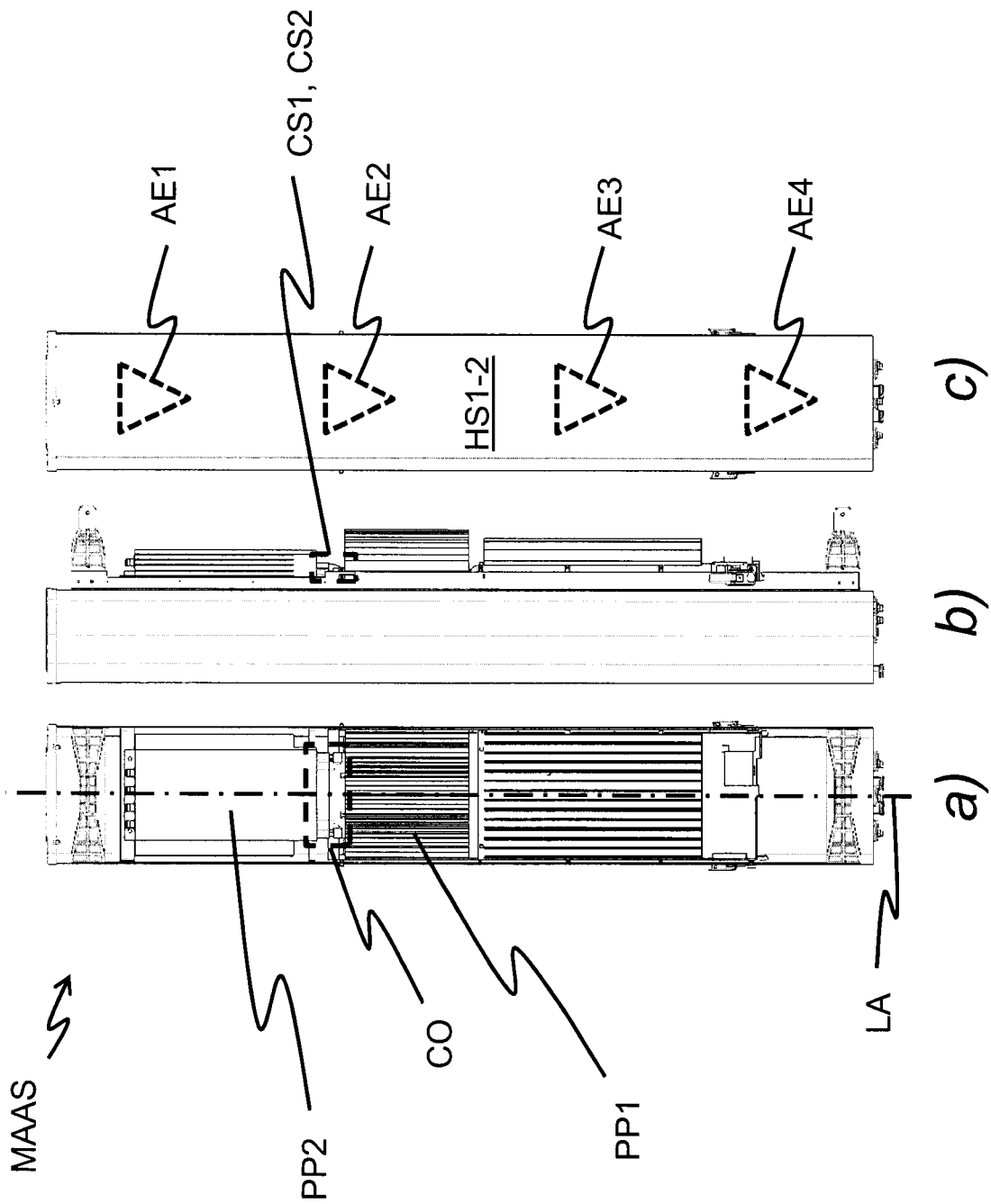


FIG. 7

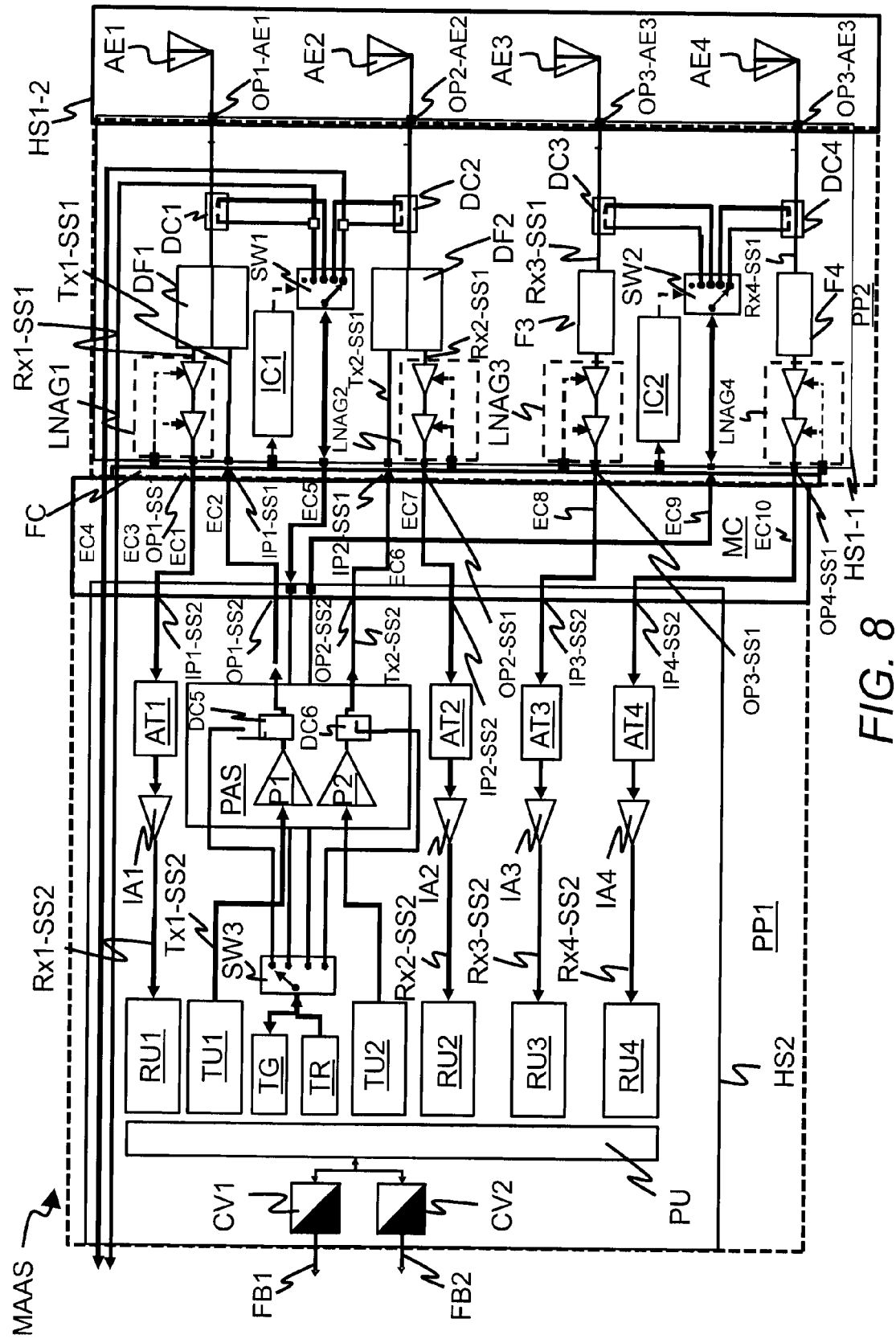


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 12 30 6577

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The Hague		11 April 2013	Criqui, Jean-Jacques
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11-04-2013

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