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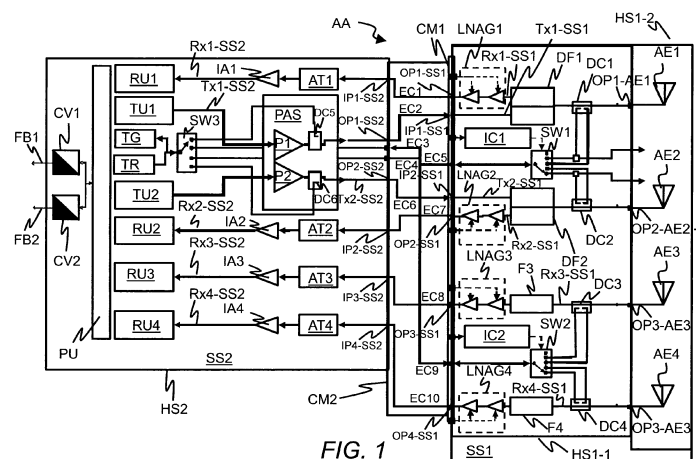
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(57) The invention relates to a first subsystem (SS1) for an active antenna unit (AA). The first subsystem (SS1) contains first connecting means (CM1) of a detachable connection of the active antenna unit (AA) adapted to connect to second connecting means (CM2) of a second subsystem (SS2) for the active antenna unit (AA), at least one input port (IP1-SS1, IP2-SS1) at the first connecting means (CM1) connected to at least one transmit path (Tx1-SS1, Tx2-SS1) for receiving amplified first radio frequency signals from at least one output port (OP1-SS2, OP2-SS2) of the second subsystem (SS2), means (DF1, DF2) for filtering the amplified first radio frequency signals in the at least one transmit path (Tx1-SS1, Tx2-SS1), and the at least one transmit path (Tx1-SS1, Tx2-SS1) for providing the amplified and filtered first radio frequency signals to at least one antenna element (AE1, AE2).

The invention further relates to a second subsystem (SS2) for an active antenna unit (AA). The second subsystem (SS2) contains at least one transmit path (Tx1-SS2, Tx2-SS2) for radio frequency signals, at least one power amplifier (P1, P2) in the at least one transmit path (Tx1-SS2, Tx2-SS2) for generating amplified radio frequency signals, at least one output port (OP1-SS2, OP2-SS2) connected to the at least one transmit path (Tx1-SS2, Tx2-SS2) at second connecting means (CM2) for providing the amplified radio frequency signals to at least one input port (IP1-SS1, IP2-SS1) of the first subsystem (SS1), and the second connecting means (CM2) of a detachable connection adapted to connect to first connecting means (CM1) of a first subsystem (SS1) for the active antenna unit (AA). The invention even further relates to an antenna array unit (AA), which contains the first subsystem (SS1) and the second subsystem (SS2).

**FIG. 1****EP 2 713 436 A1**

Description

FIELD OF THE INVENTION

[0001] The embodiments of the invention relate to radio communication and more particularly but not exclusively to an active antenna unit.

BACKGROUND

[0002] In mobile communication networks, an active antenna unit is always 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 first subsystem for an active antenna unit. The first subsystem contains first connecting means of a detachable connection of the active antenna unit adapted to connect to second connecting means of a second subsystem for the active antenna unit, at least one input port at the first connecting means connected to at least one transmit path for receiving amplified first radio frequency signals from at least one output port of the second subsystem, means for filtering the amplified first radio frequency signals in the at least one transmit path, and the at least one transmit path for providing the amplified and filtered first radio frequency signals to at least one antenna element. The object is further achieved by the second subsystem for the active antenna unit. The second subsystem contains at least one transmit path for radio frequency signals, at least one power amplifier in the at least one transmit path for generating amplified radio frequency signals, at least one output port connected to the at least one transmit path at second connecting means for providing the amplified radio frequency signals to at least one input port of the first subsystem, and the second connecting means of a detachable connection adapted to connect to first connecting means of a first subsystem for the active antenna unit. The object is even further achieved by the antenna array, which contains the first subsystem and the second subsystem.

[0007] The detachable connection may be for example a single plug connection, a single screw connection, or several plug and/or screw connections. The first connection means may contain for example a single male connector or several male connectors for electrical connections between the first subsystem and the second subsystem and the second connection means may contain for example a single female connector or several female connectors adapted to connect to the one male connector or the several male connectors. In a first alternative, the first connection means may contain a single female connector or several female connectors and the second connection means may contain a single male connector or several male connectors adapted to connect to the single female connector or the several female connectors. In a second alternative, the first connection means may contain a single male connector or several male connectors for a first group of electrical connections between the first subsystem and the second subsystem and a single female connector or several female connectors for a second group of electrical connections between the first subsystem and the second subsystem and the second connection may contain a single female connector or several female connectors for the first group of electrical connections and a single male connector or several male connectors for the second group of electrical connections.

[0008] The embodiments of the invention provide a first

benefit of eliminating by the means for filtering the amplified first radio frequency so-called unwanted out-of-band signals, which have frequency components outside a frequency band, which is licensed to an operator of the mobile communication network. Such signals are generated primarily by a power amplifier in the transmit path of the active antenna unit. Such signals also contain so-called passive inter-modulation radio frequency signals, which may be generated at metal surfaces of fabricated connections, of fabricated devices and the detachable connection between the first subsystem and the second subsystem by a non-optimal contacting. The embodiments of the invention provide a second benefit of providing the possibility to exchange the second subsystem without requiring exchanging the first subsystem, when the active antenna unit shall be modified to transmit radio frequency signals of a mobile communication standard, which is different to a currently used mobile communication standard. The embodiments of the invention provide a third benefit of facilitating a replacement of the active antenna unit, if a device of the second subsystem shows a failure. In such a case, only the second subsystem needs to be replaced and the first subsystem can be kept in its original position. The embodiments of the invention provide a fourth benefit of requiring testing of the first subsystem regarding a possible emission of the unwanted signals only once after fabrication of the first subsystem and before installation of the active antenna unit and not during replacement of the second subsystem. The embodiments of the invention provide a fifth benefit of not requiring highly skilled technicians for the replacement of the second subsystem. The first connecting means and the second connection means provide the possibility of facilitating a separation of the second subsystem from the first subsystem and an assembly of the second subsystem to the first subsystem by using the first and the second connecting means without requiring to cut electrical wires or cables or optical fibres and to weld or to solder the electrical wires or to weld the optical fibres for repairing the electrical cables and wires or the optical fibres after a replacement of the second subsystem. Furthermore, all electrical connections can be verified regarding an optimal operation by a self-test of the second subsystem. This provides the benefit of not requiring high skilled service technicians for replacing the second subsystem. The embodiments of the invention provide a sixth benefit of reducing replacement costs and thereby CAPEX (CAPEX = Capital expenditure) of a radio communication system.

[0009] According to a preferred embodiment, the means for filtering the amplified first radio frequency signals is at least one high frequency filter. The at least one high frequency filter may be for example a single bandpass filter or a combination of multiple bandpass filters (e.g. a duplex filter). The bandpass filter may provide a bandpass, which corresponds to a frequency range, which is licensed by an operator of the radio communication system. The preferred embodiment provides the

advantage, that no extra filter device is required in the transmit path within the first subsystem, in case of the detachable connection may be located between the high frequency filter of the first subsystem and an antenna port of the first subsystem.

[0010] According to a further preferred embodiment, the first subsystem (SS1) further contains at least one output port at the first connecting means connected to at least one receive path for receiving second radio frequency signals that have been received at the at least one antenna element, the at least one receive path for providing the received second radio frequency signals from the at said at least one antenna element to the at least one output port, and means for providing at the at least one output port 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 at least one input port. Preferably, the predefined range is between -130 dB and -100 dB. Preferably, the first subsystem further contains in the receive path for the radio frequency signals a single low noise amplifier or two or more low noise amplifiers connected in series for providing the power level of the receive path at the first connecting means within the predefined range. The further preferred embodiment provides the benefit that at the detachable connection a difference of the power levels in the transmit path and the receive path is reduced and that a degrading effect of a cross coupling of radio frequency signals from the transmit path of the active antenna unit to the receive path of the active antenna unit can be minimized or even eliminated.

[0011] According to an even further preferred embodiment, the first subsystem further contains the at least one antenna element and the at least one antenna element is connected to the first subsystem by a non-detachable connection. In known active antenna units one or several antenna elements are connected to the active antenna units by a detachable connection, which is located between a radio frequency filter and the one or several antenna elements. By locating the detachable connection between the one or several power amplifiers of the second subsystem and the means for attenuating the passive inter-modulation radio frequency signals of the transmit path of the first subsystem, the even further preferred embodiment provides the advantage, that passive inter-modulation radio frequency signals can be only generated at the detachable connection at an input of the means for attenuating the passive inter-modulation radio frequency signals and therefore can be attenuated to an uncritical level. When a detachable connection is used between the radio frequency filter and the one or several antenna elements as in known active antenna units, no device can be applied for attenuating such passive inter-modulation radio frequency signals. It is only possible, to measure output signals of the one or several antenna elements and to adjust the detachable connection until the passive inter-modulation radio frequency signals are reduced to an uncritical level. Such a meas-

urement and test procedure requires highly skilled technicians and takes a long time so that large costs arise, when the interface between the known active antenna unit and the one or several antenna elements needs to be released and reconnected.

[0012] According to a further preferred embodiment, the first subsystem fulfils or exceeds a predefined reliability. The predefined 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. The failure rate of components or devices depends on physical or chemical characteristics such as fracture toughness, electric strength, chemical resistance against aggressive substances, aging resistance of materials such as rubber or plastic, etc. Other factors, which influence the failure rate of components or devices of the active antenna unit are temperature, stress, vibration, moisture and energy-rich radiation such as X-radiation or gamma radiation, cosmic rays or solar wind. Inner factors of the active antenna unit, which also influence the failure rate are heat losses, mechanical internal stress, electrical current density and electrical field strength. Characteristics of a device which influence the reliability of the device are for example a working temperature range. Heat sources, which influence the working temperature of a device are the outdoor temperature and internal conversion process, which transfer electromagnetic energy into thermal energy. When the device is operated outside a predefined working temperature range or at an end of the predefined working temperature range, a probability for a device failure may increase.

[0013] The devices of the first subsystem are subject to a smaller thermal stress than the devices of the second subsystem, because a low noise amplifier of the first subsystem is usually operated at about 85 °C, whereas a high power amplifier of the second subsystem is operated above 100 °C. Preferably, devices with a low complexity (e.g. small number of solder joints), with a sufficient robustness against thermal stress and low power consumption are located within the first subsystem.

[0014] Known active antenna units are fabricated as a single subsystem which is located in a casing or housing. Even if most devices of the single subsystem achieve the predefined reliability, the complete active antenna unit needs to be replaced, when a single device such as a high power amplifier of the transmit path fails. Therefore, the further preferred embodiment provides the advantage, that all devices of the first subsystem does not need to be replaced if for example the power amplifier of the transmit path within the second subsystem is defect or does not fulfill the required performance anymore. It is only required to replace the second subsystem because the first subsystem should work without outage time until the end of the product cycle of the active antenna unit. First devices of the first subsystem may be high-quality devices, which may have been tested com-

prehensively before installation regarding a fulfilment of the predefined reliability. Therefore, the one or several first devices have a long operation time without any failures preferably within the product cycle of the active antenna unit. Second devices of the second subsystem may be low-quality devices, which may have been installed without any long testing procedure.

[0015] According to an even further preferred embodiment, the second subsystem further contains a single power supply or several power supplies or a single voltage transformer or several voltage transformers as known from conventional active antenna units for devices of the first subsystem such as low noise power amplifiers. The even further preferred embodiment provides the benefit of enabling the repair of the power supplies and voltage transformers supplying the first subsystem by simply replacing the second subsystem. This provides the further benefit, that the first subsystem does not contain any error-prone power supplies or voltage transformers..

[0016] According to a further preferred embodiment, the second subsystem has a weight below or equal to a predefined maximum weight a human is allowed to carry according to a legal requirement. Preferably, the predefined maximum weight may be a so-called one man lift weight such as 20 kg or 30 kg. A weight of known active antenna units exceeds a weight, which a single person can carry or is allowed to carry according to legal requirements. A split of the active antenna unit in the first subsystem and the second subsystem and the weight of the second subsystem below or equal to the predefined maximum weight facilitates a replacement of the second subsystem by a single technician without any lifting equipment, if the second subsystem shows a failure or needs to be replaced for a system upgrade such an upgrade to a new radio communication standard.

[0017] Further advantageous features of the invention are defined and are described in the following detailed description of the invention.

BRIEF DESCRIPTION OF THE FIGURE

[0018] The embodiments of the invention will become apparent in the following detailed description and will be illustrated by accompanying figure given by way of non-limiting illustrations.

Figure 1 shows a block diagram of an active antenna unit according to an embodiment of the invention.

Figure 2 shows three lateral views of the active antenna unit according to the embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0019] 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.

[0020] 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. 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.

[0021] 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.).

[0022] 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.

[0023] 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. Figure 1 shows a block diagram of an active antenna unit AA for transmitting and receiving radio frequency signals via antenna elements AE1 to AE4. The active antenna unit AA is shown for an FDD transmission scheme (FDD = Frequency Division Duplex). In an alternative, by replacing duplex filters DF1, DF2 as shown in Figure 1 with single filters and switches as known in the prior art, the active antenna unit may be modified to be used for a TDD transmission scheme (TDD = Time Division Duplex).

[0024] The embodiment is exemplarily shown with four

antenna elements AE1 to AE4 and 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 radio frequency signals. In further alternatives, the active antenna unit AA 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 active antenna unit AA may be adapted for receiving the 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.

[0025] The active antenna unit AA is split into a first subsystem SS1 and a second subsystem SS2. This means, the active antenna unit AA contains the first subsystem SS1, the second subsystem SS2 and a detachable connection between the first subsystem SS1 and the second subsystem SS2. The detachable connection is adapted to separate the second subsystem SS2 from the first subsystem SS1 and to assemble the second subsystem SS2 to the first subsystem SS1 and may contain for example one or several plug connections for electrical connections EC1 to EC10 between the first subsystem SS1 and the second subsystem SS2. The electrical connections EC1 to EC10 may be provided for example by cables such as coaxial cables, which are connected to corresponding ports of the first subsystem SS1 and the second subsystem SS2.

[0026] Alternatively, the detachable connection may contain one or several screw connections for the electrical connections EC1 to EC10 between the first subsystem SS1 and the second subsystem SS2. According to further alternatives the electrical connections EC1 to EC10 between the first subsystem SS1 and the second subsystem SS2 may be provided by a mixture of one or several plug connections and one or several screw connections.

[0027] The first subsystem SS1 contains first connection means CM1 and the second subsystem SS2 contains second connection means CM2. The first connection means CM1 may contain for example a single male connector or several male connectors for the electrical connections EC1 to EC10 between the first subsystem SS1 and the second subsystem SS2 and the second connection means CM2 may contain for example a single female connector or several female connectors adapted to connect to the one male connector or the several male connectors of the first connection means CM1. In a first alternative, the first connection means CM1 may contain a single female connector or several female connectors and the second connection means CM2 may contain a single male connector or several male connectors adapted to connect to the single female connector or the several female connectors of the first connection means CM1. In a second alternative, the first connection means

CM1 may contain a single male connector or several male connectors for a first group of the electrical connections EC1 to EC10 between the first subsystem SS1 and the second subsystem SS2 and a single female connector or several female connectors for a second group of the electrical connections EC1 to EC10 between the first subsystem SS1 and the second subsystem SS2 and the second connection means CM2 may contain a single female connector or several female connectors for the first group of the electrical connections EC1 to EC10 and a single male connector or several male connectors for the second group of the electrical connections EC1 to EC10.

[0028] Devices of transmit paths Tx1-SS1, Tx2-SS1 and receive paths Rx1-SS1, Rx2-SS1, Rx3-SS1, Rx4-SS1 of the first subsystem SS1 between the first connecting means CM1 and antenna ports OP1-AE1, OP2-AE2, OP3-AE3, OP4-AE4 are preferably located within a first housing HS1-1 such as a composite plastic and aluminium sheet metal housing. The antenna elements AE1 to AE4 are preferably located inside a second housing HS1-2 such as a PVC housing (PVC = polyvinyl chloride) or a fiberglass housing. The second subsystem SS2 is preferably located within a third 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 first subsystem SS1 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.

[0029] The first subsystem SS1 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 first contacting means CM1 and the second contacting means CM2 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 1, 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.

[0030] Equally, the first subsystem SS1 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 first contacting means CM1 and the second contacting means CM2 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 1, 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.

[0031] The first transmit path Tx1-SS1 contains an electrical connection between a first input port IP1-SS1 located at the first contacting means CM1 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 first subsystem SS1.

[0032] 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 1. 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.

[0033] The second transmit path Tx2-SS1 contains an electrical connection between a second input port IP2-SS1 located at the first contacting means CM1 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.

[0034] 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 1. 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.

[0035] Preferably, the first subsystem SS1 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.

[0036] The first subsystem SS1 as exemplarily shown in Figure 1 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 1. 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.

[0037] The first subsystem SS1 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 first subsystem SS1. The first and the second switch SW1, SW2 may be for example FETs (FET = Field Effect Transistor).

[0038] Preferably, all devices of the first subsystem SS1 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 first subsystem SS1 fulfill following reliabilities: The low noise power amplifier systems LNA1 to LNA4 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.

[0039] Voltage supplies and connections for voltage supply of the devices of the first subsystem SS1 are not shown in Figure 1 for simplification. Preferably, the first subsystem SS1 does not contain any voltage supplies and voltage supply is provides by one or several voltage supplies of the second subsystem SS2.

[0040] The second subsystem SS2 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 second subsystem SS2, if the second subsystem SS2 contains only a single transmit path.

[0041] The second subsystem SS2 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. Optical fibers FB1, FB2 may be connected to the converters CV1, CV2. The converters 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.

[0042] 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 1 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 1 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.

[0043] The second subsystem SS2 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.

[0044] Equally, the second subsystem SS2 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.

[0045] The second subsystem SS2 further contains with respect to receive paths Rx1-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.

[0046] According to a first alternative, the attenuators AT1, AT2, AT3, AT4 may be located in the first subsystem SS1 instead of being located in the second subsystem SS2. 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 first subsystem SS1 instead of being located in the second subsystem SS2.

[0047] The second subsystem SS2 as exemplarily shown in Figure 1 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 first connecting means CM1 and the second connecting means CM2, 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.

[0048] 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 1 for simplification.

[0049] The second subsystem SS2 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 first subsystem SS1 and for the devices contained in the second subsystem SS2. This means, that no power supplies or voltage transformer are required within the first subsystem SS1. The devices of the first subsystem SS1 are supplied by the power supplies or voltage transformers of the second subsystem SS2 via corresponding electrical connections via the first and the second connections means CM1, CM2. Such electrical connections are not shown in Figure 1 for simplification.

[0050] In addition an inlet filter with surge protection may protect the power supplies or voltage transformers

of the second subsystem SS2 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 first subsystem SS1 and the second subsystem 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 LANG2 of the first subsystem SS1 is derived from one of power rails of the second subsystem SS2. The second subsystem SS2 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 first subsystem SS1. Such well-known voltage components may have a high failure risk and are therefore preferably located only within the second subsystem SS2.

[0051] The first subsystem SS1 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 second subsystem SS2 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 second subsystem SS2 to the first subsystem SS1.

[0052] Figure 2a) shows a first lateral view of the active antenna unit AA on a side of the active antenna unit AA, where the antenna elements AE1 to AE4 are located. Figure 2b) shows a second lateral view (rotated by 90° along a longitudinal axis of the active antenna unit AA with respect to Figure 2a), which shows a preferred location of the first subsystem SS1 and the second subsystem SS2. Figure 2c) shows a third lateral view (rotated by 90° along a longitudinal axis of the active antenna unit AA with respect to Figure 2b), which also shows the preferred location of the first subsystem SS1 and the second subsystem SS2.

[0053] The description and drawing merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

[0054] Functional blocks denoted as "means for ..." (performing a certain function) shall be understood as functional blocks comprising circuitry that is adapted for performing or to perform a certain function, respectively. Hence, a "means for s.th." may as well be understood as a "means being adapted or suited for s.th.". A means being adapted for performing a certain function does, hence, not imply that such means necessarily is performing the function (at a given time instant).

[0055] The functions of the various elements shown in the Figures, including any functional blocks labeled as "means", "means for connecting", "connection means", "means for attenuating", "predistortion means", "clipping means" etc., may be provided through the use of dedicated hardware, such as "a connector", "an attenuator", "a filter", "a clipping unit", "a predistortion unit" etc. as well as hardware capable of executing software in association with appropriate software. Moreover, any entity described herein as "means", may correspond to or be implemented as "one or more modules", "one or more devices", "one or more units", etc. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non volatile storage. Other hardware, conventional and/or custom, may also be included. Similarly, any switches shown in the Figures are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the implementer as more specifically understood from the context.

[0056] It should be appreciated by those skilled in the art that any block diagram herein represent conceptual views of illustrative circuitry embodying the principles of the invention.

Claims

1. A first subsystem (SS1) for an active antenna unit (AA), said first subsystem (SS1) comprises:
 - first connecting means (CM1) of a detachable connection of said active antenna unit (AA) adapted to connect to second connecting means (CM2) of a second subsystem (SS2) for said active antenna unit (AA),
 - at least one input port (IP1-SS1, IP2-SS1) at said first connecting means (CM1) connected to

- at least one transmit path (Tx1-SS1, Tx2-SS1) for receiving amplified first radio frequency signals from at least one output port (OP1-SS2, OP2-SS2) of said second subsystem (SS2),
 - means (DF1, DF2) for filtering said amplified first radio frequency signals in said at least one transmit path (Tx1-SS1, Tx2-SS1), and
 - said at least one transmit path (Tx1-SS1, Tx2-SS1) for providing said amplified and filtered first radio frequency signals to at least one antenna element (AE1, AE2).
2. First subsystem (SS1) according to claim 1, wherein said means (DF1, DF2) for filtering said amplified first radio frequency signals is at least one high frequency filter.
 3. First subsystem (SS1) according to claim 2, wherein said at least one high frequency filter is a single band-pass filter.
 4. First subsystem (SS1) according to any of the preceding claims, wherein said first subsystem (SS1) further comprises:
 - at least one output port (OP1-SS1, OP2-SS1) at said first connecting means (CM1) connected to at least one receive path (Rx1-SS1, Rx2-SS1) for receiving second radio frequency signals that have been received at said at least one antenna element (AE1, AE2),
 - said at least one receive path (Rx1-SS1, Rx2-SS1) for providing said received second radio frequency signals from said at said at least one antenna element (AE1, AE2) to said at least one output port (OP1-SS1, OP2-SS1), and
 - means (LNAG1, LNAG2) for providing at said at least one output port (OP1-SS1, OP2-SS1) a power level of said received second radio frequency signals within a predefined range to a power level of said amplified first radio frequency signals at said at least one input port (IP1-SS1, IP2-SS1).
 5. First subsystem (SS1) according to claim 4, wherein said predefined range is between -130 dB and - 100 dB.
 6. First subsystem (SS1) according to claim 4 or claim 5, wherein said means (LNAG1, LNAG2) for providing said power level of said received second radio frequency signals within said predefined range is at least one low noise amplifier (LNAG1, LNAG2).
 7. First subsystem (SS1) according to any of the preceding claims, wherein said first subsystem (SS1) further comprises said at least one antenna element (AE1, AE2) and wherein said at least one antenna element (AE1, AE2) is connected to said first subsystem (SS1) by a non-detachable connection.
 8. First subsystem (SS1) according to any of the preceding claims, wherein said first subsystem (SS1) fulfils or exceeds a predefined reliability.
 9. First subsystem (SS1) according to claim 8, wherein said predefined reliability is either of the following: a maximum failure rate per year, a maximum mean time between failures, a minimum year over year return rate.
 10. First subsystem (SS1) according to claim 9, wherein said maximum failure rate per year is 1 percent of installed first subsystems per year.
 11. A second subsystem (SS2) for an active antenna unit (AA), said second subsystem (SS2) comprises:
 - at least one transmit path (Tx1-SS2, Tx2-SS2) for radio frequency signals,
 - at least one power amplifier (P1, P2) in said at least one transmit path (Tx1-SS2, Tx2-SS2) for generating amplified radio frequency signals,
 - at least one output port (OP1-SS2, OP2-SS2) connected to said at least one transmit path (Tx1-SS2, Tx2-SS2) at second connecting means (CM2) for providing said amplified radio frequency signals to at least one input port (IP1-SS1, IP2-SS1) of said first subsystem (SS1), and
 - said second connecting means (CM2) of a detachable connection adapted to connect to first connecting means (CM1) of a first subsystem (SS1) for said active antenna unit (AA).
 12. Second subsystem (SS2) according to claim 11, wherein said second subsystem (SS2) further comprises at least one voltage transformer or power supply for said first subsystem (SS1).
 13. Second subsystem (SS2) according to claim 11 or claim 12, wherein said second subsystem (SS2) has a weight below or equal to a predefined maximum weight a human is allowed to carry according to a legal requirement.
 14. Second subsystem (SS2) according to claim 13, wherein said predefined maximum weight is 20 kg or 30 kg.
 15. An active antenna unit (AA) comprising a first subsystem (SS1) according to any of the claims 1 to 10 and a second subsystem (SS2) according to any of the claims 11 to 14.

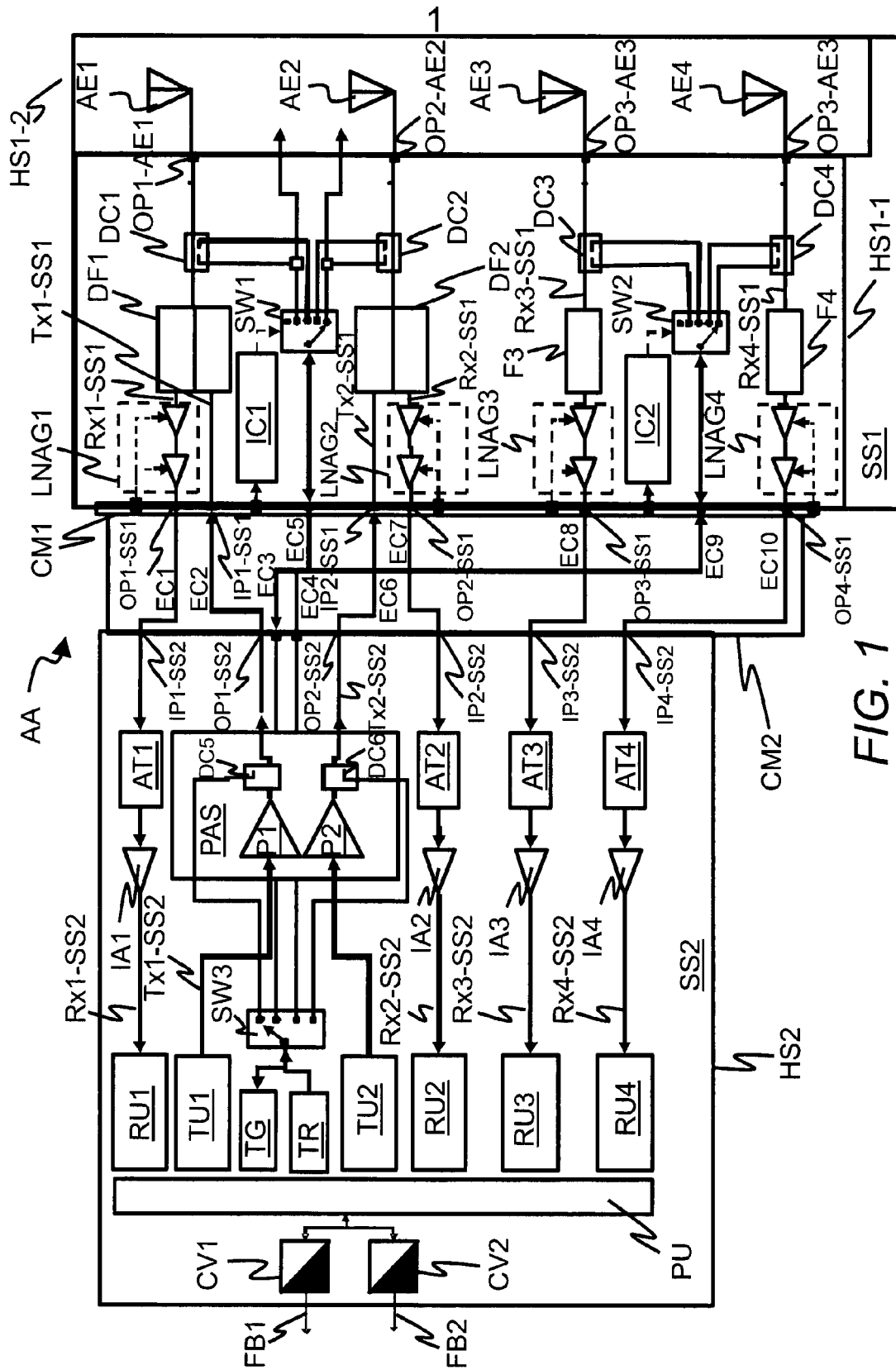


FIG. 1

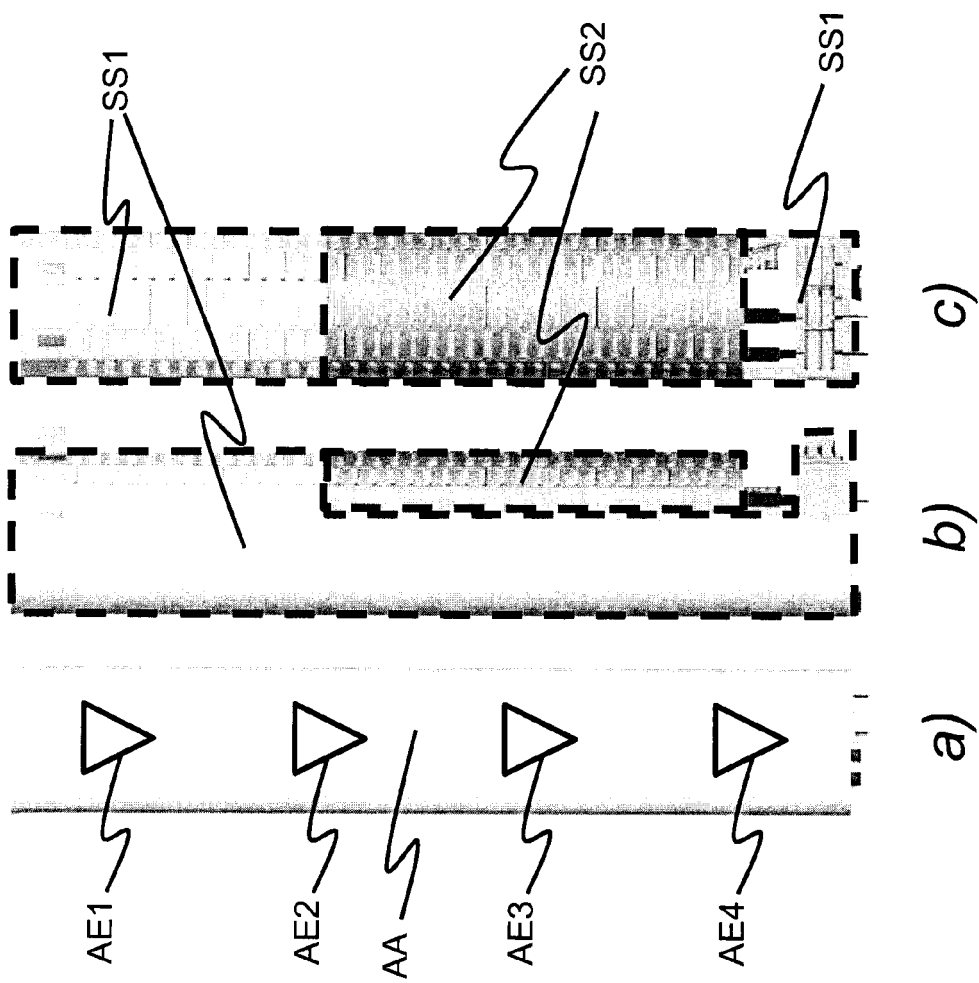


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 12 30 6181

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