and a second splitter; to split, by each of the first and second splitter, a respective one of the applied precoded signals into two or more split precoded signals; to receive, in a combiner, one of the two or more split precoded signals from the first splitter, and one of the two or more split precoded signals from the second splitter; and to transmit, by a single one of the active antenna devices the received split precoded signals.

In one embodiment, a computer program product is provided comprising the computer program and a computer readable means on which the computer program is stored.

Further features and advantages thereof will become clear upon reading the following description and the accompanying drawings.

Brief description of the drawings

Figures 1 and 2 illustrate short-comings of prior art.

Figure 3 illustrates a first embodiment of the antenna arrangement.

Figure 4 illustrates antenna element diagrams of the embodiment of figure 3.

Figure 5 illustrates a second embodiment of the antenna arrangement and antenna element diagram.

Figure 6 illustrates a third embodiment of the antenna arrangement.

~~Figure 7 illustrates precoding beams for an embodiment of the invention and for a prior art arrangement.~~

Figure ~~8~~ 7 illustrates a first simulation of radiation patterns.

Figure ~~9~~ 8 illustrates the radiation patterns of figure ~~8~~ 7 in another power scale.

Figure ~~10~~ 9 illustrates a second simulation of radiation patterns.

Figure ~~11~~ 10 illustrates a communication system in which the present invention may be implemented.

Figure ~~12~~ 11 illustrates a flow chart over steps of a method in accordance with the invention.

Detailed description of embodiments of the invention

Future wireless systems will most likely use active antennas at the base station. An active antenna is an antenna that has an amplifier built into it. This allows the amplifier to be extremely close to the antenna, which minimizes transmission line losses.

The invention provides an arrangement for pre-coding, and some background of pre-coding is therefore briefly described in the following. In a multiple-input multiple-output (MIMO) system a transmitting device and a receiving device use multiple antennas, thereby improving the data transmission rate. Precoding is used to improve the communication system capacity, exploiting spatial diversity by simultaneously sharing spatial channel with multiple users. The transmitter may use channel state information, often obtained from the user equipment, for processing the signals. The MIMO transmitter, e.g. antennas of a base station, transmits a

show that the invention reduces or even eliminates grating lobes.

Figure 8 illustrates the same radiation patterns as shown in figure 7 but wherein the power scale is linear instead of in dB as in figure 8. A user equipment 80 is placed in the direction of the precoding beam 81 and an angular spread of the user equipment 80 is shown. The angular spread of the user equipment 80 means the angular spread of transmission rays hitting the user equipment 80 and emanating from a base station comprising the active antenna arrangement 20, 30, 50. In the illustrated case, the angular spread of the user equipment 80 is larger than the beam width of the precoding beams, which means that transmission rays from the whole main beams will reach the user equipment 80. Thus, all or almost all the transmitted power will reach the user equipment 80, which is in contrast to the prior art as illustrated in figures 1 and 2, wherein almost half or even more of the transmitted power will be in the grating lobe 7.

Figure 9 illustrates a second simulation of radiation patterns. The precoding beams have here been steered 35 degrees out from broadside instead of 30 degrees. In this figure it is evident that the problem of grating lobes of the prior art becomes even more pronounced.

With reference to figure ~~11~~10, the invention also encompasses a base station 110 for a communication system 100. The communication system 100 may for example be a system conforming to the Long Term Evolution (LTE) standard, and further comprises user equipment 115 able to communication therein. Any other communication system standard in which precoded signals are or may be utilized

may also benefit from the present invention. The base station 110 comprises the active antenna arrangement 20, 30, 50 as described above.

It is noted that the precoding that is performed in or for the base station 110 can be linear or non-linear.

With reference to figure ~~12~~11, the invention also encompasses a method 150 performed in the base station 110, for example performed by a processor 111 in the base station 110. Such processor 111 is schematically illustrated in the figure. In the LTE communication system comprising eNodeB (evolved Node B), the processing may be done in the base station. In other communication systems, the processing could be done elsewhere in the communication system, for example in a base station transceiver (BST). The base station 110 comprises three or ore active antenna devices 21, 22, 23; 31, 32, 33, 34, 35; 51, 52, 53, 54, 55, 56, each comprising an antenna element 24 and a power amplifier 2. The method 150 comprises a first step of applying 151 a respective precoded signal to at least a first and a second splitter 26, 27; 41, 42, 43, 44; 63, 64, 65, 66.

The method 150 comprises a second step of splitting 152, by each of the first and second splitter, a respective one of the applied precoded signals into two or more split precoded signals.

The method 150 comprises a third step of receiving 153, in the combiner 28; 45, 46, 47; 57, 58, 59, 60, 61, 62, one of the two or more split precoded signals from the first splitter, and one of the two or more split precoded signals from the second splitter.

The method 150 comprises a fourth step of transmitting, by a single one of the active antenna devices (the received split precoded signals.

With reference again to figure ~~11~~10, the invention also encompasses a computer program 113 for the base station 110. The computer program 113 comprises computer program code which, when run on a processor 111 in the base station 110, causes the base station 110 to: apply a respective precoded signal to a first and a second splitter 26, 27; 41, 42, 43, 44; 63, 64, 65, 66; split, by each of the first and second splitter 26, 27, a respective one of the applied precoded signals into two or more split precoded signals; receive, in the combiner 28; 45, 46, 47; 57, 58, 59, 60, 61, 62, one of the two or more split precoded signals from the first splitter, and one of the two or more split precoded signals from the second splitter; and transmit, by a single one of the active antenna devices 21, 22, 23; 31, 32, 33, 34, 35; 51, 52, 53, 54, 55, 56 the received split precoded signals.

In an embodiment, a computer program product 112 is provided comprising the above-described computer program 113 a computer readable medium 114 on which the computer program 113 is stored.

The processor 111 may not only be a single CPU (central processing unit), but could comprise two or more processing units in the base station 110. For example, the processor 111 may comprise general purpose microprocessors, instruction set processors and/or related chips sets and/or special purpose microprocessors, such as ASICs (application specific integrated circuits). The processor 111 may also comprise board memory for caching purposes. The computer