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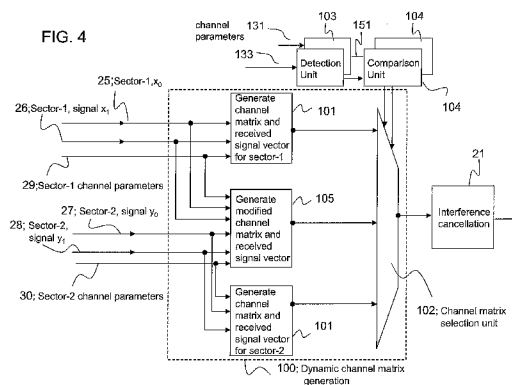
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(54) Title: SIGNAL PROCESSING FOR MULTI-SECTORED WIRELESS COMMUNICATIONS SYSTEM AND METHOD THEREOF



(57) Abstract: The present invention provides an apparatus and a method that realize dynamically processing signals received from multiple sectors to increase throughput of uplink communications in a multi-sectored wireless base station. The signal streams received from sector-1 (25) and (26) and signal streams received from sector-2 (27) and (28) are concentrated in a unit (105). Similarly, channel parameters (29) and (30) from sector-1 and sector-2, respectively, are used to create a modified channel matrix, dimension of which is much larger than that of each of channel matrices of respective sectors. Dynamic processing of signals received from multiple sectors is done by a detection unit (103) which receive channel parameters (131) and (133), and a comparison unit (104). Signals from a transmitting unit are detected within the signals received from two or more sectors, or the same signals are detected within the signal received from one sector. Based on the results of the comparison unit (104), a modified channel matrix and received signal vector from one sector is selected in a channel matrix selection unit (102) and used in a unit (21) to perform interference cancellation.

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## DESCRIPTION

SIGNAL PROCESSING FOR MULTI-SECTORED WIRELESS  
COMMUNICATIONS SYSTEM AND METHOD THEREOF

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## FIELD OF THE INVENTION

The present invention relates to a wireless communications system and method.

## 10 BACKGROUND OF THE INVENTION

Sectorization is a technique that has been used in mobile communications systems in order to minimize multiple access interference (MAI) and hence increase system capacity on each base station [Non-patent Documents 1, 2]. In this technique, a cell of a  
15 base station (BS) is divided into a plurality of sectors, and spatially separated mobile units in different sectors can use different channels or share the same channel. Here, the term channel refers to time, frequency, spreading code, interleaving pattern or any other definition as known in communications systems. Furthermore, each sector is  
20 serviced by one or more transmit and receive antennas. When adjacent sectors share the same channel, there arises a significant increase in interference among mobile units in the adjacent sectors. This kind of interference is detrimental to wireless communication, and as result throughput of data transmission between the base station and mobile  
25 units will be reduced.

In one of the related art [Patent Document 1], the base station determines an approximate location of a communication unit by comparing uplink signal received from each sector. Comparison is performed on the signal strength of the received uplink signals, although the comparison can be performed using other signal quality metrics such as BER (Bit Error Rate), Word Error Rate, CIR(Committed Information Rate), noise ratio. GPS (Global Positioning System) can also be used. This information can then be used to direct a narrower beam to a target mobile unit, and as result reducing interference. However, in uplink transmission, effect of multiple paths of transmission due to natural terrain will cause the uplink signal to be detected in signals received from multiple sectors. Furthermore, a spatially separated mobile unit may transmit a signal such that part of transmitted signal arrives at a base station in a direction that is very close to a target mobile unit.

Fig. 1 illustrates such a scenario, wherein signals from transmitting unit-1, (TU1) is transmitting through paths P1 and P2, wherein path (P2) involves a reflection at point B. Similarly, signal from transmitting unit-2, (TU2) is transmitted through paths P3.

As can be seen in Fig. 1, the direction of arrival of signal along P2 is almost the same as the signal along P3. In this situation, a very narrow beam may have to be created or the signal from this direction will be ignored completely. In practice, very narrow beams can only be created by using a large number of receiving antennas. Creating of such narrow beams ignores part of the transmitted signal that arrives in

overlapping directions with interfering signals, hence reducing the power of received signal and as result affecting the throughput of communication.

In another related art, signals from each sector are processed separately [Patent Document 2]. The processing involves demodulation and interference cancellation. Thereafter, the processed signals from the sectors are combined using Maximal Ratio Combining (MRC) [Non-patent Document 5]. Alternative methods of combining or selection can also be deduced from reference [Non-patent Document 6].

Fig. 2 illustrates such kind of a system. By combining target signal that is received from different sectors, overall signal to noise ratio is increased, hence increasing the throughput of a communications system. In addition, this technique of signal processing offers a reduced computational load in comparison to the method of creating beams that are much narrower than the size of a sector.

In multiple receive and transmit antenna system, interference cancellation, which is otherwise known as equalization can be done using different kind of algorithms [Non-patent Document 3].

As an example, in a typical Orthogonal Frequency Division Multiplexing (OFDM) based receiver [Non-patent Document 4], each subcarrier associated with each receive antenna of a given sector can be considered as a channel matrix  $H$ , resulting in a signal (vector)  $s_k$  that is given by

$$\mathbf{s}_k = \mathbf{H}_{k,i} \mathbf{x}_k + \mathbf{n}_{k,i} \quad (1)$$

where  $k$  is a subcarrier index that can take an integer value that is less than total number of available subcarriers,  $i$  is an index of a sector,  $\mathbf{H}_{k,i}$  is a channel matrix at subcarrier  $k$  and sector with index  $i$ ,  $\mathbf{x}_k$  is originally transmitted signal vector at subcarrier  $k$  and  $\mathbf{n}_{k,i}$  is a noise vector.

If we consider that Minimum Mean Square Error (MMSE) algorithm has been used to remove interference from received signal vector  $\mathbf{s}_k$  then the signal detected to have originated from the  $i$ th sector is given by (2)

$$\mathbf{x}_{k,i} = (\sigma^2 \mathbf{I} + \mathbf{H}_{k,i}^H \mathbf{H}_{k,i})^{-1} \mathbf{H}_{k,i}^H \mathbf{s}_k \quad (2)$$

In this expression, it has been assumed that channel matrix  $\mathbf{H}_{k,i}$  of  $i$ th sector at the  $k$ th subcarrier has been estimated by a channel estimation unit. There are several techniques by which this channel matrix  $\mathbf{H}_{k,i}$  can be estimated to an accurate level [Non-patent Document 8]. Having detected the original transmitted signal from a given transmitting unit, the next step is to combine all the signals that have been detected at different sectors. One way of doing this, is to utilize an optimum combination algorithm such as MRC [Non-patent Document 5].

Fig. 2 illustrates a general case in a signal flow diagram where symbols detected separately are combined to create symbols for

channel decoding, taking into consideration sector selection as described in [Patent Document 1]. The received signals at different sectors undergo preprocessing 11 and demodulation 12, respectively, and are combined by symbol combination 13 to generate a detected  
5 signal.

Fig.3 is a block diagram showing the configuration of the system shown in Fig.2. Referring to Fig.3, two signal streams (25) and (26) are associated with sector-1. In addition, channel parameters (29) are used together with the two streams (Sector-1, signal  $x_0$ ,  $x_1$ ) (25) and  
10 (26) to perform interference cancellation in unit (21-1). Similarly, two signal streams (Sector-2, signal  $y_0$ ,  $y_1$ ) (27) and (28) that are associated with sector-2, are used together with channel parameters (30) to perform interference cancellation in unit (21-2). The resulting  
15 cancelled are combined in combination unit (13). In practice, a detection unit (35) is also provided to generate information that is used to perform handover from one sector to another. Such kind of a handover is implemented using a selector (34) that select a signal among a combined signal (33), a signal from sector-1 (31) and a signal  
20 from sector-2 (32).

Detecting the location of a transmitting unit using the methods [Patent Document 1] mentioned earlier has its own disadvantage. Method based on signal to noise ratio involves generating a reference symbol and channel matrix, and this is computationally involving since  
25 it involves creating a kind of replica. Method based on BER involves

independently decoding signals detected from each sector.

In all the above-mentioned related arts, the base station does not dynamically utilize efficiently all information that is received from signal associated with each sector. In addition, there is a necessity to  
5 implement a simple algorithm for detecting if signal from a target-transmitting unit is available within the received signal associated with a given sector.

[Non-patent Document 1]

10 C.U. Saraydar and A. Yener, "Capacity Enhancement for CDMA Systems Through Adaptive Cell Sectorization," IEEE Wireless Communications and Networking Conference, vol.3, pp.139-1143, Sept., 1999.

[Non-patent Document 2]

15 N. Maeda, et al., "Throughput Comparison between VSF-OFCDM and OFDM Considering Effect of Sectorization in Forward Link Broadband Packet Wireless Access," IEEE VTC, vol.1, pp.47-51, Sept., 2002.

[Non-patent Document 3]

20 V.K. Lau, Channel Adaptive Technologies and Cross Layer Designs for Wireless Systems with Multiple Antennas, Wiley 2006.

[Non-patent Document 4]

L. Hanzo, OFDM and MC-CDMA, IEEE Press, Wiley, 2003.

[Non-patent Document 5]

25 A. F. Molisch, Wireless Communications, IEEE Press, Wiley,

2005.

[Non-patent Document 6]

S. Sanayei, et al., "Antenna Selection in MIMO Systems," IEEE Communications Magazine, Oct. 2004.

5 [Non-patent Document 7]

J. Wang and K. Araki, "Pilot-Symbol Aided Channel Estimation in Spatially Correlated Multiuser Channels," IEEE VTC, vol.1, pp.33-37, Sept., 2004.

[Non-patent Document 8]

10 J.G. Proakis, Digital Communications, 4th Edition, McGraw Hill.

[Patent Document 1]

US Patent No. 5,596,333

[Patent Document 2]

15 US Patent No. 5,625,876

[Patent Document 3]

US Patent No. 5,933,787

## SUMMARY OF THE DISCLOSURE

20 The entire disclosure of Patent Documents 1-3 and Non-patent Documents 1-8 are incorporated herein by reference thereto. The below is the result of the analysis by the present inventors.

Dynamical utilization of all information that is within the signals received from multiple sectors in a multi-sectored wireless base  
25 communication station is demanded.

In addition, implementation of a simple algorithm for detecting the presence of target signal in the signals received from multiple sectors is demanded.

Accordingly, it is an object of the present invention to provide  
5 an apparatus and a method that realize dynamically processing signals received from multiple sectors to increase throughput of uplink communications in a multi-sectored wireless base station.

The invention disclosed in this application is generally configured as follows.

10 According to one aspect of the present invention, there is provided a signal processing method in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectored coverage area; signal power gain between transmit and receive antennas of the transmitting units  
15 and the receiver within each sector being represented as a channel matrix with path gains; said method comprising:

combining a plurality of the channel matrices associated with respective sectors to generate a channel matrix which is larger than the channel matrices associated with respective sectors, and concatenating  
20 a plurality of received signal vectors associated with respective sectors to generate a received signal vector which is larger than the received signal vectors associated with respective sectors; and

using the generated channel matrix and the generated received signal vector, canceling interference from other transmitting unit  
25 sharing a given channel with a target transmitting unit.

According to another aspect of the present invention, there is provided a signal processing method in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectored coverage area; signal power gain between transmit and receive antennas of the transmitting units and the receiver within each sector being represented as a channel matrix with path gains; said method comprising:

determining if signal from a given target transmitting unit is available in the received signal of a sector;

if signal from said target transmitting unit is detected in at least two sectors,

combining a plurality of the channel matrices associated with respective sectors to generate a channel matrix which is larger than the channel matrices associated with respective sectors, and concatenating a plurality of received signal vectors associated with respective sectors to generate a received signal vector which is larger than the received signal vectors associated with respective sectors; and

using the generated channel matrix and the generated received signal vector, canceling interference from other transmitting unit sharing a given channel with said target transmitting unit;

while if signal from said target transmitting unit is detected in only one sector, canceling interference from the received signal from said transmitting unit, using said channel matrix and the received signal vector each associated with said one sector.

In the present invention, the step of determining if signals from

said target transmitting unit is available in the received signal of a sector comprises:

evaluating said path gain at subcarriers using a pilot signal specific to said target transmitting unit;

5 converting the estimated path gain of the subcarriers to a time domain impulse response ( $h_0, h_1, \dots, h_N$ );

separating said time domain impulse response into two parts, true impulse response: ( $h_0, h_1 \dots, h_L$ ) and false impulse response: ( $h_{L+1}, \dots, h_M$ ), wherein the first part corresponds to delay profile of a channel  
10 with a length corresponding to the delay spread;

evaluating the mean square value of said first part ( $h_0, h_1 \dots, h_L$ ) to obtain a first parameter (PCH);

evaluating the mean square value of said second part ( $h_{L+1}, \dots, h_M$ ) to obtain a second parameter (PNCH);

15 subtracting said second parameter (PNCH) from said first parameter (PCH) to obtain a third parameter (DNCH);

dividing said first parameter (PCH) with said third parameter (DNCH) to obtain a fourth parameter (RNCH); and

20 comparing said fourth parameter (RNCH) with a predetermined threshold, wherein if the comparison result indicates that said fourth parameter is greater than the threshold, it is determined that signal from the transmitting unit is in the signal received from a given sector.

In the present invention, the second part (false time domain impulse response) of the time domain impulse response is obtained by  
25 ignoring part of the impulse response that correspond to the channel

delay profile, and impulse response that arise from interfering mobile terminal.

In the present invention, the step of determining if signals from a given target transmitting unit is available in the received signal of a sector, comprises:

evaluating said path gain at the subcarriers of at least two different time slots, using a pilot signal that is specific to a given transmitting unit;

converting the estimated path gain of the subcarriers for each of the time slots to obtain an equivalent time domain channel impulse response;

for at least two of time slots, separating each of said time domain impulse responses into two parts,  $(h_0, h_1 \dots, h_L)$  and  $(h_{L+1}, \dots, h_N)$ , wherein the first part  $(h_0, h_1 \dots, h_L)$  has a length that corresponds to the delay spread of transmission channel;

evaluating a correlation parameter that has a correlation factor of at least said first part  $(h_0, h_1 \dots, h_L)$  of the first time slot and said first part  $(g_0, g_1 \dots, g_L)$  of any other time slot other than the first time slot; and

modifying said correlation parameter by additional signal processing to obtain a reference for comparison with a predetermined threshold, wherein if said reference parameter is greater than the threshold, it is determined that signal from the transmitting unit is in the signal received from a given sector.

In the present invention, correlation factor is an average of

correlation between true impulse response (first part of the channel impulse response) at two or more time slots.

In the present invention, the step of determining if signals from a given target transmitting unit is available in the received signal of a sector, comprises:

evaluating said path gain at the subcarriers of at least one or more time slots using a pilot signal that is specific to a given mobile unit;

evaluating a parameter that is a measure of how the path gains at different subcarriers within the same time slot, are correlated to one another; and

modifying said parameter by additional signal processing that includes either averaging or filtering to obtain a correlation parameter of a given transmitting unit and a given sector.

In the present invention, correlation parameter is modified by:

evaluating power of the first part ( $h_0, h_1 \dots, h_L$ ) of the channel impulse response at one or more time slots to obtain a normalization parameter; and

dividing normalization parameter with the correlation parameter to obtain a modified correlation parameter.

In the present invention, interference cancellation is performed using mean square error approach.

Alternatively, in the present invention, interference cancellation is performed using zero forcing approach.

Alternatively, in the present invention, interference cancellation

is performed using maximum likelihood detection approach.

According to another aspect of the present invention, there is provided a signal processing system in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectored coverage area; signal power gain between transmit and receive antennas of the transmitting units and the receiver within each sector being represented as a channel matrix with path gains; said system comprising:

a channel matrix generation unit that combines a plurality of the channel matrices associated with respective sectors to generate a channel matrix which is larger than the channel matrices associated with respective sectors, and concatenates a plurality of received signal vectors associated with respective sectors to generate a received signal vector which is larger than the received signal vectors associated with respective sectors; and

an interface cancellation unit that using the generated channel matrix and the generated received signal vector, cancels interference from other transmitting unit sharing a given channel with a target transmitting unit.

According to another aspect of the present invention, there is provided a signal processing system in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectored coverage area; signal power gain between transmit and receive antennas of the transmitting units and the receiver within each sector being represented as a channel

matrix with path gains; said system comprising:

a decision unit that determines if signal from a given target transmitting unit is available in the received signal of a sector;

a channel matrix generation unit that combines a plurality of the  
5 channel matrices associated with respective sectors to generate a  
channel matrix which is larger than the channel matrices associated  
with respective sectors, and concatenates a plurality of received signal  
vectors associated with respective sectors to generate a received signal  
vector which is larger than the received signal vectors associated with  
10 respective sectors; and

an interface cancellation unit that, if signal from said target  
transmitting unit is detected in at least two sectors, cancels  
interference from other transmitting unit sharing a given channel with  
said target transmitting unit, using the generated channel matrix and  
15 the generated received signal vector;

said interface cancellation unit canceling interference from the  
received signal from said transmitting unit, using said channel matrix  
and the received signal vector each associated with said one sector, if  
signal from said target transmitting unit is detected in only one sector.

20 In the present invention, the detection unit may comprise:

a channel estimation unit that evaluates frequency-domain path  
gain at subcarriers using pilot signal that is specific to a given mobile  
unit;

a time domain conversion unit that converts the estimated  
25 frequency domain path gain of the subcarriers to a time domain impulse

response ( $h_0, h_1, \dots, h_N$ );

a separation unit that separates said time domain impulse response into two parts, true impulse response: ( $h_0, h_1, \dots, h_L$ ) and false impulse response: ( $h_{L+1}, \dots, h_M$ ), where the true impulse response  
5 corresponds to delay spread of a channel;

a first mean gain evaluating unit that evaluates the mean square value of said first part ( $h_0, h_1, \dots, h_L$ ) to obtain a first parameter (PCH);

a second mean gain evaluating unit that evaluates the mean square value of said second part ( $h_{L+1}, \dots, h_M$ ) to obtain a second  
10 parameter (PNCH);

a subtraction unit that subtracts said second parameter (PNCH) from said first parameter (PCH) to obtain a third parameter (DNCH);

a division unit that divides said first parameter (PCH) with said third parameter (DNCH) to obtain a fourth parameter (RNCH); and

15 a comparison unit that compares said fourth parameter (RNCH) with a predetermined threshold,

if the comparison result indicates that said fourth parameter is greater than the threshold, deciding that signal from the mobile unit is said to be in the signal received from a given sector.

20 In the present invention, the separation unit generates a second part of the time domain impulse response that is obtained by ignoring part of the impulse response that correspond to the channel delay profile, and impulse response that arise from any interfering mobile unit.

25 In the present invention, the detection unit comprises:

a channel estimation unit that evaluates the frequency-domain path gain at subcarriers of at least two different time slots using a pilot signal that is specific to a given mobile unit;

a time domain conversion unit that converts the estimated  
5 frequency-domain path gain of the subcarriers for each of the time slots to obtain an equivalent time domain channel impulse response;

a separation unit that separates said time domain of at least two of the time slots into two parts, where said two parts of each of said time slots, the first part has a length that corresponds to the delay  
10 spread of transmission channel;

a correlation unit that evaluates a correlation between at least said first part ( $h_0, h_1 \dots, h_L$ ) of the first time slot and said first part ( $g_0, g_1 \dots, g_L$ ) of any other time slot other than the first time slot; and  
a correlation manipulation unit that modifies said correlation parameter  
15 evaluated by the correlation unit, by additional signal processing to obtain a reference for comparison with a predetermined threshold in the comparison unit.

In the present invention, the correlation unit evaluates correlation by averaging of correlation between first part of the  
20 channel impulse response of a combination of two time slots.

In the present invention, in determining if signals from a given target transmitting unit is available in the received signal of a sector, said detection unit evaluates said path gain at the subcarriers of at one or more time slots using a pilot signal that is specific to a given mobile  
25 unit;

evaluates a parameter that is a measure of how path gains at different subcarriers and same time slot, are correlated to one another; and

modifies said parameter by additional signal processing that includes either averaging or filtering to obtain a correlation parameter of a given transmitting unit and a given sector.

In the present invention, correlation parameter is modified by:

evaluating cross correlation of the first part ( $h_0, h_1 \dots, h_L$ ) of the channel impulse response at least one of time slot to obtain a normalization parameter; and

dividing normalization parameter with the correlation parameter to obtain a modified correlation parameter.

In the present invention, interference cancellation is performed using mean square error approach.

In the present invention, interference cancellation is performed using zero forcing approach.

In the present invention, interference cancellation is performed using maximum likelihood detection approach.

There is provided a base station comprising the signal processing system according to the present invention.

The meritorious effects of the present invention are summarized as follows.

According to the present invention, improvement in channel capacity can be realized by reducing the BER when a target signal is detected in more than one sector.

Further, according to the present invention, by dynamically changing the size of the channel matrix, overall computation complexity of the receiver is reduced since an increased size of channel matrix is used only when it is possible to increase the channel capacity.

5 Still other features and advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description in conjunction with the accompanying drawings wherein examples of the invention are shown and described, simply by way of illustration of the mode contemplated of carrying out this  
10 invention. As will be realized, the invention is capable of other and different examples, and its several details are capable of modifications in various obvious respects, all without departing from the invention. Accordingly, the drawing and description are to be regarded as illustrative in nature, and not as restrictive.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram illustrating communications system with two transmitting units (TU1 and TU2) in two sectors (sector-1 and sector-2), and one receiving base station (BS).

20 Fig. 2 is a diagram showing the configuration of a part of a generalized multi-sectored receiver of the related art.

Fig. 3 is a diagram showing the configuration of a part of a MIMO receiver unit with two received signal streams per sector.

25 Fig. 4 is a diagram showing the configuration of the example of the present invention for signal processing with a unit for dynamic

generation of channel matrix, detection unit and comparison unit.

Fig. 5 is a flow chart illustrating how the size of channel matrix is dynamically changed.

Fig.6 is a flow chart that illustrates a method for detecting if a target signal is within the signal received from a given sector.

Fig. 7 is a diagram illustrating a channel gain-based direction unit.

Fig. 8 is a diagram illustrating four possible wireless links between two transmitting and receiving antennas.

Fig. 9 shows a typical time domain impulse response of a wireless communications system.

Fig. 10 is a diagram illustrating a method for measuring the correlation of the channel parameters.

Fig.11 is a flow chart illustrating a method for measuring the correlation of the channel parameters.

Fig. 12 is an example of the OFDM receiver with a channel-matrix generation unit based on the present invention.

Fig. 13 is an example illustrating an application of present invention in channel matrix generation.

Fig. 14 is another example illustrating an application of present invention in channel matrix generation.

#### EXPLANATION OF NUMERALS

- 21 interference cancellation unit  
25 22 combination unit

23 detection unit

100 dynamic channel matrix generation unit

101 generate signal channel matrix and received signal error unit

103 channel matrix selection unit

5 103 detection unit

104 comparison unit

$H_{k,i}$  A MIMO channel matrix at subcarrier index "k" and sector index "i"

k: Subcarrier index

10

#### PREFERRED MODES OF THE INVENTION

Fig.4 shows the configuration of an example of the present invention for dynamically processing signals received from multiple sectors. The signal streams received from sector-1 (25) and (26) and signal streams received from sector-2 (27) and (28) are concatenated in a unit (105). Similarly, channel parameters (29) and (30) from sector-1 and sector-2, respectively, are used to create a modified channel matrix, dimension of which is much larger than that of each of channel matrices of respective sectors. Dynamic processing of signals received from multiple sectors is done by a detection unit (103) which receive channel parameters (131) or (133), and a comparison unit (104). Signals from a transmitting unit are detected within the signals received from two or more sectors, or the same signals are detected within the signal received from one sector. Based on the results of the comparison unit (104), a modified channel matrix and received signal

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vector, or channel matrix and received signal vector from one sector is selected in a channel matrix selection unit (102) and used in a unit (21) to perform interference cancellation.

Dynamic processing of signals received from multiple sectors is done by checking if signals from a transmitting unit can be detected within the signals received from two or more sectors, or if the same signals can only be detected in signal received from one sector.

The process of detection is done by a detection unit (103) that generates signal or evaluates a reference value that is used in a comparison unit (104).

There is provided one detection unit (103) for each sector.

The comparison unit (104) compares the reference signal with a preset threshold value to determine if signal received from a given sector contains signals from a target mobile unit.

Based on the decision made by the comparison unit (104), the dynamic channel matrix generation unit (100) generates the parameters for interference cancellation.

These parameters are channel matrix associated with each of the subcarriers or a frequency bands that have been utilized by a target transmitting unit to transmit its signal. There is also the received signal vector that is used with channel matrix to retrieve the desired signal.

If it is detected that signal from a transmitting unit is available in the signals received from more than one sector, then for each subcarrier or frequency band, the dynamic channel matrix generation

unit (100) generates a large channel matrix that is a concatenation of the channel matrix associated with the active sectors. Here, active sectors refer to the sectors within which the signals from the target mobile unit have been detected.

5 Equation (3) below shows the resulting channel matrix of a single transmitting unit given that signal from a transmitting unit has been detected in the signals received from two sectors.

$$\mathbf{H}_k^T = [\mathbf{H}_{k,1,1} \quad \mathbf{H}_{k,2,1}] \quad (3)$$

10

where T indicates transpose of a matrix, k is a subcarrier or frequency subband index that corresponds to subcarrier or frequency sub-band that was used by a target mobile terminal, and  $\mathbf{H}_{k,i,u}$  is a channel matrix of user 'u, sector with index i, at subcarrier or frequency

15 subband k.

In this example, i takes a value of 1 or 2. Similarly, dynamic channel matrix generation unit (100) generates a signal vector that is a concatenation of the signal received from the active sectors. Using a case of two active sectors, resulting concatenated vector will be given

20 by

$$\mathbf{x}_k = \begin{bmatrix} \mathbf{x}_{k,1} \\ \mathbf{x}_{k,2} \end{bmatrix} \quad (4)$$

On the other hand, if it is detected that signal from a

transmitting unit is available in only one sector, the dynamic channel matrix generation unit (100) generates a channel matrix that corresponds to only this particular sector.

Fig. 5 provides a flow chart that illustrates dynamic modification of the size of channel matrix used in interference cancellation. Processing described in steps S1, S2, S3, S4 and S5 in Fig. 5 are respectively performed by the detection units (103), the comparison and channel matrix selection unit ((104) and (102)), the unit (101), the unit (105) and the interference cancellation unit (21) in Fig. 4.

In a first step S1, it is detected if a target signal is within signal streams received in a sector.

In a second step S2, a decision is made on whether the target signal is in signal streams received in more than one sector. If the signal is in more than one sector, a fourth step is executed and if the signal is in one sector, a third step S3 is executed.

In the third step S3, channel matrix and signal vector are generated for only one sector, while in the step S4, a modified channel matrix and a larger signal vector are generated.

In a fifth step S5, the generated channel matrix and signal vector are used to perform interference cancellation.

#### <Detection Unit>

The detection unit (103) in Fig. 4 can be implemented using either the proposed channel gain approach or the proposed correlation

based approach.

<Channel Gain-based Detection Method>

Fig.6 is a flow chart that illustrates the procedure (subroutine) of the step S1 in Fig.5 for detecting if a target signal is in the signal streams received in a sector. This method is referred to as a channel gain-based detection method.

In a step S11, the power of estimated time domain channel within a region that corresponds to a delay profile (PCH) is evaluated.

In a step S12, the power of estimated time domain channel within a region that does not correspond to a delay profile (PNCH) is evaluated.

In a step S13, PCH-PNCH, that is, the difference between the power PCH calculated in the step S11 and the power PNCH calculated in the step S12, is calculated.

In a step S14, the value PCH calculated in the step S11 is normalized with the difference value PCH-PNCH calculated in the step S13.

In a step S15, the normalized value  $PCH/(PCH-PNCH)$  calculated in the step S14 with a predetermined threshold value. If the normalized value is greater than the threshold value, for example, a target signal is detected in the signal streams received in a sector.

When two transmitting units in two different sectors share the same channel, the detection unit (103) and comparison unit (104) will detect the presence of at least one of the transmitting units. As an

example if signals from only one transmitting unit can be detected in two sectors, the concatenated channel matrix will be given by

$$\mathbf{H}_k^T = \begin{bmatrix} \mathbf{H}_{k,1,1} & \mathbf{H}_{k,2,1} \\ \mathbf{0} & \mathbf{H}_{k,2,2} \end{bmatrix} \quad (5)$$

5

where 0 is a null matrix, and T indicates transpose of a matrix.

Fig.7 is a diagram illustrating one of the channel gain-based detection units described using a flow chart of Fig.6. In Fig.7, the channel parameter (131) represents time-domain channel parameters for all the possible links between transmitting and receiving antennas of a sector. In a case where each sector is serviced by two transmit antennas and two receive antennas, the time-domain channel response or parameters (131) and (133) are provided for all the possible four links of transmission between the transmitting unit and a given sector of receiving base station.

Fig. 8 illustrates the four possible links in a transmission system with two transmit antennas and two receive antennas. In Fig.8, there are provided two sets of antennas (301) of a transmitting unit and two sets of antennas (302) of a receiving unit. There are links (333), each between two antennas (301 and 302) of the transmitting unit and receiving unit. In Fig.8, reference numerals 331 and 333 designates signals transmitted on two sets of antennas (301) of the transmitting unit, respectively, and reference numerals 334 and 335 designates signals received from two sets of antennas (302) of the receiving unit,

respectively.

The frequency-domain to time domain channel conversion unit converts estimated frequency-domain channel response to a time domain impulse response of the channel for all the possible four links.

5 In one of the links, the channel impulse responses (131) or (133) is given by

$$h_i \in \{h_0 \ h_1 \ \Lambda \ h_{N-1}\} \quad (6)$$

10 where N is the number of impulses in the time domain channel impulse response.

Referring to Fig.7, the channel gain-based detection unit includes: a true time-domain channel generation unit (140) that generates an actual time domain impulse response corresponding to  
15 actual delay spread [Non-patent Document 7] of the wireless channel between the transmitting unit and base station; and

an evaluate channel gain unit (143) that evaluate a channel gain or mean square value, for example, of the actual time domain impulse response.

20 Assuming that this delay spread corresponds to  $N_d$  samples, the actual time domain impulse response will constitute of  $N_d$  samples chosen from.

In other words,

$$25 \quad h_i \in \{h_0 \ h_1 \ \Lambda \ h_{N-1}\} \quad h_{i,n} \in \{h_{i,0} \ h_{i,1} \ \Lambda \ h_{i,N_d-1}\} \in \{h_0 \ h_1 \ \Lambda \ h_{N-1}\} \quad (7)$$

In Fig.7, the channel gain-based detection unit also includes: a false time-domain channel generation unit (141) that generates a false channel impulse response (153) corresponding to pulses within the time domain channel impulse response, but excluding the true channel impulse response (ht, n) (152) of the target-transmitting unit or any other transmitting unit, which is sharing the same transmission frequency band; and

an evaluate false channel gain unit (142) that evaluate a channel gain or mean square value, for example, of the false time domain impulse response.

Mathematically, a false channel impulse response hf,n is expressed as

$$15 \quad h_{f,n} \notin \{h_{t,0} \quad h_{t,1} \quad \Lambda \quad h_{t,N_d-1}\}$$

and

$$h_{f,n} \in \{h_0 \quad h_1 \quad \Lambda \quad h_{N-1}\} \quad (8)$$

Fig. 9 illustrates a practical time domain channel impulse response of a channel with a delay spread of 40 samples. In Fig.9, the respective time intervals of a true channel impulse response ht,n corresponds to delay profile of a channel with a length corresponding to the delay spread and a false channel impulse response hf,n, are indicated.

25 In the present example, as described with reference to step S13

and step S14 of Fig. 6, and the normalization unit (144) of Fig.7, a reference parameter (151) is evaluated using the following equation:

$$R_{NCHCH} = \frac{P_{CH}}{P_{CH} - P_{NCH}} \quad (9)$$

5 where

$$P_{CH} = \frac{1}{N_d} \sum_{n=0}^{N_d-1} |h_{t,n}|^2 \quad (10)$$

$$P_{NCH} = \frac{1}{N_f} \sum_{n=0}^{N_f-1} |\hat{h}_{f,n}|^2 \quad (11)$$

10 Note that it is possible to scale the reference parameter ( $R_{NCHCH}$ ) (151) with some scaling factor.

#### <Correlation-based Detection Method>

In a variation of the present example, the detection unit (103) in  
 15 Fig.4 may well be configured as a correlation-based detection unit which uses either frequency-domain channel parameters (130) or time-domain channel parameters (131).

Fig.10 illustrates the configuration of the detection unit (103) which is implemented using a correlation-based detection approach.  
 20 The detection unit detects if a target signal is in the signal streams received in a sector. More specifically, referring to Fig.10, the detection unit (correlation-based detection unit) designated by a

reference numeral 200 includes:

a correlator (202) that receives frequency domain channel parameters (231) from a frequency domain channel estimation unit (201) that estimates frequency domain channel parameters from frequency domain receives signals (230), and measures degree of correlation of frequency-domain channel parameters (231); and

a filter 203 that filters the estimated channel correlation (232) to generate a final correlation parameter (233). The final correlation parameter (233) is then processed in a comparison unit (104) in Fig.4.

The correlation-based detection approach described with reference to Fig.10 can also use time-domain channel parameters. In this case, the correlator (202) and the filter (203) evaluates correlation between the true time domain channel impulse response  $h_{t,n}$  at two different time intervals or time-slots.

The correlation parameter can also be used to normalize channel gain parameter (Eq.10) as illustrated in the following equation.

$$R_{COR} = \frac{P_{CH}}{P_{COR}} \quad (12)$$

where  $R_{COR}$  is a correlation parameter that corresponds to the correlation between the true time domain channel impulse response at two different time intervals of time-slots, and  $P_{CH}$  has been defined in Eq.(10).

The correlation parameter can also be estimated by measuring

the correlation between the frequency-domain channel parameters at adjacent subcarriers. In a practical system, channel parameters in adjacent subcarriers are highly correlated.

Fig. 11 illustrates a flow chart of the correlation based approach for detecting the presence of a target signal. Processing steps S21, S22 and S23 described in fig. 11 are performed respectively by the correlator (202) and the filter (203) of Fig.10 and the comparison unit 104 in Fig.4. The combination of steps S21 and S22 can also be considered to correspond to the detection 104 in Fig.4.

Referring to Fig.11, in a first step S21, the correlation of the channel parameters of a sector is estimated.

In a second step S22, the estimated correlation parameter is filtered.

In a third step S23, the correlation parameter is compared with a threshold.

According to (3) and (4), the channel matrix that is forwarded to the interference cancellation unit has a matrix with increased size when signal from a transmitting unit is detected in more than one sector. This is equivalent to MIMO system with an increased number of possible paths of signal transmission. Increased number of paths minimizes interference hence reducing BER. Furthermore, when signal is detected in only one sector, the channel matrix is small and hence the overall computational complexity is reduced, while achieving the best possible BER performance.

The channel-gain based detection unit in Fig.7 detects signal

from a given transmitting unit by measuring power of the estimated channel. In absence of any transmitted signal, the power of the false impulse response is basically the same as power of the true impulse response.

5 Equation (9) provides an effective measure as to how close the power of the false impulse response is to the power of the true impulse response.

In the correlation-based detection unit (200) in Fig.10, true channel impulse responses estimated at two different time slots are not  
10 correlated if signal from a transmitting unit cannot be detected in the signal received from a given sector. In such a situation, the correlation parameter will be much smaller. A measure of the size of the correlation parameter is provided in Equation (12).

One area of wireless communications systems in which the  
15 present invention can be applied is in a receiver (base station) that receives and decode signals from an OFDM-based transmitting unit. Such a system is illustrated in Fig.12, where multiple signal streams are received using multiple antennas in a unit (302). For each received signal stream received at the unit (302), there is provided an  
20 RF receiver unit (401) that performs amplification, filtering and down-conversion, an analog-digital conversion (ADC) unit (402) that converts the analog signal to a digital signal, a synchronization unit (403) that performs time and frequency synchronization, a guard removal unit (404) that removes a cyclic prefix that had been appended  
25 at the transmitter, and a forward linear transformer (FLT) (405) that in

most cases represents an FFT (Fast Fourier Transform) operation. The receiver also includes a channel-matrix generation unit (400) that includes channel estimation and dynamic channel-matrix generation unit according to the present invention, and an interference  
5 cancellation unit (21) that cancels the interference to generate an originally transmitted target signal.

Fig. 13 is a diagram illustrating the configuration of the channel-matrix generation unit (400) in Fig.12. Referring to Fig.13, the output from the FLT unit (405) in Fig.12 are indicated by two  
10 signal streams (25 and 26) from sector-1 and (27 and 28) from sector-2.

As in a general OFDM system, these signals represent frequency domain signals that are used to estimate channel parameters in a channel estimation unit (106). The channel parameters output from the channel estimation unit (106) includes the frequency-domain  
15 channel parameters (132), and the time domain channel parameters 133. The frequency-domain channel parameters (132) include channel parameters for each of the OFDM subcarriers. The time domain channel parameters (133) include time domain true impulse response and the false impulse. The true time domain impulse response and the  
20 false time domain impulse response are then sent to the detection unit (103), which generates a detect-signal in accordance with a method described with reference to Fig.6 and Fig.7.

Output from the detection unit (103) is used by the comparison unit (104) to obtain a decision parameter that is then used by the  
25 dynamic channel-matrix generation unit (100). The dynamic

channel-matrix generation unit (100) generates channel matrix and signal vector of a subcarrier that has been selected by the signal selection unit (108).

The channel matrix and signal vector generated by the dynamic  
5 channel-matrix generation unit (100) are then used by the interference cancellation unit (21).

Fig.14 is a diagram illustrating the configuration of another example of the present invention. In the present example, the detection unit (110) adopts the correlation detection method described  
10 with reference to Fig.10 and Fig.11. The present example is also OFDM-based receiver shown in Fig.12, where the channel-matrix generation unit (400) is replaced with a channel-matrix generation unit (401) as shown n Fig.14.

Referring to Fig.14, the output from the FLT unit (405) includes  
15 two signal streams (25 and 26) from sector-1 and (27 and 28) from sector-2. In the present example, the channel parameters include only frequency-domain channel parameters (132). The frequency-domain channel parameters (132) are then supplied to the detection unit (110), which generates a detect-signal using a method described with  
20 reference to Fig.10 and Fig.11. Note that it is also possible to use the time domain channel parameters (133) as with in Fig.12. The output from the detection unit (110) is used by the comparison unit (104) to decision parameter that is then used by the dynamic channel-matrix generation unit (100). The dynamic channel-matrix generation unit  
25 (100) generates channel matrix and signal vector of a subcarrier that

has been selected by the signal selection unit (108). Generated matrix and signal vector are then used by the interference cancellation unit (21).

The present example enables an improvement in channel capacity by reducing the BER when a target signal is detected in more than one sector.

In addition, by dynamically changing the size of the channel matrix, overall computation complexity of the receiver is reduced since an increased size of channel matrix is used only when it is possible to increase the channel capacity.

The present invention can be applied to any multi-sectored base station. This includes the base stations for mobile communications.

The above description was made in connection with the examples described above. The present invention, however, is not limited to the configurations of the examples described above alone, and of course includes various variations and modifications that could be made by those skilled in the art within the scope of the present invention.

It should be noted that other objects, features and aspects of the present invention will become apparent in the entire disclosure and that modifications may be done without departing the gist and scope of the present invention as disclosed herein and claimed as appended herewith.

Also it should be noted that any combination of the disclosed and/or claimed elements, matters and/or items may fall under the

modifications aforementioned.

## CLAIMS:

1. A signal processing method in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectored coverage area; signal power  
5 gain between transmit and receive antennas of the transmitting units and the receiver within each sector being represented as a channel matrix with path gains; said method comprising:

combining a plurality of the channel matrices associated with  
respective sectors to generate a channel matrix which is larger than the  
10 channel matrices associated with respective sectors, and concatenating  
a plurality of received signal vectors associated with respective sectors  
to generate a received signal vector which is larger than the received  
signal vectors associated with respective sectors; and

using the generated channel matrix and the generated received  
15 signal vector, canceling interference from other transmitting unit  
sharing a given channel with a target transmitting unit.

2. A signal processing method in a base station receiver that receives and processes single carrier or multiple carrier signals from a  
plurality of transmitting units in a sectored coverage area; signal power  
20 gain between transmit and receive antennas of the transmitting units  
and the receiver within each sector being represented as a channel  
matrix with path gains; said method comprising:

determining if signal from a given target transmitting unit is  
available in the received signal of a sector;

25 if signal from said target transmitting unit is detected in at least

two sectors,

combining a plurality of the channel matrices associated with respective sectors to generate a channel matrix which is larger than the channel matrices associated with respective sectors, and concatenating  
5 a plurality of received signal vectors associated with respective sectors to generate a received signal vector which is larger than the received signal vectors associated with respective sectors; and

using the generated channel matrix and the generated received signal vector, canceling interference from other transmitting unit  
10 sharing a given channel with said target transmitting unit; while if signal from said target transmitting unit is detected in only one sector, canceling interference from the received signal from said transmitting unit, using said channel matrix and the received signal vector each associated with said one sector.

15 3. The method according to claim 2, wherein the step of determining if signals from said target transmitting unit is available in the received signal of a sector comprises:

evaluating said path gain at subcarriers using a pilot signal specific to said target transmitting unit;

20 converting the estimated path gain of the subcarriers to a time domain impulse response  $(h_0, h_1, \dots, h_N)$ ;

separating said time domain impulse response into two parts, true impulse response:  $(h_0, h_1, \dots, h_L)$  and false impulse response:  $(h_{L+1}, \dots, h_M)$ , wherein the first part corresponds to delay profile of a channel  
25 with a length corresponding to the delay spread;

evaluating mean square value of said first part ( $h_0, h_1 \dots, h_L$ ) to obtain a first parameter (PCH);

evaluating mean square value of said second part ( $h_{L+1}, \dots, h_M$ ) to obtain a second parameter (PNCH);

5 subtracting said second parameter (PNCH) from said first parameter (PCH) to obtain a third parameter (DNCH);

dividing said first parameter (PCH) with said third parameter (DNCH) to obtain a fourth parameter (RNCH); and

10 comparing said fourth parameter (RNCH) with a predetermined threshold, wherein if the comparison result indicates that said fourth parameter is greater than the threshold, it is determined that signal from the transmitting unit is in the signal received from a given sector.

4. The method according to claim 3, wherein the second part ( $h_{L+1}, \dots, h_N$ ) of the time domain impulse response is obtained by ignoring  
15 part of the impulse response that correspond to the channel delay profile, and impulse response that arise from interfering mobile terminal.

5. The method according to claim 2, wherein the step of determining if signals from a given target transmitting unit is available  
20 in the received signal of a sector, comprises:

evaluating said path gain at the subcarriers of at least two different time slots, using a pilot signal that is specific to a given transmitting unit;

25 converting the estimated path gain of the subcarriers for each of the time slots to obtain an equivalent time domain channel impulse

response;

for at least two of time slots, separating each of said time domain impulse responses into two parts,  $(h_0, h_1 \dots, h_L)$  and  $(h_{L+1}, \dots, h_N)$ , wherein the first part  $(h_0, h_1 \dots, h_L)$  has a length that  
5 corresponds to the delay spread of transmission channel;

evaluating a correlation parameter that has a correlation factor of at least said first part  $(h_0, h_1 \dots, h_L)$  of the first time slot and said first part  $(g_0, g_1 \dots, g_L)$  of any other time slot other than the first time slot; and

10 modifying said correlation parameter by additional signal processing to obtain a reference for comparison with a predetermined threshold, wherein if said reference parameter is greater than the threshold, it is determined that signal from the transmitting unit is in the signal received from a given sector.

15 6. The method according to claim 5, wherein the correlation factor is an average of correlation between the first part of the respective channel impulse responses at least two different time slots.

7. The method according to claim 2, wherein the step of determining if signals from a given target transmitting unit is available  
20 in the received signal of a sector, comprises:

evaluating said path gain at the subcarriers of at least one or more time slots using a pilot signal that is specific to a given transmitting unit;

evaluating a parameter that is a measure of how the path gains at  
25 different subcarriers within the same time slot, are correlated to one

another; and

modifying said parameter by additional signal processing that includes either averaging or filtering to obtain a correlation parameter of said target transmitting unit and a given sector.

5 8. The method according to claim 5, wherein the correlation parameter is modified by:

evaluating power of the first part ( $h_0, h_1 \dots, h_L$ ) of the channel impulse response at one or more time slots to obtain a normalization parameter; and

10 dividing normalization parameter with the correlation parameter to obtain a modified correlation parameter.

9. The method according to claim 1 or 2, wherein interference cancellation is performed using at least one of mean square error approach, zero forcing approach and maximum likelihood detection  
15 approach.

10. A signal processing system in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectorized coverage area; signal power gain between transmit and receive antennas of the transmitting units  
20 and the receiver within each sector being represented as a channel matrix with path gains; said system comprising:

a channel matrix generation unit that combines a plurality of the channel matrices associated with respective sectors to generate a channel matrix which is larger than the channel matrices associated  
25 with respective sectors, and concatenates a plurality of received signal

vectors associated with respective sectors to generate a received signal vector which is larger than the received signal vectors associated with respective sectors; and

an interface cancellation unit that using the generated channel matrix and the generated received signal vector, cancels interference from other transmitting unit sharing a given channel with a target transmitting unit.

11. A signal processing system in a base station receiver that receives and processes single carrier or multiple carrier signals from a plurality of transmitting units in a sectored coverage area; signal power gain between transmit and receive antennas of the transmitting units and the receiver within each sector being represented as a channel matrix with path gains; said system comprising:

a decision unit that determines if signal from a given target transmitting unit is available in the received signal of a sector;

a channel matrix generation unit that combines a plurality of the channel matrices associated with respective sectors to generate a channel matrix which is larger than the channel matrices associated with respective sectors, and concatenates a plurality of received signal vectors associated with respective sectors to generate a received signal vector which is larger than the received signal vectors associated with respective sectors; and

an interface cancellation unit that, if signal from said target transmitting unit is detected in at least two sectors, cancels interference from other transmitting unit sharing a given channel with

said target transmitting unit, using the generated channel matrix and the generated received signal vector;

said interface cancellation unit canceling interference from the received signal from said transmitting unit, using said channel matrix and the received signal vector each associated with said one sector, if  
5 signal from said target transmitting unit is detected in only one sector.

12. The system according to claim 11, wherein the detection unit comprises

a channel estimation unit that evaluates frequency-domain path  
10 gain at subcarriers using pilot signal that is specific to a given transmitting unit;

a time domain conversion unit that converts the estimated frequency domain path gain of the subcarriers to a time domain impulse response  $(h_0, h_1, \dots, h_N)$ ;

15 a separation unit that separates said time domain impulse response into two parts, true impulse response:  $(h_0, h_1, \dots, h_L)$  and false impulse response:  $(h_{L+1}, \dots, h_M)$ , wherein the first part  $(h_0, h_1, \dots, h_L)$  corresponds to delay spread of a channel;

a first mean gain evaluating unit that evaluates mean square  
20 value of said first part  $(h_0, h_1, \dots, h_L)$  to obtain a first parameter (PCH);

a second mean gain evaluating unit that evaluates mean square value of said second part  $(h_{L+1}, \dots, h_N)$  to obtain a second parameter (PNCH);

a subtraction unit that subtracts said second parameter (PNCH)  
25 from said first parameter (PCH) to obtain a third parameter (DNCH);

a division unit that divides said first parameter (PCH) with said third parameter (DNCH) to obtain a fourth parameter (RNCH); and

a comparison unit that compares said fourth parameter (RNCH) with a predetermined threshold, wherein if the comparison result indicates that said fourth parameter is greater than the threshold, it is determined that signal from the transmitting unit is in the signal received from a given sector.

13. The system according to claim 12, wherein the separation unit generates a second part of the time domain impulse response that is obtained by ignoring part of the impulse response that correspond to the channel delay profile, and impulse response that arise from any interfering transmitting unit.

14. The system according to claim 11, wherein the detection unit comprises:

15 a channel estimation unit that evaluates the frequency-domain path gain at subcarriers of at least two different time slots using a pilot signal that is specific to a given transmitting unit;

a time domain conversion unit that converts the estimated frequency-domain path gain of the subcarriers for each of the time slots to obtain an equivalent time domain channel impulse response;

a separation unit that separates said time domain impulse response into two parts, true impulse response:  $(h_0, h_1, \dots, h_L)$  and false impulse response:  $(h_{L+1}, \dots, h_M)$ , wherein the first part  $(h_0, h_1, \dots, h_L)$  corresponds to delay spread of a channel;

25 a correlation unit that evaluates a correlation between at least

said first part ( $h_0, h_1 \dots, h_L$ ) of the first time slot and said first part ( $g_0, g_1 \dots, g_L$ ) of any other time slot other than the first time slot; and

a correlation manipulation unit that modifies said correlation parameter evaluated by the correlation unit, by additional signal processing to obtain a reference for comparison with a predetermined threshold in the comparison unit.

15. The system according to claim 14, wherein the correlation unit evaluates correlation by averaging of correlation between the first part of the channel impulse response of a combination of two time slots.

10 16. The system according to claim 11, wherein in determining if signals from a given target transmitting unit is in the received signal of a sector, said detection unit evaluates said path gain at the subcarriers of at one or more time slots using a pilot signal that is specific to a given transmitting unit;

15 evaluates a parameter that is a measure of how path gains at different subcarriers and same time slot, are correlated to one another; and

modifies said parameter by additional signal processing that includes either averaging or filtering to obtain a correlation parameter of a given transmitting unit and a given sector.

17. The system according to claim 16, wherein the correlation parameter is modified by:

25 evaluating cross correlation of the first part ( $h_0, h_1 \dots, h_L$ ) of the channel impulse response at least one of time slot to obtain a normalization parameter; and

dividing normalization parameter with the correlation parameter to obtain a modified correlation parameter.

18. The system according to claim 10 or 11, wherein interference cancellation is performed using at least one of mean square error approach, zero forcing approach and maximum likelihood detection  
5 approach.

19. A base station comprising the signal processing system as set forth in any one of claims 10 to 18.

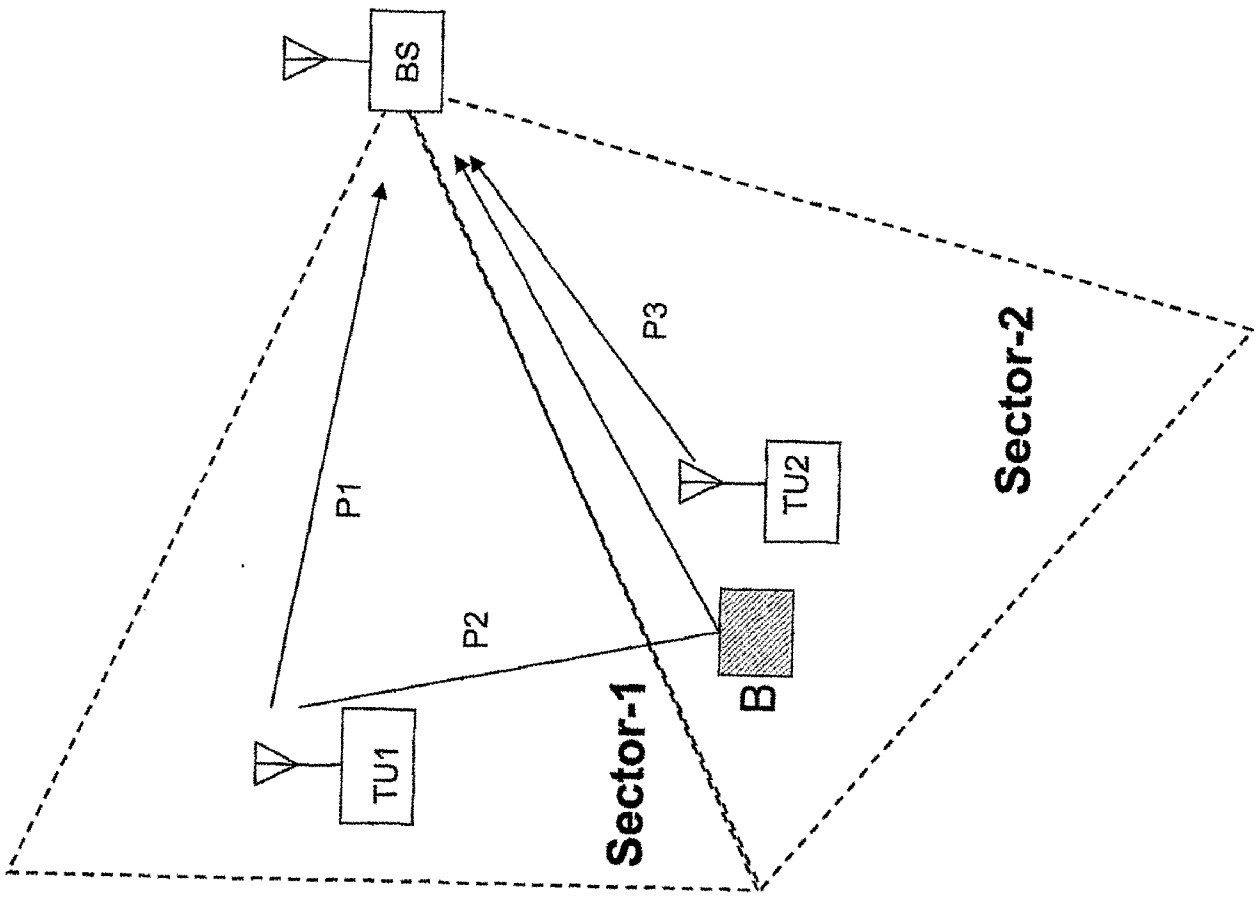


FIG. 1

FIG. 2

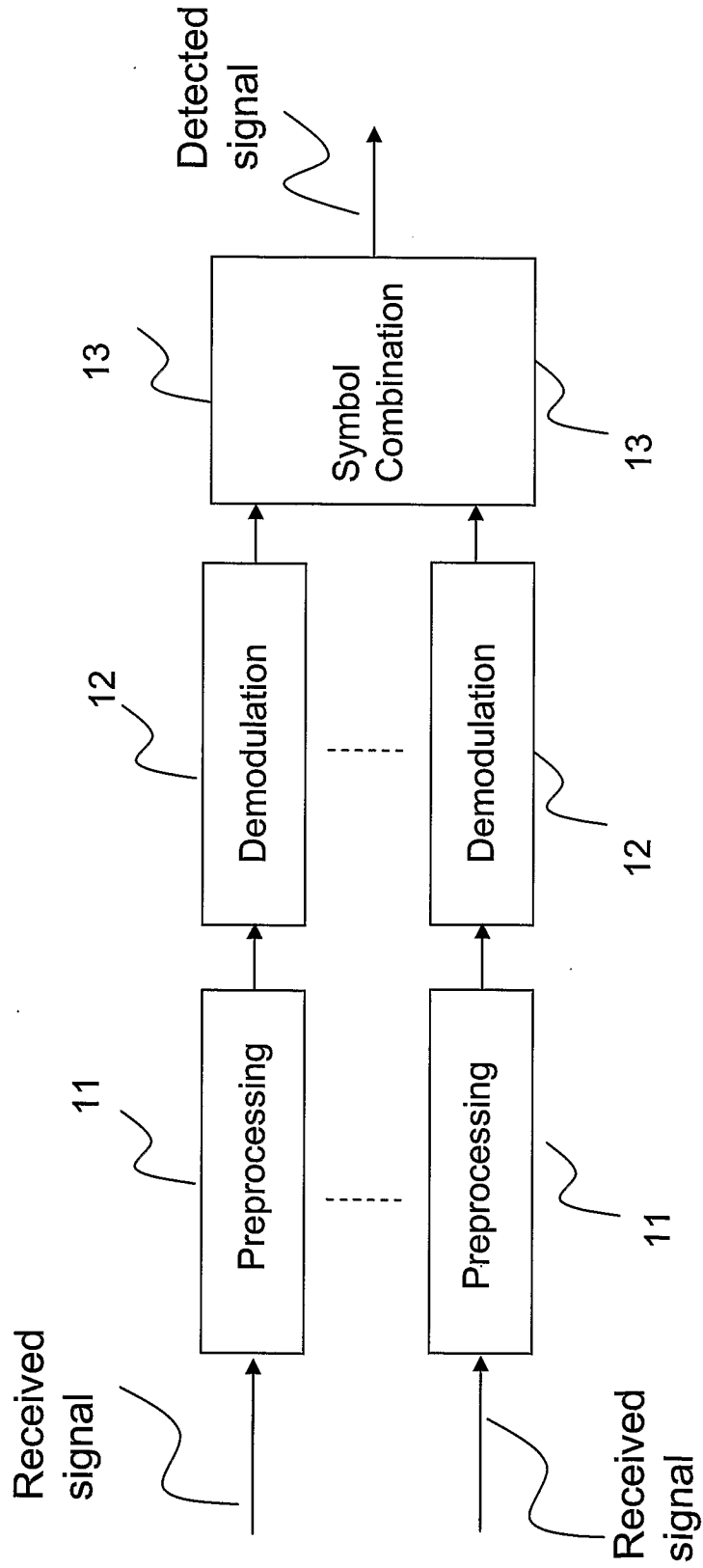
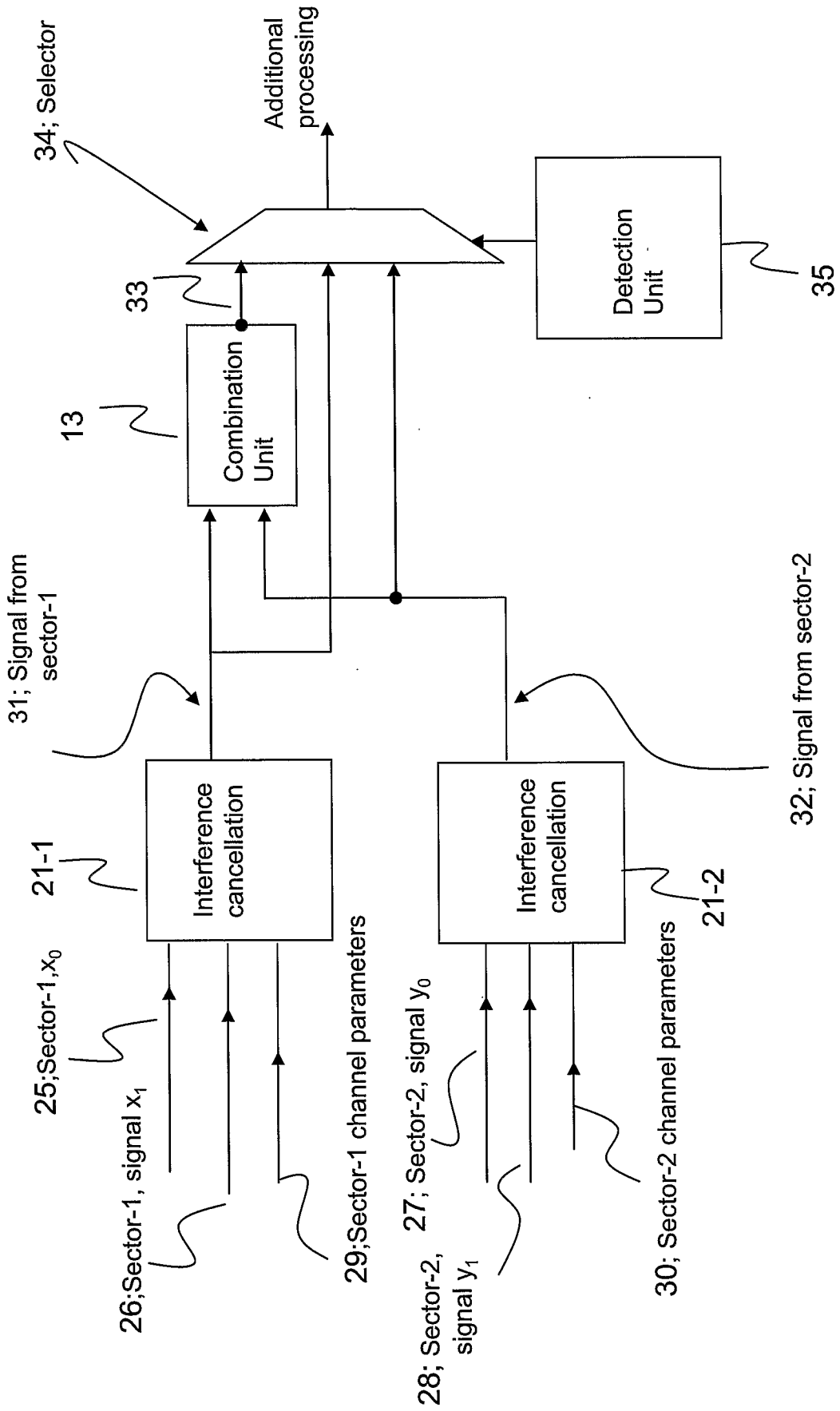


FIG. 3



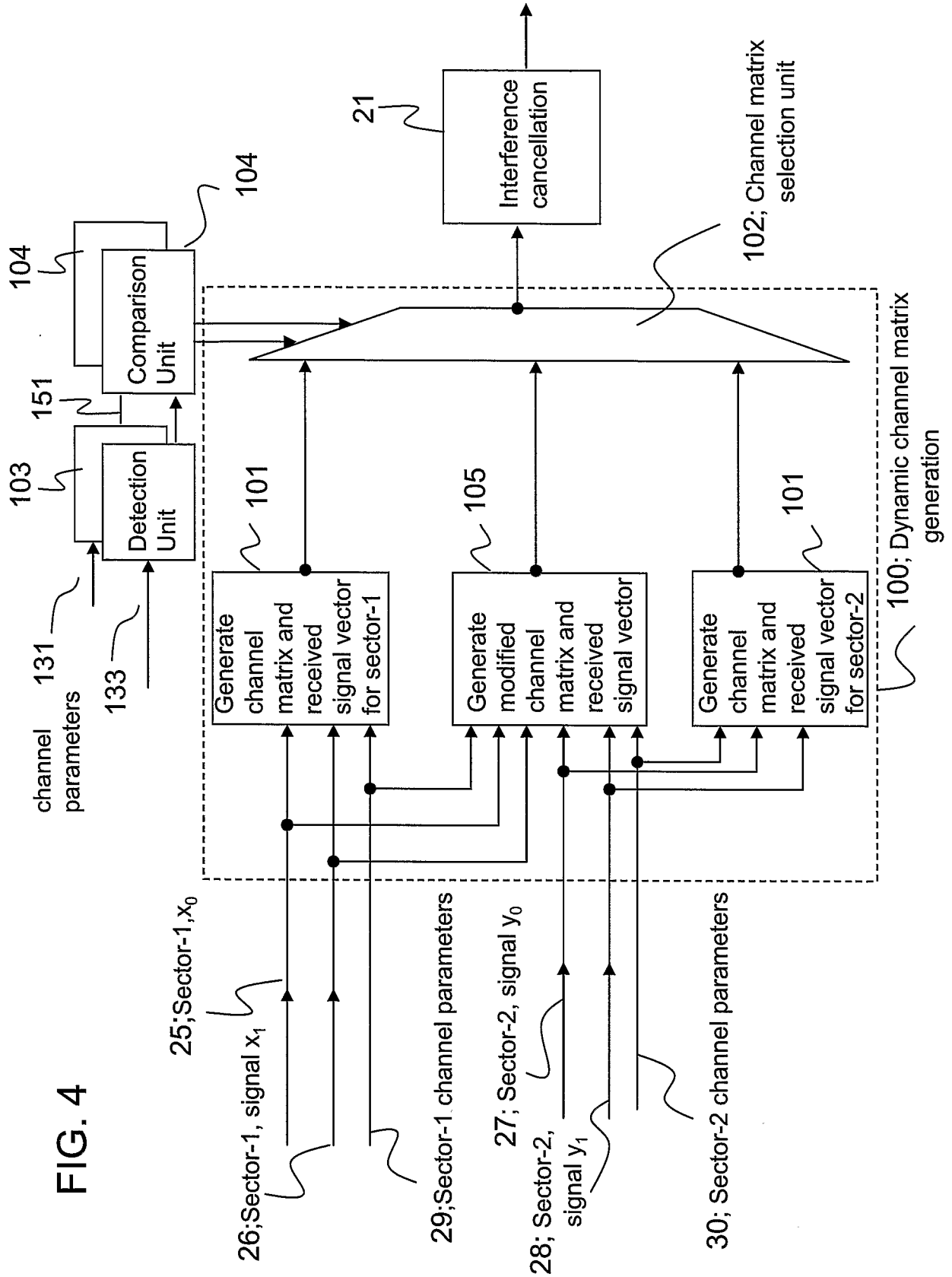


FIG. 4

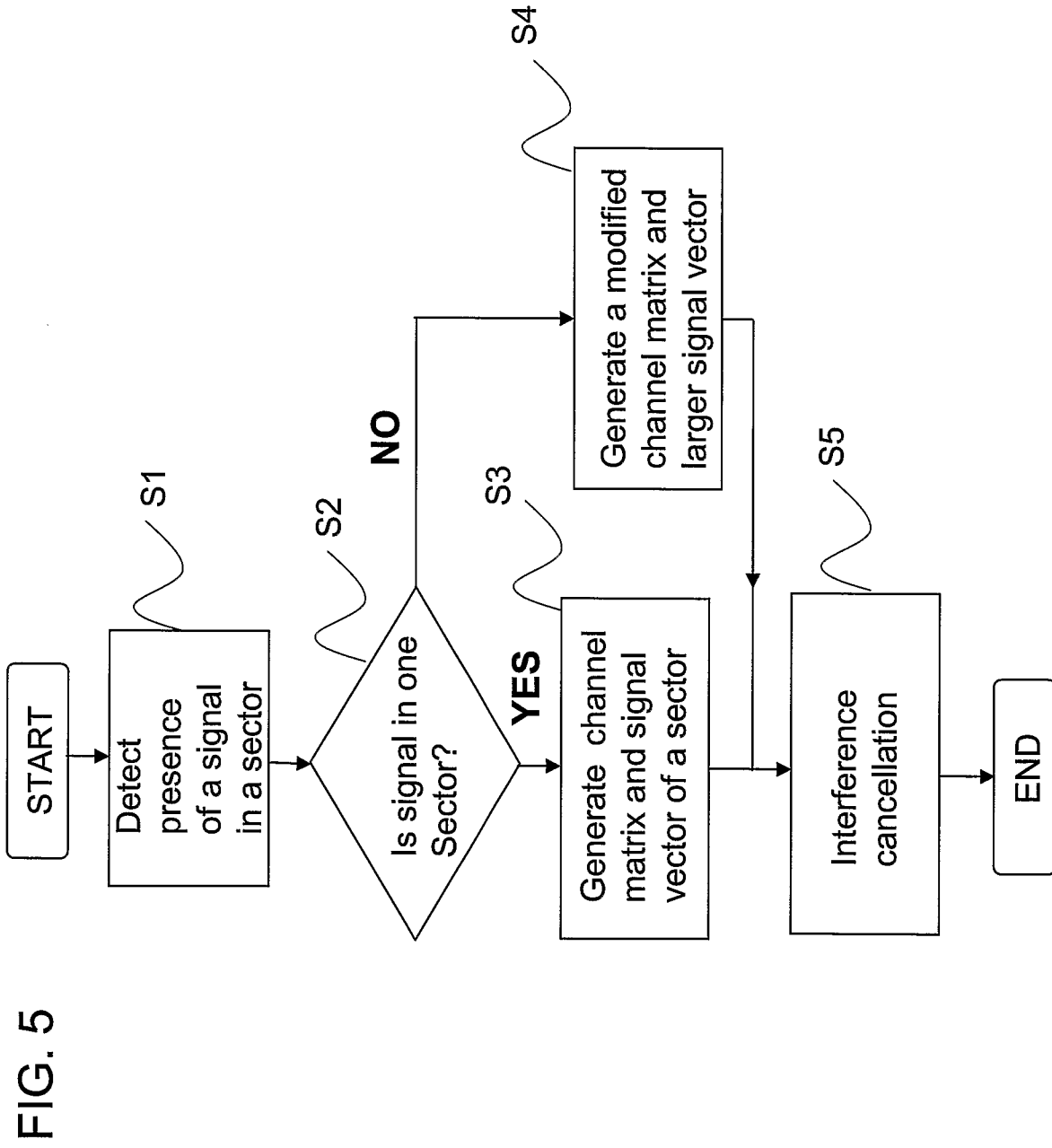


FIG. 6

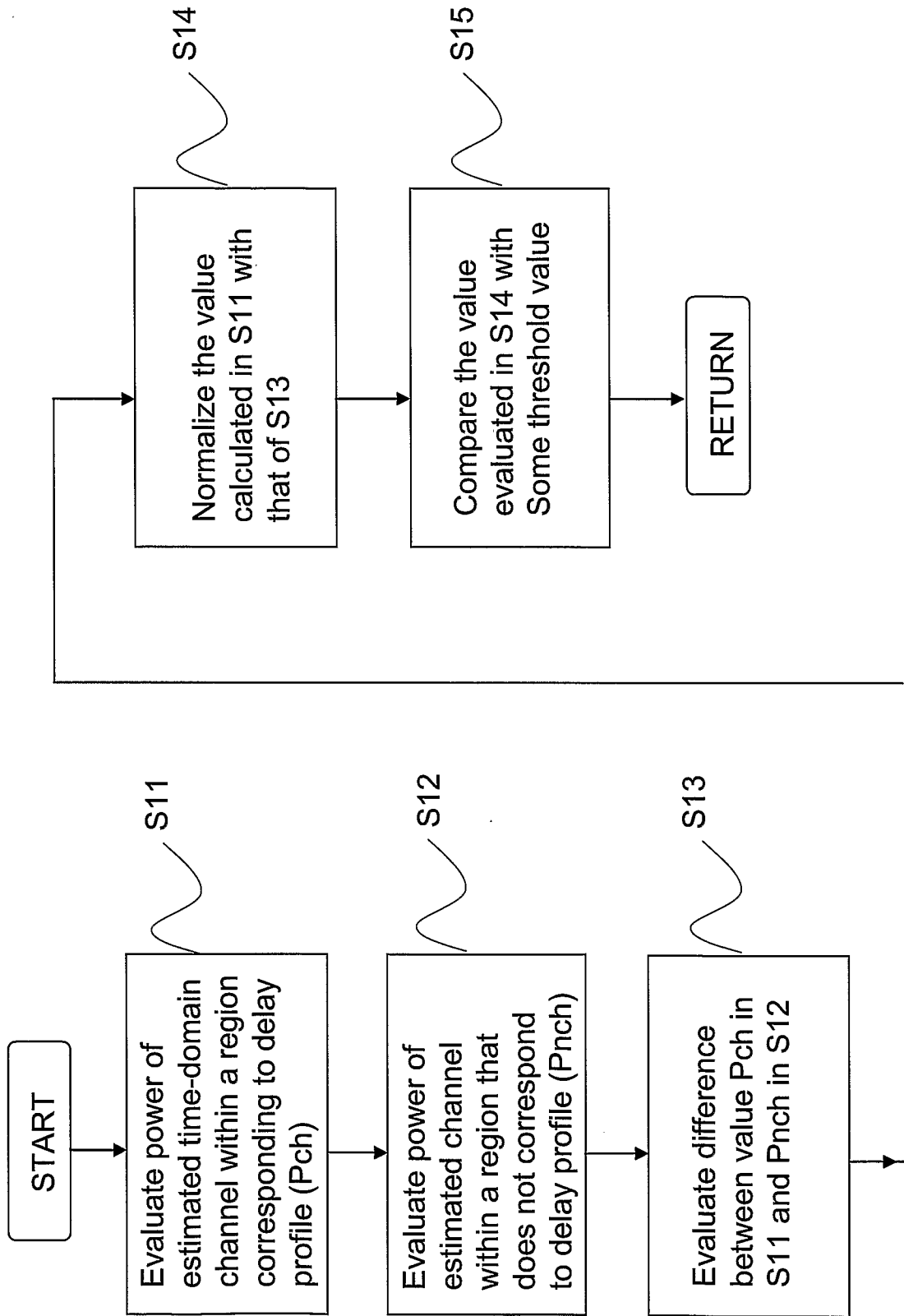


FIG. 7

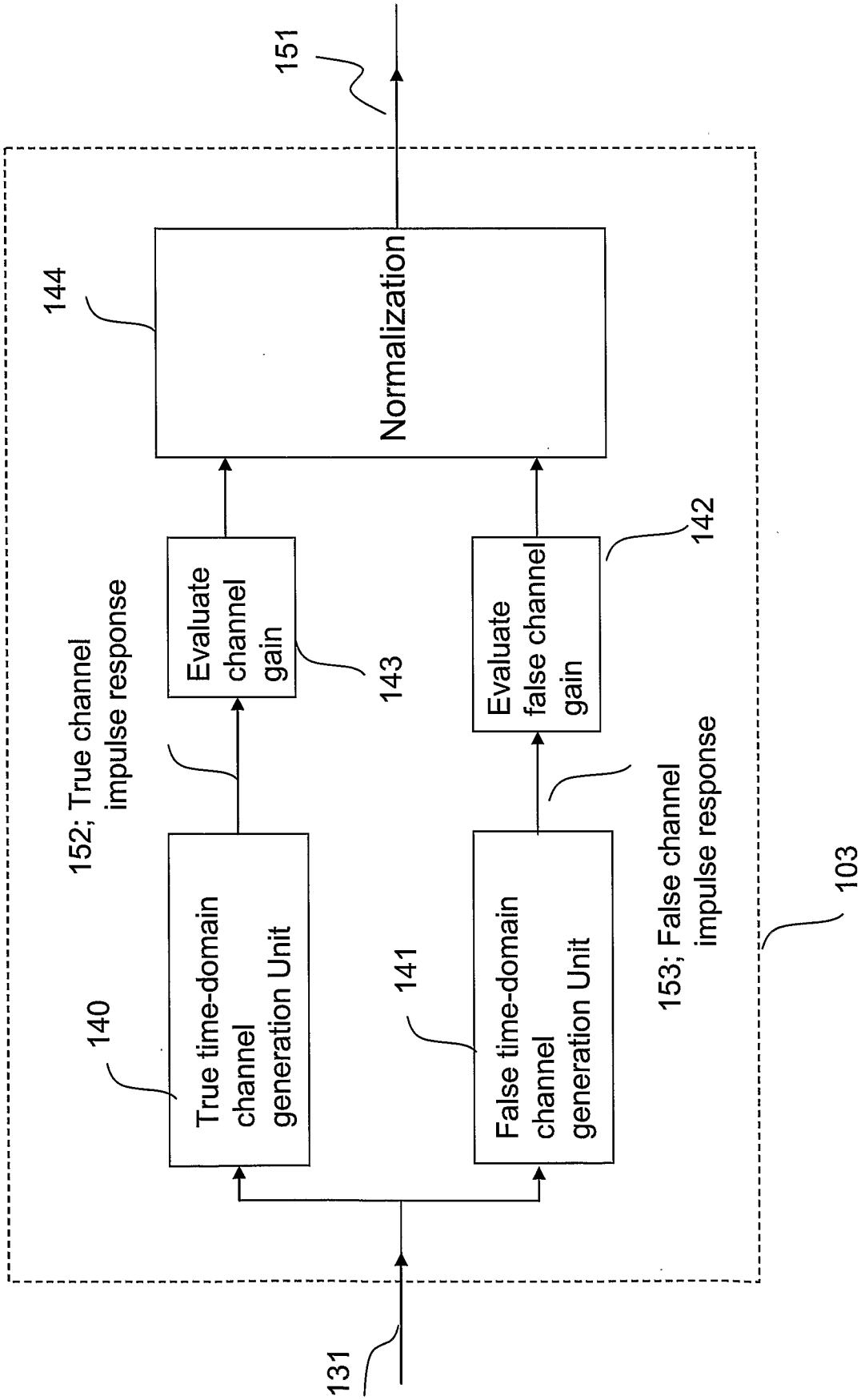
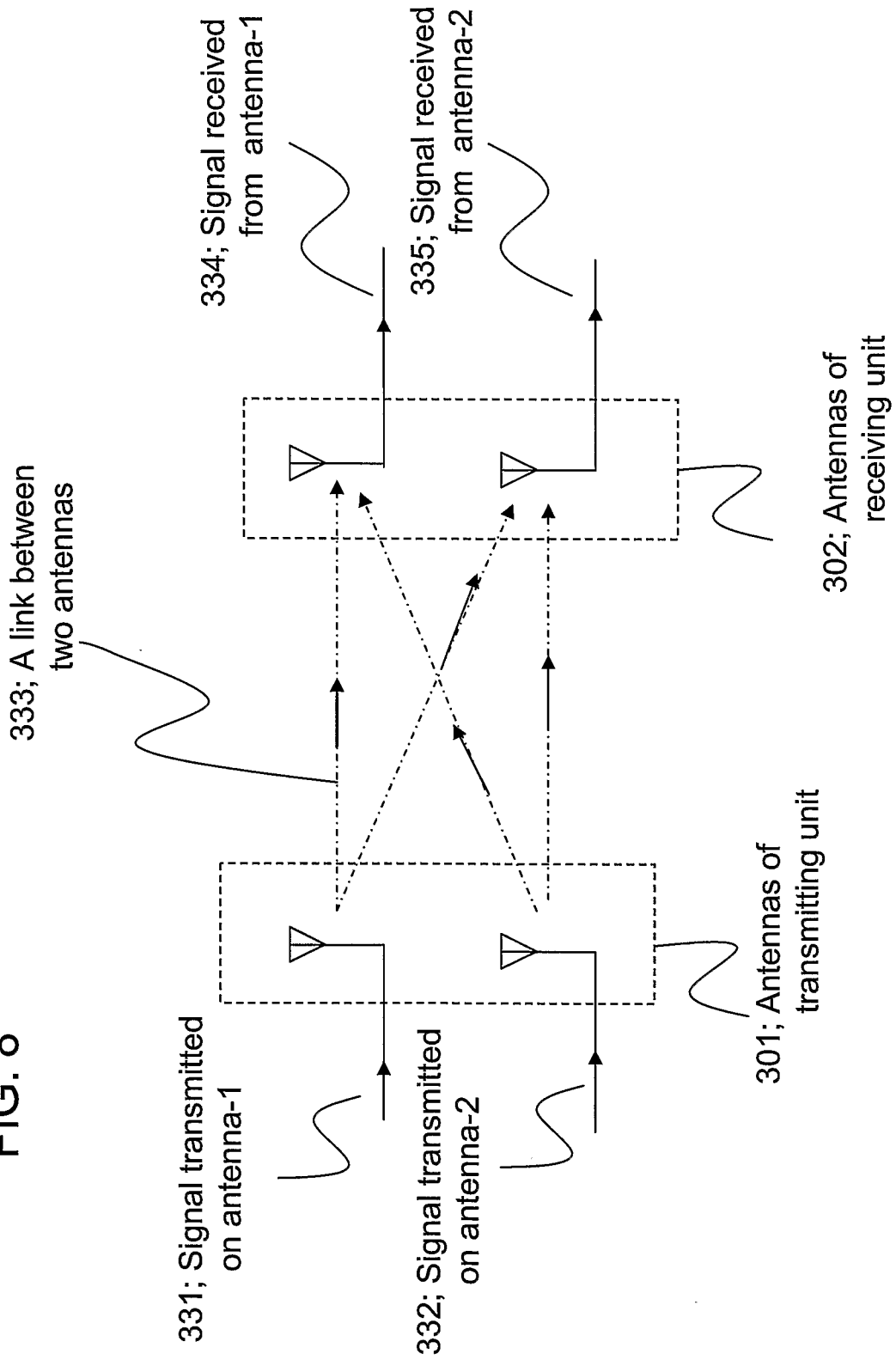


FIG. 8



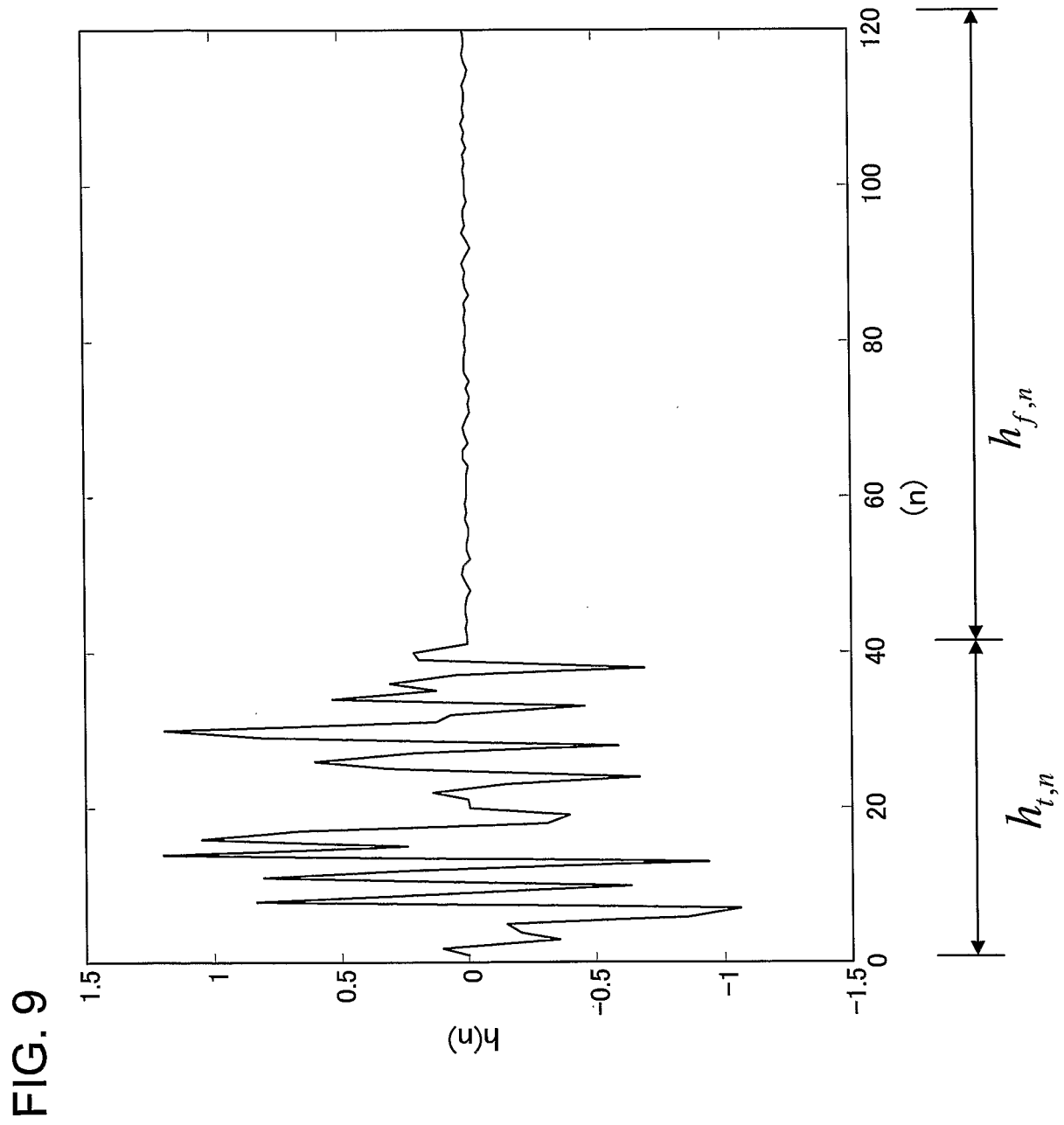
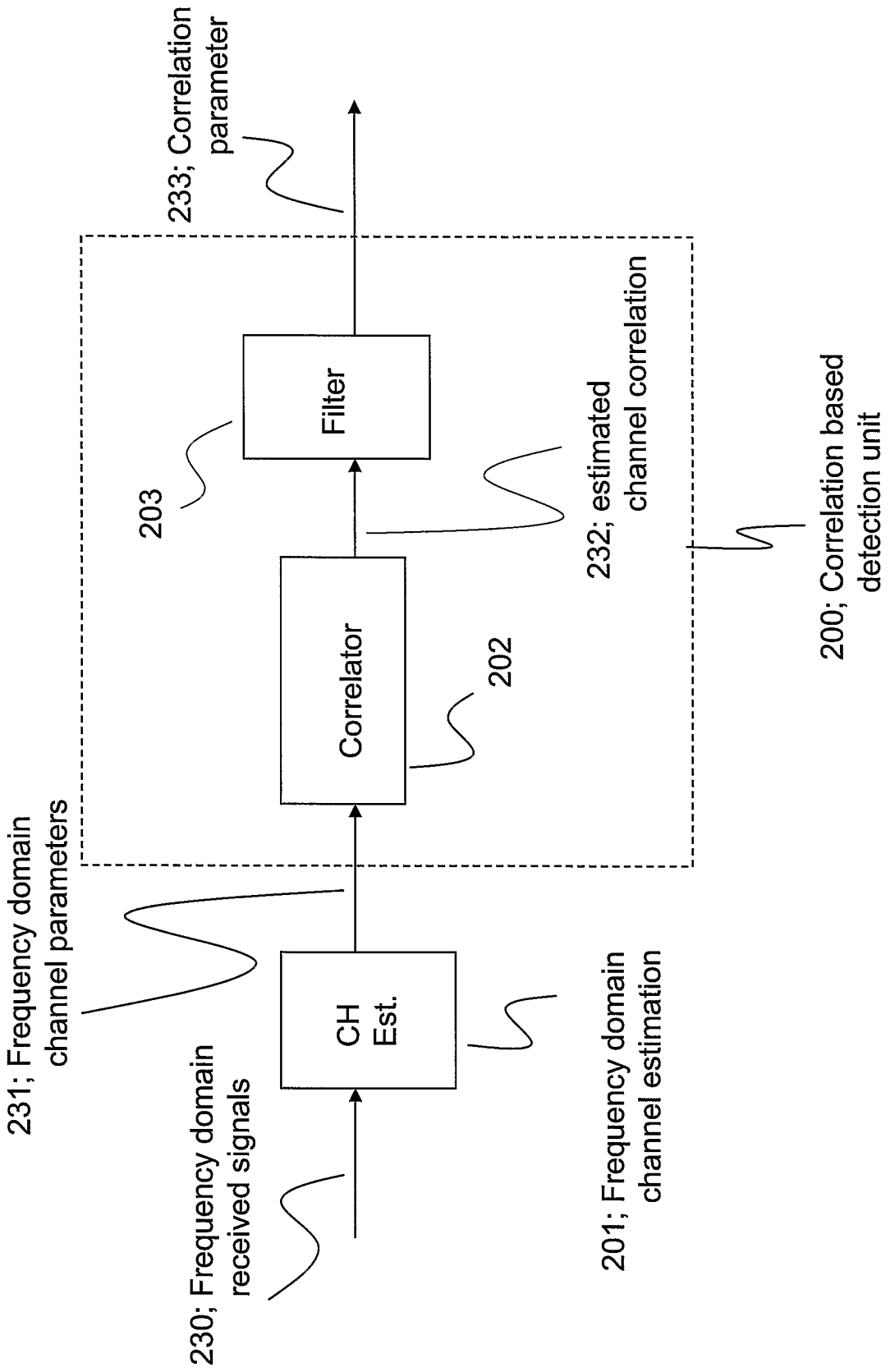


FIG. 10



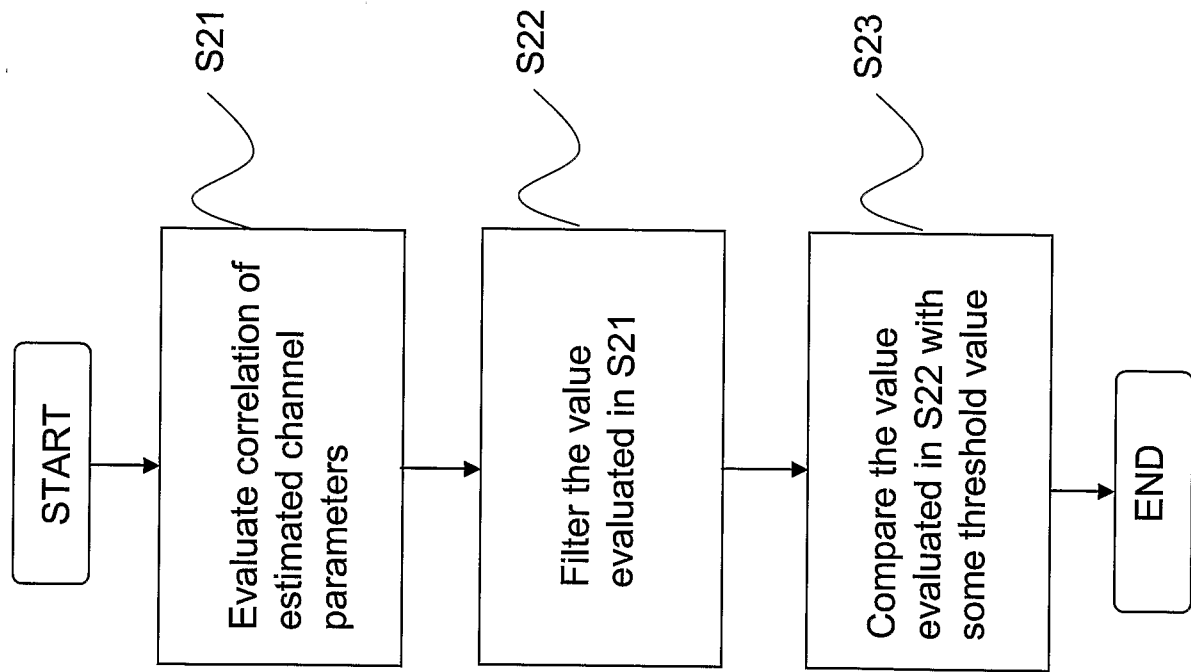


FIG. 11

FIG. 12

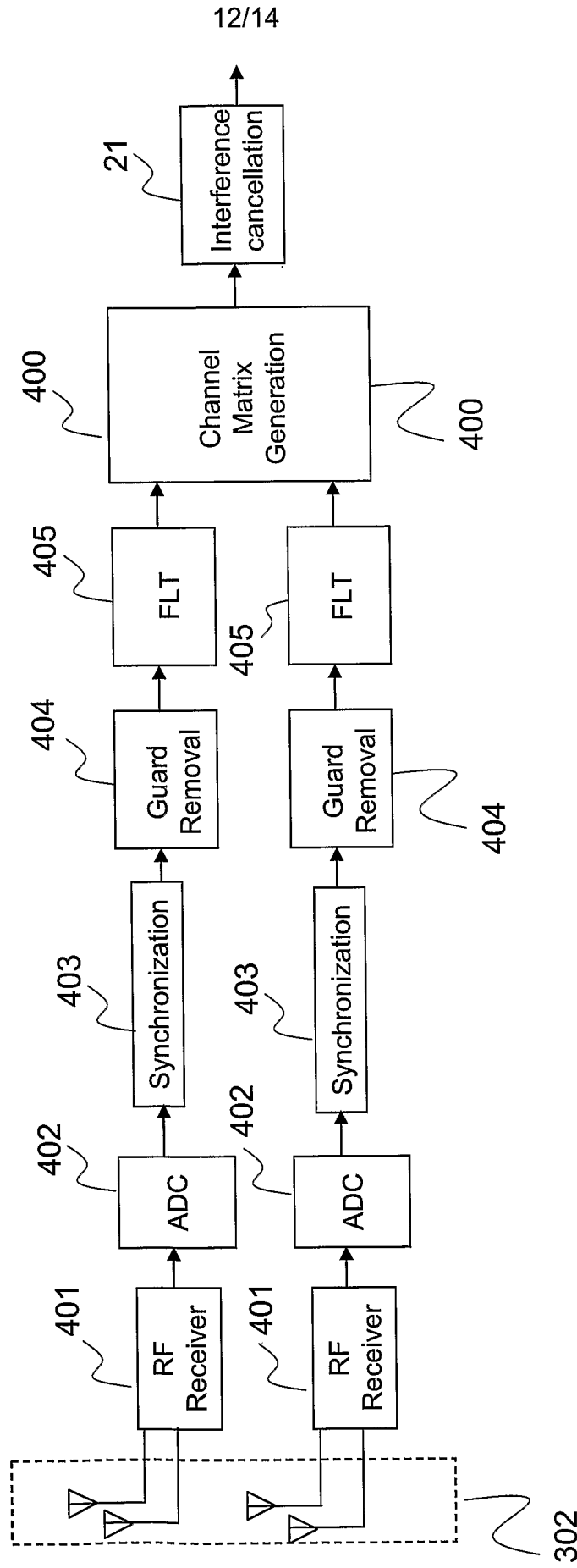


FIG. 13

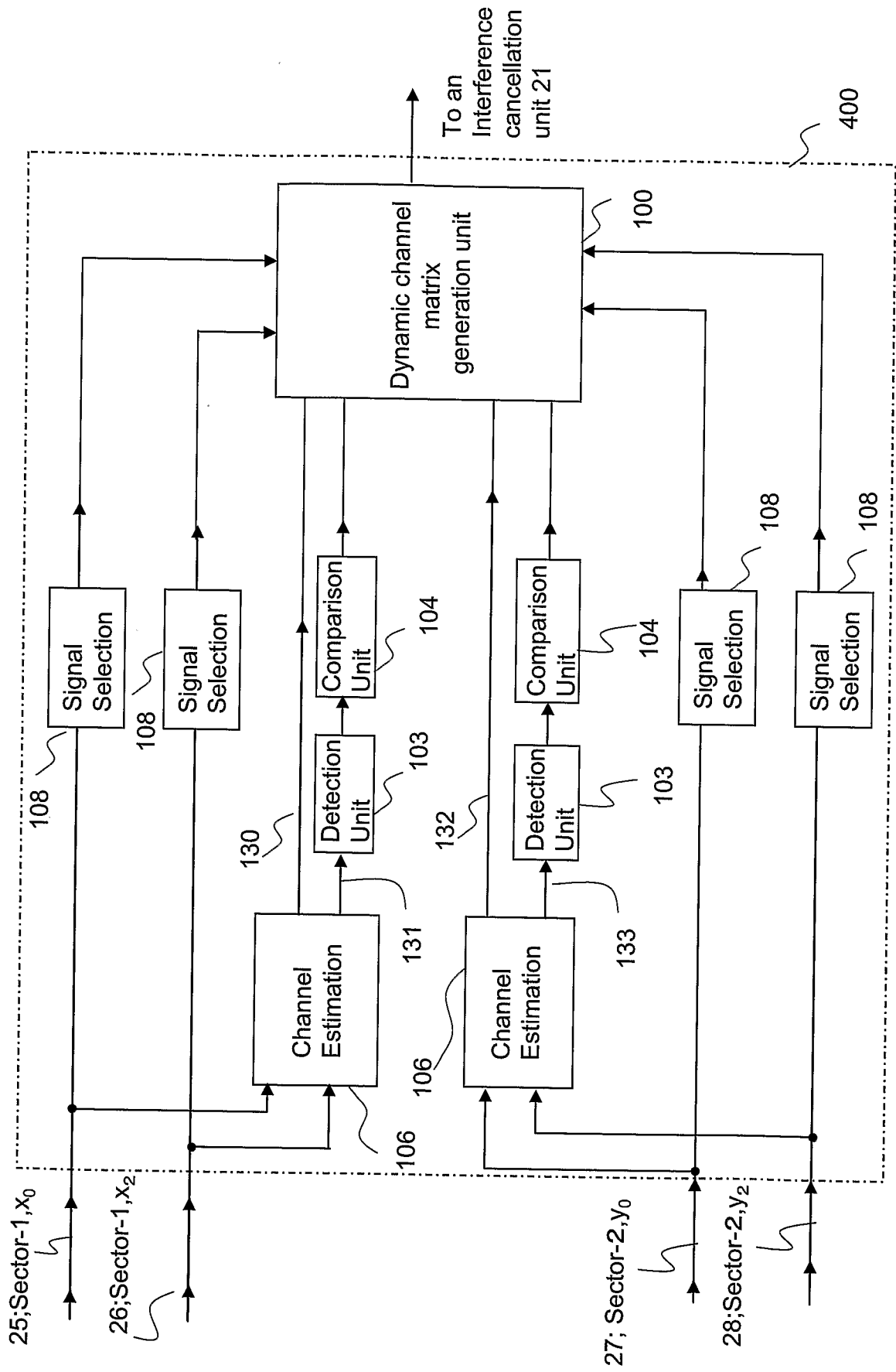
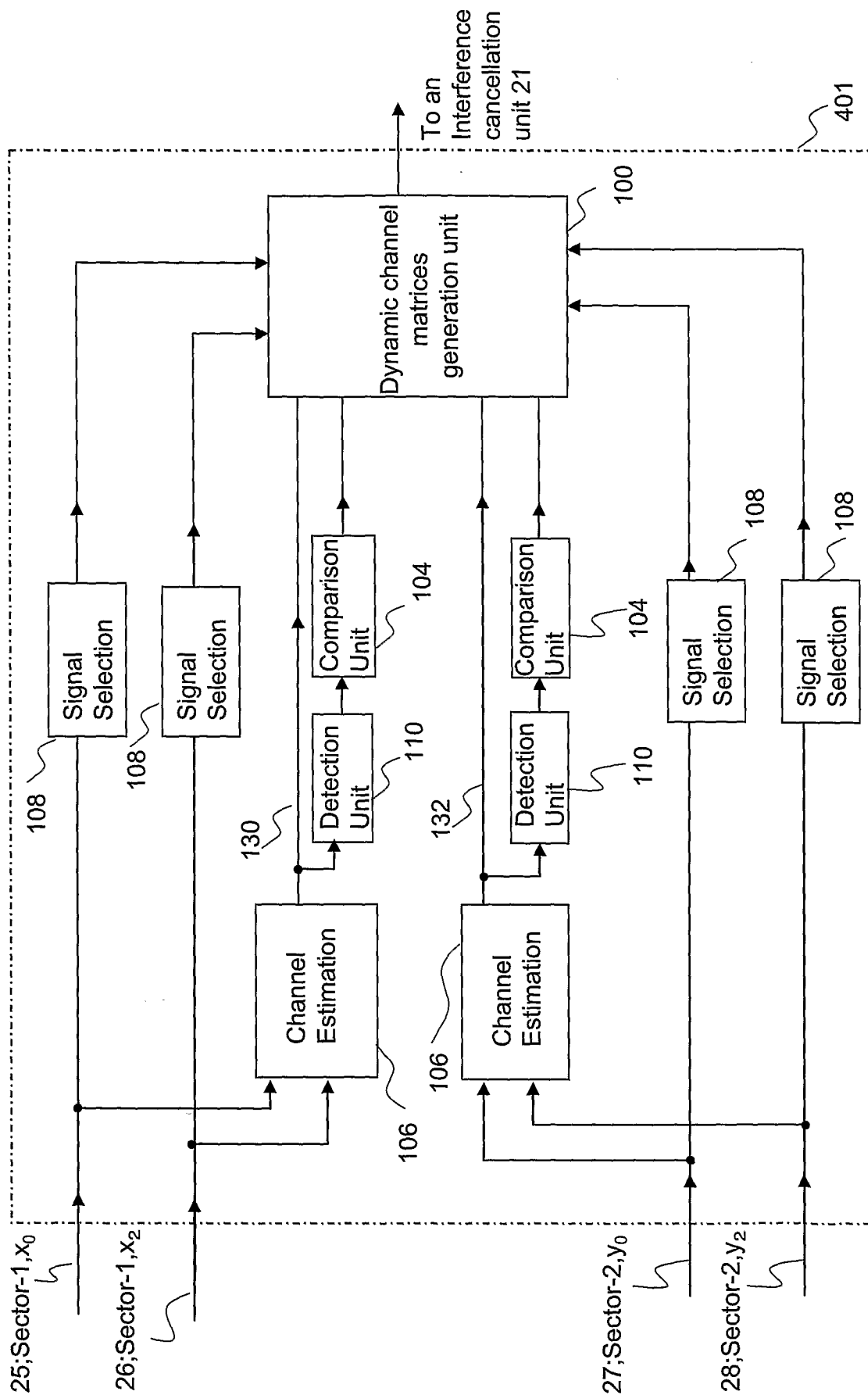


FIG. 14



# INTERNATIONAL SEARCH REPORT

International application No  
PCT/JP2007/075423

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> INV. H04B7/04				
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
Minimum documentation searched (classification system followed by classification symbols) H04B				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, INSPEC				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
A	WO 2006/133631 A (SHANGHAI ULTIMATE POWER COMM T [CN]; WANG YINGMIN [CN]; YANG GUILIANG) 21 December 2006 (2006-12-21) abstract page 6, last paragraph - page 11, paragraph 1 figures 1,2  <div style="text-align: center;">----- -/--</div>	1,2,10, 11		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <span style="margin-left: 200px;"><input checked="" type="checkbox"/> See patent family annex.</span>				
* Special categories of cited documents :				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;">                     *A* document defining the general state of the art which is not considered to be of particular relevance                      *E* earlier document but published on or after the international filing date                      *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)                      *O* document referring to an oral disclosure, use, exhibition or other means                      *P* document published prior to the international filing date but later than the priority date claimed                 </td> <td style="width: 50%; border: none; vertical-align: top;">                     *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                      *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone                      *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.                      *&amp;* document member of the same patent family                 </td> </tr> </table>			*A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family
*A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family			
Date of the actual completion of the international search  <div style="text-align: center; font-size: 1.2em;">10 October 2008</div>		Date of mailing of the international search report  <div style="text-align: center; font-size: 1.2em;">16/10/2008</div>		
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer  <div style="text-align: center; font-size: 1.2em;">Yang, Betty</div>		

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/JP2007/075423

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>SARAYDAR C U ET AL: "Capacity enhancement for CDMA systems through adaptive cell sectorization" WIRELESS COMMUNICATIONS AND NETWORKING CONFERENCE, 1999. WCNC. 1999 IE EE NEW ORLEANS, LA, USA 21-24 SEPT. 1999, PISCATAWAY, NJ, USA, IEEE, US, 21 September 1999 (1999-09-21), pages 1139-1143, XP010353652 ISBN: 978-0-7803-5668-9 cited in the application abstract</p>	1, 2, 10, 11

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2007/075423

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2006133631 A	21-12-2006	CN 1882168 A	20-12-2006
		EP 1891814 A1	27-02-2008
		KR 20080031869 A	11-04-2008
		US 2008102836 A1	01-05-2008

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