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(54) Method and system for predicting the best reception frequency

(57) A method for predicting the best reception frequency at a multiplicity of temporal or local points along a path segment from a multiplicity of frequencies on which a transmitter network comprising a multiplicity of transmitters broadcasts at least one radio or television program is described. The method comprises defining for the path segment at least two discrete frequency values out of the multiplicity of frequencies on which the transmitter network broadcasts; scanning the reception signals in a multiplicity of runs at the multiplicity of points over the at least two of the multiplicity of frequencies on which the transmitter network broadcasts; evaluating the broadcast frequencies and signal qualities of the signals received during scanning; storing the evaluation results per frequency and program; and predicting from the stored evaluation results the best reception frequency or frequencies for the at least one program along the path segment.

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Description

BACKGROUND

1. Technical Field

[0001] The embodiments described herein relate to a system and method for predicting the best reception frequency.

2. Related Art

[0002] Mobile receiving devices, for example, radio and television receivers in motor vehicles, encounter the problem that the progressive motion of the devices continuously changes the transmission terrain. This can result in a broadcasting station no longer being received at the currently set frequency. However, broadcasting stations are also commonly available on at least one other frequency; by, e.g., automatically switching the receiving device to this frequency, the broadcasting station can thus continue to be heard or seen. To quickly switch to an alternative frequency though, the alternative frequency must be detected quickly and reliably.

[0003] Modern mobile receiving devices are equipped with a circuit for checking the reception quality of a set station at an alternative frequency of said station. The information about alternative frequencies is generally derived from encoded information that is transmitted during a broadcast, for example, using radio data system (RDS) signals. The reception quality at one or more alternative frequencies is checked either regularly or when the reception quality of the selected station at the set frequency deteriorates.

[0004] Mobile receiving devices are commonly equipped with two separate receivers for this purpose, with one receiver continuously selecting and checking alternative frequencies in the background. A dedicated circuit compares the quality of the station received by the background receiver at the alternative frequency with the set program. This background check is carried out without the user noticing any interruption in reception. However, this concept is relatively costly because both receivers must be fully equipped with tuners, intermediate frequency (IF) filters, IF stages with demodulators, RDS decoders, signal quality test equipment, etc.

[0005] Another known way to check alternative frequencies uses only one receiver. To do this, the tuner's phase-locked loop (PLL) briefly switches to an alternative frequency. Reception at the alternative frequency is checked, and a determination is made as to whether or not the alternative frequency provides better reception than the currently set frequency. If reception at the alternative frequency is poorer, the receiver switches back to the original frequency and possibly checks another alternative frequency. Although this concept is more economical, it has the disadvantage that the check pauses and briefly but noticeably interrupts the program to which the user is listening.

[0006] Other common ways to detect better alternative frequencies of broadcast stations (broadcast programs) include RDS alternative frequency following algorithms and digital audio broadcast (DAB) service following algorithms, which use global positioning system (GPS) signals and location tables or maps of broadcasting stations. The position of the receiver device is localized and the best frequency is selected through the use of the frequency map. Traditional location techniques such as GPS typically deliver very accurate location information, but considerations of cost, size, form factors and power requirements may make them too costly and impractical. Moreover, as more systems become dependent on GPS, an alternate robust backup and/or referencing system would be advantageous.

[0007] Therefore, a more cost-effective method or system that allows mobile receiver devices to quickly and automatically search through and tune into alternative frequencies of a broadcasting station is desired.

SUMMARY

[0008] A method for predicting the best reception frequency at a multiplicity of temporal or local points along a path segment from a multiplicity of frequencies on which a transmitter network comprising a multiplicity of transmitters broadcasts at least one radio or television program is described herein. The method comprises defining for the path segment at least two discrete frequency values out of the multiplicity of frequencies on which the transmitter network broadcasts; scanning the reception signals in a multiplicity of runs at the multiplicity of points over the at least two of the multiplicity of frequencies on which the transmitter network broadcasts; evaluating the broadcast frequencies and signal qualities of the signals received during scanning; storing the evaluation results per frequency and program; and predicting from the stored evaluation results the best reception frequency or frequencies for the at least one program along the path segment.

[0009] Also described herein is a system for predicting the best reception frequency at a multiplicity of temporal or local points along a path segment from a multiplicity of frequencies on which a transmitter network comprising a multiplicity of transmitters broadcasts at least one radio or television program. The system comprises a unit configured to define for the path segment at least two discrete frequency values out of the multiplicity of frequencies on which the transmitter network broadcasts; a receiver configured to scan the reception signals in a multiplicity of runs at the multiplicity of points over the at least two frequencies on which the transmitter network broadcasts; an evaluation unit configured to evaluate the broadcast frequencies and signal qualities of the signals received during scanning; a memory configured to store the evaluation results per frequency and program; and a predictor configured to predict from the stored evaluation results the best reception frequency or frequencies for the at least one program along the path segment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The figures identified below are illustrative of some embodiments of the invention. The figures are not intended to be limiting of the invention recited in the appended claims. The embodiments, both as to their organization and manner of operation, together with further objects and advantages thereof, may best be understood with reference to the following description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a schematic diagram illustrating the broadcasting behavior of a transmitter network relative to a path segment;

FIG. 2 is a table illustrating the reception pattern along the path segment depicted in FIG. 1;

FIG. 3 is block diagram illustrating an exemplary system for predicting the estimated best reception frequency from a pattern, as shown in FIG. 2; and

FIG. 4 is a diagram depicting, in its upper part, the signal strength of three defined frequencies of three runs over time and, in its lower part, the corresponding increase of the distance traveled on the path segment over time.

DETAILED DESCRIPTION

[0011] FIG. 1 shows transmitters T1, T2, T3 and T4, their transmission regions R1, R2, R3 and R4, and vehicle V traveling along path segment P. Transmitters T1, T2, T3 and T4 transmit broadcasts of sufficient strength for vehicle V to receive the broadcasts from within the respective transmission regions R1, R2, R3 and R4. For the sake of explanation, transmitters T1 and T3 may transmit broadcast program A on separate frequencies F1 and F3, and transmitters T2 and T4 may transmit broadcast program B on separate frequencies F2 and F4. Transmission regions R1, R2, R3 and R4 may not have - due to differences in geographical terrain, transmitter characteristics, environmental characteristics and so on - a smooth oval or circular shape, as illustrated in FIG.1. Rather, transition regions R1, R2, R3 and R4 may vary in size and shape over time, further weakening the availability and integrity of a transmitted program.

[0012] The driver (not shown) of vehicle V may listen to a desired program, for example, program B, while driving along path segment P. At points P1 and P2 of path segment P, the program is provided by transmitter T4 on frequency F4, to which the receiver (not shown in FIG. 1) in vehicle V is tuned. However, at point P3 and maybe at points P4, P5 and P6, the signal from transmitter T4 that carries program B may be too weak so that the system may be forced to select a different frequency (e.g., frequency F2, on which transmitter T2 broadcasts program B; if program B is not available, a different program, e.g., program A, may be transmitted from a different source, e.g., transmitter T2, even though the driver may not want to listen to or watch another program). An iterative tuning and retuning process may be unpleasant for the driver. For example, when the vehicle is leaving a tunnel, is in bad weather conditions, is in mountainous terrain, etc., it is difficult for the system to switch to the best available frequency. Even when the system successfully finds a desired program at an acceptable quality level, the driver may miss significant portions of the program due to the time and effort that must be spent tuning that program.

[0013] As already mentioned, some known systems and methods additionally evaluate GPS signals in connection with program-identifying RDS information and location tables or maps of broadcasting stations (broadcast frequency maps) in order to find the best available alternative frequency and to find it faster. Reliable GPS signals may be unavailable in many areas due to bad weather conditions or lack of line-of-sight with a required number of geosynchronous GPS satellites in, e.g., tunnels, locations surrounded by tall buildings, mountainous terrain or other areas where interference disrupts the signal. Furthermore, some vehicles may not include any GPS functionality at all. If GPS information is available, vehicle V can easily be localized and the most desirable frequency can be selected with the frequency maps. Without GPS signals, selection becomes very difficult, almost impossible.

[0014] Considering a situation in which no navigation information (such as GPS information) is available, the receiver system in vehicle V on path segment P of FIG. 1 may gather certain information on the way, as shown in the table of FIG. 2. When driving along path segment P, the system may record at certain time intervals (e.g., controlled by a timer) or at certain distances (e.g., controlled by the vehicle's odometer; i.e., at certain points on path segment P) the discrete reception frequency spectrum, i.e., the (discrete) signal strengths over (discrete) frequencies and the broadcast program identification information corresponding to the particular frequencies. In the example shown in FIG. 2, it is assumed for the sake of simplicity that the discrete signal strength has only two states, sufficient strength (Yes) and insufficient strength (No), that there are only two programs (programs A and B) provided at only four different frequencies (frequencies F1 through F4) and that the system records the information at certain points on path P (e.g., at points P1, P2, P3, P4, P5 and P6).

[0015] At points P1 and P2, program A can be received on frequency F1 and program B can be received on frequency F4, but no sufficient signal strength is present on frequencies F2 and F3. At point P3, both programs A and B can be received on frequencies F1, F2, F3 and F4. At point P4, program A can be received on frequency F3 and program B can be received on frequencies F2 and F4. At point P6, only program B is receivable and only on frequency F3. The pattern of "Yes" and "No" for the particular points P1 through P6, programs A and B and frequencies F1 through F4 is distinctive for the segment of path P that extends between points P1 and P6. The underlined reception quality indicators ("Yes") represent the choice of the listener.

[0016] For particular radio transmitters/programs, the discrete frequency values may be manually defined by the user for a particular region or may be defined by the radio data system. These discrete frequency values may be used to generate, for example, the states of a Markov process or any other suitable process. In probability theory and statistics, a Markov process is a commonly used stochastic process satisfying a certain property called the Markov property. A process satisfies the Markov property if predictions can be made for the future of the process based solely on its present state or on the process's full history. That is, conditional on the present state of the system, its future and past are independent.

[0017] Several runs of the tuner search algorithm on the same path segment provide information about listening frequencies, alternative frequencies, their weights and reception quality such as reception signal/field strength or bit error rate (BER). The historical information of the several runs on the same path segment may be used for prediction. Listening frequency sequences, as selected by the user/listener, may be correlated with each other to find a shift between the different runs. In order to detect the correlation, methods including cross-correlation or any other suitable algorithms may be employed.

[0018] Because of the discrete values, the correlation may be made in a binary way. The transaction probabilities between the different states of the Markov process may be calculated using the several runs. The information of the alternative frequencies from the several runs is fused with the transaction probabilities using a Markov decision process algorithm. The reception signal/field strength or the BER may be used as weighting factors in probability value calculations. Finally, the prediction probabilities of the discrete frequencies for this particular transmitter (program) are obtained.

[0019] The vehicle position may be localized relative to the virtual path (road) segment by using the history of the listening and alternative frequencies. Virtual path or virtual location means a path or location that cannot be absolutely localized by the system, but the system is capable of recognizing that it has already been on that particular path segment or at that particular location before. When the virtual localization of the vehicle is done, the best frequency is proposed for the particular transmitter (program) using the historical information of the several runs.

[0020] Referring now to FIG. 3, scanning receiver SR (e.g., the scanning receiver of a multiple receiver configuration or a single receiver in scan mode) receives reception signal RS (e.g., a modulated high-frequency radio signal from a single antenna or multiple antenna configuration [not shown] mounted in vehicle V of FIG. 1). Scanning receiver SR provides at least one signal that allows for evaluating reception signal RS in signal quality evaluation unit SQE and may also provide a signal that allows for detecting the program identification code in program identification unit PI. Furthermore, frequency scan control unit FSC, which controls scanning receiver SR, provides information on the currently adjusted reception frequency of scanning receiver SR. User behavior evaluation unit UBE monitors the adjustments and inputs made by the user in terms of the selected program and the selected frequency on which the program is broadcast. If no program identification unit is available, user behavior evaluation unit UBE may also serve as a user interface that allows the user to input information that identifies the currently tuned program.

[0021] Frequency scan control unit FSC, program identification unit PI, signal quality evaluation unit SQE and user behavior evaluation unit UBE provide signals to pattern generation unit PG, which is clocked by clocking unit CLK and which provides a reception pattern at each clock cycle. The clock cycles may correspond to certain time intervals or to certain distances covered by vehicle V. Reception patterns (e.g., the patterns for points P1 through P6 shown in FIG. 2) output by pattern generation unit PG at either clock cycle are supplied to pattern processing unit PP, which processes the information contained in the patterns alone or, optionally, together with patterns already stored in pattern storage unit PS. Such pattern processing may include certain statistical evaluations (such as calculating probability and weighting factors), information management (such as data compression, classification and grouping of identical or similar patterns) and reduction of redundant data. The processed information is then stored in pattern storage unit PS and represents the history of the received patterns. The history depth may be limited, e.g., by the storage capacity of pattern storage unit PS.

[0022] The history of received patterns stored in pattern storage unit PS is evaluated in pattern recognition unit PR if identical or similar patterns have already been recorded. If this is the case, vehicle V has already been at the particular location or particular path segment identified by this particular pattern or group of patterns. Pattern recognition may be configured to recognize similar patterns even if vehicle V passes the segment of path P in both directions, i.e., back and forth. In contrast to GPS, the present system does not know its exact position, but it knows if it has already been there (referred to herein as "virtual location"). It also knows what frequency was selected or what the best reception frequency was when it was at the particular location. If it has been at the location more than once, the storage may provide statistics that show how often certain frequencies have been chosen by the user or the system itself on the basis of, for instance, reception signal quality. The statistics based on the history of the signal quality and/or user behavior at the location or on the path segment may be used to find the best frequency for the particular location or path segment. Pattern evaluation unit PE calculates the most promising alternative frequency FA from the information provided by pattern recognition unit PR and pattern storage unit PS, employing, for example, the Markov process, and outputs it.

[0023] Referring again to FIG. 2, a pattern may be defined not only for either of programs A or B, each being broadcast on two frequencies, but also for both programs together, which also considers the case that a user may switch to another program when the currently selected program on its currently tuned frequency is not satisfying. In the example of FIG. 2, there are thus four different discrete broadcasting frequencies available: F1 through F4. These discrete frequency values may be considered the states of a Markov process, or Markov chain in the present case, due to their discrete state domain. The reception signal/field strength or the BER may be used as weighting factors in probability value calculations. The programs A and B may serve asfilters. The Markov process/chain or any other suitable process is intended to provide the probability that at a specific position the current state (current reception frequency) will stay as it is or change to any one of the remaining three states (frequencies). The probabilities may depend, for example, on the signal quality or the program currently being listened to. The higher the quality, the higher will be the probability that this frequency is selected or continued. Furthermore, the probability that the already selected program will be maintained is higher than the probability that another program will be switched to.

[0024] FIG. 4 depicts, in its upper part, listening frequencies F1, F2 and F3 over three runs as frequency f [MHz] over time t [s] and, in its lower part, the corresponding change of virtual distance traveled d along a particular segment of the virtual path corresponding to path P with time t as provided by pattern recognition unit PR. The virtual path is an image or model of path P as modeled by the system's pattern recognition unit PR. Virtual distance traveled d represents the progression vehicle V makes on a particular path segment. Listening frequencies F1, F2 and F3, as shown in the upper part of FIG. 4, are provided by scanning receiver SR and are saved after driving the particular path segment three times. In the lower part, it can be seen that virtual distance traveled d [m] stays constant in the area between the two vertical lines. A reason for this may be that vehicle V is in a tunnel and there is no signal reception, which may be interpreted by the system as the vehicle not moving. It is assumed that the listening frequencies overlap in most of the regions, but there still may be frequencies that can be observed in only one run.

[0025] In FIG. 5, diagram A, the listening frequencies of an actual run 4 are shown. The prediction results are given in diagrams B, C and D of FIG. 5. It can readily be seen that the probability values are reduced from B to D and that A and B are very similar. In the prediction results shown in diagram B, there is a signal - highlighted by a circle - at the frequency of 99.8 Mhz at a travel time of around 50 s. This prediction appears strange because at this position and frequency, there is no signal at all in any of runs 1, 2 or 3. The explanation for this is that in run 4, at this particular position, the frequency changes from 98.4 to 101.1. This change is not known in the histories of runs 1, 2 or 3. Therefore, the transition probability is zero. The prediction algorithm trusts only alternative frequency probabilities that give frequency results as good as or better than 99.8 MHz.

[0026] As outlined above, a virtual location/path may be extracted from the pattern history and then, by way of the extracted virtual location/path, the best alternative frequency may be chosen.

[0027] Common RDS alternative frequency following algorithms and DAB service following algorithms do not use any predictions. The system and method disclosed herein predicts the most preferable frequency for the particular transmitter (program) with no GPS or the like involved. Saved information from the several runs of the particular path segment is used for the prediction algorithm. The history of the listening and alternative frequencies with different parameters are fused together to obtain the detection of the virtual mobile receiver location and, based thereon, the best frequency selection for the receiver. The algorithm may be based on a Markov decision process or any other appropriate approach. For example, this concept will help make reliable, fast and high-quality frequency selections in bad weather, in tunnels, when experiencing interference, under noisy conditions and if no GPS is installed in the vehicle.

[0028] The system and method may include detecting program identification codes, detecting signal strengths for a multiplicity of frequencies and programs to generate a (transition) pattern, storing the generated transmitter/program (transition) patterns (e.g., as virtual [path] maps) and querying the map with the detected transition patterns to determine the virtual location of the device. To retrieve its virtual location or travel path, the system or method may measure one or more transitions between transmitters and/or programs and use the measured pattern to query the virtual map. A comparison between the measured pattern and the virtual map may thus provide a direct correlation between the pattern and the assumed physical location of the vehicle. For example, a specific pattern of a transmitter network may correspond to a particular location on a highway or other road. Correlation of a measured transmitter and/or transition pattern with one or more transition patterns in the virtual map may provide approximate physical location information in locations where absolute location determination services (e.g., GPS) are not available. For example, GPS signals may be unavailable due to lack of line-of-sight with a required number of geosynchronous GPS satellites in, e.g., tunnels, locations surrounded by tall buildings or other areas where interference disrupts the signal.

[0029] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the invention. The words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention. Additionally, the features of various implementing embodiments may be combined to form further embodiments of the invention.

Claims

1. A method for predicting the best reception frequency at a multiplicity of temporal or local points along a path segment from a multiplicity of frequencies on which a transmitter network comprising a multiplicity of transmitters broadcasts at least one radio or television program, the method comprising:

    defining for the path segment at least two discrete frequency values out of the multiplicity of frequencies on which the transmitter network broadcasts;
    scanning the reception signals in a multiplicity of runs at the multiplicity of points over the at least two frequencies on which the transmitter network broadcasts;
    evaluating the broadcast frequencies and signal qualities of the signals received during scanning;
    storing the evaluation results per frequency and program; and
    predicting from the stored evaluation results the best reception frequency or frequencies for the at least one program along the path segment.

2. The method of claim 1, where predicting the best reception frequency or frequencies comprises a Markov process in which the states of the Markov process are given by the discrete frequency values and in which the weighting factors for transaction probability calculations are based on the signal qualities of the at least two frequencies on which the transmitter network broadcasts.

3. The method of claim 1 or 2, where the signal quality is represented by the signal strength or the bit error rate.

4. The method of any of claims 1 through 3, where listening frequency sequences, as selected by a user or a multiplicity of users during the different runs, are correlated with each other to find a shift between different runs.

5. The method of claim 4, where transaction probabilities between different states are calculated from the shifts during the multiplicity of runs.

6. The method of any of claims 1 through 5, where defining the discrete frequency values comprises:

    forming reception patterns of the received signals being evaluated according to their broadcast frequencies and signal qualities;
    storing the reception patterns for the multiplicity of temporal or local points along the path segment;
    recognizing the latest evaluated pattern(s) in the stored patterns;
    identifying identical, similar and otherwise correlated patterns;
    classifying the latest evaluated pattern(s); and
    defining the discrete frequency values based on the classification of the latest evaluated pattern(s).

7. The method of claim 6, where recognizing the latest evaluated pattern(s) comprises comparing or correlating the latest evaluated pattern(s) with the stored patterns.

8. The method of any of claims 1 through 7, where the pattern further comprises the program selected by the user.

9. A system for predicting the best reception frequency at a multiplicity of temporal or local points along a path segment from a multiplicity of frequencies on which a transmitter network comprising a multiplicity of transmitters broadcasts at least one radio or television program, the system comprising:

    a unit configured to define for the path segment at least two discrete frequency values out of the multiplicity of frequencies on which the transmitter network broadcasts;
    a receiver configured to scan the reception signals in a multiplicity of runs at the multiplicity of points over the at least two frequencies on which the transmitter network broadcasts;
    an evaluation unit configured to evaluate the broadcast frequencies and signal qualities of the signals received during scanning;
    a memory configured to store the evaluation results per frequency and program; and
    a predictor configured to predict from the stored evaluation results the best reception frequency or frequencies for the at least one program along the path segment.

10. The system of claim 9, where the predictor is configured to employ a Markov process in which the states of the Markov process are given by the discrete frequency values and in which the weighting factors for transaction probability calculations are based on the signal qualities of the at least two fre-

quencies on which the transmitter network broadcasts.

11. The system of claim 9 or 10, where the signal quality is represented by the signal strength or the bit error rate.

12. The system of any of claims 9 through 11, where listening frequency sequences, as selected by a user or a multiplicity of users during the different runs, are correlated with each other to find a shift between different runs.

13. The system of claim 12, where transaction probabilities between different states are calculated from the shifts during the multiplicity of runs.

14. The system of any of claims 9 through 13, where defining the discrete frequency values comprises:

a unit configured to form reception patterns of the received signals being evaluated according to their broadcast frequencies and signal qualities;
a memory configured to store the reception patterns for the multiplicity of temporal or local points along the path segment;
a recognition unit configured to recognize the latest evaluated pattern(s) in the stored patterns;
a pattern recognition unit configured to identify identical, similar and otherwise correlated patterns and to classify the latest evaluated pattern(s); and
a unit configured to define the discrete frequency values based on the classification of the latest evaluated pattern(s).

15. The system of claim 14, where recognizing the latest evaluated pattern(s) comprises comparing or correlating the latest evaluated pattern(s) with the stored patterns.

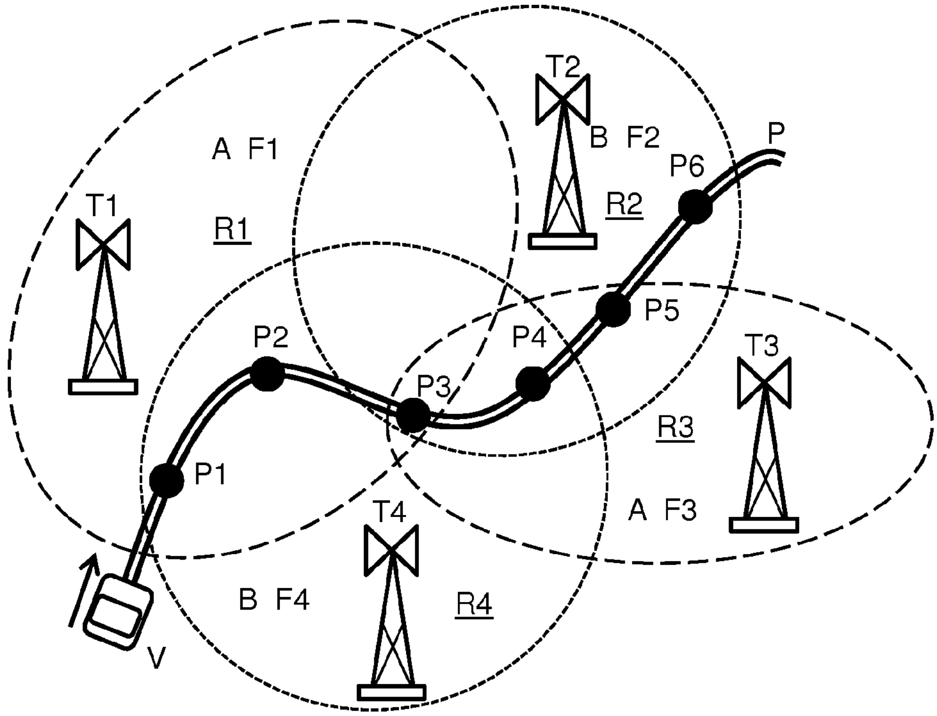
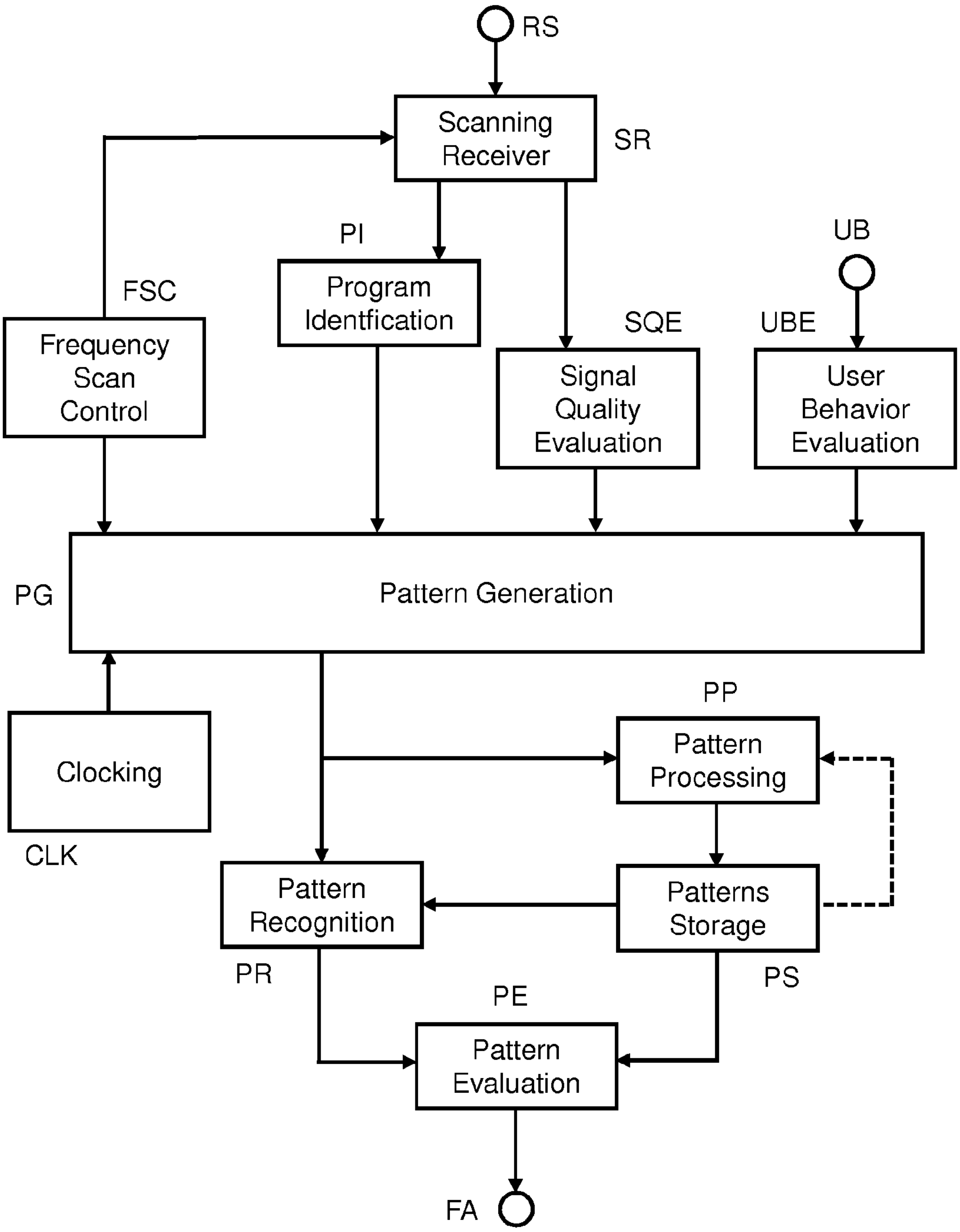


FIG 1

Reception ?	Frequ. F1 Program A	Frequ. F2 Program B	Frequ. F3 Program A	Frequ. F4 Program B
Point P1	Yes	No	No	Yes
Point P2	Yes	No	No	Yes
Point P3	Yes	Yes	Yes	Yes
Point P4	No	Yes	Yes	Yes
Point P5	No	Yes	Yes	No
Point P6	No	Yes	No	No

FIG 2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UB
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Pattern Evaluation
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FIG 3

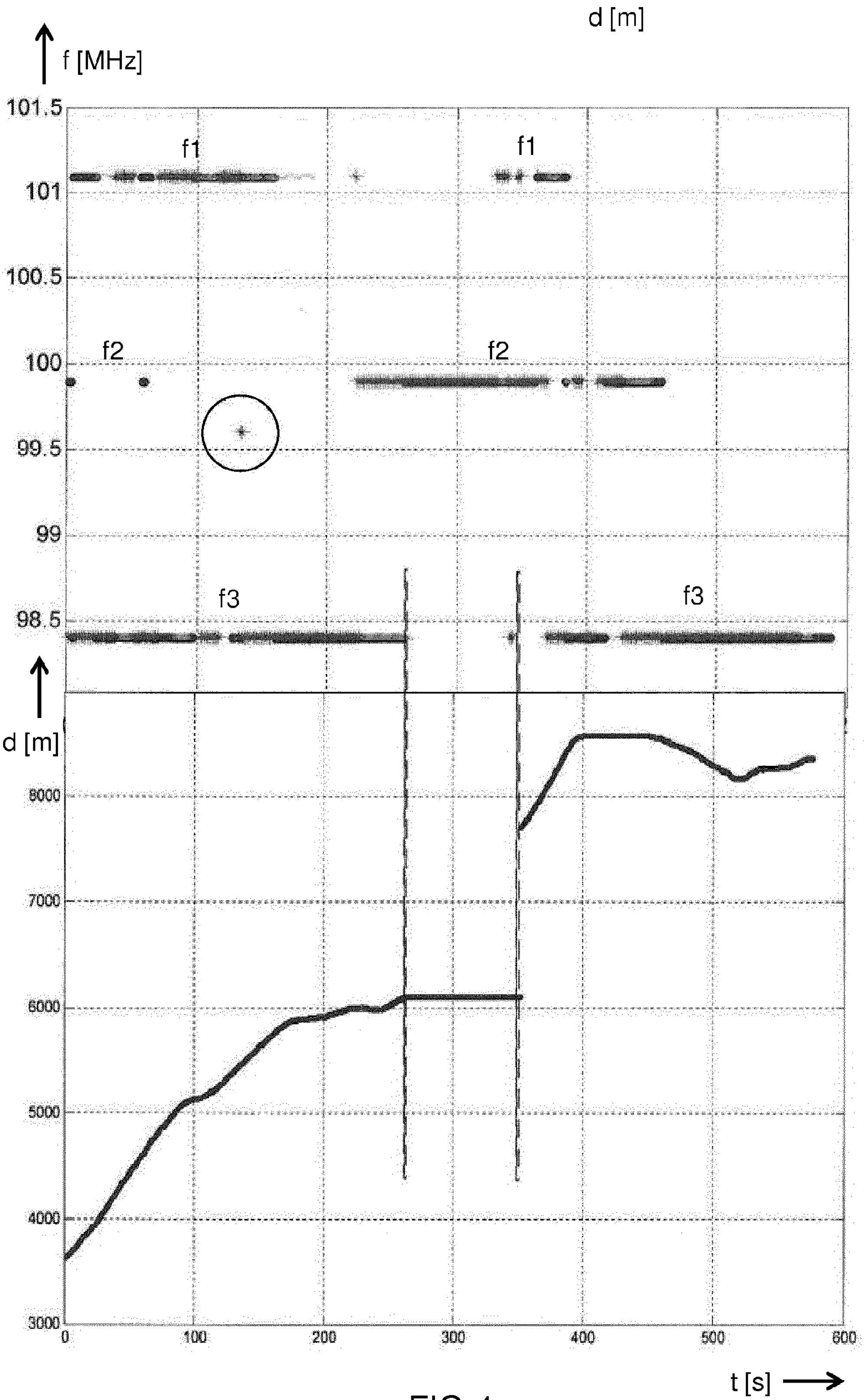
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FIG 4

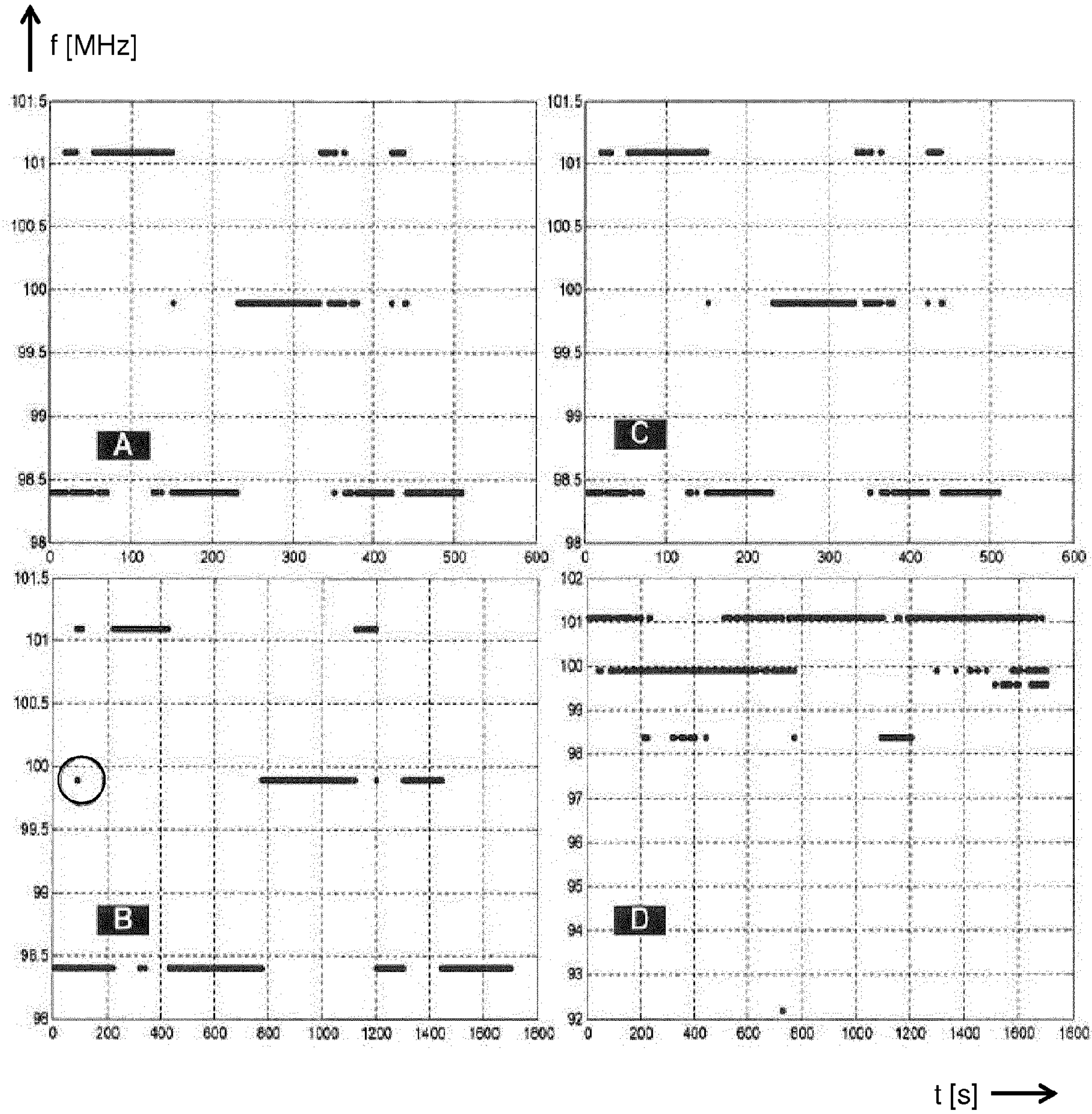

FIG 5

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 4203

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/311940 A1 (UPPALA SRIKANTH [US]) 18 December 2008 (2008-12-18) * paragraphs [0041], [0048] - [0050], [0054], [0057] - [0059], [0062] - [0071], [0073] * * figures 7-12 * -----	1-15	INV. H04H20/26 H04H60/65
X	EP 1 659 711 A1 (HARMAN BECKER AUTOMOTIVE SYS [DE]) 24 May 2006 (2006-05-24) * column 10, lines 22-26 * * column 12, lines 21-44 * * column 13, lines 39-49 * * figures 5,7,10 * * paragraph [0080] * -----	1,3,9	
X	US 2005/024264 A1 (HARRISON EDWARD R [US]) 3 February 2005 (2005-02-03) * figure 3A * * paragraphs [0029], [0030], [0032] - [0033], [0036], [0038] * -----	1,9	
A	US 2010/220818 A1 (YAMAMOTO KOHSUKE [JP] ET AL) 2 September 2010 (2010-09-02) * paragraph [0085] * -----	4	TECHNICAL FIELDS SEARCHED (IPC) H04H

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	15 August 2013	Iovescu, Vladimir

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 17 4203

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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15-08-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008311940 A1	18-12-2008	US 2008311940 A1	18-12-2008
		US 2010233980 A1	16-09-2010
EP 1659711 A1	24-05-2006	EP 1659711 A1	24-05-2006
		US 2006195239 A1	31-08-2006
US 2005024264 A1	03-02-2005	CN 1580810 A	16-02-2005
		US 2005024264 A1	03-02-2005
US 2010220818 A1	02-09-2010	JP 4525634 B2	18-08-2010
		JP 2007312052 A	29-11-2007
		US 2010220818 A1	02-09-2010
		WO 2007135942 A1	29-11-2007

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82