FOUR CHANNEL STEREOPHONIC BROADCASTING SYSTEM AND RECEIVING DEVICE

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ABSTRACT
A four channel broadcasting system of the instant invention utilizes an FM broadcasting wave of the pilot tone system having a main channel domain containing a first composite signal, a first sub-channel domain containing a second composite signal, and a second sub-channel domain containing a third and fourth composite signals. One embodiment is disclosed in which the first, second, third, and fourth composite signals take the form LF+2RF+LB+RB, LF−RF+2LB−2RB,2LF−2LB,RF−2RB, respectively. A second embodiment is disclosed in which the first, second, third, and fourth composite signals take the form LF+RF−LB<−135°+RB<+45°,LF−RF+LB<−45°+R−B<−45°,LF+RF+LB<+45°+R−B<−135°,LF−RF+LB<+135°+RB<+135° respectively. Various matrixing arrangements for formulating four discrete output signals LF,RF, LB,RB from the four composite signals are also disclosed.

8 Claims, 12 Drawing Figures
FOUR CHANNEL STEREOPHONIC BROADCASTING SYSTEM AND RECEIVING DEVICE

BACKGROUND OF THE INVENTION

This invention relates to FM stereophonic broadcasting and, more particularly, to a four-channel stereophonic broadcasting system utilizing an FM radio wave as a transmission medium and a receiver set adapted therefor.

As well known in the art, various known four-channel stereophonic sound transmission systems generally are divided into two classes: one being called a discrete system in which four-route sound signals are independently recorded or broadcasted and regenerared, and the other being called a matrix system in which four-route signals are combined by an encoder into two channel components and thereafter the two combined sound signals are regenerated by supplying them to a matrix device whereby reproduced sounds may have characters like those possessed when raw sounds were picked up to thereby provide for the effect that sounds are properly oriented and for the feeling of presence.

The discrete system four-channel FM stereophonic broadcasting system that employs main channel, first sub-channel, and second sub-channel domains is currently experimentally in operation by one broadcasting station in the U.S.A. (called the Dorren system), and it appears certain that the above discrete system four-channel stereophonic broadcasting will spread hereafter.

On the other hand, the matrix system of four-channel stereophonic broadcasting now in practice, transmits four sound signals of the four-channel stereophonic information after they are encoded into the form of two composite signals by means of the main channel and first sub-channel domains. Further, radio receiver sets are currently manufactured and sold that include a decoder and four amplifiers to receive the matrix system four-channel stereophonic radio wave and regenerate the four-channel stereophonic sounds.

In view of the foregoing background of the present-day stereophonic broadcasting, it would be convenient and important to perfect a novel four-channel stereophonic broadcasting method whereby the broadcast signal is compatible with monaural and two-channel stereophonic receivers currently employed, but can be decoded by use of the aforementioned receiver including a decoder into the form of the matrix system four-channel stereophonic sounds, and, if a second sub-channel domain is added thereto in the future, can be decoded into discrete system four-channel stereophonic sounds.

Therefore, it is an object of the present invention to provide a novel stereophonic broadcasting method and a receiver set adapted to regenerate the sound signals from the radio wave as broadcasted in accordance with the instant novel broadcasting method.

It is a specific object of the present invention to provide a novel four-channel stereophonic broadcasting method which is adapted to broadcast by use of a single radio wave medium any one of monaural, two-channel stereo, matrix system four-channel stereo, and discrete system four-channel stereo information and gives compatibility and natural feeling to a hearer even when a user selects any type of the present-day known radio receivers or demodulating means.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a novel four-channel stereophonic broadcasting method which utilizes an FM broadcasting wave of the pilot tone system that utilizes a main channel domain and a first sub-channel domain, as well known in the art. The present stereophonic broadcasting method provides additionally a second sub-channel domain to permit transmission and regeneration of the matrix system four-channel stereophonic information as well as the discrete system four-channel stereophonic information.

In the broadcasted wave, the main channel domain carries all signals of the four-channel stereophonic information. The first sub-channel domain carries signal components from which two composite signals can be derived by combining the signal components with the signals included in the main channel domains. The two composite signals may be produced by encoding the four signals of the matrix system four-channel stereophonic information. The second sub-channel domain carries signal components from which the signals of the discrete system four-channel stereophonic information can be derived by combining the signal components with the signals of the main channel domain and the first sub-channel domain.

For demodulation of the four-channel stereophonic wave broadcasted in accordance with the present broadcasting method and regeneration of the four-channel stereophonic sound signals, the present invention provides further a discrete system four-channel stereophonic receiver set and a discrete system four-channel stereophonic adapter to be used in conjunction with a conventional stereophonic receiver of the matrix system four-channel type. The instant receiver has variety in internal structure as will become clear as description proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1, 4, 7 and 10 are frequency spectrum diagrams of multiplex signals employable in the present invention;

FIGS. 2, 5, 8 and 11 are vector diagrams of signal components frequency-modulated in the domains of main channel, first sub-channel and second sub-channel, corresponding to the frequency spectrum diagrams of FIGS. 1, 4, 7 and 10, respectively;

FIGS. 3, 6, 9 and 12 are explanatory schematic diagrams showing decoder matrix sections of receivers according to the present invention, corresponding to FIGS. 2, 5, 8 and 11, respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before describing the four individual embodiments it should be noted that the broadcast signal formats of FIGS. 1, 4, 7 and 10 in combination with the vector relationships shown in FIGS. 2, 5, 8 and 11 provide suffi-
cient information to enable anyone of ordinary skill in the art to generate the described signals.

Referring first to FIGS. 1 through 3 showing a first embodiment of the present invention, FIG. 1 is a frequency spectrum diagram of a multiplex signal employable in the present invention. In the drawing, a first signal M1 is employed directly as a main channel component, a second signal S1 is converted to a carrier suppressed AM double-sideband signal with the center frequency of 38 kHz and employed as a first sub-channel component, and third and fourth signals S2 and S3 are converted through quadrature modulation to a carrier suppressed AM double-sideband signal with the center frequency of such as 76 kHz and employed as a second sub-channel component. The three above channel components are together frequency modulated onto a carrier in the VHF band. The 19 kHz signal shown in the drawing is a so-called pilot carrier. The signal group consisting of signals M1 and S1 and the pilot carrier corresponds to the signal arrangement according to the so-called pilot tone system which provides the standard FM broadcasting radio wave now widely employed throughout the world.

FIG. 2 is a vector diagram of signal components M1, S1, S2 and S3 shown in FIG. 1. It will be understood that, if the composite signal shown in FIG. 1 is received and regenerated by a monaural receiver, only the signal M1 is extracted and, because the signal M1 includes all signal components which are to be oriented on left-front (Ll), right-front (Rl), left-back (La) and right-back (Ra) sides, respectively, as appreciated from the vector diagram, music can be enjoyed by use of the monaural receiver without an artificial feeling. Further, in the case where the signal is received by a conventional FM stereo receiver, signals S4 and S5 can be derived from the signals M1 and S1 through a matrix device MT1 including a phase inverter PI, as shown in FIG. 3. Because the signals S4 and S5 include chiefly signal components which are to be oriented on left and right sides, respectively, they can be employed directly as two-channel sound signals.

The matrices operate in an apparent manner in view of the drawings. Matrix MT1 will be explained in detail. The other matrices operate in the same manner. Matrix MT1 has two inputs and two outputs. The first and second inputs receive the signals M1 and S1 respectively. The first output is the vector sum of M1 and S1. As shown at S4, the vector sum results in cancellation of RP and reinforcement of LR. The second output is the vector sum of M1 and S1 inverted. As shown at S5, the vector sum results in cancellation of LR and reinforcement of RP.

The two above signal components (S4 and S5) correspond to composite signals produced by encoding four signals into two, and this feature of signal encoding process is called a CBS or SQ system developed by Columbia Broadcasting System Incorp., U.S.A.

Then, if the above signals S4 and S5 are supplied without modification to loudspeakers positioned on left-front and right-front sides to regenerate corresponding sounds, and the signals M1 and S1 are also supplied to a matrix device MT2 including −45° and +45° phase shifters and a phase inverter to derive signals S6 and S7 which are in turn supplied to loudspeakers positioned on left-back and right-back sides to regenerate corresponding sounds, the matrix system four-channel stereophonic sound field can be produced.

Signals S2 and S3 shown in vector representation in FIG. 2 are obtained by demodulating the second sub-channel signal component as broadcasted. As shown schematically in FIG. 3, signals S8 and S9 are obtained by applying the signal M1 of the main channel and one signal S2 included in the second sub-channel to a matrix device MT3 including a phase inverter PI. Signals S10 and S11 are obtained through matrix operation by applying the signal S1 of the first sub-channel and the other signal S3 included in the second sub-channel to a matrix device MT4 including a phase inverter PI. Further, the signals S8 and S10 are processed by a matrix device MT5 including a phase inverter PI to obtain signals S12 and S13, and the signals S9 and S11 are processed by a matrix device MT6 including −45° and +45° phase shifters and a phase inverter PI to obtain signals S14 and S15. As shown in vector representation in FIG. 3, the signals S12 through S15 have no crosstalk therebetween but the same phase relationship, so that by applying these signals to corresponding loudspeakers positioned on left-front, right-front, left-back and right-back sides around a hearer, the discrete system four-channel stereophonic sound field can be produced.

In the first embodiment of FIGS. 1 through 3, pre-consideration is given in designing the decoder so that the structures of matrix devices MT5 and MT6 correspond to those of matrix devices MT1 and MT2, respectively, which serve to generate the signals S4 through S7 of the matrix system four-channel stereophonic information. Therefore, in case a user possesses a decoder or receiver of the matrix system type, it is possible to regenerate the discrete system four-channel stereophonic sound output by attaching a circuit device capable of processing the second sub-channel component to obtain the signals S8 through S11, as an adapter to the conventional receiver, while operating simultaneously the matrix devices MT1 and MT2 originally included in the receiver, this being one of the advantages of the present invention.

FIGS. 4 through 6 show a second embodiment of the present invention wherein, while the same modulated signal as that of the first embodiment is employed, the combination of matrix devices to form the decoder differs from the arrangement of matrix devices of the first embodiment. That is, the signals M1 and S1 shown in FIG. 5 are applied to the matrix device MT1 including the phase inverter PI to obtain the signals S4 and S5 which can be directly employed as the two-channel stereophonic sound signals, as described in connection with the first embodiment.

Different from the first embodiment, the signals S4 and S5 of the second embodiment are applied to a matrix device MT7 including −90° phase shifters to obtain signals S7 and S6′, and the latter signal S6′ is then applied to a phase inverter PI to obtain the signal S6.

Thus, it will be understood that, even by use of two matrix devices MT1 and MT7 and one phase inverter PI, as is the case of the second embodiment, all the signals of the matrix system four-channel stereophonic information can be obtained, similar to the first embodiment.

The right hand half of the circuit shown in FIG. 6 is for obtaining the discrete system four-channel stereophonic sounds by use of the second sub-channel signal
component. That is, signals S16 and S17 are obtained by applying the signals S2 and S3 to a matrix device MT8 for matrix processing. Here, it should be noted that if a carrier signal to be added in demodulating the second sub-channel component is phase shifted a 45°, the signals S16 and S17 can be obtained directly as demodulation signals, thus, the above provision obviates the use of the matrix device MT8.

In FIG. 6, the signals S4 and S16 are applied to a matrix device MT9 including a phase inverter PI for matrixing to produce signals S18 and S19 and, then, the signals S5 and S17 are applied to a matrix device MT10 including a phase inverter PI for matrixing to produce signals S20 and S21. Thereafter, the signals S19 and S21 are applied to a matrix device MT11 including a 90° phase shifters for matrixing to produce signals S22 and S23, and the latter S23 is processed by a phase inverter PI to produce a signal S23.

By supplying the thus obtained signals S18, S20, S22 and S23 to loudspeakers positioned on left-front, right-front, right-back and left-back sides, respectively, around the hearer, the discrete system four-channel stereophonic sounds can be regenerated and heard.

FIGS. 7 through 9 show a third embodiment of the present invention utilizing the same frequency spectrum feature as that employed in the foregoing embodiments. As shown schematically in FIGS. 7 and 8, a signal M1 is a composite monaural signal including four signals with a weight put upon front signal components, thus, by regenerating this composite signal, a natural monaural sound can be heard. This main signal M1 and a signal S24 in the first sub-channel are processed by the matrix device MT1 included in the conventional receiver to produce signals S27 and S28. The obtained signals S27 and S28 have signal components whose majority portions are to be oriented on left and right sides, respectively, thus, by use of these two signals without modification the two-channel stereophonic sounds can be heard. Here, it will be noted that the two above signal components correspond to two composite signals produced by encoding four channel signals; this latter feature was proposed by Peter Scheiber, U.S.A., and is called the Scheiber system. Accordingly, by use of a matrix device MT12, including attenuators each with the attenuation coefficient of 0.414 and phase inverters PI, four signals S29 through S32 can be derived from the signals S27 and S28.

As will be understood from FIG. 9, the four signals S29 through S32 permit hearing of substantially properly oriented four-channel stereophonic sounds as they are applied to loudspeakers, while a little crosstalk effect will remain in the view point of the matrix system four-channel stereophonic information.

Signals S25 and S26 included in the second sub-channel in an FM mode are, after demodulation, applied to a matrix device MT13, including phase inverters PI, through respective attenuators each with the attenuation coefficient of 0.828, shown in rectangular block "X 828". The matrix device MT13 receiving also the signals S29 through S32 generates signals S33 through S36. The resulting signals S33 through S36 are in turn processed by a matrix device MT14 including "X 414" attenuators and phase inverters PI to obtain four independent sound signals S37 through S40.

FIGS. 10 through 12 show a fourth embodiment of the present invention which is designed so that the discrete system four-channel stereophonic sounds are directly obtained, contrary to the above third embodiment where the matrix system four-channel signals are additionally produced. The main channel signal M2 and the first sub-channel signal S24 are matrix-processed by the matrix device MT1 to obtain the signals S27 and S28 as is the case of the third embodiment; however, in this fourth embodiment, the signals S25 and S26 obtained from the second sub-channel are combined at a matrix device MT15 together with the signals S27 and S28 to generate signals S41 through S44. Because these signals S41 through S44 include a little crosstalk component each, the signals S25 and S26 after being phase inverted are added at a next matrix device MT16 in order to cancel the crosstalk components.

Though specific embodiments of the present invention have been described hereinabove, it should be understood that the broadcasting method and receiver set of the present invention are not to be limited only to the specific features described hereinabove and illustrated in the drawings. For example, the set of various signal components that are to be frequency modulated through the main channel, first sub-channel and second sub-channel domains should not be limited to those sets which have the foregoing specific vector relationships. The requirements which are to be satisfied in the present invention are that: the main channel domain includes at least four signal components of the four channel routes; the first sub-channel domain includes signal components from which two composite signals that may be produced by encoding four signals of the matrix system four-channel stereophonic information can be derived through combining them with the signals included in the main channel domain; and the second sub-channel domain includes signal components from which the discrete system four-channel stereophonic sound signals can be derived through combining them with the signals included in the main channel and first sub-channel domains. Therefore, so far as the above requirements are fulfilled, various signal components in various relative modes can be selected freely as the main channel, first sub-channel and second sub-channel signal components.

Further, though all the demodulating means were constructed by matrix circuits in the illustrated embodiments, they can also be realized by use of switching (time-dividing) means as is the case of the pilot tone system stereophonic receiver.

What is claimed is:

1. A discrete system four-channel stereophonic receiver adapted to receive a four-channel stereophonic frequency modulated wave of the following format: a main channel domain having all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated as R1, L1, R2 and L2 and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:
a first sub-channel domain having all four signals of four-channel stereophonic information in said first sub-channel domain, said four signals comprising a second composite signal in said first sub-channel domain such that the vector representations of said four signals of said second composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

\[
\begin{align*}
R_f &< 0^\circ \\
L_f &< 0^\circ \\
R_a &< -135^\circ \\
L_a &< -45^\circ
\end{align*}
\]

a second sub-channel domain having all four signals of four-channel stereophonic information in said second sub-channel domain, said four signals comprising third and fourth composite signals in said second sub-channel domain such that the vector representations composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

\[
\begin{align*}
R_f &< 0^\circ \\
L_f &< 0^\circ \\
R_a &< -135^\circ \\
L_a &< +45^\circ
\end{align*}
\]

and the vector representations of said four signals of said fourth composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

\[
\begin{align*}
R_f &< 0^\circ \\
L_f &< 0^\circ \\
R_a &< +135^\circ \\
L_a &< +135^\circ
\end{align*}
\]

4. A discrete system four-channel stereophonic receiver comprising:

first means for matrix-processing said first and third composite signals to generate a fifth composite signal consisting of the signals designated \( R_f \) and \( L_f \) and a sixth composite signal consisting of the signals designated \( R_a \) and \( L_a \),

second means for matrix-processing said second and fourth composite signals to generate a seventh composite signal consisting of the signals designated \( R_f \) and \( L_f \) and an eighth composite signal consisting of the signals designated \( R_a \) and \( L_a \), and combining means for receiving said fifth, sixth, seventh and eighth composite signals and deriving therefrom four independent sound signals \( R_f \), \( L_f \), \( R_a \), and \( L_a \).

5. A discrete system four-channel stereophonic receiver as recited in claim 4 wherein said combining means comprises:

third means for matrix-processing said fifth and seventh composite signals to generate said independent sound signals designated \( R_f \) and \( L_f \), and

fourth means for matrix-processing said sixth and eighth composite signals to generate said independent sound signals designated \( R_a \) and \( L_a \).

6. A discrete system four-channel stereophonic receiver adapted to receive a four-channel stereophonic frequency modulated wave of the following format:
a main channel domain having all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated as \( R_f \), \( L_f \), \( R_a \) and \( L_a \) and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

\[
\begin{align*}
R_f &< 0^\circ \\
L_f &< 0^\circ \\
R_a &< +45^\circ \\
L_a &< -135^\circ
\end{align*}
\]

a second sub-channel domain having all four signals of four-channel stereophonic information in said second sub-channel domain, said four signals comprising a second composite signal in said first sub-channel domain such that the vector representations of said four signals of said second composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

\[
\begin{align*}
R_f &< 0^\circ \\
L_f &< 0^\circ \\
R_a &< -45^\circ \\
L_a &< -45^\circ
\end{align*}
\]

and the vector representations of said four signals of said fourth composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

\[
\begin{align*}
R_f &< 0^\circ \\
L_f &< 0^\circ \\
R_a &< -135^\circ \\
L_a &< +45^\circ
\end{align*}
\]
and $L_r$ and a sixth composite signal consisting of the signals designated $R_r$, $R$, and $L_r$, second means for matrix-processing said third and fourth composite to generate a seventh composite signal consisting of the signals designated $L_r$, $R_r$, and $L_r$, and an eighth composite signal consisting of the signals designated $R_r$, $R$, and $L_r$, and combining means for receiving said fifth, sixth, seventh and eighth composite signals and deriving therefrom four independent sound signals $R_r$, $R$, $R$, and $L_r$.  

4. A discrete system four-channel stereophonic receiver as recited in claim 3 wherein said combining means comprises:

3. A discrete system four-channel stereophonic receiver adapted to receive a four-channel stereophonic frequency modulated wave of the following format: a main channel domain having all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated a $R_r$, $L_r$, $R$, and $L_r$ and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 0^\circ$
- $L_r < 0^\circ$
- $L_r < 0^\circ$
- $L_r < 0^\circ$

5. A discrete system four-channel stereophonic receiver adapted to receive a four-channel stereophonic frequency modulated wave of the following format: a main channel domain having all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated a $R_r$, $L_r$, $R$, and $L_r$ and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 0^\circ$
- $L_r < 0^\circ$
- $L_r < 0^\circ$
- $L_r < 0^\circ$

6. A discrete system four-channel stereophonic receiver adapted to receive a four-channel stereophonic frequency modulated wave of the following format: a main channel domain having all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated a $R_r$, $L_r$, $R$, and $L_r$ and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 0^\circ$
- $L_r < 0^\circ$
- $L_r < 0^\circ$
- $L_r < 0^\circ$
second sub-channel domain such that the vector representations of said signals comprising said third composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

- $L_1 < 0^\circ$
- $L_2 < 180^\circ$

and the vector representations of said signals comprising said fourth composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 0^\circ$
- $R_a < 180^\circ$

said discrete system four-channel stereophonic receiver comprising:

- first means for matrix-processing said first and second composite signals to generate a fifth composite signal and a sixth composite signal each comprising all four signals of four-channel stereophonic information,
- second means for matrix-processing said third, fourth, fifth and sixth composite signals to generate seventh, eighth, ninth and tenth composite signals each consisting of a different combination of three of said four signals of four-channel stereophonic information, and
- means for decoding said seventh, eighth, ninth and tenth composite signals to derive therefrom four independent sound signals $R_r$, $L_r$, $R_a$, and $L_a$.

7. In a frequency modulated broadcasting system for discrete four-channel stereophonic information, the method of broadcasting said four-channel information comprising:

- generating a pilot signal,
- modulating a main channel carrier with all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated as $R_r$, $L_r$, $R_a$, and $L_a$ and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 0^\circ$
- $L_r < 0^\circ$
- $R_a < +45^\circ$
- $L_a < -135^\circ$

modulating a first sub-channel suppressed carrier having a frequency equal to a first multiple of said pilot signal with all four signals of four-channel stereophonic information in said first sub-channel domain, said four signals comprising a second composite signal in said first sub-channel domain such that the vector representations of said four signals of said second composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

- $2 R_r < 0^\circ$
- $2 L_r < 0^\circ$

and the vector representations of said four signals of said second composite signal are of equal magnitudes and have the following angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 180^\circ$
- $L_r < 0^\circ$
- $R_a < -45^\circ$
- $L_a < -45^\circ$

8. In a frequency modulated broadcasting system for discrete four-channel stereophonic information the method of broadcasting said four channel information comprising:

- generating a pilot signal,
- modulating a main channel carrier with all four signals of four-channel stereophonic information in said main channel domain, said four signals being designated as $R_r$, $L_r$, $R_a$, and $L_a$ and comprising a first composite signal in said main channel domain such that the vector representations of said four signals of said first composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

- $R_r < 0^\circ$
- $L_r < 0^\circ$
- $R_a < +135^\circ$
- $L_a < +135^\circ$

modulating a first sub-channel suppressed carrier having a frequency equal to a first multiple of said pilot signal with all four signals of four-channel stereophonic information in said first sub-channel domain, said four signals comprising a second composite signal in said first sub-channel domain such that the vector representations of said four signals of said second composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:
quadrature modulating a second sub-channel suppressed carrier having a frequency equal to a second multiple of said pilot signal with all four signals of four-channel stereophonic information in said second sub-channel domain, and four signals comprising third and fourth composite signals in said second sub-channel domain such that the vector representations of said signals comprising said third composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

\[ R_1 < 180^\circ \]
\[ L_1 < 0^\circ \]
\[ R_2 < 180^\circ \]
\[ L_2 < 0^\circ \]

and the vector representations of said signals comprising said fourth composite signal have the following relative magnitudes and angular displacements from the positive x-axis in two-dimensional space:

\[ L_3 < 0^\circ \]
\[ L_4 < 180^\circ \]

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