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SIGNAL TRANSMISSION SYSTEM

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This invention relates to electrical transmission systems and more particularly to electrical filter systems. Still more particularly this invention relates to transmission systems employing filters or similar circuits or networks set up to transmit currents having a band of frequencies, the width of which may be changed in accordance with signal currents or voltages or other causes.

This invention involves a band selective network having limits which are variable under control of a signal current or voltage or other effect. The network may be supplied, for example, with a band of frequencies comprising a substantially continuous spectrum of randomly related currents extending over a wide band, such as the band that may be obtained from a noise generator or other source, and this band may be widened or narrowed according to signals or other causes. The network of this invention may include, for example, an oscillator for supplying current having a frequency which directly depends on the signal voltage or current, and a modulator for superimposing the received current on the oscillator current for raising the received band of frequencies in the frequency spectrum. The currents of the elevated frequencies may then be transmitted through a band filter of fixed limits which may transmit only a portion of the elevated frequencies. The frequencies transmitted by the filter may then be demodulated with the same oscillator current to return the elevated frequencies transmitted by the filter to their original position in the frequency spectrum. The demodulated band of frequencies will be of a width which will correspond to the magnitude of the impressed signal current or voltages or other cause. The filters employed may be of any suitable type, such as the crystal filters disclosed in Patent 2,045,991 granted June 30, 1936, to W. P. Mason.

This invention will be better understood from the more detailed description hereinafter following when read in connection with the accompanying drawing in which the circuit arrangement shown illustrates one form of apparatus for producing a band of frequencies of a width which depends on a signal current or voltage or other factor.

Referring to the drawing, there is shown an input circuit L_1 which may receive from a source SC currents of frequencies substantially continuously distributed over a band. These currents may be obtained from a noise generator of any well-known type or from any complex source of currents, such as the thermal agitation of free electrons in a resistive impedance or the random fluctuations of the electron current in the space path of a thermionic vacuum tube. The input circuit L_1 is connected to a band filter F_1 which may transmit only a predetermined band of frequencies as, for instance, 1000 to 1100 cycles, all other received frequencies being suppressed by filter F_1. The transmitted currents together with the current of an oscillator O are fed to a balanced modulator MD which is of well-known type and serves to produce two side bands of the current obtained from oscillator O, the current of oscillator O being suppressed in the balanced circuits of the modulator. The oscillator O is of the variable-frequency type, the frequency of which is varied in accordance with variations in the amplitude or phase of the signal current or voltage or other effect received over a signal control circuit L_2. The oscillator frequency may have a mean value of, for example, 148,950 cycles and many swing over a range of plus or minus 50 cycles according to the magnitude of the control current or voltage.

Assuming that the signal current or voltage in circuit L_2 is of zero magnitude or is entirely absent, then the oscillator current will be at its mean value of 148,950 cycles, and the lower side band resulting from modulation will extend from 147,850–147,950 cycles while the upper side band will extend from 149,950–150,050 cycles. These side bands are then transmitted to a second band filter F_2 which has fixed limits of, for example, 150–156 kilocycles. This filter will suppress all of the lower side band obtained from modulator MD as well as part of the upper side band, i. e. the part below the lower cutoff frequency of the filter. Hence those frequencies of the upper side band which are above the lower cutoff point of the filter F_2 will alone be transmitted, or 150,000–150,050 cycles. A band of this width traversing filter F_2 and evelated in the frequency spectrum will correspond to an oscillator frequency which is at its mean value due to the absence of a control signal.

Currents of the frequencies passed by filter F_2 are then fed along with the oscillator current to a balanced demodulator DM of well-known type, the demodulator acting to return the elevated band of frequencies to its original position in the frequency spectrum. The band of frequencies obtained from the demodulator DM in the illustration given will extend from 1050–1100 cycles and currents of these frequencies will appear in the output circuit L_3 leading to a load circuit LC. The reduced band of frequencies returned to its original position in the frequency spectrum will correspond to the condition of zero control voltage. The demodulator DM also creates an upper side band which may be eliminated by any simple selective means (not shown) such as an output transformer of suitable characteristic or a low-pass filter.

Instead of a control voltage in line L_2 of zero value, the control voltage may be positive or negative within certain limits. When the control voltage increases and reaches its maximum positive value, the frequency of the oscillator current will rise to, for example, 149 kilocycles. When this happens, the upper side band resulting from modulation in modulator MD will extend from 150,000 to 150,100 cycles, all of the components of which will lie within the frequency limits of filter F_2. All of the upper side band will therefore be transmitted by filter F_2 and the entire lower side band will be suppressed. This upper side band will be returned by the action of demodulator DM to its original position in the frequency spectrum, the demodulated band including frequencies from 1000 to 1100 cycles. Thus when the signal or control voltage or effect is at its maximum positive value, the band transmitted to line L_3 will be widened to its maximum value to equal the limits of filter F_1.

On the other hand, when the control voltage of line L_2 is at its maximum negative value, the oscillator frequency in the assumed case will be 148,900 cycles. The side bands resulting from modulation will lie outside the limits of filter F_2 and hence substantially no current will traverse filter F_2. There will then be substantially an absence of current in line L_3.

Thus it will be observed that with an oscillator supplying a current which varies in frequency in accordance with signals or other effects, the band of frequencies fed to the output circuit L_3 will be changed in width to correspond to the values of the signals or other control effects. The band may be increased in width to limits which are determined by the frequency limits of filters F_1 and F_2, whichever is the narrower.

It has been shown that when the oscillator current frequency is below the lower frequency limit of filter F_2, only the upper side band resulting from modulation contains components within the range of filter F_2 which are transmitted and thereafter demodulated. It is the lower region of the upper side band that may be "trimmed" or cut off due to the presence or absence of a control voltage as already explained. In a case where the oscillator current frequency is above the upper limit of filter F_2 the upper region of the lower side band resulting from modulation will likewise be "trimmed" or removed due to the presence or absence of a control voltage.

It has been shown that the lower edge of the upper side band obtained from filter F_1 may be "trimmed" according to signals or other control effects while the upper edge of the band remains unchanged. It is also possible to "trim" the upper edge of the band of frequencies emanating from filter F_1 while not affecting the lower edge of the band. An example of this type of modulating action will now be given.

Assume, for example, that the frequency limits of band filter F_1 are 10,000–10,100 cycles, that the mean frequency of oscillator O is 145,950 cycles and that the oscillator frequency is variable within limits of plus or minus 50 cycles in accordance with any signal or control voltage in circuit L_2 as assumed in previous examples. At the mean oscillator frequency condition, the lower side band obtained from modulator MD will extend from 135,850 to 135,950 cycles. The upper side band will extend from 155,950 to 156,050 cycles. If the filter F_2 has the frequency limits of 150–156 kilocycles, as was also assumed in prior illustrations, then the lower side band will be entirely suppressed while only part of the upper side band will be transmitted. The only part of the upper side band transmitted will extend from 155,950 to 156,000 cycles—which is the lower part of the upper side band. The upper part of the upper side band will be "trimmed" or suppressed by the modulating action. Upon demodulation in demodulator DM, the band of frequencies 155,950–156,000 cycles will be lowered in the frequency spectrum to a band extending from 10,000 to 10,050 cycles. Thus part of the upper region of the original band transmitted by filter F_1, i. e. 10,050–10,100 cycles, will be suppressed or "trimmed." The demodulator DM also creates an upper side band which may be eliminated by any simple selective means (not shown) such as an output transformer of suitable characteristic or a low-pass filter.

As the frequency of oscillator O rises to, for example, its maximum value of 146 kilocycles, then the upper side band resulting from modulation will extend from 156,000 to 156,100 cycles. All of this side band (and of course the lower side band) will be outside the limits of filter F_2 and will therefore be suppressed. The line L_3 will therefore receive no current during this status.

However, when the oscillator frequency falls to, for example, its minimum value, of 145,900 cycles, the upper side band will comprise the frequencies between 155,900 and 156,000 cycles, all of the components of which come within the range of filter F_2. Upon demodulation the band will comprise frequencies between 10,000 and 10,100 cycles which has the same width as the original band traversing filter F_1.

It will be noted that the upper edge of the band traversing filter F_1 may be "trimmed" by having the frequency spacing between the side bands resulting from modulation greater than the band width of filter F_2. The filter F_2 must have a pass band which is wide enough to permit one of the side bands to be swept across its edge at a rate corresponding to the frequency of the modulating signal voltage or current in circuit L_2.

Whether the upper or lower edge of the band is "trimmed" is determined by the side band which comes within the range of filter F_2 and by the edge of the latter filter which the side band is swept across. This may be generalised as follows: When the lower side band from modulator MD sweeps across the lower edge of the filter F_2, the upper portion of the band traversing filter F_1 will have been "trimmed." When this same side band sweeps across the upper edge of the filter F_2, the lower portion will have been "trimmed." When the upper side band sweeps across the lower edge of the filter F_2, the lower portion of the band traversing filter F_1 will have been "trimmed"; while the upper portion will have been "trimmed," if this same side band sweeps across the upper edge of filter F_2. In all cases the "trimming" of the band of filter F_1 is of a frequency width which depends on and corresponds to the signal current or voltage in circuit L_2.

It will be understood that the currents in line L_3 may be amplified, if desired, and modulated on current of a carrier frequency by well-known apparatus and then transmitted over a radio or wire circuit or link to a distant point. At the distant point the received band of frequencies may be amplified, if desired, demodulated and thereafter impressed upon a square law detector of well-known type to reproduce the original speech or other signals corresponding to the speech or other signals in circuit L_2. The currents of line L_6 may be transmitted by systems of amplitude modulation or frequency modulation as will be clear to those skilled in the art.

It will be apparent that by arranging two networks, such as that shown in the drawing, both connected in tandem, the "trimming" action may be caused to take place at both ends of the band simultaneously and, if desired, equal changes in width at the two edges of the band may be obtained.

The structure used to vary the frequency of the current of oscillator O in accordance with the signal waves or other effects received over line L_2 may be any suitable well-known type, such as the structure disclosed in Patent 2,250,104 granted July 22, 1941, to J. F. Morrison or Patent 1,941,068 granted December 26, 1933, to E. H. Armstrong. It is this variable frequency that is employed in this invention to change the width of the band of noise or other currents, whether of a complex nature or not, supplied through filter F_1. The band of frequencies fed through filter F_1 may include frequencies substantially continuously distributed over a band of the spectrum which may be of any desired width.

The frequencies used in the examples and the swings in the oscillator frequency are given merely for illustrative purposes and are not to be construed as limitations on the invention.

While this invention has been shown and described in certain particular embodiments merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A signal transmission system for transmitting a frequency band having its width varied in accordance with signals, comprising a source of alternating current, a source of signals, means for varying the frequency of said alternating current in accordance with said signals, a source supplying a substantially continuous band of frequencies having a predetermined constant width, and means responsive to changes in the frequency of said alternating current to vary proportionally the instantaneous width of the band of frequencies.

2. The combination of a source of currents having energy substantially continuously distributed over a band of frequencies of predetermined limits, said limits being fixed and constant, an oscillator, an independent source of variable voltage, means for varying the frequency of said oscillator in accordance with changes in the voltage of the latter source, and means for changing the instantaneous width of the band of frequencies transmitted from the first source in proportion to the varying voltage, said means including a modulator and a filter and a demodulator all connected in tandem, the oscillator being connected in common to the modulator and the demodulator.

3. A band selective transmission system, said system including a source of signal currents having significant amplitude variations, a generator for generating currents having frequencies substantially continuously distributed throughout a wide frequency range, a first band pass filter for selecting a limited band of frequencies of constant limits from the frequencies supplied by said generator, an oscillator, means for varying the frequency of the oscillations produced by said oscillator in accordance with variations in the amplitude of the signal currents, a first modulator for combining said band of frequencies together with the variable frequencies from the oscillator to produce upper and lower side-bands having positions in the frequency spectrum which vary in accordance with variations in the instantaneous amplitude of the signal currents, a second band pass filter having a pass band of substantially greater width than said band of frequencies and adapted to eliminate one of said side-bands and to trim part of the other side-band, the amount trimmed being proportional to the instantaneous amplitude of said signal currents, and a second modulator for restoring to their original positions in the frequency spectrum those frequencies from said generator that were passed by the second band pass filter.

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