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FREQUENCY REDUCING SYSTEM

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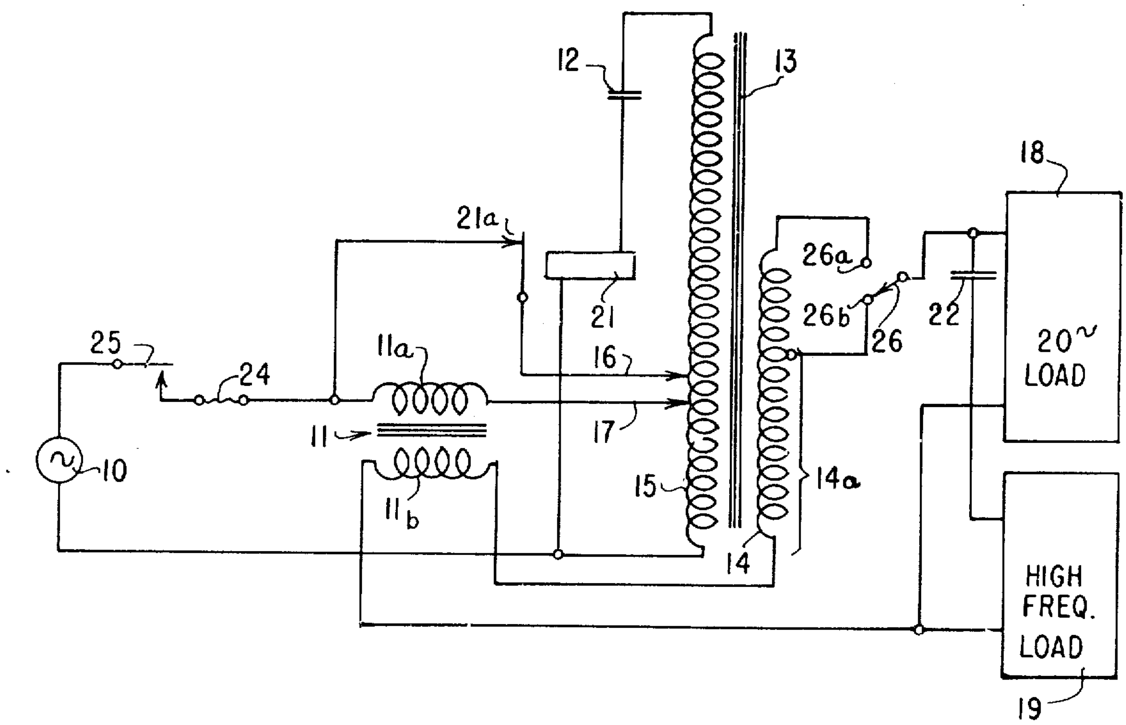

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FREQUENCY REDUCING SYSTEM

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The present invention relates to frequency reducing systems, and, more particularly, to improvements in frequency reducing systems of the static type disclosed in Patent No. 2,088,618—Stocker, and No. 2,088,619—Stocker, granted August 3, 1937.

In systems of this type, a resonant circuit is provided which is tuned to a fundamental or resonant frequency lower than that of the current supply source. When such a resonant circuit is periodically shock-excited, each shock excitation produces in the circuit an alternating current of the resonant frequency having an amplitude of decreasing value due to the internal losses of the circuit and also to the abstraction of energy by the connected load. If, however, the periodicity of shock excitation is sufficiently high, oscillation of the circuit at the fundamental or resonant frequency is sustained. Systems of this form utilize a non-linear impedance element in the form of a saturable core reactor connected between the resonant circuit and the supply source, as the vehicle for periodically shock exciting the resonant circuit to sustain its oscillation.

Static frequency reducing arrangements of the character briefly referred to above have particular utility in the telephone field where they are utilized in the production of a ringing voltage of low frequency, which is used in the signaling of called subscriber substations. In the usual ringing or signaling operation, a revertive or ring-back tone signal is transmitted to the calling substation for the purpose of informing the calling subscriber that the called substation is being signaled. From the standpoint of audibility, it is preferable to use a ring-back or revertive tone signal of a frequency higher than the frequency conventionally utilized for the energization of the standard telephone ringer. Accordingly it has previously been the practice to utilize an iron core tone coil in the resonant circuit of a static frequency reducing system of the character described above, this coil being designed so that its core is saturated on each half cycle of the current traversing the resonant circuit, whereby harmonics of the fundamental frequency are produced and supplied to the output circuit of the system for use as the revertive tone signal voltage. It has been found that the revertive tone signal voltage which may be obtained from a static frequency reducing system in this manner contains a limited number of harmonics of the fundamental frequency, is of limited magnitude, and may be insufficient to provide a readily discernible audible signal when reproduced at the end of a long line to which the voltage is applied. It has also been found that the presence of the tone coil in the resonant circuit of a system of this character, causes a reduction in the low frequency output capabilities of the system due to the absorption of the low frequency energy by the tone coil.

It is an object of the present invention to provide an improved static frequency reducing system wherein the above-noted difficulties are obviated.

It is another object of the invention to provide an improved frequency reducing system of simple arrangement, which utilizes no moving parts and includes provisions for supplying low and high frequency currents to low and high frequency loads when energized from a source of current having a frequency higher than that of the low frequency output current.

It is a further object of the invention to provide an improved static frequency reducing system, wherein provisions are made for augmenting the harmonics of the supply source frequency introduced into the output circuit of the system, both as regards the magnitude of the harmonic voltages and the frequencies of the harmonics supplied to the output circuit of the system.

According to another object of the invention, the increase in the harmonic content of the output voltage is realized without lowering or otherwise affecting the low frequency load carrying capabilities of the system.

It is still another and more specific object of the invention to provide a static frequency reducing system of the character described, wherein a channel separate from that used to deliver the low frequency energy to the output circuit, is provided for transmitting the high frequency harmonic energy to the output circuit.

According to a still further object of the invention, the non-linear impedance element which is used periodically to excite the resonant circuit, is also utilized to augment the high frequency components of the system output voltage.

The invention, both as to its organization and method of operation, together with furher objects and advantages thereof, will best be understood by reference to the specification taken in connection with the accompanying drawing in which the single figure illustrates a static frequency reducing arrangement connected and arranged in accordance with the present invention.

Referring now more particularly to the drawing, the static frequency reducing system there illustrated comprises a tuned resonant or oscillatory circuit which serially includes a condenser 12, the primary winding 15 of a transformer 13 and the winding of a start relay 21. This resonant circuit is connected through the upper winding of a saturable core reactor 11, a protective device in the form of a fuse 24, and the contacts of a circuit breaker 25 to the terminals of a source of alternating current 10 of low internal impedance which may comprise any suitable alternating current generator, transformer, power line, or network, capable of supplying the necessary power at the frequency required to operate the system. In the illustrated arrangement of the system, an output circuit comprising the secondary winding 14 of the transformer 13, is provided for delivering twenty cycle and high frequency currents to the loads 18 and 19, respectively. A condenser 22 of the proper size to block the passage of low frequency twenty cycle currents, is used for transmitting the high frequency components of the output current to the high frequency load 19. For the purpose of adjusting the magnitude of the low frequency voltage applied to the input side of the load 18, a two-position switch 26 is provided which may be switched between the contacts 26b and 26a to include either the section 14a of the secondary winding 14 or all of this winding in the output circuit of the system.

To consider the resonant circuit in somewhat greater detail, it is noted that the constants of the condenser 12, the impedance of the winding of the relay 21, the effective impedance of the transformer winding 15, and the shunt impedance through the reactor 11 and the source 10 are so proportioned that this circuit will resonate at a frequency which is substantially an odd integral fraction of the supply current frequency. In other words, the constants of the resonant circuit are so selected that the supply current frequency is an odd harmonic of the resonant frequency of the circuit. In the illustrated arrangement, wherein a load requiring twenty cycle current is to be supplied, a source 10 having a sixty cycle output frequency may be used, and the constants of this circuit are so chosen that the circuit will resonate at the demanded load current frequency of twenty cycles.

In considering the operation of the system as thus far described, it will be understood that if the switch 25 is closed, sixty cycle current is supplied from the source 10 to the resonant circuit comprising the winding 15, the winding of the relay 21 and the condenser 12 through the winding 11a of the saturable core reactor 11. If now the resonant circuit is shock-excited in the manner explained below, it will start to resonate at its fundamental frequency of twenty cycles. The resulting twenty cycle current flowing through the winding 11a of the reactor 11 combines vectorially with the sixty cycle current flowing through this winding, so that once during each cycle of the sixty cycle wave the current traversing this winding momentarily exceeds by a substantial amount the current value required to saturate the reactor core. During each excursion of the current beyond the knee of the saturation curve of the reactor, the reactance of the reactor drops sharply to a very low value, with the result that the current peaks sharply at a value which is several times greater than the instantaneous current values prevailing in the winding 11a of the reactor during the intervals separating the peaks. These sharp transient peaks furnish the periodic shock excitation required to maintain the resonant circuit oscillating at its fundamental frequency.

The voltage which is induced in the secondary winding 14 of the transformer 13 through the coupling between this winding and the winding 15, is characterized by the fundamental and harmonic components of the twenty cycle current traversing the resonant circuit. This voltage is impressed across the twenty cycle load 18 either through the contact 26a or the contact 26b of the switch 26. It will also be understood that such high frequency harmonic components of the induced voltage as appear in the secondary winding 14 of the transformer 13 are passed through the low frequency blocking condenser 22 and are impressed across the high frequency load 19.

Various methods of supplying or starting a flow of current of the desired fundamental frequency in the resonant circuit may be utilized. In the usual arrangement, a large transient voltage is produced in the resonant circuit which, if of sufficient magnitude, will cause a current of the fundamental frequency to start flowing in the resonant circuit. This current will then be sustained by the action of the non-linear impedance element or saturable core reactor 11 acting in conjunction with the other elements of the circuit in the manner explained above. In conventional starting arrangements, the magnitude of the starting transient is largely determined by the tuning of the resonant circuit. For example, if a large condenser 12 is employed, then a large charge may be stored on this condenser. Alternatively, if a reactor 11 having a large inductance is employed, considerable energy may be stored in the magnetic field thereof. If, however, these elements are small, the energy storage capacities thereof are limited. Moreover, since it is the discharge of the stored energy which produces the starting transient and largely determines its magnitude, it will be apparent that the ease of starting is necessarily controlled to a certain extent by the tuning of the circuit. The most desirable tuning for easy starting may not be the most desirable tuning of the circuit for sustained operation thereof after an oscillatory condition of the circuit is established.

In the present system, a starting arrangement is employed wherein the relay 21 connects the current source 10 through its break contacts 21a directly to the tap 16 along the winding 15 of the transformer 13. With this arrangement, the condenser 12 is charged through the winding of the relay 21. This relay is designed to be slightly slow to operate so that it remains in its restored position until the condenser 12 becomes fully charged. Upon operating, the relay 21 opens its break contacts 21a to interrupt the low impedance path shunting the winding 11a of the reactor 11, thus permitting the energy stored in the condenser 12 to be discharged through this winding. This discharge is of an oscillatory type and has the same frequency as the fundamental frequency of the resonant circuit. Thus a current of the resonant frequency is started flowing in the resonant circuit, which is sustained in the manner explained above.

From the above explanation, it will be understood that the voltage to which the condenser 12 is charged during a starting operation may be readily adjusted by changing the position of the tap 16 along the winding 15, and thus altering the voltage applied to the condenser during the starting interval. Changing the position of the tap 16 along the winding 15 in no way affects the tuning or operation of the circuit after a sustained oscillatory condition of the circuit is established. Thus the starting voltage applied to the condenser 12 is controlled solely by the position of the tap 16 along the winding 15, while the tuning of the circuit after the starting period is ended, and with the relay 21 operated, is controlled solely by the position of the tap 17 along the winding 15. In this regard it will be understood that, by varying the position of the tap 17 along the winding 15, the fundamental frequency of the resonant circuit may be adjusted to the exact desired value of twenty cycles.

For the purpose of augmenting the high frequency content of the voltage appearing in the output circuit of the system, the saturable core reactor 11 is provided with a second winding 11b in the output circuit of the system. As indicated above, the physical and winding constants of the reactor 11 are such that during each cycle of the current supplied to the primary winding 11a from the source 10, the core of the reactor becomes over-saturated to produce a sharply peaked current transient in this winding. Harmonics of the supply current frequency are thus produced in the winding 11b by the excursions of the primary current beyond the saturation bend of the reactor core saturation curve. Since the winding 11b is connected in series with the secondary winding 14 of the transformer 13, it will be understood that the voltage appearing thereacross combines vectorially with that across the winding 14 to be impressed across the two load circuits 18 and 19. It will also be apparent that the turn ratio between the windings 11a and 11b may be selected to introduce harmonic voltages of the required magnitude into the output circuit.

Among the advantages of the above-described arrangement for augmenting the high frequency components of the generated output voltage, is that of producing in this voltage a greater number of high frequency components than are produced in the output voltages of the known systems of the prior art, wherein tone coils are used. In this regard it is noted that, due to the steepness of the current transients produced in the winding 11a of the reactor, the voltage induced in the winding 11b of the reactor during each such transient comprises an unusually large number of the harmonics of the supply current frequency. A second advantage is that of appreciably increasing the low frequency output capabilities of the system by reducing the losses of the resonant circuit.

While one embodiment of the invention has been disclosed, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention.

What is claimed is:

1. In a frequency reducing system which is adapted to be energized by a source of alternating current of given frequency, a resonant circuit tuned to oscillate freely at a fundamental frequency which is lower than said given frequency, means including a non-linear impedance element for energizing said circuit from said source of alternating current and for causing said circuit to oscillate at its fundamental frequency, an output circuit coupled to said resonant circuit, and means coupled to said impedance element for introducing harmonics of said given frequency into said output circuit independently of the coupling between said circuits.

2. In a frequency reducing system which is adapted to be energized by a source of alternating current of given frequency, a resonant circuit tuned to oscillate freely at a fundamental frequency which is lower than said given frequency, means including a non-linear impedance element for energizing said circuit from said source of alternating current and for causing said circuit to oscillate at its fundamental frequency, an output circuit coupled to said resonant circuit, and means including said impedance element for introducing harmonics of said given frequency into said output circuit.

3. In a frequency reducing system which is adapted to be energized by a source of alternating current of given frequency, a resonant circuit tuned to oscillate freely at a fundamental frequency which is lower than said given frequency, means including a non-linear impedance element for energizing said circuit from said source of alternating current and for causing said circuit to oscillate at its fundamental frequency, an output circuit coupled to said resonant circuit, and means comprising an impedance element serially included in said output circuit and coupled to said impedance element for introducing harmonics of said given frequency into said output circuit independently of the coupling between said circuits.

4. In a frequency reducing system which is adapted to be energized by a source of alternating current of given frequency, a resonant circuit tuned to oscillate freely at a fundamental frequency which is lower than said given frequency, means including a saturable core reactor for energizing said circuit from said source of alternating current and for causing said circuit to oscillate at its fundamental frequency, an output circuit coupled to said resonant circuit, and means comprising an inductance element inductively coupled to said reactor for introducing harmonics of said given frequency into said output circuit independently of the coupling between said circuits.

5. In a frequency reducing system which is adapted to be energized by a source of alternating current of given frequency, a resonant circuit tuned to oscillate freely at a fundamental frequency which is lower than said given frequency, means including a saturable core reactor for energizing said circuit from said source of alternating current and for causing said circuit to resonate at its fundamental frequency, an output circuit coupled to said resonant circuit, and means comprising an inductance element inductively coupled to said reactor and serially included in said output circuit for introducing harmonics of said given frequency into said output circuit independently of the coupling between said circuits.

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