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SATURABLE REACTOR VOLTAGE REGULATOR WITH SERIES CONNECTED MAIN AND CONTROL INDUCTANCE WINDINGS

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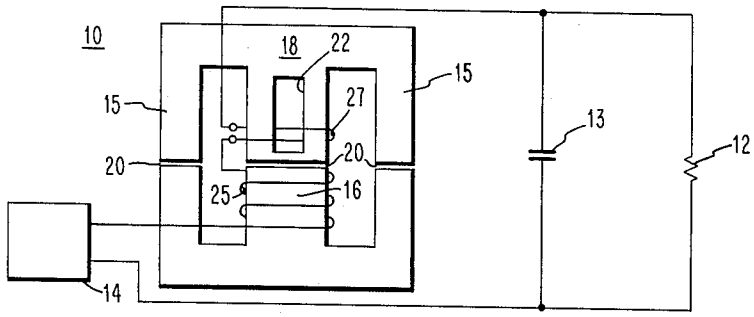


FIG. 1

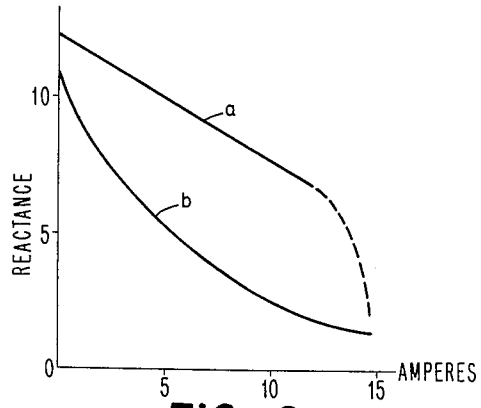


FIG. 2

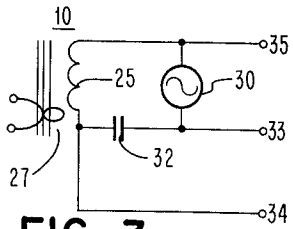


FIG. 3

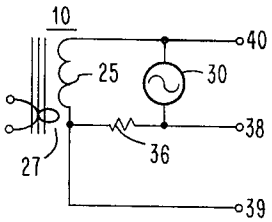


FIG. 4

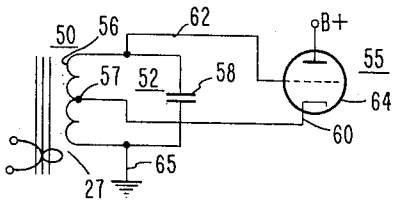


FIG. 5

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SATURABLE REACTOR VOLTAGE REGULATOR WITH SERIES CONNECTED MAIN AND CONTROL INDUCTANCE WINDINGS

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This invention relates generally to inductance devices and it has reference in particular to a saturation-controlled choke.

One object of this invention is to provide an inductance device having improved operating characteristics.

Another object of this invention is to provide for using a controlled inductance choke having a main winding and an auxiliary saturation control winding to make the operating characteristics more linear.

Yet another object of this invention is to provide a controllable inductance device having a magnetic core with a main winding thereon and an opening therein with a saturation control winding arranged in a figure-8 configuration therethrough.

It is also an object of the present invention to provide for using a saturation-controlled choke device as a controllable phase shift device.

Another important object of this invention is to provide for using a saturation-controlled choke device as a frequency modulator in a resonant tank circuit.

It is also an important object of this invention to provide a linear swinging choke having a main impedance winding and a serially connected saturation control winding disposed to be connected in either an alternating current circuit or in an ulfiltered rectified alternating current circuit.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a schematic diagram showing a saturation-controlled choke embodying the invention in one of its forms.

FIG. 2 illustrates curves showing the relative operating characteristics of the choke of FIG. 1 and a typical swinging choke.

FIG. 3 is a schematic diagram of a phase shift circuit embodying the invention.

FIG. 4 is a schematic diagram of a phase shift circuit also embodying the invention.

FIG. 5 is a schematic diagram showing an application of the invention as a modulator in a FM resonant tank circuit.

In practicing the invention in one of its forms, a three-legged core of the magnetic material has air gaps in each of the legs and a window in the central leg. A main inductance winding on the central leg is connected in a series with an unfiltered rectified alternating current source and a load. A figure-8 saturation control winding is located on the central leg, passing around portions of the leg and through the window, and being connected in series with the main inductance winding so as to control saturation of the central leg and provide a more linear swinging choke characteristic.

Referring particularly to FIG. 1 of the drawing, the reference numeral **10** may denote generally a saturation-controlled inductance or choke device which is connected in circuit between a load device such as the resistor **12** and a source of pulsating current such as an unfiltered rectified alternating current source **14**. A filter capacitor **13** is connected across the load **12** when rectified A.-C. is used.

The choke device **10** comprises in the present instance a three-legged core of magnetic material having outer legs **15** and a central leg **16** connected by end portions **18**. The legs **15** and **16** are each provided with an air gap **20**, while the central leg **16** is further provided with an opening or window **22**. A main inductance winding **25** is disposed on the central leg **16** and is connected in series circuit relation with the source **14** and the load **12**.

In order to maintain a critical inductance condition and provide a more linear operating characteristic for the choke device **10**, which may be disposed to operate as a swinging choke under varying load conditions, an auxiliary saturation-control winding **27** is also disposed about portions of the central leg portion **16**, passing through the window **22** so as to provide a figure-8 configuration which results in a localized control flux about the window. While the control winding **27** may be connected to a separate source of direct current, in-phase alternating current or pulsating direct current, depending on the particular application, in the present instance, the winding **27** is connected in series with the main inductance winding **25** to the output of the unfiltered rectified A.-C. source **14** so as to provide a local flux around the window **22** in accordance with the load current for controlling the inductance effects of the load current.

Referring to FIG. 2, it will be seen from the curve *a* that the inductance device **10** has a substantially linear operating characteristic from no load to a full load condition of approximately 12.5 amperes, after which saturation causes the characteristic to droop considerably. This substantially linear curve up to full load conditions is a great improvement over the characteristic curve *b* which was taken for a typical type of swinging choke of approximately the same rating, but not embodying the features of the present invention. It will be noted that the curve *b* has a substantially drooping characteristic throughout its operating range and is not nearly as linear as the curve *a* for the choke device of the present invention.

A saturation-controlled choke device **10** such as shown in FIG. 1 may be readily utilized as a variable inductance device for controlling the phase relations of voltages in a phase shift circuit such as shown in FIG. 3. By connecting the inductance winding **25** in series with an alternating current source **30** and a capacitor **32**, and connecting the control winding **27** to a variable direct current source, the relative values of the inductive and capacitative voltages between the terminals **33** and **35** may be made to vary with different degrees of saturation of the choke device **10**. For example, as the current through the control winding **27** is increased, the inductance of the winding **25** decreases and the voltage between the terminals **34** and **35** will decrease, while the voltage between the terminals **33** and **34** will increase. Since the phase relations of the voltages across the inductance winding **25** and the capacitor **32** are substantially opposite, this provides a readily controllable phase shift circuit.

Referring to FIG. 4, it will be seen that a somewhat similar phase shift circuit employing a saturation-controlled choke device **10** is provided by utilizing a resistor **36** in place of the capacitor **32**. By varying the control current through the saturation control winding **27**, the voltage across the inductance winding **25** is varied, and the phase relations of the voltages between the terminals **38–39** and **38–40** may be readily varied.

Referring to FIG. 5, it will be seen that a saturation-controlled choke device **50** similar to that shown in FIG. 1 may be utilized as a variable inductance device in a resonant tank circuit **52** for modulating the frequency of

an oscillator 55. The inductance winding 56 of the choke device 50 may be provided with a center tap 57, but in other respects, it is substantially identical with the saturation-controlled choke device 10 hereinbefore described. A capacitor 58 is connected across the impedance winding 56 to provide a tuned circuit, and the tank circuit is connected to the oscillator 55, having the center tap 57 connected to the cathode 60 of the oscillator, with a connection at 62 intermediate the capacitor and impedance winding 56 being connected to the grid 64 of the oscillator, while a connection 65 from the lower end of the tank circuit is connected to ground. By varying the control current through the saturation control winding 27 of the inductance device 50, the frequency of the oscillator may be varied. Thus, the control winding 27 may either be used to actually vary the frequency or, in conjunction with a suitable control circuit, to regulate the frequency of the oscillator if desired.

In one embodiment of the invention, the three-legged core has overall dimensions of 4 x 4 inches and a stack height of 1⅛ inches. The central leg is 1⅛ inches wide while the outer legs are approximately ⅝ inch wide. The window in the central leg is approximately ½ inch wide by ¾ inch high, and the air gaps in the outer legs are about .020 inch. The main inductance winding comprises 75 turns and the control winding 5 turns on each side of the window connected in a figure-8 configuration. The curve *a* of FIG. 2 was made using this embodiment with a 60 cycle load up to approximately 12½ amperes.

From the above description and the accompanying drawing, it will be apparent that the present invention provides a simple and effective manner for controlling the inductance of a choke. The figure-8 control winding provides an effective flux control of the core without introducing the usual circulating D.-C. flux, since the control flux in the present instance is localized about the window. This method of control may be applied in a plurality of manners for either providing more linear characteristics for the choke or for varying the inductance for control purposes. The invention is not limited to a three-legged core structure, however, as a simple core structure with air gaps and a figure-8 saturation control winding may be readily used.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. In an inductance device, a core of magnetic material having an opening through a portion thereof and an air gap therein, an inductance winding on said core and a saturation control winding connected in series with the inductance winding, said control winding passing through said opening with a figure-8 configuration so as to provide a local control flux about the opening in accordance with the current in the inductance winding.

2. In a linear swinging choke, a three-legged core of magnetic material having an opening through the central leg and an air gap in each of the legs, an inductance winding wound about the central leg, and a control winding connected in series with the inductance winding, said control winding being wound about the central leg through said opening in a figure-8 configuration.

3. In combination with a circuit connected to an unfiltered rectified alternating current source, a linear choke having a three-legged core of magnetic material with an opening in the central leg and an air gap in each of the legs, an inductance winding on the central leg connected in circuit with said circuit, and an auxiliary control winding connected in series with the inductance winding, said control winding being wound through said opening in a figure-8 configuration.

4. In an inductance device, a core of magnetic material having an air gap therein and an opening through a portion of said core, an inductance winding on said core for connection in series with a source of periodically varying current and a load and a control winding passing through said opening having a figure-8 configuration and connected to vary the self inductance of the inductance winding.

5. A reactor comprising, a three-legged core of magnetic material having a central leg with an opening therethrough and each leg having an air gap therein, an inductance winding disposed about said central leg, and a control winding on said central leg passing through said opening and having a figure-8 configuration, said control winding being connected in circuit with said inductance winding for controlling the self inductance thereof.

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