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Sinnott et al.

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[54] **HIGH POWER ELECTRICALLY VARIABLE INDUCTOR**

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[52] **U.S. Cl.** **336/110,** 336/160, 336/172, 336/212

[51] **Int. Cl.**.....**H01f 21/00**

[58] **Field of Search**.....336/110, 155, 160, 336/172, 212, 214, 215

[56] **References Cited**

FOREIGN PATENTS OR APPLICATIONS

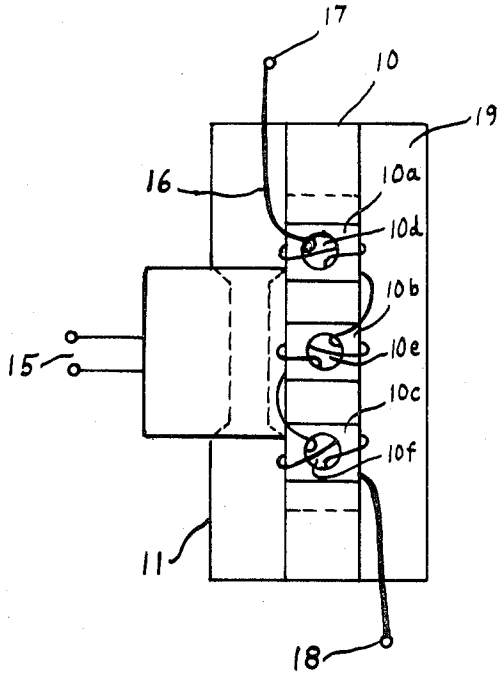
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[57] **ABSTRACT**

A high power electrically variable inductor includes a U-shaped ferrite core with an electromagnet and a permanent magnet attached to the U-core. The RF variable inductor winding is wound on a multiplicity of separate sections of the U-core. The area of the ferrite material at the RF winding is reduced to minimize the DC magnetic field.

2 Claims, 2 Drawing Figures



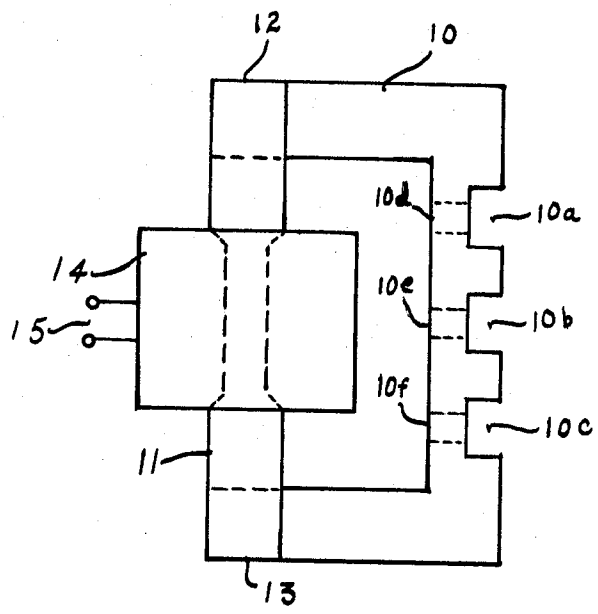

12
10
10d
10a
14
10e
10b
15
10f
10c
11
13

FIG. 1

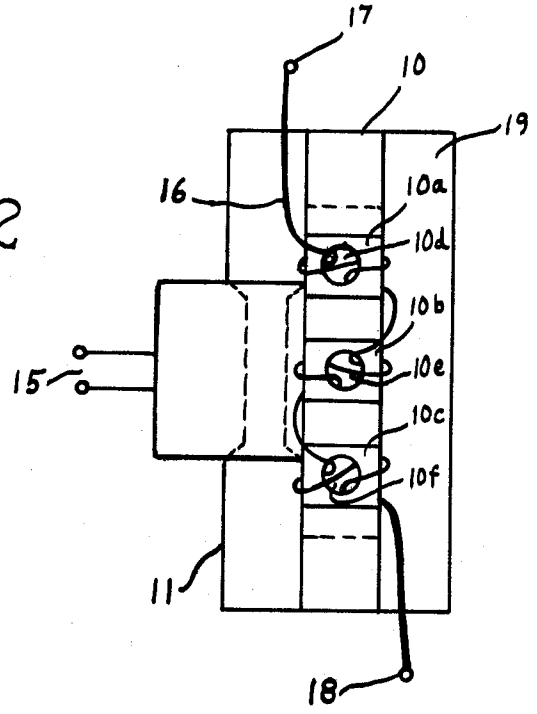

17
10
19
16
10a
10d
10b
15
10e
10c
10f
11
18

FIG. 2

HIGH POWER ELECTRICALLY VARIABLE INDUCTOR

BACKGROUND OF THE INVENTION

In the prior art, there is utilized high frequency saturable-core magnetic apparatus in which the inductance of a signal winding is controlled by varying the magnitude of a current through a control winding. In such magnetic control devices, called controllable or variable inductors, the control and signal windings are wound on portions of the same or magnetically interconnected ferromagnetic core structures. Variations in the current flowing through the control windings changes the degree of magnetic saturation of desired portions of the core structure, so varies the effective inductance of the signal winding. Thus, the magnitude of alternative current passed through the signal winding can be controlled in accordance with variations produced in the control current flowing through the control winding.

One of the uses of saturable-core magnetic devices exists in automatic tuning systems, for example, in tuning systems for HF or VHF power amplifiers or antennas. However, this requires high power electrically variable inductors and the prior art devices have limitations as to RF power handling capability of the RF inductor. Another limitation resides in the DC power requirements for the control winding. The present invention improves substantially the power handling capability of the RF inductor while simultaneously decreasing the DC power requirement of the control winding. Another advantage of the device of the present invention is its rapid tuning ability.

SUMMARY OF THE INVENTION

A high power electrically variable inductor is provided. It is comprised of a U-shaped ferrite core with an electromagnet and permanent magnet attached to the U-core. A balanced RF variable inductor winding is wound on three (or more) separate sections of the U-core. The area of the ferrite material at the RF winding is reduced to minimize the DC magnetic field required for permeability tuning. A permanent magnet biases the ferrite material in the RF winding region to a lower permeability, higher Q state thus making possible lower RF loss. Increasing DC current in the electromagnet decreases the permeability further which changes the RF inductance.

DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a front view of the preferred embodiment excluding an RF inductor winding and shunt permanent magnet; and

FIG. **2** shows the side view of FIG. **1** including the RF inductor winding and shunt permanent magnet.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Now referring in detail to FIG. **1**, there is shown U-shaped ferrite core **10** which is readily saturable. The area of U-shaped ferrite core **10** has been substantially reduced at sections **10***a*, **10***b*, and **10***c*. Holes **10***d*, **10***e*, and **10***f* have also been provided through U-shaped ferrite core **10** at sections **10***a*, **10***b*, and **10***c*, respectively. The RF inductor winding (not shown in FIG. **1**) is wound utilizing sections **10***a*, **10***b*, and **10***c*, and associated holes **10***e*, **10***f*, and **10***d*, respectively. Magnet steel bar **11** is attached to ends **12** and **13** of U-shaped ferrite core **10** by any suitable conventional means. Coil **14** is wound around magnet steel bar **11**. Electromagnetic coil **14** is provided with terminals **15** which receives a variable DC input from any conventional source and operates as a control winding.

Referring to FIG. **2**, there is shown a side view of FIG. **1** in which RF variable inductor winding **16** is clearly illustrated. Terminal **17** thereof receives the RF input signal and terminal **18** provides the RF output signal. Permanent magnet bar **19** is shown and may be attached by any suitable conventional means to U-shaped ferrite core **10**. Bar **19** serves as a shunt magnet.

RF variable inductor winding **16** is a balanced winding. Equal number of turns appear on opposite sides of each of holes **10***d*, **10***e*, and **10***f*. Three separate winding sections are series connected to form RF variable inductor **16** and is as illustrated in sections **10***a*, **10***b*, and **10***c*, and associated holes **10***d*, **10***e*, and **10***f*, respectively. The area of the ferrite material at sections **10***a*, **10***b*, and **10** thus at the RF winding has been substantially reduced to minimize the DC magnetic field required for permeability tuning. Permanent magnet bar **19** biases the ferrite material in the RF winding region to a lower permeability, higher Q (lower RF loss), state. Increasing DC current in the electromagnet decreases the permeability still further which changes the RF inductance.

In the configuration shown in FIGS. **1** and **2**, a 4 to 1 change in RF inductance with Q greater than 100 over the entire range can be obtained with 1 watt of DC power used by the electromagnet for tuning. In addition, the RF induction can handle 320 volt-amperes (peak).

It is emphasized that the use of a shunt permanent magnet reduces the required magnet DC tuning power. Still further, the series connection of three sections of the RF inductor, all of which are tuned by the same electromagnet increases the RF power handling capability of the RF inductor while reducing the required electromagnet tuning power.

It is claimed:

1. A high power electrically variable inductor comprising a U-shaped ferrite core having two arms, and a connecting member, said connecting member having first, second, and third sections with substantially reduced areas to minimize the DC magnetic field, each of said sections also having holes therethrough, a balanced RF variable inductor winding consisting of three series connected portions, each of said portions having an equal number of turns on opposite sides of the associated hole and wound on the associated section thereof, said balanced RF variable inductor winding including an input terminal for the reception of a high power RF input signal and an output terminal providing a high power RF output signal, an electromagnet attached across the ends of said two arms closing said U-shaped ferrite core, said electromagnet receiving a varying DC input signal thus operating to vary the magnitude of the inductance of said balanced RF variable inductor winding, and a shunt permanent magnet also attached to said U-shaped ferrite core biasing the ferrite material in the RF variable inductor winding region to a lower permeability.

2. A high power electrically variable inductor as described in claim **1** wherein said electromagnet is comprised of a magnet steel bar and an electromagnet coil wound thereon.

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