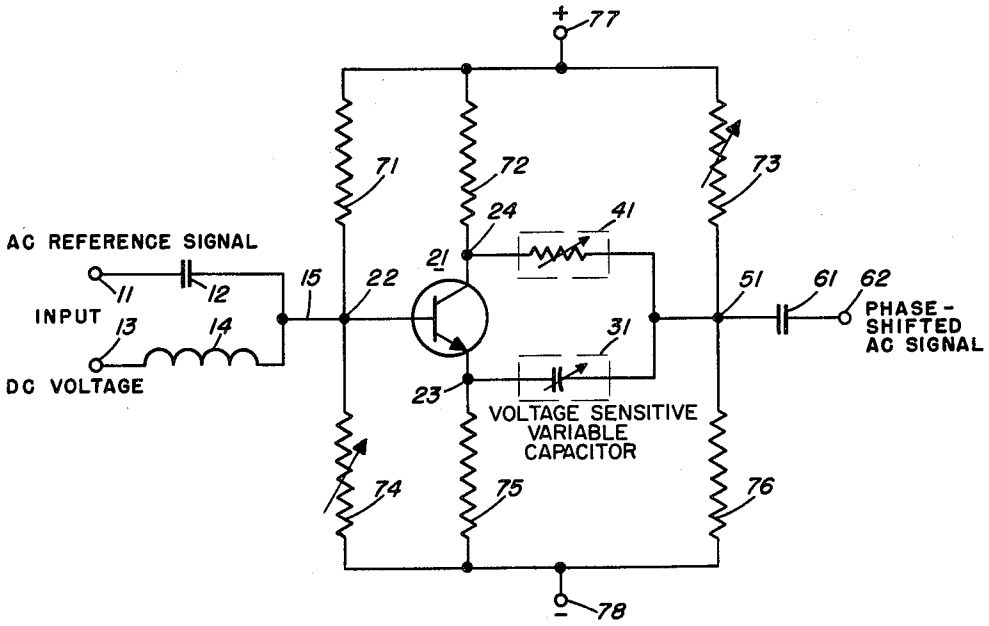
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PHASE SHIFTER USING TWO VOLTAGE SENSITIVE ELEMENTS

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PHASE SHIFTER USING TWO VOLTAGE SENSITIVE ELEMENTS

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This invention relates to phase shifters and more particularly to voltage sensitive variable phase shifters.

The phase shifting circuits developed in the prior art, although quite advantageous for most applications, have the limitation that an incoming signal of constant amplitude can be shifted only through a fixed phase angle. The present invention overcomes this limitation.

The present invention has the capability of shifting a constant amplitude waveform through a range of phase angles automatically. By using voltage sensitive impedance elements in combination with an active element, a voltage sensitive automatic variable phase shifter is provided for shifting a waveform in accordance with a D.C. signal applied thereto.

An object of this invention is the provision of a variable phase shifter.

A further object of the invention is the provision of an automatic variable phase shifter.

A still further object of this invention is to provide a constant amplitude signal with a variable phase shift.

An additional object is the provision of a voltage sensitive phase modulation system.

Another object is to delay or shift a constant amplitude signal through a specified range of phase angles.

Various other objects and features of the invention will hereinafter be more fully apparent from the following description of the drawing which will illustrate one embodiment of the invention. The embodiment disclosed is illustrative of the invention but is in no way intended to limit the invention as defined by the appended claims.

Referring now to the single figure of drawing which illustrates the invention, there is shown a first input terminal **11** having one end of a capacitor **12** connected thereto and a second input terminal **13** having one end of an inductor **14** connected thereto. The other ends of the capacitor and inductor are tied together at terminal **15**. An electron discharge device or transistor **21** has its base electrode **22** connected to the terminal **15**; the emitter terminal **23** is connected to one terminal of a voltage sensitive variable capacitor **31** for example a varicap; and the collector terminal **24** is connected to one terminal of a voltage sensitive variable resistor or varistor **41**. The other terminals of the voltage sensitive variable capacitor and varistor are tied together at terminal **51**. A coupling capacitor **61** is connected to the terminal **51** while the other end serves as the output terminal **62** of the device. Suitable biasing for the device **21** is provided by the fixed and settable resistors **71** through **76** and the D.C. potential applied at terminals **77** and **78**.

The varistor **41** may be one of any of the numerous devices, generally two electrode semiconductor elements whose resistance varies with the voltage applied thereto. In the illustrated embodiment, the characteristic voltage-current curve is linear. Many devices exhibiting the features described hereinbefore are available, the most common of which are made of silicon carbide compounds. There are other varistors manufactured whose resistance varies in response to the current or polarity of the applied signal. All of the devices described herein may exhibit non-linear characteristics as well.

The voltage sensitive variable capacitor **31**, similarly, is a commercially available element whose capacitance value varies with the signal applied.

If there is an increasing potential across the varistor and voltage sensitive variable capacitor, the resistance and capacitance decrease accordingly whereby there is an increase in the capacitive reactance and a decrease in resistance, thus causing a phase shift to an incoming signal, such phase shift being linear, and may be an angle of as much as 90°.

The signal to be shifted is applied at terminal **11**, through capacitor **12** which of course passes only the A.C. component of the signal. Similarly, a D.C. potential is applied at input **13** through the inductor **14** which isolates this potential from any spurious A.C. signals. The bias on the transistor **21**, maintained by means of resistors **72** and **75**, is of such a nature that the collector **24** is kept positive with respect to the emitter **23**. The biasing resistors **71**, **73**, **74**, and **76** are adjusted to maintain a constant voltage across the varistor and voltage sensitive variable capacitor so that the output terminal is at approximately ground thereby allowing the collector and emitter to always be positive and negative, respectively, with respect to the output.

Of course, by referring to the characteristic curves of the voltage sensitive variable capacitor and varistor the bias may be set at an optimum point. Of necessity, to prevent output distortion, the input signal amplitudes are kept small and therefore have no deleterious effect on the biasing.

As the D.C. signal applied increases, for example, positively, this causes the terminal **15**, the base of the transistor, to become more positive, the terminal **23**, the emitter, more positive; and the terminal **24**, the collector, more negative; all with respect to terminal **51**. The result of such an action causes the voltage sensitive variable capacitor and varistor to increase in value and thereby causes an increase in resistance and a decrease in capacitive reactance whereby the phase angle of the A.C. input is changed.

Of course, if the D.C. level is decreased the phase angle changes in the opposite direction. It is thus possible to change the phase angle of the A.C. signal by as much as plus or minus forty-five degrees ($\pm 45°$).

Obviously, if the output terminal **62** is tied to the input terminal **11** of a duplicate device, an additional 45° phase change is possible, providing a total possible shift of $\pm 90°$. The terminals **13**, of both devices, may be tied to the same controlled D.C. source.

It is a further capability of the present invention to provide phase modulation. For example, if the D.C. input signal carries amplitude information such as a binary signal, two levels of D.C., or a decimal signal, ten levels of D.C., by maintaining the A.C. signal at a constant amplitude, the D.C. is phase modulated and thereby converted to information impressed upon the A.C. carrier or phase modulated information.

The condition responsive elements, the varistor **41** and voltage sensitive variable capacitor **31**, may be replaced by current or polarity sensitive similar elements to provide a current or polarity sensitive phase shifter.

A new and improved variable phase shifter has been described which is voltage, current or polarity sensitive, which will shift or modulate an incoming signal of constant amplitude through a phase angle of 90°.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A voltage sensitive variable phase shifter comprising:
(a) an electron discharge device having at least three terminals
(b) a first condition responsive element connected to one of said terminals
(c) a second condition responsive element connected to a second of said terminals, said first condition responsive element exhibiting different impedance characteristics from said second condition responsive element, whereby one signal applied to a third of said terminals is phase shifted in accordance with another signal applied to said third terminal.

2. The phase shifter of claim 1 wherein:
(a) said first condition responsive element is a varistor; and
(b) said second condition responsive element is a voltage sensitive variable capacitor.

3. The phase shifter of claim 1 wherein:
(a) said electron discharge device is a semiconductor.

4. The phase shifter of claim 2 wherein:
(a) said electron discharge device is a transistor.

5. A voltage sensitive variable phase shifter comprising:
(a) a transistor having
(1) a base electrode
(2) an emitter electrode
(3) and a collector electrode;
(b) a fixed capacitor having one end connected to said base and having another end to which an A.C. voltage signal is applied;
(c) a fixed inductor having one end connected to the terminal defined by said base and said one end of said capacitor and having another end to which a D.C. voltage is applied;
(d) a second fixed capacitor having a first terminal and a second terminal, said second terminal serving as an output for said phase shifter;
(e) a voltage sensitive variable capacitor having a first terminal connected to said emitter and having a second terminal connected to said first terminal of said second fixed capacitor;
(f) a voltage sensitive resistor having a first terminal connected to said collector and a second terminal connected to the terminal defined by the connection between said second terminal of said variable capacitor and said first terminal of said second capacitor whereby said A.C. signal is shifted through a preselected phase angle which may be as much as 90°, dependent upon the amplitude of said D.C., signal.

References Cited by the Examiner

Low-Frequency Phase-Shift Modulator-Coombs, Electronics, December 1954, pp. 198, 200, 202, Figure 2.

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