

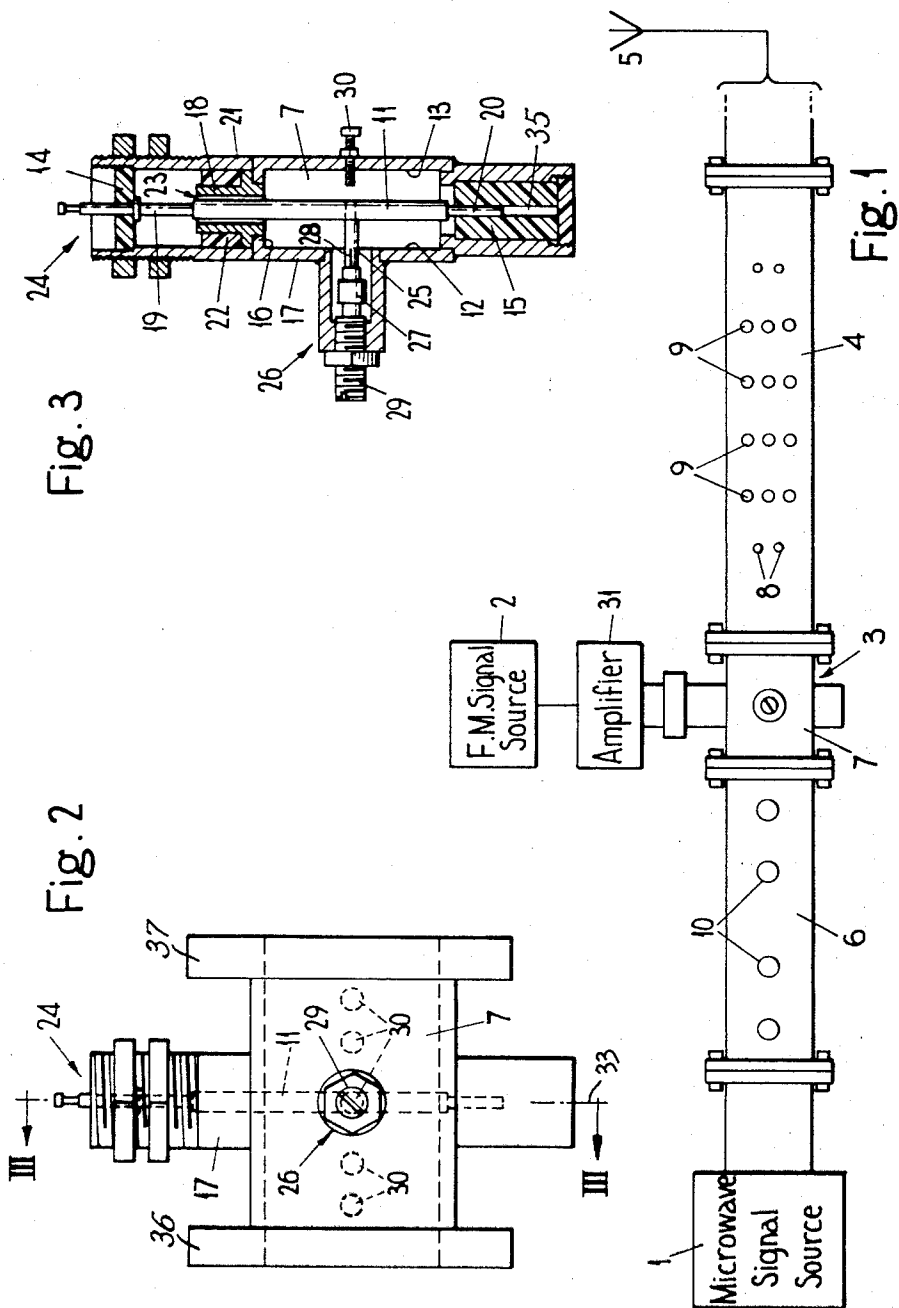
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MICROWAVE MODULATOR USING VARIABLE CAPACITANCE DIODE

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MICROWAVE MODULATOR USING VARIABLE CAPACITANCE DIODE

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3 Claims

ABSTRACT OF THE DISCLOSURE

A microwave frequency changer utilizing as a nonlinear element a varactor diode. This diode is coupled to a length of waveguide connected between a microwave source on one hand and a filter that passes the microwave output signal on the other. A relatively low frequency modulating signal is supplied to the diode over a co-axial line. The filter reflects back to the diode the unwanted modulation side-band so as to reduce the overall power loss between the microwave input and output signals.

This invention relates to frequency changers.

More particularly the invention is concerned with frequency changers that are adapted to handle microwave signals which for the purpose of the present specification are defined as signals having frequencies in excess of 1,000 megacycles per second. Such a frequency changer is hereinafter referred to as a "microwave frequency changer."

It is well known to utilise a non-linear impedance for the purpose of amplitude modulating a first signal consisting of oscillations of a single frequency f_1 with a second signal consisting of oscillations of a relatively lower single frequency f_2 . If now the first signal is completely modulated (that is to say the output signal has a modulation factor of unity) the signal resulting from such modulation is of the form $A \sin f_1 t + A/2 \sin (f_1 + f_2)t + A/2 \sin (f_1 - f_2)t$, where A is the amplitude of the first signal before modulation. In other words each of the side-band components of the modulated signal has only one half the amplitude of the first signal and accordingly only one quarter of the power. If therefore this principle of modulation is made use of in a frequency changer in which a filter is arranged to select one of the modulation side-bands to provide the output of the frequency changer there is an overall loss of 6 db from purely theoretical conditions.

One object of the present invention is to provide a microwave frequency changer that has less overall loss than that discussed in the last paragraph.

According to the present invention a microwave frequency changer which utilises a non-linear element that is arranged to modulate a microwave signal with a lower frequency signal has a filter which is arranged to select the signal containing one side-band resulting from the modulation, this filter being so disposed that, during use, at least part of the signal supplied thereto other than the said side-band is reflected back to said non-linear element in the appropriate phase to give an overall power loss between the microwave signal and the selected side-band signal passed by the filter that is less than 5 db.

Preferably the non-linear element is a variable capacitance semiconductor diode.

According to a feature of the present invention a microwave frequency changer comprises a length of waveguide of rectangular cross-section, a waveguide path for supplying a microwave signal to one end of said length of wave-

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guide, a first member lying across the length of waveguide parallel to the broad faces thereof, a coaxial transmission path for supplying a relatively low frequency signal to the first member, a second member which is connected at one end of the first member within the length of waveguide and which lies parallel to the narrow faces of the waveguide, a variable capacitance semiconductor diode that is connected between the other end of the second member and a wall of the waveguide, and a filter which is connected to the other end of the length of waveguide and which is arranged to select the signal containing one side-band resulting from modulation of the microwave signal by the relatively low frequency signal, this filter being so disposed that, during use, at least part of the signal supplied thereto other than said side-band is reflected back to the variable capacitance diode in the appropriate phase of give an overall power loss between the microwave signal and the selected side-band signal passed by the filter that is less than 5 db.

It is to be understood that the first and second members may together be of unitary form while a single waveguide may constitute both the said length of waveguide and the waveguide path.

One example of a microwave frequency changer in accordance with the present invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 shows the complete frequency changer diagrammatically,

FIGURE 2 shows in more detail the construction of part of the frequency changer, and

FIGURE 3 shows a cross-section of the line III—III in FIGURE 2.

Referring now to FIGURE 1, the frequency changer is arranged to modulate a microwave signal which is supplied by a source 1 and which has a single frequency in the region of 6,000 megacycles per second with a frequency-modulated signal which is supplied by a source 2 and which has a mean frequency in the region of 70 megacycles per second. The actual modulation is carried out by a variable capacitance semiconductor diode (sometimes known as a "varactor") which is contained within a device 3, one side-band of this modulation being selected by means of a filter 4 to provide the output signal of the frequency changer that is passed to an antenna 5. A filter 6 which has a narrow pass band is connected between the source 1 and the device 3.

Referring now also to FIGURES 2 and 3 which show the construction of the device 3 in more detail, the device 3 comprises a short length of waveguide 7 of oblong cross-section which is bolted by means of flanges 36 and 37 at the ends thereof between the filters 4 and 6 which are themselves both waveguide filters. (It may be mentioned here that the filters 4 and 6 are both of known construction, the filter 4 having a plurality of posts such as those referenced 8 and 9 in FIGURE 1 and the filter 6 having a plurality of posts 10.) A cross-bar 11 of circular section is mounted so as to extend right across the length of waveguide 7, this cross-bar being parallel to and equally spaced from the two broad faces 12 and 13 of the waveguide. The cross-bar 11 is supported by members 14 and 15 of electric insulating material so that there is no direct electric connection between the cross-bar and the waveguide walls (of which only the walls 16 and 17 are referenced in FIGURE 3).

The cross-bar 11 extends at one end through the narrow waveguide wall 16 and the extended portion is embraced by a cylindrical member 18 that is secured to the wall 16 and electrically connected thereto. The cross-bar 11 also has two colinear end portions 19 and 20 which are of somewhat smaller cross-section than the main body thereof. The portion 19 is embraced over most of its length by

a cylindrical member 21 which is also secured and electrically connected to the waveguide wall 16 and an annular member 22 of dielectric insulating material is disposed between the members 18 and 21. The cross-bar portion 19 and the member 21 provide a coaxial transmission line connector 24 while the annular gap 23 between the cross-bar 11 and the member 18, which gap has an electrical length approximately equal to a quarter wavelength at the frequency of the source 1, together with the member 22 act in known manner to provide a choke that prevents the escape of any appreciable portion of the microwave signal from the length of waveguide 7 to the coaxial connector 24.

The portion 20 of the cross-bar 11 extends into a hole 35 through the insulating member 15 and has an electrical length approximately equal to a quarter wavelength at the frequency of the source 1 so as to prevent the escape of appreciable microwave energy from that side of the waveguide 7.

An amplifier 31 (FIGURE 1) is connected between the frequency-modulated signal source 2 and the co-axial connector 24.

A short cylindrical member 25 is secured at one end, for example by soldering, to the cross-bar 11 so that this member lies perpendicular to the cross-bar. The other end of this member 25 extends into a circular hole in the broad wall 17 of the length of waveguide 7 and adjacent thereto there is provided a holder 26 for the variable capacitance diode 27, this holder which is of generally cylindrical form being mounted on and electrically connected to the waveguide wall 17. The variable capacitance diode 27 has a pin (not shown) at one end thereof which engages with spring fingers 28 formed at the end of the member 25 remote from the cross-bar 11 while the diode 27 is secured to a screw 29 which screws into the end of the holder 26. The screw 29, the diode 27 and the member 25 are colinear and the arrangement enables the position of the diode 27 to be adjusted by turning the screw 29.

Five matching screws 30 (FIG. 2) project into the waveguide 7 from the side opposite the waveguide wall 17. These matching screws 30 are adjusted so that during use maximum microwave power is passed to the variable capacity diode 27 from the source 1 on one hand and on the other hand to optimize the power of both the wanted side-band component and the unwanted side-band component of the signal passed to the filter 4. The position of the diode 27 is also adjusted, as aforesaid, to optimize the output power.

As previously mentioned, the filter 4 which has a relatively wide pass band is arranged to select the wanted side-band component as the required output signal of the frequency changer. Its spacing from the variable capacitance diode 27 is such that the unwanted side-band component is reflected thereby back to the diode in the appropriate phase for it to be reconverted by the diode into the wanted side-band.

The microwave signal source 1 may consist of a chain of frequency multiplier stages. The narrow band filter 6 serves to ensure that only the signal of the required microwave frequency is fed to the variable capacitance diode 27 and also presents a high impedance to the side-band components developed by the diode 27 so as to prevent the power of said side-band components being dissipated by the source 1.

It is believed that operation of the frequency changer is optimized when the following conditions are satisfied:

(1) the filter 4 effectively presents an open circuit at the plane 33 (FIGURE 2) to the microwave signal supplied by the source 1. (In this connection the filter 4 effectively presents a short-circuit at the frequency of that signal at approximately the plane of the line 32 in FIGURE 1 so that the electrical distance between the planes 32 and 33 is approximately equal to an odd number of quarter wavelengths at that frequency.)

(2) the filter 6 similarly presents an open circuit at the plane 33 to the wanted sideband signal, and

(3) the sum of the admittances presented by the filters 4 and 6 at the plane 33 after transformation through the cross-bar junction presents a suitable impedance, preferably a short circuit, to the diode 27.

In one construction of the microwave frequency changer described above the overall loss between the power of the microwave signal supplied thereto and the microwave output signal is of the order of 3 db.

I claim:

1. A microwave frequency changer comprising a length of waveguide of oblong cross-section, a waveguide path for supplying a microwave signal to one end of said length of waveguide, a first member lying across the length of waveguide parallel to the broad faces thereof, a coaxial transmission path for supplying a relatively low frequency signal to the first member, a second member which is connected at one end of the first member within the length of waveguide and which lies parallel to the narrow faces of the waveguide, a variable capacitance semiconductor diode that is connected between the other end of the second member and a wall of the waveguide, and a filter which is connected to the other end of the length of waveguide and which selects the signal containing one side-band of the two side-bands which are symmetrically disposed about the frequency of said microwave signal and which result from modulation of the microwave signal by the relatively low frequency signal and reflects the signal containing the other side-band resulting from such modulation, said filter being disposed to reflect at least part of the signal supplied thereto other than said side-band back to the variable capacitance diode in a phase to give an overall power loss between the microwave signal and the selected side-band signal passed by the filter that is less than 5 db.

2. A frequency changer according to claim 1 wherein the filter is a waveguide filter.

3. A frequency changer according to claim 1 wherein the waveguide path contains a filter having a relatively narrow pass band that includes the frequency of the said microwave signal.

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