Hysteresis type detection apparatus for detecting the voltage standing wave ratio (VSWR) of a transmitting system. When the detection apparatus determines that the VSWR exceeds a predetermined value, it actuates a servo-system which adjusts impedances in a coupling unit between the transmitter and the antenna and continues the adjustment until the VSWR is at a value substantially lower than it was upon initial actuation of the servo-apparatus.

3 Claims, 10 Drawing Figures
FIG. 1

FIG. 2
VOLTAGE STANDING WAVE RATIO DETECTING AND ADJUSTING APPARATUS

The present invention is directed generally to electronics and more specifically to a signal transmitting system using an antenna.

In most signal transmission systems using a radiating type antenna the power is applied to the antenna at a reduced level until the VSWR is adjusted to less than a prescribed value. At this point, the power is increased substantially. Some units incorporate a time delay which continues driving the adjustment apparatus in the same direction for a prescribed time after the VSWR is reduced below the prescribed amount to hopefully result in an even lower VSWR at the end of the prescribed time. When the higher power output is provided, the reflected power detector still operates on providing an indication for the same absolute value of reflected power. Thus, if the additional time provided was not sufficient to drive the VSWR to a value such that the absolute value of the reflected power at the new forward power level exceeds the prescribed amount, the device will still not be operating satisfactorily.

The present invention uses a ratio detecting apparatus so that the actual ratio of reflected power to forward power is detected and thus the device does not need to rely on an experimentally determined time delayed adjustment. Rather, if the VSWR is less than the prescribed amount at the low power transmission level the ratio detector will still provide the same indication at the higher level assuming that power levels have no effect on the ratio.

It is therefore an object of the present invention to provide an improved VSWR detection circuit.

A further object of the present invention is to provide improved VSWR detection and adjustment apparatus for a transmission system.

Further objects and advantages of the present inventive concept may be ascertained from a reading of the specification and appended claims in conjunction with the drawings wherein:

FIG. 1 is a schematic diagram of one embodiment of a hysteresis type ratio detector.

FIG. 2 is a block diagram of an overall transmission system including coupling phase and impedance detection and adjustment means and further forward and reflected power detection means in combination with a hysteresis type ratio detector for actuating the servo-adjustment means when the transmission system is unbalanced by more than a predetermined amount.

FIGS. 3-10 provide detailed schematic diagram illustrations of various blocks of FIG. 2.

In FIG. 1 an input terminal 10 supplies a forward power signal indication through a resistor 12 to a first input means 14 of an operational or differential amplifier generally designated as 16. Amplifier 16 has positive and negative power terminal means 18 and 20, respectively. A reflected power input terminal 22 is connected through a resistor 24 to a second input 26 of amplifier 16. An output 28 of amplifier 16 is connected through a resistor 30 to an apparatus output terminal 32. Apparatus output terminal 32 is connected through a zener diode 34 to ground or reference potential 36 for the purpose of preventing the output from exceeding a predetermined value as set by the zener diode 34. Output terminal 28 is also connected through a first resistor 38 and a second resistor 40 back to input terminal 26. A junction point between resistors 38 and 40 is connected through a resistor 42 to ground 36. A further zener diode 44 is connected from input 26 of amplifier 16 to ground 36. A FET transistor generally designated as 46 has its source connected to ground 36 and its drain connected through a resistor 48 to input terminal 26 of amplifier 16. A gate of transistor 46 is connected through a resistor 50 to ground 36 and is also connected through series connection of a diode 52 and a resistor 54 to output 28 of amplifier 16.

The operation of FIG. 1 is relatively easy to understand and for initial explanation purposes the circuit including the FET can be ignored. If the signal appearing at input 14 as passed through resistor 12 is less than the signal appearing at 26 as passed through resistor 24, the output will be at a positive level. Although the signals at terminals 10 and 22 may be different absolute values when the output from amplifier 16 is zero, the resistors 12, 24 and 48 in combination with FET 46 adjust these signals so that the output at 28 will be approximately zero when 14 and 26 are equipotential. However, an operational amplifier with input signals applied thereto is an unstable device and acts like a switch due to the high gain therethrough in combination with the feedback and thus the output at 28 would only be at a zero condition for a substantially instantaneous time.

When the signal appearing at input 26 is only minutely less than the forward power signal as appears at input 14, the amplifier 26 will suddenly switch so that the output which was previously at a large positive value will become suddenly at a large negative value. This change in output signal may be fed to the output 32 and is also supplied back through the feedback network comprising resistors 38, 40 and 42 to reinforce this action at input 26.

The negative signal at output 28 had previously kept the FET in an ON condition. With FET 46 in an ON condition part of the signal appearing at input terminal 22 is shunted to ground. In other words, the input signal is divided so that only a partial effect of the voltage applied at 22 actually appears at 26. With FET 46 turned OFF due to the positive going condition of the output signal, the entire voltage appearing at input 22 is supplied to input 26 of amplifier 16. By this action the signals appearing at 22 have a much greater effect on the input of amplifier. Thus, the reflected power signal will have to drop to a much lower value than was necessary to initially switch the amplifier before the effect at 26 produces a voltage which is lower than that appearing at input 14. When this does occur, however, the amplifier will again switch so that the output is negative and transistor 46 is again switch to an ON condition. Thus, the input signal at 26 is again drastically lowered and the device will remain in this condition until the ratio of the power signals appearing at 10 and 22 are again altered to provide the same conditions as produced the initial switching action.

In view of the above, it may be determined that the device of FIG. 1 has a hysteresis effect in that it will switch the output signal when a given ratio occurs but will remain in that condition until a much different and much lower ratio is obtained. This hysteresis effect is produced by the circuitry utilizing the FET 46.
BLOCK DIAGRAM SYSTEM OF FIG. 2

In FIG. 2 an antenna 70 is connected to an output of a tuning network, hereinafter called a coupler 72, which has signals supplied therethrough by a transceiver or other signal transmitting device 74 on a lead 75. A forward power discriminator 76 is coupled to lead 75 for receiving signals from the transceiver 74 and to supply an output indicative of the forward power detected signal to one input of a VSWR ratio detector 78. A reflected power discriminator 80 also detects signals on lead 75 as obtained from transceiver 74 and supplies outputs indicative thereof to the detector 78. A phase discriminator 82 is coupled to lead 75 to receive voltage and current signals from transceiver 74 and provides these signals to operate a servomechanism 84 which operates an adjustment within coupler 72 to vary the transformation impedance therein and thus, the phase of signals therein. An impedance discriminator 86 is coupled to lead 75 and thus, to the transceiver 74 to also receive voltage and current indications and thereby determine impedance. The impedance discriminator 86 provides an operating signal to a servomechanism 88 which is mechanically connected to coupler 72 to provide additional adjustments over and above those provided by servo 84. Each of the servos 84 and 88 are connected to an output of detector 78 which provides actuation signals so that the servos 84 and 88 may operate.

In operation the transceiver 74 initially supplies a low power signal through the coupler 72 to antenna 70. This low power preliminary operation is used as a time when the coupler is adjusted to obtain maximum efficiency from the transmitting system. The formula for obtaining VSWR is as follows:

\[
\text{VSWR} = \frac{1 + \sqrt{\text{Reflected Power}}}{1 - \sqrt{\text{Forward Power}}} = \frac{1 + \sqrt{\text{Reflected Power}}}{1 - \sqrt{\text{Forward Power}}}
\]

VSWR as previously indicated is the voltage standing wave ratio. It is desirable that this ratio be as low as possible and this is accomplished by making the reflected power a minimum value. Such minimum value of the reflected power is theoretically obtained by adjusting impedance ratios in the coupler so that the impedance of the antenna as seen through the coupler by the transmitter is the same as the output impedance of the transmitter. This impedance will have both inductive and capacitive components.

It is undesirable to continuously alter the impedance of the coupler since this causes unnecessary reduction in the life of the equipment. Thus, adjustment systems are designed such that an adjustment is effected only when the VSWR exceeds a predetermined amount. It is desirable to reduce the VSWR to a value far below the value at which the adjustment occurs so that further adjustment will not be needed for some time. Thus, the detectors 76 and 80 supply input signals to ratio detector 78 which provides an output to the servos 84 and 88 to actuate these servos when the ratio of the reflected power to forward power reaches or exceeds certain prescribed limits. The actuation of the servo systems adjusts coils within coupler 72 through the use of the detection circuits 82 and 86 until the ratio of reflected to forward power drops to a new value much lower than that causing initial actuation. At this time the output signal from detector 78 is deleted and the servo systems 84 and 88 are no longer activated.

The circuits shown in FIGS. 3-10 are merely detailed schematics indicative of one embodiment of the invention. As such, they are not pertinent to the invention other than illustrating one possible implementation of the blocks of FIG. 2.

The circuit schematic of FIG. 3 illustrates the coupler 72 of FIG. 2. The lead labeled RF IN is the lead from transceiver 74. This is passed through a coil generally designated as 99 which is variable in inductance and in the position of the tap located on the inductor. As may be seen from the dashed lines, the two adjustments are available from the servo-mechanism units. These mechanical inputs correspond to the dash line mechanical outputs of servos 84 and 88 in FIG. 2. As will be ascertained, the changing of the inductance will change the phase of the signal being transmitted through the coupler and the change of the tap will change the impedance ratio of the signal coupling between the transceiver 74 and the antenna 70. A lead at the right side of FIG. 3 labeled RF OUT is the lead going to antenna 70. The portion labeled drum switch 58 is merely illustrative of the connections of the drum switch 58 which is shown in the schematic in the home position. Other positions are indicative of different operating frequencies and are not pertinent to the present invention, although have been shown for completeness of illustration.

FIG. 4 includes the circuitry for the forward power detector or discriminator 76 and the reflected power detector or discriminator 80. In addition, it illustrates the circuitry for the phasing discriminator 82 and the impedance discriminator 86. The outputs from these two circuits which are labeled forward power discriminator (M) and reflected power discriminator (U) are the same as the two input leads to the VSWR detector 78 of FIG. 2.

FIG. 5 again is not pertinent to the present inventive concept but is merely shown for completeness as it is a frequency band selection circuit for the coupler 72.

FIG. 6 illustrates the VSWR detector 78 of FIG. 2 and illustrates in more detail the basic concept of FIG. 1. The circuitry of FIG. 6 is being illustrated again so as to provide complete information as to interconnection with other parts of the overall system of FIG. 2.

FIG. 7 again is not pertinent to the invention since it is merely a portion of coupler 72 for controlling in part some of the other operations of the coupler 72.

FIG. 8 illustrates additional circuitry cooperating with that of FIGS. 5 and 7 in the coupler 72. The input KK in FIG. 8 labeled VSWR is the signal received from the similarly designated lead of FIG. 6.

FIG. 9 includes two servo preamps as utilized in the input portion of the servos 84 and 88. The signal inputs CCC and DDD of FIG. 9 are received from corresponding outputs in the digital logic circuitry of FIG. 8 through which the output signals from the VSWR detector 78 pass. These enabling or disabling signals cause the servos 84 and 88 to reposition or refrain from repositioning depending upon the mismatch or VSWR between the transceiver 74 and the antenna 70.

The output servo amplifiers of FIG. 10 operate to drive the tap and coil motors of FIG. 3.
While I have illustrated a specific embodiment of the invention, I do not wish to be limited to only that embodiment shown but rather to the concept of using a hysteresis type ratio detector in conjunction with a servo controlled signal transmitting coupling system wherein the ratio of the forward power to reflected power is detected rather than the absolute value of the reflected power.

I claim:

1. Hysteresis type ratio detector apparatus comprising, in combination:
differential amplifier means including first and second input means and output means;
first and second apparatus signal input means for supplying two variable amplitude signals the ratio of which is to be compared;
means connecting said first and second apparatus signal input means to the first and second input means of said amplifier means, respectively;
apparatus output means for providing an output signal when the ratio of signals supplied by said first and second apparatus input signals exceeds a first given ratio in one direction of voltage change from a reference potential and the output signal continuing until the input signals exceed a second given ratio in a direction of voltage change opposite said one direction;
variable impedance means, including control means, for varying in impedance in response to a control signal;
means connecting said variable impedance means to said first input means of said amplifier means for altering applied signal levels to said amplifier means to change from one given ratio to the other given ratio when the impedance of said variable impedance means changes; and
means connecting said output means of said amplifier means to said apparatus output means and to said control means of said variable impedance means.

2. Apparatus as claimed in claim 1 wherein:
said variable impedance means includes a field effect transistor in series with a resistor and is turned OFF when the ratio is exceeded in said one direction; and
said variable impedance means is voltage sensitive.

3. Apparatus as claimed in claim 1 comprising in addition:
reference potential means;
field effect transistor means and first resistance means comprising a part of said variable impedance means and connected between said first input means of said differential amplifier means and said reference potential means, said field effect transistor means including gate means;
diode means and second resistance means connected in series between said control means of said variable impedance means and said gate means of said field effect transistor;
first Zener diode means connected between said apparatus output means and said reference potential means for limiting the absolute amplitude of signals appearing at said apparatus output means; and
second Zener diode means connected between said first input means of said differential amplifier means and said reference potential means for limiting the absolute amplitude of signals applied to said first input means of said differential amplifier means.

* * * * *