STABILIZATION OF FUNDAMENTAL-FREQUENCY MICROWAVE OSCILLATORS FOR RADIO-RELAY SYSTEMS

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Opening Statement for Panel Discussion

In radio link equipment, frequency control of the transmitter by the use of a resonant cavity has been used since the very early days of the radio link technology and many different AFC arrangements have been designed. One simple design uses a cylindrical cavity where both the two orthogonal TE_{111} modes are exited. One mode is tuned slightly lower than the other, and diode detectors sample the power from the two modes but with opposite polarity, so the combined voltage from the two detectors appears as a discriminator curve.

This type of AFC cavity has been used by Farinon for almost 10 years in radio link systems where the specification for transmitter frequency stability is ± .002% from 0^0 to + 50^0C and ± .005% from -30^0 to $+55^0$C. The cavity is made of invar, sealed and filled with nitrogen, and incorporates thermal expansion compensation. The detuning effect from the diodes is minimized by very weak coupling, so the loaded Q of the cavity is dominated by the transmission line that feeds it.

AFC with cavity reference is quite attractive for radio link equipment above 4 GHz, in particular when fundamental frequency sources such as Gunn oscillators, are used. The component count in the cavity and DC amplifier is quite low compared with other frequency stabilization schemes, and this is important in reliability comparisons. The total manufacturing cost is also favorable. From a system point of view there is seldom any advantage in a tighter frequency tolerance than mentioned above. The main reason for good frequency control is to minimize the effect of a tone in the baseband due to beat with an interfering transmitter at the same nominal frequency. This unwanted tone will have a higher level the further apart the two frequencies are, but can be reduced by the use of a low frequency wobling that spreads the spectrum. Carrier beat problems do not exist in digital radio.

In a conventional IF heterodyne repeater system, the incoming signal is mixed with a SHF source (LO) and the difference frequency (70 MHz) is amplified, filtered and limited and then mixed with another SHF source to give a RF signal for further amplification and retransmission. For a system of many hops the accumulated frequency error can be quite large even with very accurate crystal controlled oscillators. The error can be reduced by deriving the receiver LO from the transmitter LO by means of a shift oscillator and a mixer. Only the shift oscillator error adds up. Another way to solve this problem and still use cavity AFC circuits is to let the cavity sample the transmit output frequency and control the transmit source to correct for the error of the incoming signal as well as the receive local oscillator. (Fig. 1)

With this scheme the output frequency of each transmitter is only dependent of the accuracy of the cavity. Certain refinement of the DC amplifier makes it possible to apply a ± 10 MHz sweep signal for test purpose and still keep each transmitter on frequency. Also, TV signals can be transmitted over many hops with satisfactory low square-wave tilt.

For remodulating type radio link equipment and also, for IF repeaters of the type described above, the receiver local oscillator frequency error can be allowed to be much larger than the error of the transmitter frequency provided that the IF filter is wide enough to not cause any intolerable intermodulation due to inaccurate IF frequency. For medium and large channel capacity equipment an error of about ± 1 MHz can easily be accepted. Because of this consideration a very simple local oscillator can be used. At Farinon we have for the last 7 years used an oscillator where a diode is coupled directly, but very weakly, to a pillbox type invar cavity that in turn has a variable coupling to the mixer for setting of the correct LO power output. In principle, by adjusting the match of the diode through the cavity to the output, all the diode power can be extracted with a high degree of stabilization provided the unloaded Q of the cavity is considerably higher than the loaded Q. For the LO application this is not necessary or desireable since the mixer needs only a few mW, and there is no price advantage in using Gunn diodes with less than 50 mW power capability. Very weak coupling is therefore used to optimize the stabilization effect of the cavity, and the resulting frequency drift is within ± 0.01% from 0^0 to 50^0C. A single tuning control makes it easy to reset the frequency within a 10% band.

In summary, even with all the possible schemes for frequency stabilization that are available today, "old fashioned" cavities can still be used with advantage both regarding cost, simplicity-reliability, and flexibility.

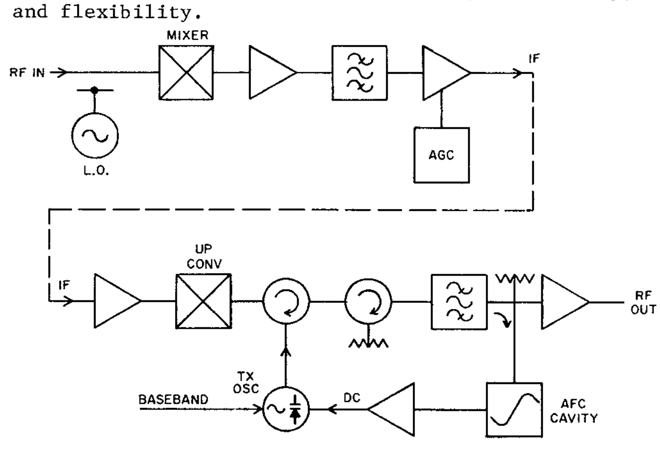

Fig. 1 IF HETERODYNE REPEATER
AFC cavity corrects for frequency error of RF input signal and RF oscillators.

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