

5

10

C

15

25

30

35

field and as it ages (or whenever the oscillator unit is replaced).

What is needed, then, is a method -- integral to the radio itself -- for adjusting the frequency for maximum accuracy. In modern HF SSB radios, it is now possible to do automatic calibration within the radio itself in the field, without the use of precision test instrumentation but simply using elements of the radio itself, because the frequency error is multiplied in the radio receiver such that it can easily be measured at the audio output with conventional microprocessors using known methods of frequency sampling.

It is, therefore, one object of the invention to provide a method for automatically and integrally calibrating the frequency of the oscillator according to the basic prevailing characteristics of the oscillator to achieve appreciable frequency stability, using only an external frequency reference signal.

Summary of the Invention

According to the present invention, there is provided a radio according to claim 1.

In a preferred embodiment, there is provided a system for automatically and integrally calibrating the temperature of an oscillator to achieve frequency stability in a system where the temperature of an oscillator can be set. The temperature calibration is performed by integrally determining the present optimal operating temperature for the oscillator and integrally resetting the temperature of the oscillator to that optimal temperature. Thus, frequency vs. temperature stability is achieved; frequency calibration may follow in accordance with the invention.

Brief Description of the Drawings

An exemplary system in accordance with the present invention will now be described, by way of example

only, with reference to the accompanying drawings, in which:

Figure 1 is a graph that illustrates a typical frequency deviation vs temperature characteristic for a crystal.

Figure 2 is a block diagram of a synthesized radio incorporating the present invention.

Figure 3 is a block diagram of the Processing Unit of Figure 2 and constructed according to the present invention.

Detailed Description of the Invention

Figure 2 is a block diagram of a synthesized radio incorporating the present invention. The synthesized radio includes a frequency oscillator 10 providing a reference frequency, a synthesizer 12 providing a first and second injection frequency for first and second Intermediate Frequency mixers 14 and 16 and whose programmable frequency dividers are loadable from a processor 18, and a demodulator, 20 whose ordinary audio output is advantageously used in accordance with at least the preferred embodiment of the present invention to provide frequency deviation and calibration information to the processor.

The oscillator 10 of this synthesized radio can be accurately calibrated because the frequency error of the internal reference frequency is transformed to the base-band and multiplied by the ratio of the received frequency to the reference frequency. Thus, with an internal reference frequency of 11.4 MHz and with the receiver tuned to a 10 MHz and an external frequency of 10.001 MHz, a tone of approximately 1 KHz will be produced at the audio output -- a 0.1 ppm oscillator error is reflected in the audio output as an approximate 1000 ppm deviation. This multiplication of the frequency error is then easily measured in the audio output by modest microprocessors clocked by low cost crystals.

Figure 3 is a block diagram of the processor 18 of Figure 2 and constructed according to the present invention. The processor includes a microprocessor 22 coupled to the audio output of the receiver and is used in accordance with at least the preferred embodiment of the present invention to provide frequency deviation and calibration information to the processor and further includes digital-to-analogue converters 24 and 26 to supply temperature and frequency calibration information to the oscillator.

To calibrate the oscillator, the receiver is tuned to a calibration frequency (received from a calibrated transmitter, from an external precision test instrument or from a transmitted frequency standard -- time and frequency reference signals are commonly available in the HF band for navigation and time distribution purposes). Next, the voltage generated using the Temperature Digital-to-Analogue converter 24 is varied to drive the oven temperature of the oscillator 10 across its design range from its minimum temperature to its maximum temperature. This feature is the subject of U.K. Patent Application Publication No.2220317.

Once a sufficient number of frequency/temperature points have been noted (for example, a minimum of three is required for the parabolic curve approximation of Figure 1), the oven temperature at which the least frequency deviation exists can be determined. Again, for the basic parabolic characteristic of Figure 1, this optimum temperature (where the slope is zero) is determined from coefficients of the parabola $f=At^2+Bt+C$ where:

$$T_{\text{calibration}} = B/2A \quad \text{and where}$$

$$A = [(f_1 - f_0)(t_2 - t_0) - (f_2 - f_0)(t_1 - t_0)] / (t_1 - t_0)(t_2 - t_0)(t_1 - t_2)$$

and

$$B = [f_2 - f_0 - A(t_2^2 - t_0^2)] / t_2 - t_0$$

from the temperature/frequency pairs (t_0, f_0) , (t_1, f_1) and (t_2, f_2) .

Finally, the voltage corresponding to the optimum temperature $T_{\text{calibration}}$ is generated through the Temperature D/A 24 and the Frequency Tuning D/A 26 is adjusted (varying the voltage on varicap diodes in the oscillator) until the frequency deviation measured at the audio output disappears. The calibration is complete when the values of both the Temperature and the Frequency Tuning D/As are stored in non-volatile memory.

As time passes, the change in frequency deviation at the audio output is measured and noted (the microprocessor is utilized to note said resultant frequency deviations using digital frequency sampling techniques).

Thus, what has been provided is a system for automatically and integrally calibrating the temperature of an oscillator to achieve frequency accuracy and stability in a synthesized radio where the temperature of an oscillator can be set. The temperature calibration is performed by integrally determining the present optimal operating temperature for the oscillator and integrally resetting the temperature of the oscillator to that optimal temperature. Thus, frequency vs. temperature stability is achieved; frequency calibration may follow in accordance with the invention.

The method of calibration of the invention is suitable for use with any oscillator where frequency accuracy and stability is a concern, including those that are not oven temperature controlled. It is particularly advantageous for field frequency adjustments to compensate for crystal aging.

While the preferred embodiment of the invention has been described and shown, it will be understood by those skilled in the art that other variations and modifications of this invention may be implemented.



CLAIMS:

- 5 1. A single side-band radio comprising a voltage controlled oscillator for generating an internal reference frequency signal, a mixer for mixing a signal synthesized from the internal reference frequency signal with a received calibration frequency signal, thereby transforming
10 any error in the frequency of the internal reference signal to the baseband, multiplied by the ratio between the received frequency and the reference frequency, and calibrating means, connected to the control input of the voltage controlled oscillator, for measuring this error in
15 the baseband and automatically adjusting the internal reference frequency to reduce the error measured at the baseband.
2. A radio according to claim 1, wherein the
20 calibrating means comprises a microprocessor for carrying out digital frequency sampling to measure the frequency of the baseband.
3. A radio according to claim 1, wherein the
25 frequency error of the reference frequency signal gives rise to an error at least 1000 greater in the baseband.
4. A radio according to any one of the preceding
30 claims, wherein a microprocessor-driven digital-to-analogue converter is provided to adjust the frequency of the oscillator by altering the voltage supplied to varicap diodes in a frequency generator of the oscillator.
-