A circuit including a DC-FM phase locked loop.

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Description

The present invention relates to a circuit including a DC-FM phase locked loop for use in measuring and control transmitters.

The circuit comprises a voltage controlled oscillator (VCO) having a control input for a modulation signal and connected with its output via a divider stage to one input of a phase comparator. A first filter is connected between the comparator output and a further control input of said VCO. A reference frequency generation means is connected to the other input of said phase comparator, and a second filter via which said modulation signal is supplied to said generation means is provided.

A prior art circuit of this type is known from US-A-36 22 913 which discloses a DC-FM phase locked loop consisting of a VCO having a control input for a modulation signal, a frequency divider connected between the output of said oscillator feeding one input of a phase comparator. A second input of said phase comparator is connected to receive a reference frequency, and the output of said phase comparator is connected via a filter to a frequency control input of said oscillator. Further, a quartz-stabilized but frequency-variable frequency generator is provided for the generation of said reference frequency. The modulation signal is fed via a low-pass filter to the control input of said frequency generator so as to cause the output reference frequency produced by said generator to fluctuate, in response to low-frequency and DC components of said modulation signal, by substantially the same amount as the output frequency of said frequency divider.

It is an object of the present invention to provide a circuit of the type described above in which the action of the phase locked loop is maintained even when the modulation frequency is low.

According to the present invention there is provided a circuit including a DC-FM phase locked loop as described above in which the reference frequency generation means includes a fast-switching frequency synthesizer free of phase jumps and an analog-to-digital converter. The analog-to-digital converter is fed with said filtered modulation signal and connected with its output to control inputs of said synthesizer. Further, the first filter is substantially slower than said second filter and has a passband of the order of 1 Hz.

Accordingly, with modulation frequencies well above those at which the phase locked loop commences to tend to counteract the modulation, the reference frequency at the phase comparator already commences to fluctuate in the same direction and in the same quasi-same amount, so that the error signal at the phase comparator output tends to zero.

Preferably, the digital signals derived from the modulation signal are used for controlling the output of a frequency synthesizer, which can be provided with a resolution (as the case may be by means of additional components) as fine as desired. The circuit may be used with advantage even if the VCO is modulated with a relatively high frequency, even when so modulated in an asymmetric manner so that the modulation signal comprises ultimately a considerable DC component.

The invention will now be described, by way of example only, with reference to the accompanying drawing, which is a simplified block diagram of a circuit in accordance with the present invention.

A voltage controlled oscillator (VCO) produces at its output a signal having a carrier frequency which, by means of a signal fed to a first control input, is frequency modulated. Output 2 is further connected to the input of a frequency divider 4 which divides the output frequency with a ratio of 1:1. Divider output 5 is connected to a first input of a phase comparator 6, whose second input is fed with a quartz-stabilized reference frequency. The resulting error signal at output 7 of the phase comparator is passed via a low pass filter 8 to a second control input 9 of VCO 1. Control inputs 3 and 9 of the VCO 1 could affect one and the same component, say a varactor diode, but it is preferred to use two distinct components having different characteristics.

The signal is also applied to the input of a low pass filter 10. The time constant of the filter 10 is adapted to that of filter 8 such that the filter 10 is substantially "slower" than the filter 10. For example, the filter may have a pass band of 1 Hz while the filter 10 has its upper limit at, say, 500 Hz. The output of the filter 10 is connected to the input of an analog-to-digital converter 11 which produces, in response to its input amplitude, binary-coded output signals which are transmitted in parallel via bus 12 to control inputs of a frequency generator 13. The latter is preferably a frequency synthesizer which upon being switched will not exhibit phase jumps and may immediately supply the quartz-stabilized reference frequency to the respective input of phase comparator 6. This is indicated by the broken line 14.

The frequency generator 13 is controlled by the signals on bus 12 such that its output frequency changes in the same amount as the frequency of VCO 1, after division by divider 4, will vary due to control signal. Consequently, both inputs of the phase comparator will fluctuate in identical sense and by the same amounts so that no error signal is produced and the slow modulation will not be counteracted.

In the preceding paragraph, the term "same amounts" is not entirely correct, because the fre-
quency synthesizer 13 cannot be continuously tuned but exhibits incremental frequency changes, the minimum increment being defined by one least significant bit on bus 12. This defines also the best resolution capability.

To minimize this drawback, the alternative embodiment shown in solid lines is preferred. A quartz-stabilized reference frequency \( f_{\text{REF}} \), applied at input 15 of generator 13, serves as the frequency basis of the latter. The same frequency is fed to a first input of mixer circuit 17 (at input 16) while the second input of the mixer is fed with the output signal \( f_{\text{out}} \) of generator 13. At the output 18 of mixer 17, accordingly, the sum (or difference) of \( f_{\text{REF}} \) and \( f_{\text{out}} \) is available and is applied, via divider 19, to the phase comparator 8. The division ratio \( m:1 \) is accordingly selected under consideration of \( f_{\text{REF}} \pm f_{\text{out}} \).

The resolution capability of the system is thereby improved by the factor \( f_{\text{REF}} / f_{\text{out}} \), and for this reason \( f_{\text{REF}} \) is selected to be considerably higher than \( f_{\text{out}} \). It should be remembered that \( f_{\text{out}} \) is normally not constant, but incrementally changing in response to signals on bus 12 (it would be possible to define \( f_{\text{out}} \) in the format \( f_{\text{nom}} = f_{\text{cor}} \), where \( f_{\text{nom}} \) is the nominal frequency of generator 13 with absence of a signal \( f_{\text{cor}} \), and \( f_{\text{cor}} \) is the correction signal due to the presence of an input signal of A/D converter 11).

In an implemented circuit, the following data applied:
Nominal frequency of VCO 1: 480 MHz
\[ n = 1000 \]
\[ f_{\text{REF}} = 480 \text{ KHz} \]
\[ f_{\text{nom}} = 10.5 \text{ MHz} \]
\[ f_{\text{cor}} = 60 \text{ KHz} \]
\[ f_{\text{nom}} / f_{\text{cor}} = 175. \]
The figures given above are to be considered as exemplary only.

The VCO 1 was made up from discrete components, its control input 3 being substantially linear. Frequency dividers are readily available, the mixer 17 was a simple diode mixer. A low pass filter of first or second order may be used as filter 8, and a simple RC-component may be used as low pass filter 10. As the A/D converter, circuit IC AD 573 manufactured by the company Analog Devices, Norwood, Mass. U.S.A. was used. The frequency synthesizer used was of a type wherein a change of one least significant control bit will result in an output frequency change of .6 Hz.

**Claims**

1. A circuit for use in measuring and control transmitters, comprising:

- a voltage controlled oscillator (1) fed with an analog modulation signal \((f_{\text{mod}})\) at a control input (3) and connected with its output (2) via a divider stage (4) to one input of a phase comparator (6);
- a first filter (8) connected between the comparator output (7) and a further control input (9) of said voltage controlled oscillator;
- reference frequency generation means (11, 13) connected to the other input of said phase comparator, and
- a second filter (10) via which said modulation signal is supplied to said generation means;

characterized in that:

- said reference frequency generation means includes:
  - a fast-switching frequency synthesizer (13) free of phase jumps, and
  - an analog-to-digital converter (11) fed with said filtered modulation signal and connected with its output to control inputs of said synthesizer, and in that
- said first filter (8) is substantially slower than said second filter (10) and has a passband of the order of 1 Hz.

2. A circuit as claimed in claim 1, wherein the frequency synthesizer output signal is directly fed to said phase comparator as the reference frequency for the latter.

3. A circuit as claimed in claim 1, wherein the frequency synthesizer output is mixed with a substantially higher quartz-stabilized frequency \((f_{\text{REF}})\) and the frequency mix is fed to the input of a frequency divider (19) having a division ratio such that said reference frequency will be produced at its output.

4. A circuit as claimed in claim 3 wherein said quartz-stabilized frequency \((f_{\text{REF}})\) is fed to said frequency synthesizer as a frequency basis thereof.

**Revendications**

1. Un circuit prévu pour l'utilisation dans des émetteurs de télémesure et de télécommande, comprenant :

- un oscillateur commandé par tension (1) qui reçoit un signal de modulation analogique \((f_{\text{mod}})\) sur une entrée de commande (3) et dont la sortie (2) est connectée par l'intermédiaire d'un étage diviseur (4) à une entrée d'un comparateur de phase
(8);
- ein premier filtre (8) connecté entre la sortie du comparateur (7) et une entrée de commande supplémentaire (9) de l'oscillateur commandé par tension;
- des moyens de génération de fréquence de référence (11, 13) connectés à l'autre entrée du comparateur de phase, et
- un second filtre (10) par l'intermédiaire duquel le signal de modulation est appliqué aux moyens de génération; caractérisé en ce que :
- les moyens de génération de fréquence de référence comprennent :
  - un synthétiseur de fréquence à commutation rapide (13) ne présentant pas de sauts de phase, et
  - un convertisseur analogique-numérique (11) qui reçoit le signal de modulation filtré et dont la sortie est connectée à des entrées de commande du synthétiseur, et en ce que
    - le premier filtre (8) est notabllement plus lent que le second filtre (10) et il a une bande passante de l'ordre de 1 Hz.

2. Un circuit selon la revendication 1, dans lequel le signal de sortie du synthétiseur de fréquence est directement appliqué au comparateur de phase, à titre de fréquence de référence pour ce dernier.

3. Un circuit selon la revendication 1, dans lequel le signal de sortie du synthétiseur de fréquence est mélangé avec une fréquence notablement plus élevée, stabilisée par quartz ($f_{ref}$), et le signal résultant du mélange des fréquences est appliqué à l'entrée d'un diviseur de fréquence (19) ayant un rapport de division tel que la fréquence de référence apparaisse à la sortie de ce diviseur.

4. Un circuit selon la revendication 3, dans lequel la fréquence stabilisée par quartz ($f_{ref}$) est appliquée au synthétiseur de fréquence à titre de base de fréquence pour celui-ci.

**Patentansprüche**

1. Ein Schaltkreis zur Werwendung in Meß- und Steuersendern, umfassend:
- einen spannungsgesteuerten Oszillator (1), an einem Steuereingang mit einem analogen Modulationssignal ($f_{mod}$) gespeist und mit seinem Ausgang (2) über eine Teilerstufe (4) mit einem Eingang eines Phasenkomparators (6) verbunden,