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MEASUREMEN.T PHASE NOISE CRYSTAL OSCILLATOR

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One of the most important characteristics of high frequency oscillators (HFO) used in communication devices, navigation equipment, digital devices, systems orientation autopilot aircraft, missile guidance systems, radar equipment – is the phase noise generated oscillations, in other words , the distortion of the generated signal [1].

The ideal signal generated by a crystal oscillator (CG) should not be distorted shape, and location of its edges should exactly repeat from period to period, that is, it must exactly match their mathematical function, $U = U_o sin(t/T)$ for a sinusoidal signal where: T – the period of oscillation, t – current time.

Waveform distortion due to the nonlinear regime autogeneration, electrical frequency multiplication, and other factors, spectral analysis explains "admixing" to the basic ideal signal with frequency ω of its harmonics with multiple frequencies (2ω, 3ω, 4ω ...) and amplitudes corresponding to that signal distortion [2].

In that case, if the waveform distortion is random chaotic can speak of a phase noise in the signal . Phase noise in the reference oscillator leads to a deterioration of the radio systems: degradation of the radio communication, reduce the accuracy of location of objects in the GPS navigation data transmission losses, reduced sensitivity of radar and others. Today, phase noise is one of the main parameters of the CG, which reduce is of paramount importance .

Phase noise measurement is performed on special analyzers spectral analysis, determine how its power is distributed over the frequency range from zero to infinity. In practice, it is usually limited by the operating frequency detuning of the signal in the range from *0,1 Hz* to *100 kHz* (and sometimes from *0,01 Hz* to *1 MHz*) [3].

The measurement results are presented in the form of the curve $L(\Omega)$, where Ω – frequency analysis *Hz*; $L(\Omega)$ – logarithm of the spectral power density of the "noise" of the signal $S(\Omega)$, measured in a *1 Hz* bandwidth at a distance from the lasing frequency Ω: $L(\Omega)$, $dBc = 10Log[S(\Omega)/2]$.

The dependence of $L(\Omega)$ is divided into three zones differing slope $L(\Omega)/\Omega$: proximal zone occupies a range of from 0Ω to *10 Hz* has a slope $L(\Omega)/\Omega$ about *30 dBc* per decade (a decade – the change *Ω10 times*); middle zone , which occupies the frequency range Ω approximately *10 Hz* to *10 kHz*, is characterized by a slope $L(\Omega)/\Omega$ from *10* to *20 dBc* per decade; far zone (or noise-floor), starting from Ω = *10 kHz*, has almost no slope of $L(\Omega)/\Omega$.

In the formation of the CG noise involved various sources , concentrated in the oscillator circuit , temperature control system and a quartz resonator (CR). Their influence on the noise CG occurs by a complex interaction between them and the parameters of the resonator. Despite the well-known convention, it is assumed that the phase noise $L(\Omega)$ at different detuning Ω generated by various sources of noise.

Far field (noise-floor) is formed mainly intrinsic noise buffer amplifier. Thus , the higher the level of the generated signal at the input of the buffer amplifier , the lower the contribution of noise in the CG and the lower level $L(\Omega)$. Limit reduce noise-floor limited Johnson noise equal at room temperature – *174 dBm/Hz*. Therefore, the lower levels of phase noise reduction required temperatures CG [4].

The middle zone $L(\Omega)$ is formed by noise amplifier oscillator , closed through the CD positive feedback . At the level of phase noise in this area influences the loaded quality factor KR: the higher the Q_L, the lower the frequency of the upper middle zone and the middle zone of the transition frequency in noise-floor.

In the formation of the near field dependence $L(\Omega)$ involving the same sources as in the middle zone, but added to them related to the influence of noise on the resonator and the thermostat. Effect of noise on the thermostat due to fluctuations in its temperature , called through the thermodynamic effect of the frequency fluctuations of the CD. Usually this factor is concentrated in the range of *0,01Ω* to *5 Hz*, and can be reduced by optimizing the design of the oven and increase the thermodynamic stability of the CR.

Sources of noise in the CR have flicker nature and occur mainly due to defects on the wafer surface and the subelectrode areas such as scratches, quartz particles , defects adhesion film electrodes , and others. In addition to improving the quality of processing and application technology of the plate film electrodes to reduce noise above factors resulting increase in the thickness of the plate (excitation at higher harmonics of the motor), provides a reduction ratio “surface” energy (fluctuating due to these defects) to the energy fluctuations in the volume of the plate.

In addition to the above factors, a significant effect on the noise of the CG has its own noise varicap in series with the CR and the noise voltage regulator, which is the right choice for a low-noise CG is crucial.

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