METHOD AND APPLICATION ALGORITHM FOR LOWERING THE IMPACT OF THE TIMING JITTER ON THE STATISTICAL INDICATORS OF THE SIGNAL SAMPLING BASED MEASUREMENTS

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This paper presents new test method and its application algorithm for lowering the impact of the timing jitter on the statistical indicators of signal sampling based tests. The results - simulated and experimental are demonstrated proving the effectiveness of the proposed test method.

1. INTRODUCTION

This paper proposes new developed test method for lowering the impact of the timing jitter on the statistical indicators of signal sampling based tests. Based on a simulation of the mathematical model of sampled measurement in presence of jitter [1] it is made an evaluation of the positive effect of the method's application. The results of the method's application in industrial environment are presented [4]. It is given the application algorithm of the proposed test method.

2. EXISTING METHODS FOR LOWERING THE IMPACT OF THE TIMING JITTER ON THE STATISTICAL INDICATORS OF THE TESTS

In the base of the digital signal processing (DSP) based test methods is the amplitude measurement of a known spectrum component of interest defined in the test program - spectral bin, frequency of interest [4, 5]. The effect of jitter can be associated with random timing variable denoted as *tj*, and added to the period *T* of the sampled signal. The presence of frequency jitter in the signal sampling process will cause the neighboring spectral components to become subject of the amplitude measurement as well. This will worsen the measurement accuracy and repeatability and will have catastrophic impact on the values of σ, *Cp* and *Cpк* [2]. One possible approach would be lowering the frequency resolution of the measurement with results in frequency domain [4] thus integrating the neighboring spectral bins covering the frequency shift. This way the frequency bin of interest would always appear on the place subject of measurement. A major disadvantage of this approach is the significant increase of the wideband noise of the overall signal spectrum [4, 5].

Another possible approach is the identification of the jitter source and its further elimination. This approach however might take big engineering efforts and there is always risk the cause of jitter to remain unclear and/or unfeasible to solve. In this case another way for solving the problem is needed.

3. METHOD WITH PEAK-SEARCH IN A PREDEFINED FREQUENCY RANGE OF THE SIGNAL SPECTRUM

An effective solution of the problem would be implementing the following method. Instead of calculating the amplitude of preliminary specified frequency bin, the test program searches for the peak amplitude value within a predefined frequency range of the signal spectrum. The peak values of the frequency shift *F*min and *F*max caused by the timing jitter are studied using analog instruments for correlation measurements (spectrum analyzer etc.). Shown in fig. 1, the frequency range called *search-band-width (SBW)* is specified according to:

$$SBW = F_{max} - F_{min} \tag{1}$$

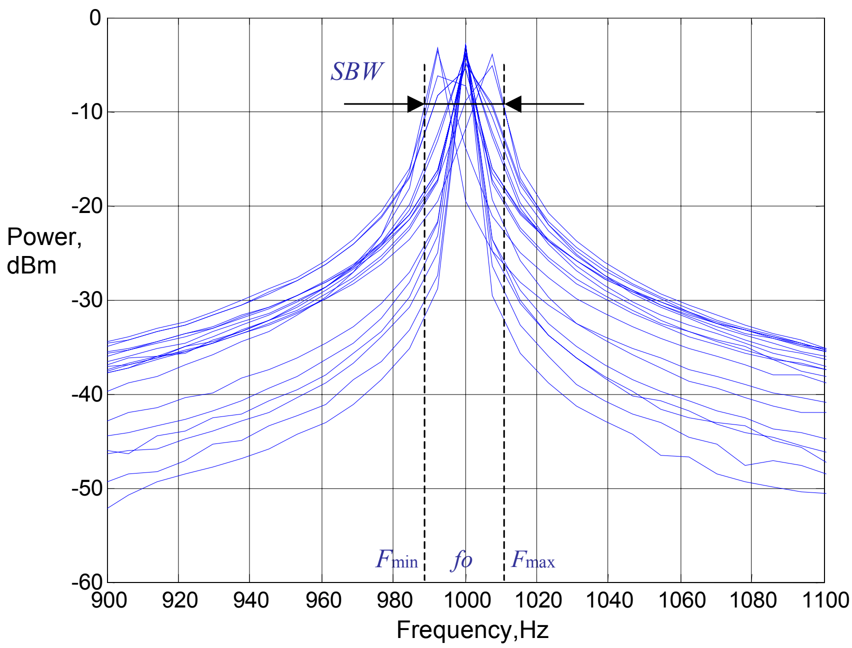

Fig. 1

Within the *SBW* it can be assumed that the peak amplitude belongs to the frequency of interest - *fo*. Fig. 2 shows the graphic results (in red) of the mathematically simulated relation between σ, and *tj*/*T*, % obtained after the application of the method. In blue it is given the same relation when a standard DSP measurement is used. The two graphs comparison demonstrates the method's high efficiency in many times suppressing the parasitic increase of σ, caused by the timing jitter.

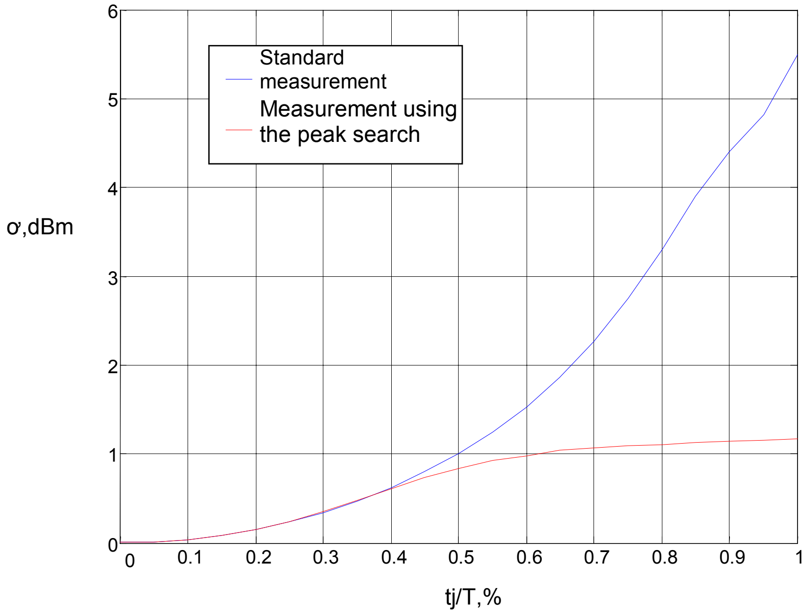

Fig. 2

4. ALGORITHM OF A TEST FUNCTION FOR THE PEAK-SEARCH METHOD APPLICATION

The algorithm gives the sequence of a test function applying the peak-search method. The so proposed algorithm is presented as a pseudo-code. For maximum clarity of the example it is assumed that it is measured the carrier component of the transmit spectrum of a radio communication IC.

```
TEST FUNCTION TxSpectrum
{
PROGRAMMING of the power supplies;
PROGRAMMING of the Transmit frequency and other parameters of the IC;
PROGRAMMING of the Signal capture instruments;
PROGRAMMING of the DSP parameters – fs, number of samples, fres;
START of digital pattern activating the IC in transmit mode;
START of the Signal capture instruments;
MOVE of the captured data to the compute memory of the tester;
    COMPUTE BLOCK
    {
    Definition of the SBW numerical value;
    FFT (Fast Fourier Transformation) on the signal capture data;
    Calculation of the amplitudes in the output Fourier spectrum;
    Search for the maximum amplitude in the range: fo± SBW/2;
    TEST of the measured value against the test limits;
    }
}
```

5. EXPERIMENTAL RESULTS OF THE METHOD'S APPLICATION

The following results obtained in an industrial environment illustrate the real-life effect of using the method. It is measured the amplitude of the carrier frequency in the transmit spectrum of radio communication IC [6]. The approximate value of the ratio $tj/T \approx 0.75\%$ as seen on spectrum analyzer. Fig. 4 presents the test results distribution of production lot of 150 ICs without using the peak-search method. The distribution is parasitically widened and σ=6.291 dBm. Fig. 5 shows the distribution of the same lot of 150 ICs but after the method has been used. This distribution has value of σ=2.295 dBm. The presented experimental results prove the very high efficiency of the proposed method – lowering the standard deviation value down to 2.74 times in the presented case and down to 6 times the worst studied in [1] case - $tj/T \approx 1\%$. The theoretically obtained result for lowering the value of σ in the presented case ($tj/T \approx 0.75\%$) is 2.63 times i.e. the experimental and the theoretical values differ with less than 4%, proving the relevance of the adopted method for studying the problem.

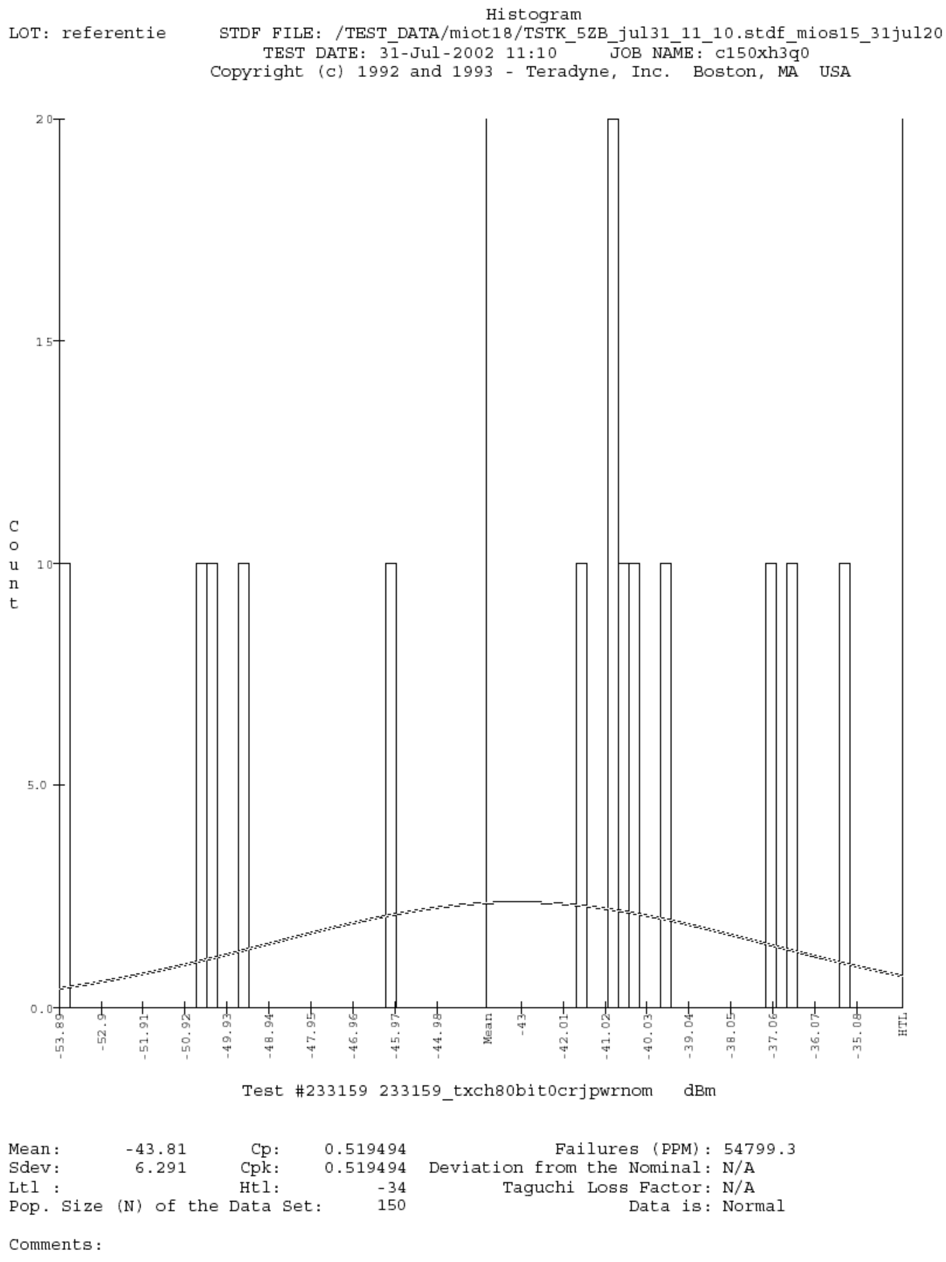

Fig. 4

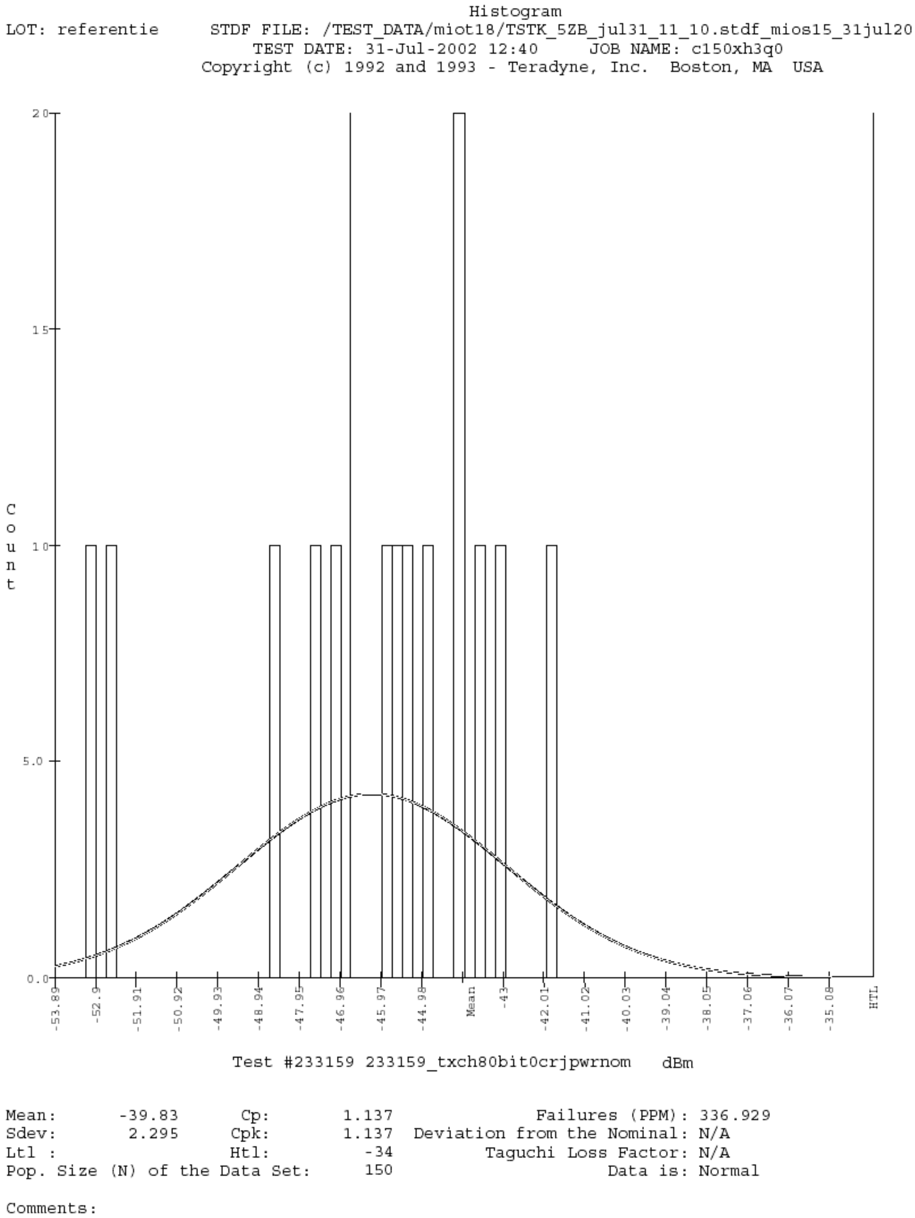

Fig. 5

The comparison of the experimental and theoretical results helps drawing the following conclusions.

6. CONCLUSIONS

1. The experimental data prove that the proposed method overcomes the weakness of the traditional DSP measurement method in presence of timing jitter, significantly improving the statistical indicators of the tests.
2. The negligible difference between the theoretically calculated and the practically measured optimizing effect of the method on the value of σ proves

the relevance of the developed mathematical model for studying the processes of signals sampling in presence of timing jitter. The model plays major role for the analytical study and description of the problem given in [1].

3. The proposed algorithm helps the easy application of the method wherever the timing jitter causes problems with the accuracy, stability and statistics of the signal sampling based measurements with results in frequency domain.
4. The application of the method has an immediate economical effect by:
   - Shortening the product qualification and its production test by lowering the time needed for tests' correlation and industrialization
   - Helps the constant over time high quality of the IC production, significantly improving the quality determinative statistical indicators
   - Saves rejecting of functional ICs in case of test results distribution marginal to the test limits
   - Does not engage additional computing and hardware resources

This paper presents a new developed DSP based test method for measurement in presence of timing jitter and application algorithm based on the identification of the amplitude peaks in a predefined frequency range of the sampled signal spectrum.

The method's powerful effect of suppressing the σ value at very low level independently of the jitter quantity increase is demonstrated graphically.

Experimental results of testing a lot of 150 ICs in an industrial environment are presented, using traditional DSP and the proposed method in turn, proving the high effectiveness of the last one in improving the statistics results of the tests.

7. REFERENCES

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