Long Practical Expirience of Large Scale Quantity Manufacturing of E-10 Stability DOCXOs and the Futher Development of Subject Concept

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I. ABSTRACT

During last 10 years the mobile phone networks are being widely spread. Accordingly the market for base stations' equipment has been drastically increased. This phenomenon became one of the key driving forces for pushing development of OCXOs technology.

One of the most critical components of base station equipment for the networks of CDMA–"family" is an ultra-precision crystal oscillator meeting following key requirements for frequency stability: (1…2)E-10 vs. operating temperature, 1E-10/day, and 2E-8/year. In year 2000 the appropriate model of double-oven oscillator (DOCXO) – MV89 – was developed, and from 2001 Morion has started with large scale quantity manufacturing of those.

Actually there is a very tight combination of top technical requirements and large scale quantity manufacturing with acceptable costs. To overcome the certain difficulties all critical stages of subject technology, i.e. starting from SC-cut contoured blank, then crystal, then DOCXO itself and its testing, were reworked with significant improvements. About 50,000 units of subject DOCXOs were manufactured and delivered. Now this line is still in good shape providing up to 500 units weekly.

The important issues of large scale quantity manufacturing technology are being highlighted combined with statistical analysis of main production DOCXOs parameters. Large collected Data Base is being used as fundament for reasonable conclusions.

At the end the further developments of DOCXOs technology are being presented. There are designs and technical data of low profile (17 mm height), and miniature (36x27x19mm) DOCXOs' models. Their technical data are very close to those achieved for original "large" model (2''x2''x1.5'') being a main subject of the paper, i.e. (1…2)E-10 vs. operating temperature - 20…+70 ^{o}C and (2…3)E-8/year. The serial manufacturing of both a.m. new DOCXOs' models has been already successfully started.

II. INTRODUCTION

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Further R&D have resulted in new low profile DOCXO's industrial model MV180 meeting the same frequency stability but 17 mm height.

The key issues related to the long practical experience of large scale quantity manufacturing of E-10 stability DOCXOs and further development of subject concept are highlighted in paper below.

III. KEY FEATURES OF ULTRA-PRECISION CRYSTAL OSCILLATOR MANUFACTURE.

Combination of very tight requirements to the parameters of oscillator is ensured through design of oscillator, high quality of components used and unique manufacturing processes. In particular, frequency stability vs. temperature at a level of ±(1-2)E-10 is guaranteed by the use of double oven design. Long-term frequency stability of ±(1-2)E-8/year and short-term frequency stability of (1-2)E-12 are mainly defined by the used CR quality. In the large-scale production stability of obtaining the specified parameters at a reasonable cost price depends on the available high-performance equipment, operating personnel qualification, and technological process organization. MV89 DOCXO design was developed at Morion, Inc. in 2001 [1] and after being launched has undergone a series of insignificant changes to remove

shortcomings found at manufacturing oscillators in large quantities. The oscillator structure chart is given in Fig.1

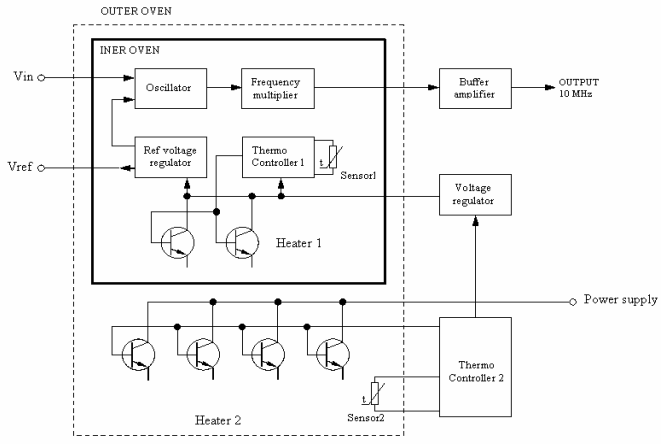

Fig.1.

Physically, the oscillator is enclosed in a standard case of 50.8*50.8*38 mm in size. A two stage thermostat maintains CR temperature with accuracy of ±0.05°C and temperature gradient of about 0.1 °C at the ambient temperature change from -40 °C to 70 °C.

CR is one of the main oscillator's components. 5 MHz SC-cut CR on 3rd mechanical harmonic in HC-40 cold-welded case is used in the oscillator to ensure the specified parameters. These resonators full-scale production, starting from crystal elements made with an angle cut accuracy of ±(10…15)", was created at Morion, Inc. CR manufacture technological process was built and adjusted so that the output of fit resonators in terms of long-term stability reaches 85%.

High frequency stability of each oscillator is proved by 100% measurement of key parameters during manufacturing.. A certain difficulty lies in measuring of such parameters like the long-term frequency stability, frequency stability vs. temperature with an accuracy of < 1E-10 for large quantity of tested oscillators. To ensure the proper tests a measurement station for 3800 test positions and temperature testing equipment for 150 test positions were built. All measurements are automatic. The testing equipment sufficient for testing of over 600 oscillators per week.

The technological process organization is aimed to the reduced oscillator manufacture labor expenditures and increased products output. The process macro flowchart is given in Fig. 2.

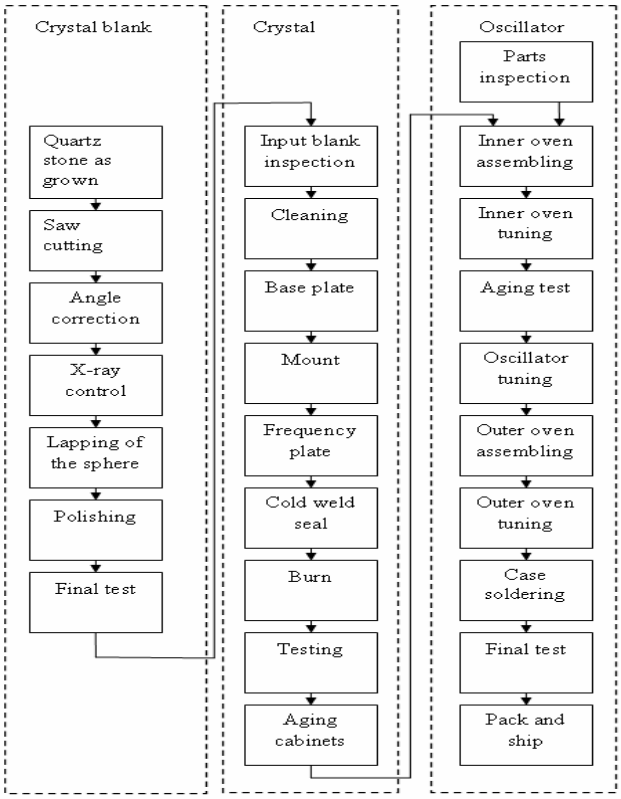

Fig. 2.

The MV89 oscillator manufacture process line has operated at Morion Inc. since 2001. 50 000 oscillators have been manufactured to date. The oscillator output diagram by years is given in Fig.3.

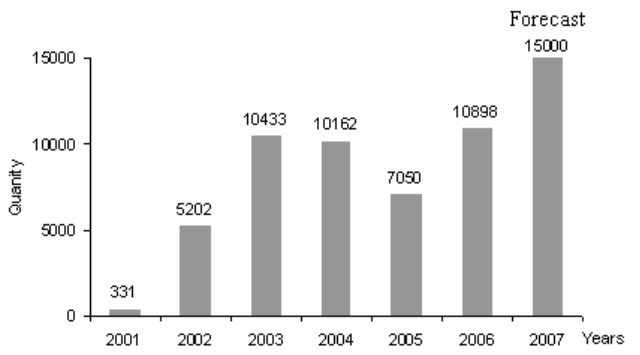

Fig.3.

IV. MAIN PARAMETERS STATISTICAL ANALYSIS.

Quality of CR manufacture within the oscillator production period was evaluated by an average daily frequency instability after 30 days of continuous operation. The diagram of the average daily frequency instability with 85% oscillator spread limits from 2001 to 2007 is given in Fig.4.

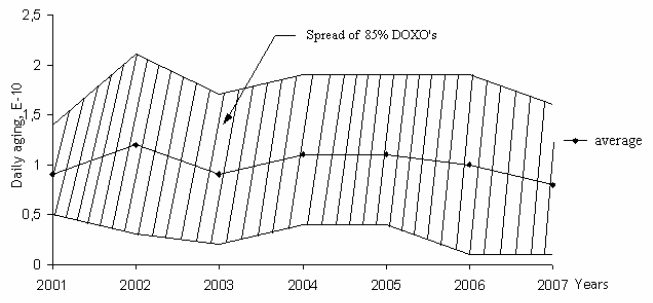

Fig.4.

Quality of oscillator manufacture within the oscillator production period was evaluated by frequency stability vs. temperature in a -10 °C to 70 °C operating temperature range. The diagram of the average value of stability vs. temperature for oscillators made from 2001 to 2007is given in Fig.5.

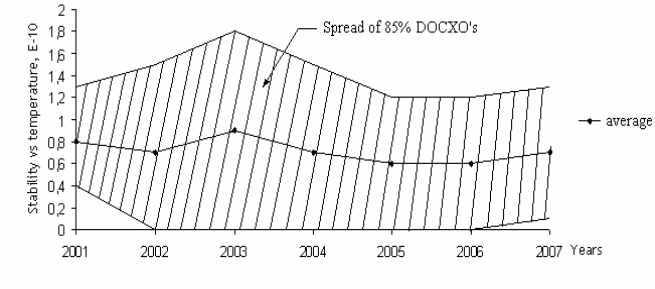

Fig.5.

Presented results permit making some quality conclusions

-insignificantly changed average parameter shows the technological process stability

- somewhat increased average daily aging in 2002 was due to deviations in the resonator production technological process, accompanied with a reduced output of yielded resonators

- somewhat increased average frequency stability vs. temperature in 2003 was due to a sharp increase in the oscillator output (doubled) compared to the previous year, resulting from an insufficient experience of additionally employed operating personnel.

As the technological process and personnel skills improved since the oscillator production start, the oscillator manufacture labor expenditures decreased. The labor expenditures change compared to the same as of the full-scale production beginning is given in the diagram of Fig. 6.

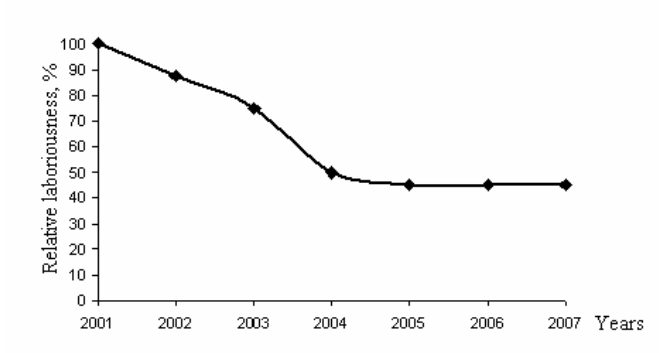

Fig. 6.

V. PRODUCTION PROSPECTS.

Further toughening of requirements for this class of oscillators is mainly characterized with the decreased overall size and the same frequency stability requirements. Therefore, in 2006, MV180 oscillator with overall dimensions of 50.8*50.8*17 mm and 51*41*19 mm was developed and successfully launched at Morion Inc. MV180 oscillator's main technical parameters are as follows:

-frequency		5 or 10 MHz
-long-term frequency stability		±(1…2)E-8/year
-short-term frequency stability (Alan deviation)		(1…2)E-12/s
-frequency temperature stability (-20 °C…70 °C)		± (1…2)E-10
-phase noise	1Hz	-100dB/Hz
	10Hz	-130dB/Hz
	100Hz	-140dB/Hz
	1000Hz	-150dB/Hz

More than 2000 of MV180 oscillators have been manufactured to date.

VI. CONCLUSION.

Morion Inc. has successfully solved the problem of creating the design and technological process of stable full-scale crystal oscillator production with a frequency temperature stability level of ± (1…2)E-10 and long-term stability of ±(1…2)E-8/year with reasonable enough labor expenditures.

REFERENCE:

[1] S.V.Anastasiev , A.A.Volkov , Y.L.Vorokhovsky , Morion Inc. St. Petersburg. "A New High Stability DOCXO. Statistics of the Results of Frequency Stability Measurements", Proceedings of Frequency Control Symposium and PDA Exhibition, 2002, p 633-638.