A NEW HIGH STABILITY DOCXO. STATISTICS OF THE RESULTS OF FREQUENCY STABILITY MEASUREMENTS.

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SUMMARY

Recently the significant increase of demand for Ultra Stable Quartz Oscillators has been evidenced. Such oscillators are used for many applications including CDMA, GPS/GLONASS, etc. The following major requirements are usually applied for these oscillators: frequency stability vs. Temperature changes of +/-(1..2)* 10^{-10}; long term stability of +/-(1..2)* 10^{-8}/year; short term stability of <5* 10^{-12} for time intervals of 1 through 100 seconds. As the world experience shows, very tight combinations of requirements can be met in Double Oven crystal oscillator (DOCXO). However, development, production and measurement of such DOCXOs is a quite technically complicated task.

In the R&D laboratory of the Morion, Inc. the design of DOCXO was made with parameters satisfying the above mentioned requirements. Also the process of serial production of such DOCXOs has been worked out.

The major parameters of MV89 type DOCXO:

Nominal frequency:	4.096; 5.0; 8.192; 10.0 MHz
Frequency stability in operating temperature range of -20..+70 °C:	±1.0* 10^{-10}; ±1.5* 10^{-10}; ±2.0* 10^{-10};
Aging per day:	±1.0* 10^{-10};
Short-term stability for 1..100 s:	<5* 10^{-12};
Output level:	>0 dBm into 50 Ohms load;
Power consumption:	<3.5 W (steady state @ 25°C);
Dimensions:	2"*2"*1.5" (50.8*50.8*38mm).

The design of DOCXO is based on previous designs of Morion's precision oscillators and takes into account the modernizing of existing technology.

A new DOCXO has two modifications: MV89A with standard frequencies 8.192, 10 MHz and MV89B – 4.096 and 5.0 MHz. MV89A differs from MV89B by presence of frequency doubler. High quality SC-cut crystals in cold weld package HC40 are used in both modifications. Long term stability of

most of these crystals is enough to meet the specification requirements in serial production.

DOCXO consists of three main parts:

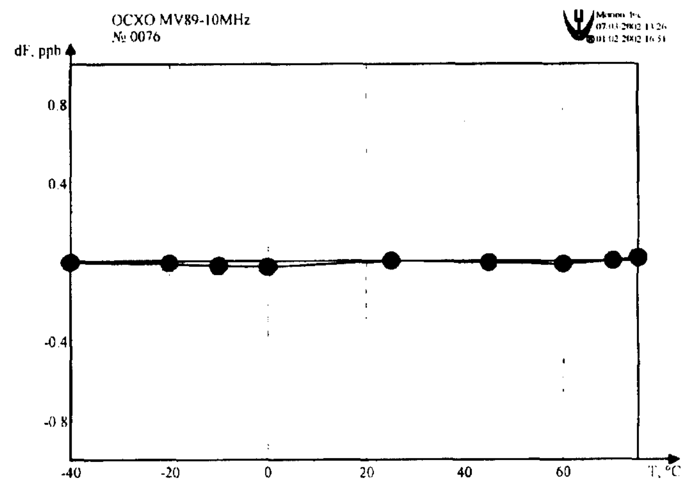
- inner oven with a crystal, oscillator circuitry and VCO;
- outer oven with a thermocontroller of inner oven and reference voltage regulator;
- base plate with a thermocontroller of outer oven and buffer amplifier.

This structure is mounted in hermetically sealed metal case with standard pin-out.

MAIN CHARACTERISTICS OF FREQUENCY STABILITY

Temperature stability.

Frequency stability in ambient temperature range depends on stability of an average temperature of crystal and stability of temperature gradients in the crystal blank. In double oven structure it is possible to achieve the stability of crystal temperature approximately 0.01°C. Calculated temperature gradients are about 0.1°C. It is important to maintain the temperature of oscillator circuit constant to avoid frequency deviation caused by changing of components characteristics. Achieved frequency stability in ambient temperature range -40°C ÷ 75°C for MV89 is shown in Fig.1.



T, °C	Frequency, MHz	Dev., ppb	I, mA
-40	9.999 999 992 278	-0.008 900	712.50
-20	9.999 999 992 207	-0.016 000	582.00
-10	9.999 999 992 120	-0.024 700	524.60
0	9.999 999 992 055	-0.031 200	465.30
25	9.999 999 992 367	0.000 000	318.90
45	9.999 999 992 286	-0.008 100	203.85
60	9.999 999 992 200	-0.016 700	120.88
70	9.999 999 992 347	-0.002 000	66.34
75	9.999 999 992 521	0.015 400	46.14

Checkpoint type	Value	Limit	+
|ptpF[-20:60]|	0.031 200	<1ppb	+
|ptpF[-40:75]|	0.046 600	<1ppb	+
|ptpF[-20:70]|	0.031 200	<1ppb	+
|ptpF[-10:70]|	0.031 200	<1ppb	-

Fig.1.

Statistical data shows that 70% of total quantity produced meet $\pm 2*10^{-10}$ in temperature range -40°C ÷ +75°C 90% meet $\pm 2*10^{-10}$ in temperature range -10°C ÷ +70°C. And about 85% meet $\pm 1*10^{-10}$ vs. temperature –10 ÷ +70°C.

Long term stability.

Fig.2 shows typical frequency vs. time characteristic of MV89.

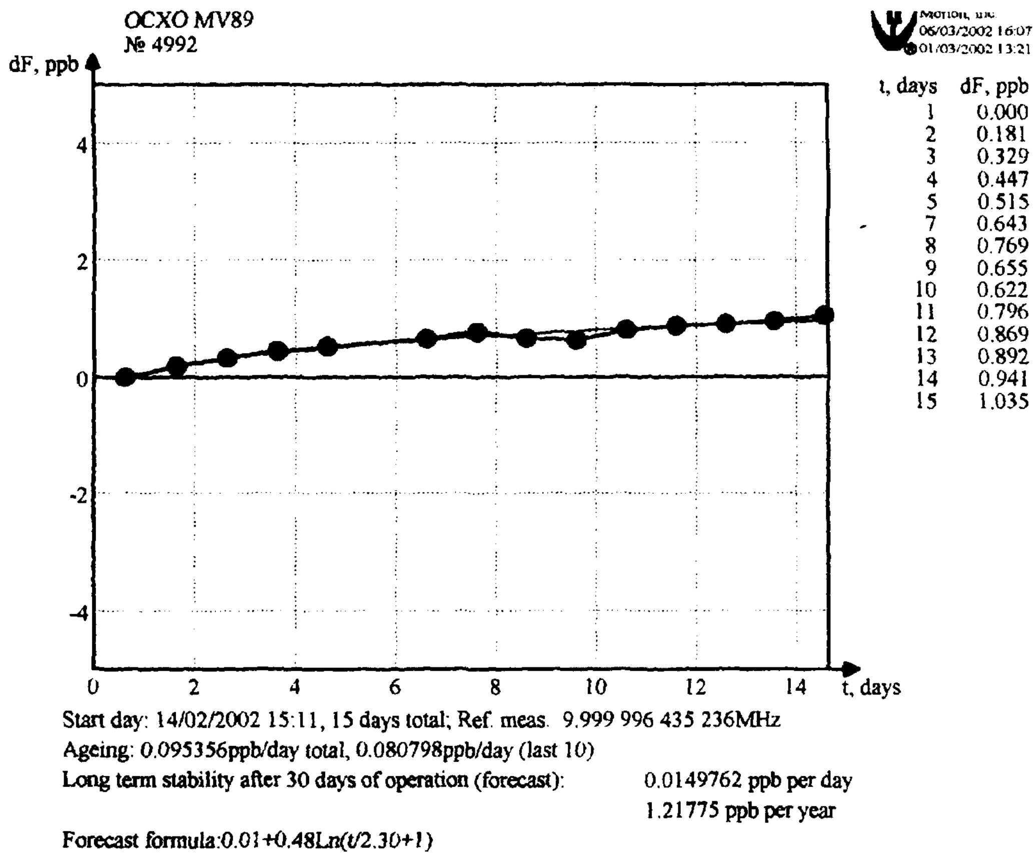


Fig.2.

Long term stability mainly defined by the quality of crystal. More than 80% of crystals used in MV89 meet $\pm 2*10^{-10}$/day and 70% meet $\pm 1*10^{-10}$/day
Those DOCXO reliably have according long term stability in 1st year $\leq \pm 2*10^{-8}$ and $\leq \pm 1*10^{-8}$. They may be reliably delivered for very tight requirements like $\leq \pm 5*10^{-8}$ for 10 years of operation.

Short term stability.

Fig.3 shows typical Allan variance characteristic of MV89.

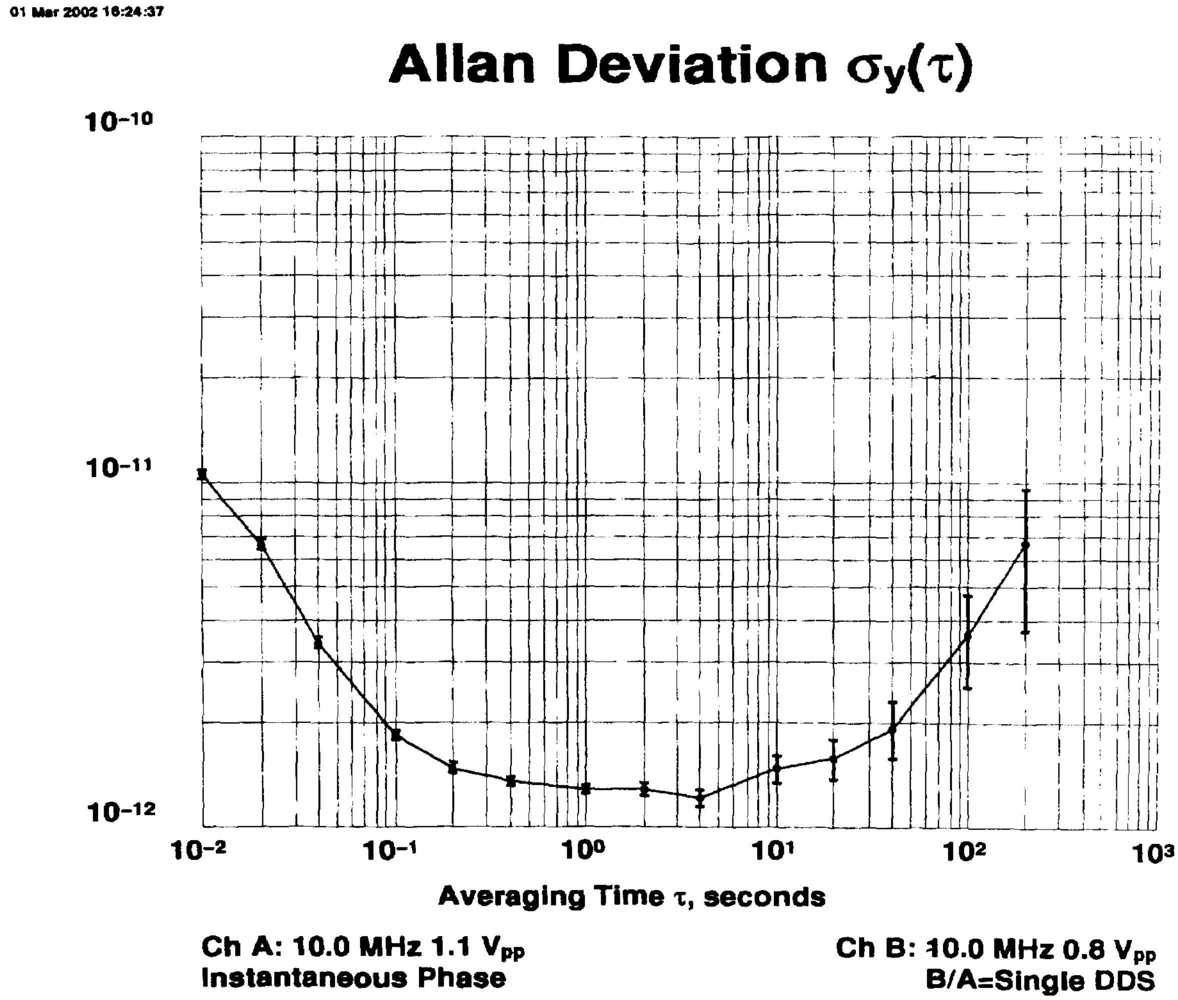


Fig.3.

Statistical data shows that 90% of total quantity meet Allan variance for average time interval

1s – $2*10^{-12}$

10s – $3.5*10^{-12}$

100s – $5.5*10^{-12}$

Phase noise.

Fig.4 shows the typical phase noise plot of MV89A 10 MHz.

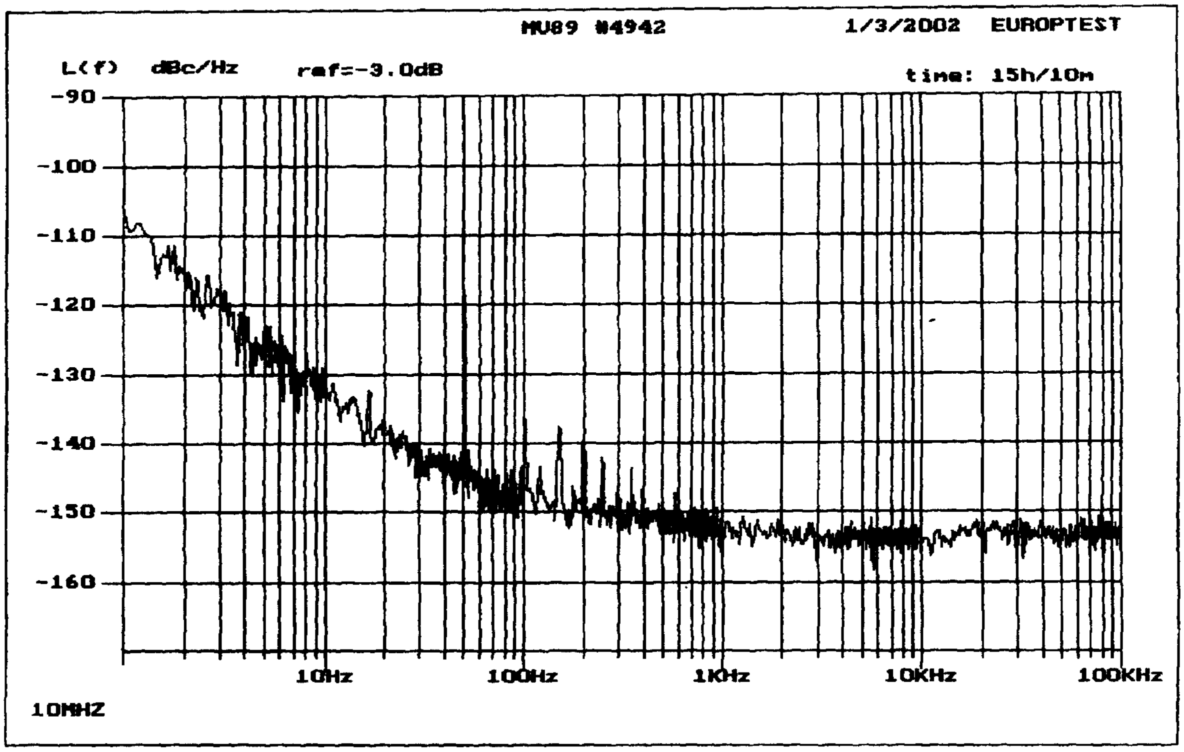


Fig.4.

Statistical data: more than 98% of total quantity of MV89A units meet phase noise

at offset	1 Hz	-100 dBc
	10 Hz	-130 dBc
	100 Hz	-145 dBc
	1000 Hz	-150 dBc

CONCLUSION

The introduced DOCXO is being produced at Morion, Inc. Now our R&D department is working out a new DOCXO with a reduced height and low power consumption.