ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 7, July 2017

Ultra small package stramtum 3E SMD OCXO

[1] Ambica N, [2]Arpitha N D ,[3]Lavanya N, [4]Manasa U K,[5]Padma R
[1][2][3][4] Final year ECE [5] Assistant Prof of ECE
[1][2][3][4][5] GSSSIETW, Mysuru

***Abstract* - Oven controlled crystal oscillator have been widely used in global positioning systems, communications, metering, telemetry control, spectrum, network analyzers and other electronic equipments as a source of time-frequency signal with high precision. OCXO is currently has the highest frequency stability and has the best accuracy in the market.**

OCXO consists of Quartz Crystal, oscillator circuit, temperature sensor, heat source and oven control circuit. Usually, thermistors are used as the temperature-sensing device. The thermistors sense an ambient temperature variation by a change to a slightly different resistance value. The controller circuitry consists of passive components, and it controls the amount of power generated in the heat source. OCXO use a heater to stabilize the temperature of the crystal at turnover point, thereby stabilizing the oscillating frequency. This design optimization achieves higher stability, even more compact size

Index Terms: OCXO, SMD, STRATUM 3E,AGING.

I. INTRODUCTION

An OCXO(Oven Controlled Crystal Oscillator) typically consists of a precision quartz crystal, an oven block, a temperature sensor, a heating element, oven circuitry, oscillator circuitry and insulating material. The crystal and other temperature sensitive circuit elements are placed in oven block to maintain a stable temperature. By keeping the crystal at constant temperature, great improvement in oscillator performance can be realized. Ovenized crystal oscillator are typically used for high precision frequency applications. The crystals for these oscillators are manufactured so the upper turning point is above the highest specified temperature range.

An OCXO's oven temperature is usually set such that the oscillator functions at the upper turning point of the crystal's frequency vs. temperature curve. Furthermore, to function well, an OCXO's oven temperature must be at least 5 to 7 degrees above the highest ambient operating temperature.

The greatest drawback OCXO's are the size of the devices. As technology moves forward, both the size and power requirements of these devices continues to decrease. In this project we are mainly concentrating on reducing size and the frequency should be stable for any changes in temperature. Power consumption and warm-up time are both closely related to the size of the entire OCXO package. Warm-up time is a function of the thermal properties of resonator, the oscillator circuit and oven construction, the input power and the oscillator's temperature prior to turn on. It's ranges from 3 minutes to 10 minutes. Power requirement for an OCXO ranges from less than 1W to more than 10W.

II. EXISTING ALGORITHM

The temperature of the crystal and circuits should kept constant as the temperature outside the oscillator varies. Controlling the temperature inside the oscillator with an oven maintains this constant temperature. If the package size is reduced then it will be easier to improve less power consumption. Fig 1. shows a block diagram of OCXO structure. Its main components are an oscillator, crystal resonator, temperature sensor, control circuitry and heating source. OCXO output oven portion

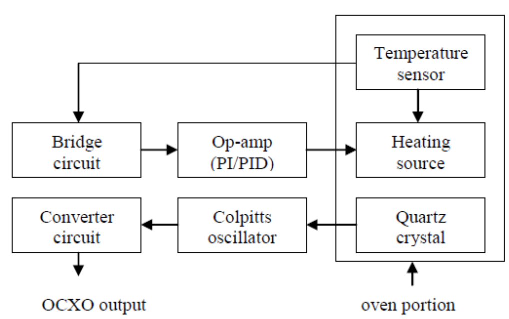

Fig 1. Block diagram of OCXO

A proportional control is an electronic servo system which continuously supplies power to the oven; it varies the amount of oven power, continuously compensating for the ambient temperature changes. In many Vectron oven controlled oscillators, a thermistor

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 7, July 2017

is heat sunk to the oven's metal shell to sense temperature. The thermistor is one leg of a resistance bridge, as shown in Fig 2.

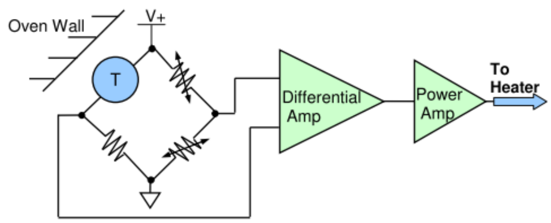

Fig 2. OCXO functional diagram

The bridge operates such that if the temperature at the oven decreases due to an ambient temperature change, the change in thermistor resistance causes the bridge to unbalance, developing an increase in bridge output voltage. This voltage is amplified in a high-gain differential amplifier. The output of the differential amplifier is further amplified in a power amplifier which drives directly into the oven winding. Thus, the small voltage increase resulting from bridge unbalance generates a large voltage increase across the oven winding. This increase in power to the oven generates more heat, compensating for the temperature decrease which was initially sensed by the thermistor. Similarly, an increase in temperature at the oven causes a reduction in bridge output voltage, which results in reduced power into the oven and a compensating temperature decrease.

PID (Proportional integral and derivative) controller is used to control the temperature of the oven constantly over temperature range. Proportional band is a temperature band expressed in % of full scale or degrees within which the controller's proportioning action taken place. The wider the proportional band, the greater the area around the set point in which the proportional action takes place. This is sometimes referred to as gain, which is reciprocal of proportional band .Integral also known as reset is a function which adjusts the proportional bandwidth with respect to the set point to compensate for offset from set point, that is, it adjusts the controlled temperature to set point after the system stabilizes. Derivative, also known as rate, senses the rate of rise or fall of system temperature and automatically adjusts the proportional band to minimize overshoot or undershoot.

In conversion circuit the output which we get is in the form of sine wave is converted into digital wave by the use of NAND gate due to the reason in analog output we get more harmonics. CMOS two input NAND gate is used which is an universal gate. The special feature of NAND gate is, it produces an logic 0 and 1 if we keep one input as constant and change other. One input of NAND gate is kept constant which is an reference input another input is given from amplifier output of the amplifier output of OCXO. If the OCXO output is below the reference level then the output of NAND gate is 1 and in case if OCXO output is equal or above the referenca level then the output will be 0. So that analog to digital conversion will be done.

Colpitts oscillator uses a parallel resonant tuned circuit. The amplifier is an emitter-follower. Feedback is provided via a tapped capacitor voltage divider (C2 and C3) shown in Fig 3. It is different from other oscillators because of biasing arrangement. Transistor biasing resistors can increase the effective resistance of the tuned circuit (LC or crystal) thus reducing its Q and decreasing the loop gain.

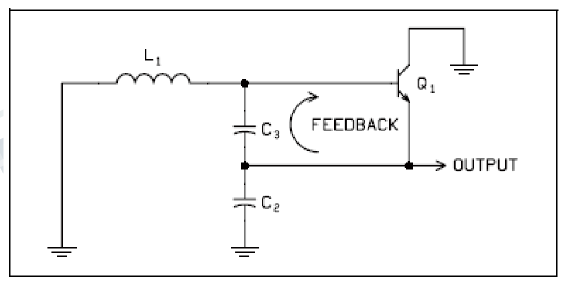

Fig 3. Colpitts oscillator

III. PROPOSED ALGORITHM

The drawback of existing OCXO is the size of the device and power consumption. In order to reduce this we start reducing components. The major difference is removal of PID controller. The simplified block diagram is shown in Fig 4.

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 7, July 2017

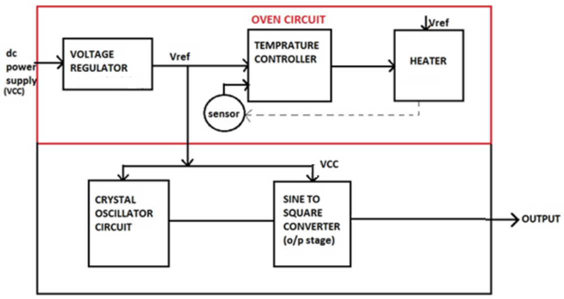

Fig 4. Simplified block diagram

Here we are using 3V voltage regulator to maintain constant power supply to the circuit. This reduces the overall current flow in the oscillator upto 180mA. For sine to square wave conversion buffer or inversion circuit is used.

A. Components used

	Components	Package
Passive components	Resistors and Capacitors	0402
	Inductors	0603
Active components	Opamp	DFN8 3*2
	LDO	DFN
	D flip flop	QFN 1*1.45*0.5mm
	Transistor	SOT 3 PIN

Table 1. Components and packages

Resistor and belongs to 0402 family, the resistor ranges from 0.2Ω to 4.7MΩ. Capacitor ranges from 6.8pF to 1µF. Dual Flat No lead (DFN) is a style of IC package that has no pins or wires but uses contact pads instead. Quad Flat No lead (QFN) is also same as DFN except it has contact pads on 4 sides. Small Outline Transistor (SOT) package has contact pad on 3 sides.

A family of small devices, the LD6805 low dropout (LDO) regulator series is optimized for portable applications with challenging space requirements. With a high power supply rejection ratio (PSRR) of 75 dB and a voltage drop of 250 mV at 150 mA current rating, it ensures long battery lifetime and superior operating stability.

B. Gap analysis

Features	Existing oscillator	Simplified oscillator
Components	70	38
Device dimension	25x22x12mm	21x13x12mm
Cost	High	Low
Device size	Big	Small
Space occupation at customer end	More	Less
Process time	More	Less
Crystal	HC-37	HC-45

Table 2. Gap analysis

C. PCB design

Depending on accuracy which is needed on that basis the PCB software design, here Zuken Cadstar software version 14 is used. The manufacturing of PCB material depends on the type of application for example high speed design. Here FR4 (Fire Redundant) material it can withstand the temperature from 140 – 200 degrees. In PCB manufacturing and designing the IPC standards (Interconnecting and Packaging electronic circuits) should be followed.

BOARD SIZE	17.0mm X 9.5mm, ± 0.1 mm
NO., OF LAYER'S	4 LAYER
PCB THICKNESS	0.8mm ±0.1mm
FINISHED COPPER THICKNESS	35 MIcrons
BOARD MATERIAL	EPOXY BONDED GLASS FIBRE BOARD(FR4) ROHS UL94V
PLATING	NI : 3-7 µ Min
FINISH	GOLD : 0.05 to 0.12 µ,GLOSSY FINISH
TOLERANCE	GENERAL: ± 0.1 mm// HOL DIA : ±0.05 mm
TG	170° C - LOW CTE

Table 3. PCB details

IPC2221A- generic standard on PCB based on commercial requirements, IPC2222-standard for rigid, IPC 6012- for manufacturing PCB, IPC-A-600 class2- for control acceptance and IPC7351,SM782- to create footprints based on solder ability, bound area. Further PCB details shown in Table 3.

Planning the multilayer PCB stack up configuration is one of the most important aspects in achieving the best possible performance of a product. Planes in multilayer PCB's provide significant reduction in radiated emission over 2 layers PCB. As a rule of thumb, a 4 layers board will be producing 15 db less radiation than 2 layers board. Four evenly spaced layers with the planes in center, makes board symmetrical. Another common mistake is to have the planes closely coupled with larger distance between signal layer and planes this certainly creates good interpalne capacitance but does not help with signal integrity crosstalk or EMC. To improve EMC performance it is best to space signal layers as close to the planes as possible (< 10 mil) and use a large core (~40 mil) between power and ground plane keeping overall thickness of the substrate to (~62 mil).

Layers	Function	Material	Thickness
F1	Place components	Copper Prepreg	17.5µm
F2	Signal routing	Copper Core	35µm
F3	Signal routing	Copper Prepreg	35µm
F4	Place components	Copper	17.5µm

Table 4. PCB layers

The standard thickness of the PCB used is 0.8 mm. measurements are taken in terms of MILS that is 1mm= 39.37 mils. On the PCB the pads, DRN, routes, vias should be located first. The most popular thin dielectric material (fiber glass epoxy resin) FR4 is used in the form of core or prepreg as given in Table 4. Prepreg is used to interconnect 2 layers and also for isolation it should be under IPC standards like 1080, 2116, 7623. Core is adjustable according to the requirements with copper foil bonded to both sides. After making design plane and looking for things like speed signal etc. It's time to start routing it is done through vias by using both buried and blind vias as in Fig 5.

Above the F1 and F4 layers the components are placed here we are using the SMD package components. Here placement of components should according to the designer specification. Size of the components should according to the standard IPC7351B. The polarities of diode, transistors, and capacitors should as specified in the circuit in each and every step IPC standards should be followed. The electrical constraints should be maintained such as spacing between wires etc. For final visual inspection the IPC610E standard is used. The bow or twist of the PCB panel should be verified properly.

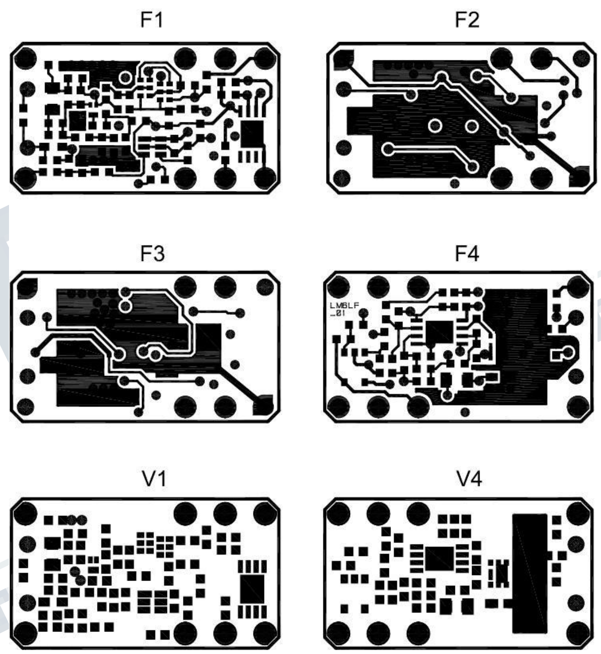

Fig 5. Four layers of PCB with contacts

D. Assembly

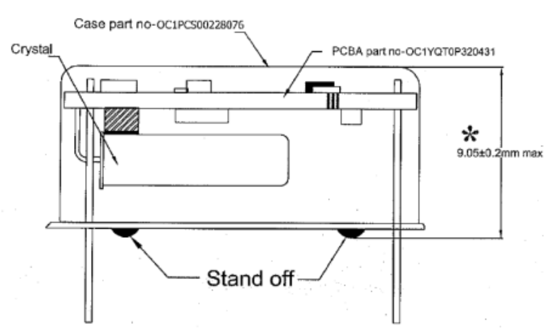

Fig 6. Assembly overview

The OCXO assembly is placed on the base plate with help of fixation. The crystal is placed in between base plate and PCB which makes the height of the package got reduced. The crystal should be at 90 degree parallel to the PCB. Below the base the standoff is there for support. Visual inspection should be made across gap between crystal and base. The IPC 610 standard should be maintained for assembly.

For overall process the types of soldering used are:

1. Hot soldering: This is done with the soldering machine at temperature of 380 degrees with the help of copper wire.

2. Cold soldering: This process is done by using injection tube consist of glue which is made up of chemicals like tin, silver and copper.

Solder paste is glue used for bonding the electronic components permanently on the PCB. Here we use cold soldering to mount all components of OCXO on the ready PCB and left for about 6 hours to dry.

IV. RESULTS AND DISCUSSION

A. Frequency stability

Frequency variations relative to time are indicative of oscillator stability. Stability is usually expressed as the fractional frequency change over a period of time. Aging refers to continuous change in crystal oscillator frequency with time.

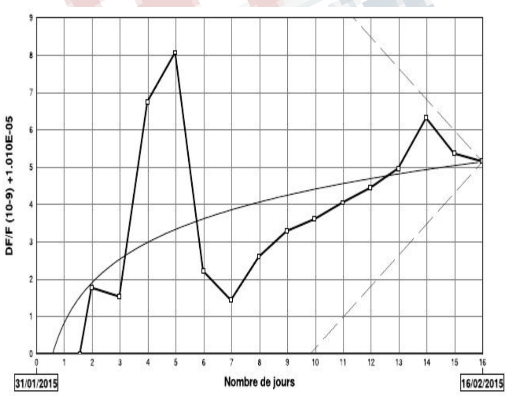

Fig 7. Frequency stability curve

In the Fig 7. X-axis refers to number of days, here we taken for 16 days. Y-axis refers to frequency scale. There are two curves in the fig, one is standard logarithmic curve other is the obtained frequency curve. Frequency stability is taken from average of last 5 days. Then it is calculated for several months to years.

B. Temperature stability

Frequency-temperature stability measures how much an oscillator's frequency changes as the ambient operating temperature changes. In this project for 10MHz oscillator frequency stability v/s operating temperature range is <±5ppb pk-pk, i.e. for any change in temperature, the frequency change is <±0.05Hz. In Fig 8. One is frequency plot and other one is temperature plot.

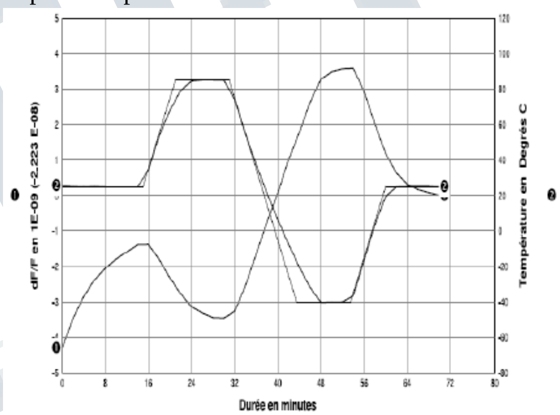

Fig 8. Temperature stability curve

C. Phase noise

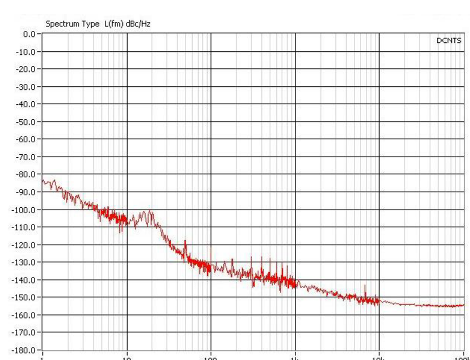

Fig 9. Phase noise graph

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 7, July 2017

One of the major issues facing oscillator designers is the phase noise phenomenon. Phase noise is an undesirable entity that is present in all real world oscillators and signal generators. It can cause distortion or complete loss of incoming information in traditional receivers and high bit error rates in phase modulated applications. To check noise we are using a setup called NOISEXT. According to our circuit design , the phase noise for 10MHz OCXO should be below 90db. Output graph shown in Fig 9. depicts that the results is achieved, hence the waveform is started at -80db, which is less than the desired value.

D. Oscillator output

Fig 10. Oscillator square wave output

APPLICATION

OCXO's are a more robust product in terms of frequency stability. This type product tends to be better suited for many applications like Wireless, Wire line, Military, and Spacecrafts and Industrial communication/network applications. Stratum 3E, that was defined in Bellcore documents is a new standard created as a result of SONET equipment requirements. Stratum 3E tracks input signals within 7.1 Hz of 1.544 MHz from a Stratum 3 or better source. The drift with no input reference is less than 1 x 10-8 in 24 hours. This is less than four frame slips in 24 hours. A Stratum 3E clock system requires a minimum adjustment (tracking) range of 4.6 x 10-6.

CONCLUSION AND FUTURE ENHANCEMENT

Evaluation of the miniature OCXO performance and discussion about cost, power and size reduction to be presented. In addition to this, the output of existed OCXO is achieved in simplified OCXO i.e. the specifications of OSC7 is achieved in dual in line (DIL) OCXO. In the future further reduction in size and power consumption can reduce still more.

REFERENCES

[1] John Vig, “Quartz Crystal Resonators and Oscillators For Frequency Control and Timing Applications, A Tutorial”, July 2001

[2] I.V. ABRAMSON, "Recent advances in composite heated quartz resonators intended for high stability mobile OCXOs", Omsk Piezoengineering Co. Ltd. - Omsk, Russia.

[3] http://www.vectron.com/OCXO-application-note

[4] http://www.raltron.com/stratum-levels-defined

[5] www.rakon.com

[6] http://www.4timing.com/stratum3.htm