The importance of Crystal Temperature Control

The debate on oscillator stability has to date been centered around the Q of the crystal and other parameters of the RF circuit used. Crystals are unstable with temperature and this stability aspect needs addressing just as carefully as the RF electronics. The following comments relate to AT cut overtone crystals as commonly used in microwave equipments. The cutting angle of the quartz controls the knee point. That is the operating point at which the frequency shift is least with temperature change. Common cut angles give knee points of 25C, 40C and 60C although since the angle is so critical some variation from the expected point will be found. 25C is satisfactory for low frequency equipment with little internal heating and has the advantage that the knee slope angle is shallow with temperature changes. 40C is useful for clip heaters but if the equipment temperature rises above the clip temperature then the stability is lost. 60C ensures that for the majority of the time the crystal is above the influence of ambient temperature changes within the equipment. In the G8ACE MKII OCXO part of the setup procedure is to explore for the knee point during the alignment. Two reasons, first suppliers do not necessarily supply what is required and prefer their own spec of quoting stability in ppm over a given temperature range. Most cut angles will easily fit into this spec. It is most important when ordering a crystal to quote for OCXO use and the required turnover point. Secondly as mentioned above the precision required for the cutting angle leads to some variation anyway in the actual knee point and only by individual oven adjustment will this point be found with certainty. A guide to the enormity of the frequency change with temperature is that a commonly used 106.5 MHz 60C crystal will move some 800Hz during the heating phase starting from 15C. Multiplied by 96 for 3cms and this represents some 75Khz of system calibration shift. To confirm this point consider a commercial 5 or 10MHz OCXO where large shifts in frequency occur during warm up but then is quite stable.
Once the knee point has been determined the stability can be good but some crystals do move in frequency very slowly. This is assumed to be part of the aging process. However it has been observed that small adjustments to the oven temperature around the knee point affect the amount of frequency creep. For a crystal operated for say 8 hours daily the crystal will retrace overnight and each subsequent day will repeat the process. Powering the OCXO 24 hours a day the frequency creep will slow down but there will be variations between samples. It has been noted that the creep amount is dependant on exactly where the oven temperature is set about the knee point. Nothing has been found in documents relating to this unless the writer has misunderstood that published. Eric, F1GHB has spent some time also looking into the finer aspects of stability and has kindly sent his results which are shown in page two of the pdf document. For the advanced setup process access to either GPs or Rubidium or similar source is necessary. Once the creep rate of the OCXO has been determined the OCXO temperature is adjusted in increments to +/- 0.5v either side of the knee point and the change in the frequency creep noted until the flattest time/frequency response is achieved. In the absence of a high stability source for advanced setup a beacon could be used in the 3cm instance but it must be chosen with care. GB3MHX whilst free running is quite stable. GB3SCX is also very stable with Hz errors quoted by Andy G4JNT from time to time. Other beacons driven by Adret sources could also be suitable. This document plus the information from Eric F1GHB can be found at these sites:

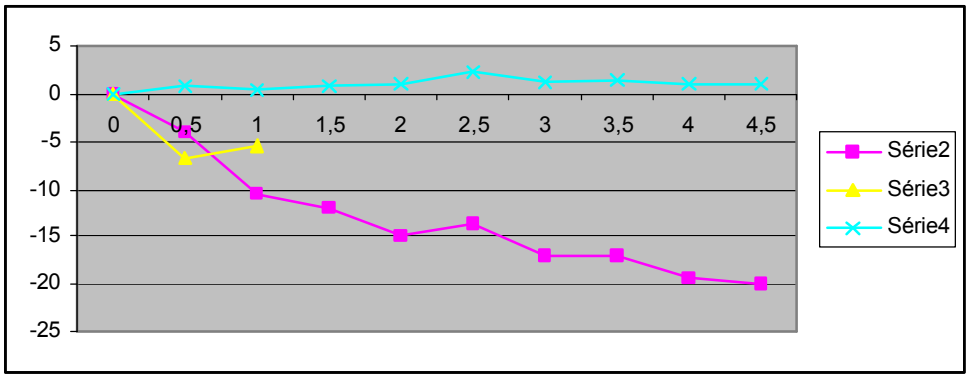
http://www.microwaves.dsl.pipex.com/mk2/advanced.pdf

http://www.microwaves.mcmail.com/mk2/advanced.pdf

Below are the results relating to advanced oven setup for the OCXO kindly supplied by Eric, F1GHB.

Example of turnover point adjustments on a G8ACE OCXO

(OCXO powered during several months before adjustment and measurement done against a rubidium source on 4,5 days)



Serie 2 :

First drift which has been noticed after first turnover-point adjustment (following the G8ACE procedure)

Voltage on TP = 5,64V

Serie 3 :

First attempt to re-adjust the turnover point

Voltage on TP = 5,97V

Serie 4 :

Second attempt to re-adjust the turnover point

Voltage on TP = 6,25V

Same OCXO on around 30 days