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Control Characteristcs Adjustment and Matching to the OCXO used

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Oscillator preparation:

1. **General:**

Virtually any Oscillator can be used if an EFC input (Electronic Frequency Control) is available. However, due the CRO regulation mechanism, an oscillator with a high stability should be used. Normally only OCXO's should be used. The EFC input should accept 0.4 to 4.8 V and the result should be a rather small frequency change with a larger voltage variation (sufficient but not too wide frequency adjustment.) External additional HW can be used to adapt other voltage ranges.

Take care that the voltage level of the signal fx is sufficient but not too high. Use an oscilloscope to check the level of the output of the pre-amplifier at the CRO-Digital board.

Before the oscillator is actually used, let it run for some days to some weeks. Also after the CRO and the oscillator have been turned on, wait for a sufficient time to warm the system up. The CRO can only synchronize the oscillator if it is stable and warmed up and if the OCXO frequency is near the intended frequency. The location of the CRO-ANALOG part should be close to the OCXO. It is recommended to supply the CRO-ANALOG part by the OCXO supply. If possible do never switch the power off.

First connection:

Provided all settings of the CRO has been correcetly done, reference signal (1PPS) is connected and the level of fx is ok, continue with the procedure below.

Set up the right frequency in the CRO setup menue and set the **p-factor** to a value between 100 and 1000. This allows for the synchronisation of not well adjusted OCXOs.
For the very first time , use a regular frequency counter and adjust the frequency of the OCXO as good as possible. +/- some Hz are ok.

Connect the OCXO to the fx input and verify if 2.5V are conneted at the EFC input of the OCXO. **Fx** and **1PPS** in the CRO-Display should now show **ok**. An synchronisation should now be possible

Connect the PC to the CRO via the RS232 interface and start the On-Line Analysis Tool. Select the **100 sec loop** function at the CRO (CRO supported coarse ajustment). Make sure that 2.5V are connected to the EFC input of the OCXO (provided the CRO –Analog part is connected to the EFC input).

Set the **Display Timeframe** to 900 and change (increasing or decreasing) the resolution **absDiff** und **dDiff** until you can see a useful result. A sawtooth diagram should then be seen in the **absDiff** area and a noisy horizontal line in the **dDiff** area.

The intention is to get a sawtooth as flat as possible. Adjust the capacitor of the OCXO until you reache the goal. Helpful is the **dDiff** area in this case. The noisy horizontal line should be close to the 0-line. If one is successful decrease the resolution of **absDiff** and **dDiff** and repeat the procedure. Is the graph stabile for some minutes, reduce the **p-factor** and start again. It would be perfect to reach a **p-factor** of 1. Usually that can only be reached using commercial OCXOs (HP10811/544 etc). For self-made OCXOs try to reach a value below 50 or smaller.

Hint: For a **p_factor** of 1 and small values of **absDiff** und **dDiff** , the adjustment is extremely sensitive . It is nearly impossible and not nesseccary to reach an absolutely horizontal graph, but try to reach it as close as possible. If the inclination of the saw-tooth is not stabile, the oscillator is not warmed up or simply not suitible for the CRO.

2. Getting the oscillator course characteristic:

The CRO needs to know aproximately the oscillator control curve characteristic. There is way to capture the control characteristic automatically. Use the „**characteristic get“** in the CRO setup . The complete EFC range of 0.3V to 4.8V will now be captured in 0.1 V steps and the appropriate frequency calculated. The captured data will be stored in an EEPROM after the procedure has been completely finished. If you cancel the procedure, the old values are still valid. The capturing process lasts about 1.5 hours. Take care that there are no errors indicated in the error counters while taking the control characteristic, if possible. After that the CRO is ready for "take off".

Bear in mind that you need this procedure after every change of the capacitor of the OCXO and after some months if the limit of the regulation voltage has been reached.

General hints:

Basically there are two start-up sequences after a hardware reset. Either the control loop has been open at switching off (A) or the loop was closed (B).

(A): Control loop was open (measuring instrument mode)

The hardware resets to the measurement mode. That means the control loop is open and the DAC is set to 2.5 Volts. The hardware immediately tries to synchronize to GPS or TV signals. The operation is as above. Appropriate key inputs set the oscillator matching operation.
(B): Control loop was closed (Control Loop Mode)

The hardware operates in the control loop mode, i.e. the control loop is open at first and the DAC is programmed with the last DAC control value. After a preprogrammed delay time the control loop is closed. Key inputs provide then the measurement mode.

Using the CRO as a measuring instrument:

Without the CRO-Analog part , the CRO-Digital part can already be used as a precise measuring instrument. It allows convincing and documented tests about the quality of oscillators.

Synchronisation of frequency standards and beacon or local Oscillators (LO's):

Normally the CRO is used to control oscillators as a master oscillator for frequency counters or as reference oscillator for LOs, Beacons or for GHz transceivers etc. In any case a high precision OCXO with a very good stability must be used to reach the goal.

The HP10811 or HP10544 OCXO's can strongly be recommended. Their stability (electrical and mechanical) and their EFC ranges represent an optimum for the CRO. This can normally not be reached if homebrew oscillators are used. These are , despite of an oven, much more sensitive with regard to temperature and have a rather worse dynamic behaviour. Therefore they usually exhibit a huge EFC range, that inevitably leads to a poor system performance, because the end of the EFC area will be reached rather early. There are two ways to improve this behaviour.

The first possibility is to extend the EFC control voltage range by CRO external circuitry. It is up to the user to do so.

The second option is fully supported by the CRO and one can live with the result. However, things may get a bit worse. This option is rather flexible and allows the user to chose the quality of regulation in a wide range , almost steadily, from worse to better results.
It is simply based on the devision of the phasecounter by a certain value before continuing the calculation. This value is called "**p-factor**" (**p**recision **factor**). The p-factor can be choosen by the user and the value can be between 1 and 1000 in different steps. The calculated measurement result is then wrong by the p-factor, i.e. after calculation the precision must be multiplied by the p-factor value. For example if the result of the calculation is 5*exp-10 and the p-factor is 100 than the effective result is 5*exp-8. The CRO display takes care about the p-factor. In case of the Off-line/On-line Analysis tool the suer must enter the f-actor manuelly.

An additional minor draw back is that not all frequencies (related to 1Hz) can be controlled. Due to the internal pre-divider, not all frequencies can be set exactly. Only even and depending on the frequency, modulo 2,4 and 8 frequencies are possible. Therefore an offset can occur. However , this offset does not influence the precision of fx (it's simply an offset!).

The formula is:

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             | (Finput + X) |     fx = real locked frequency
       fx =  | ------------ |     Finput = CRO frequency input
             |    2 * X     |     X = see table below

   Table:
   ---------------------------------------------------------------------
         < 20MHz: X = 1 . Offset max 1Hz.
                  Example: Finput=16.000057 MHz  -> fx=16.000058 MHz
                           Finput=10.000001 MHz  -> fx=10.000002 MHz
                           Finput=10.000000 MHz  -> fx=10.000000 MHz
                           Finput= 9.999999 MHz  -> fx=10.000000 MHz
                           Finput= 9.999998 MHz  -> fx= 9.999998 MHz

   20MHz < 40MHz: X = 2 . Offset max 2Hz.
                  Example: Finput=35.123458 MHz  -> fx=35.123460 MHz
                           Finput=35.123457 MHz  -> fx=35.123456 MHz
                           Finput=25.000000 MHz  -> fx=25.000000 MHz

   40MHz < 80MHz: X = 4 . Offset max 4Hz.
                  Example: Finput=70.123459 MHz  -> fx=70.123456 MHz
                           Finput=60.525000 MHz  -> fx=60.525000 MHz

          > 80MHz: X = 8 . Offset max 8Hz.
                  Example: Finput=108.009896 MHz -> fx=108.009904 MHz
                           Finput=108.009895 MHz -> fx=108.009888 MHz
                           Finput=123.444640 MHz -> fx=123.444640 MHz
  ---------------------------------------------------------------------
   Bear in mind, that the real frequency (fx) must be entered in the
   CRO-Online Tool.
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<u>Diagnosis functions: (Description not available yet)</u>

Additional remarks:

Extract the CPU before programming the EPLD's. If the display remains without characters after switching on, adjust the contrast pot.
Without LCD it takes about 10 secs for the CRO to start reading data from the serial interface.
