Factory setup/calibration for WSPR-TX_LP1 Transmitter

What is Factory Setup?
The factory setup is a process where some information is stored in EEPROM in the WSPR-TX_LP1 product that will assist PC configuration software to determine what product is plugged in to a serial port and more importantly it assist the firmware to calibrate out any frequency error in the internal TCXO reference oscillator.

How it is done?
It is a done using a PC software and frequency measurement equipment connected to a WSPR-TX_LP1 transmitter.
It is normally performed before a WSPR-TX-LP1 is shipped to a customer but can also be performed by the customer if needs arises.

The factory setup stores two pieces of information in the WSPR-TX_LP1 Arduino EEPROM.
1. Hardware version and revision.
2. The TCXO frequency

1 The Hardware version and revision is so that future PC configuration software can display this information. If it is incorrect, nothing bad happens.

2 The TCXO frequency information on the other hand is used by the PLL calculation in the firmware and influences the output frequency of the transmitter.
In other words - it is important to get it right.

When should factory setup/calibration be performed?
The factory setup is performed by ZachTek before delivery of a WSPR-TX_LP1 to a customer but there can be situations where it needs to be done or repeated by the customer. There are typically two situations that indicate the customer should run the factory setup.
1. If the user notices that, the WSPR-TX is not on frequency it can mean that the TCXO information is not set, have an incorrect value or has moved away from its initial value.
2. If the user sees a message in the Information windows in the PC Configuration window that says that there is no factory information found in EEPROM when the WSPR-TX_LP1 boots up
   (You can press the Arduino Reset Button to force a reboot and see if there is such a message)
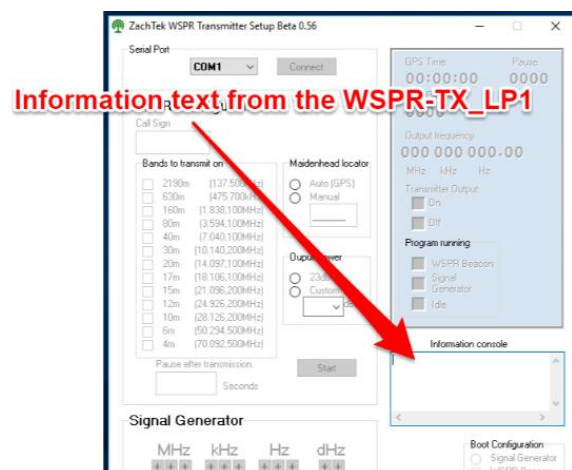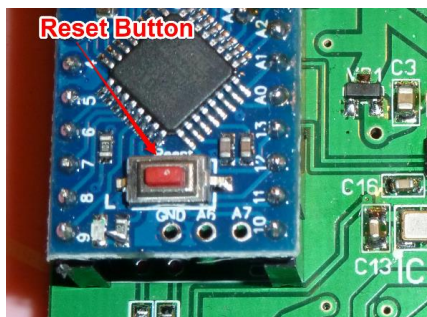
The message would say "*No factory data found for Model # and Reference frequency, guessing on values*"

Performing the Factory setup/calibration

1. **Optionally upgrade to the latest firmware.**
   It can be a good idea to make sure you are running the latest firmware in your WSPR-TX_LP1.
   It should at least be Standard firmware Beta 0.56 as this was the version were the TCXO correction using EEPROM values was introduced in to the firmware.
   The latest firmware can be downloaded here:
   https://github.com/HarrydeBug/1011-WSPR-TX_LP1/tree/master/Standard%20Firmware

   How to update the firmware is outside the scope of this document and there are other documents/webpages that will help you with that step.

2. **Download the Factory setup PC Software.**
   Download and install the Configuration software from GitHub :
   https://github.com/HarrydeBug/1011-WSPR-TX_LP1/tree/master/PC%20Software/

3. **Attach the WSPR-TX_LP1**
   Plug in the WSPR-TX_LP1 that is to be setup to a USB port in the computer.
4. **Determine what Serial port it is using.**
   You need to know what serial port the WSPR-TX_LP1 was assigned to when plugged in.
   The easiest way to determine this is to start the PC Configuration software and testing the Serial ports in it until you find the correct one. Taka note what port it was using and close the PC configuration software.

5. **Start the Factory Setup program and connect.**
   Start the Factory setup software and choose the serial port from step 4 from the drop down list and click the connect button.
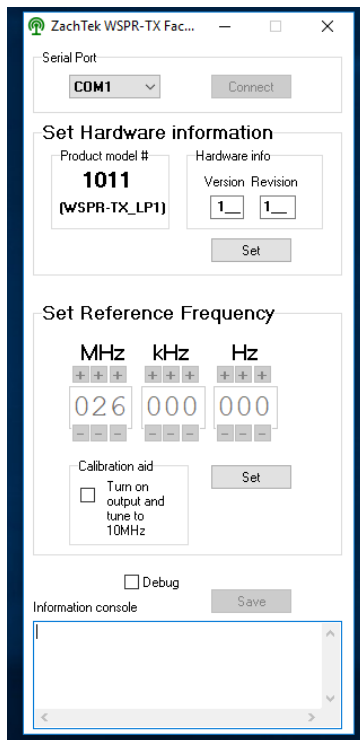
6. **Set hardware info.**
   The revision of the hardware is found screen-printed on the bottom of the
   PCB. In the example below this PCB says "V1R5" so you would enter 1 in the
   Version field and 5 in the Revision field and click the "Set" button
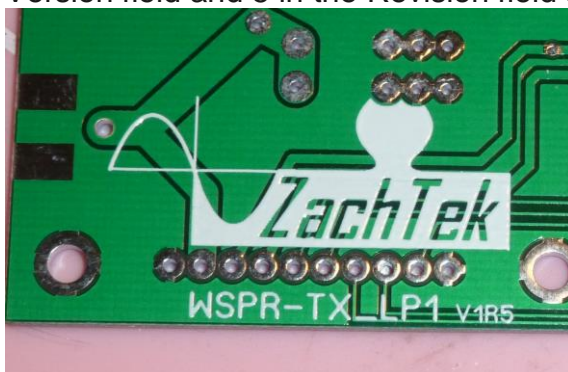
7. **Set Reference Frequency.**
   Set the reference frequency by either clicking in the numbers fields and enter
   the digits or use the plus or minus buttons above and below the fields to set it
   to the wanted frequency.
   Usually the fitted TCXO used as reference frequency has an output around
   26MHz but I sometimes uses 25MHz for supply reason.
   Of the ten or twenty TCXO I have measured so far most of them has had a
   frequency that is only a few hertz away from its nominal frequency. If you have
   no way of measuring the frequency of the TXCO then a good guess would be
   to set it at 26 000 000Hz.
   Later in this document, I will go over how to directly or indirectly measure the
   reference frequency.
   Once the reference frequency have been set, click the "Set" button

8. **Save it.**
   Once the information has been set click the "Save" button in the lower right
   corner.

In the Information console, there should be a confirmation text that the factory confirmation was saved. If no such text shows up then make sure, you have connected to the correct serial port and repeat the steps above until to get the confirmation text.

9. **Disconnect and use.**
   You may now close the serial port, and start using the WSPR-TX_LP1.
   You might want to run the signal generator in the PC configuration program and verify with a few select frequencies that the calibration is good.

Determining and calibrating the Reference frequency.
In step 7 you entered the reference frequency. To be able to do that you of course need to determine the frequency that the TCXO is oscillating on.
There are basically three ways to do that that I will outline now.

1. **Using a previously measured value.**
   Before I ship a WSPR-TX_LP1 I usually measure the TCXO frequency and prints it on a label that I stick to the PCB. I measure it with a frequency counter that is pretty well calibrated so the value at the time of calibration should be accurate down to one Hertz.
   This is the easiest method as there are no equipment needed. Just read the value of the label and plug it in the Factory Setup software.

2. **Measuring the oscillator frequency.**
   The direct way of determining the frequency reference frequency is to measure it with a frequency counter over C8. Se picture.
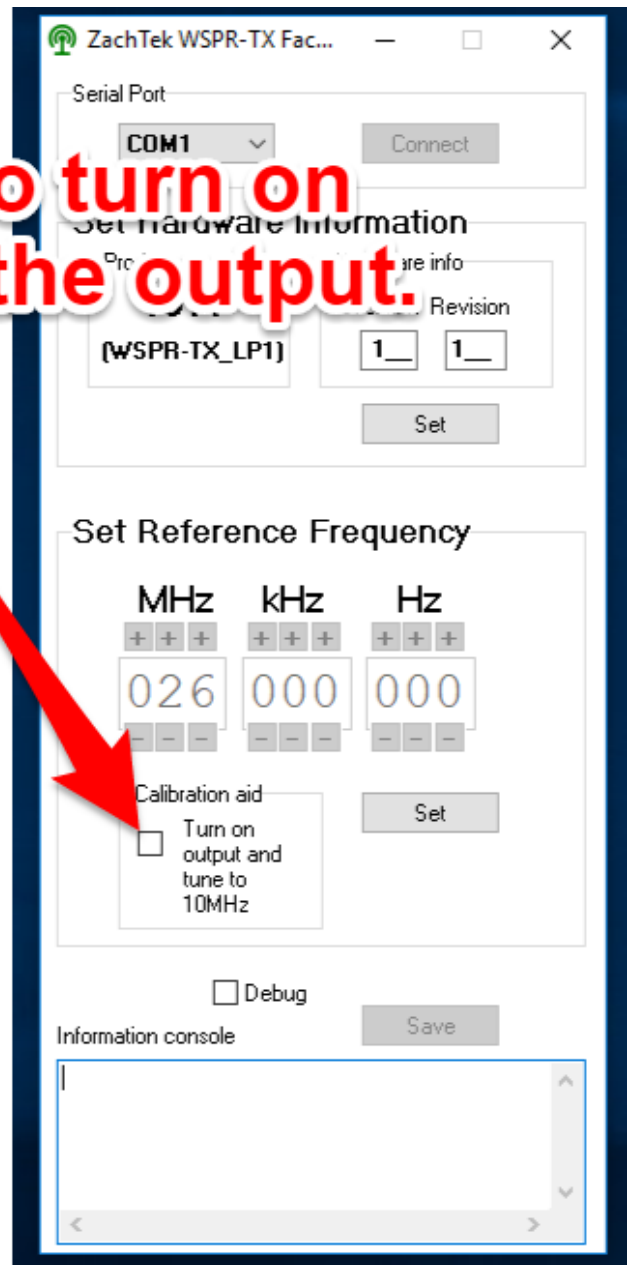   Use a high impedance input counter and read it of C8 once the WSPR-TX has been turned on for a few minutes so the TCXO is stable in frequency.
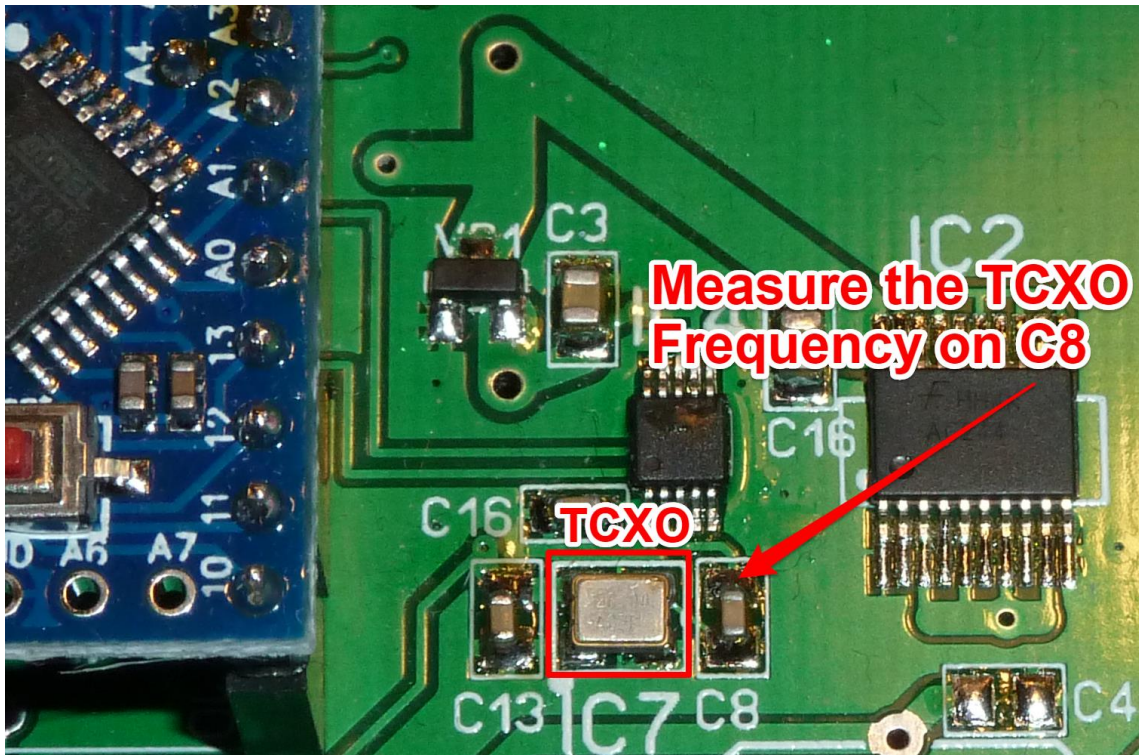
3. **Indirectly determine the reference frequency using 10MHz output.**
   There is a tick box saying " Turn on Output and tune to 10MHz"

Tick this to turn on 10MHz at the output.

If you tick this option the WSPR will go in Signal Generator mode with 10 000 000Hz as the set frequency.
If the reference frequency is not correct then the 10MHz will be affected and will also not be correct.

You will then measure or compare this 10MHz with a known 10MHz source. Typically you toggle between checking the 10MHz output and changing the reference frequency some small amount in the factory program and clicking "the Set" button.
You do this several times until the output is exactly 10MHz. The value displayed for the factory frequency in the software when you are done is the correct TCXO frequency as inferred by this indirect way of determining it.

Comparing with an oscilloscope and a 10MHz calibration source.
One way of comparing the 10MHz is to use an oscilloscope with two inputs, one input from the WSPR and one from a 10MHz calibration source.
Display both signals and synch on one of them.

Change the reference frequency in the factory software until they are booth on the same frequency.
When they are the same frequency, both traces in the oscilloscope will remain stationery and not move in either direction.

Comparing with a shortwave receiver and a 10MHz time station.
Another way of comparing the frequency output with a known source can be made if you are in a part of the world where there is time and frequency station transmitting on exactly 10MHz.
Instead of using an oscilloscope you would use a shortwave receiver tuned to 10MHz.
You would put a piece of wire in the output of the WSPR so its output can be picked up by the shortwave receiver.
The trick is to be able to hear both the time station and the WSPR transmitter in the receiver.
One can then hear the frequency difference and trim the WSPR to zero beat with the time station.

For each Hertz change in the reference frequency the 10MHz output will change less than 0.5 Hertz in the opposite direction.
E.g if you increase the reference frequency from 26 000 000 Hz to 26 000 001 Hz then the 10 MHz output will go down in frequency with less than 0.5 Hz.

You will need to click the "Set" button each time you change the reference frequency for the 10MHz output to change.
Once the correct reference frequency have been set and the 10MHz output is exactly 10 MHz then click the Save button.

If you need more information, check out the documentation pages on my website or email me at harry@zachtek.com.

See you on the bands!

//Harry