iScan Linearization Kit

Preface

Thank you for choosing the iScan to scan and control your tunable laser! Your iScan system is equipped with a "Linearization kit", which comprises a fiber-based marker etalon and a software tool.

The iScan itself is a tool to stabilize the optical frequency of tunable lasers to arbitrary set points (target values): An electronic feedback to the laser ensures that the actual optical frequency matches the set point as precisely as possible. Therefore, altering the set point will induce a controlled change of the laser frequency. The set point can be altered manually or programmatically, continuously or stepwise, immediately or upon external trigger. In this way, a variety of controlled laser frequency jumps and scans can be performed.

The accuracy of the frequency control depends on several factors (Fig. 1).
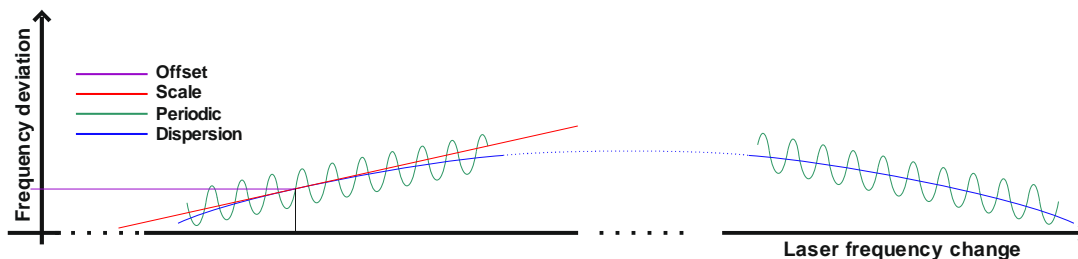
Fig. 1: Contributions to the frequency deviations in an iScan controlled system

While offset and scale are adjusted by single numbers and dispersion does not play a role but for very large scans (several nanometers), the periodic distortion is more complicated. It is a deviation between the chosen set point and the actual laser frequency that appears as a periodic function of the frequency value. The period is 1 free spectral range (FSR) of the etalon in the iScan. So the error vanishes when the laser frequency changes by exact multiples of 1 FSR. The iScan is mostly manufactured with FSR=8GHz, 3.85GHz, 2.7GHz or 2GHz. The scale distortion is typically 1% of the FSR (maximum 1.5%). So with a standard iScan with FSR=8GHz, the laser frequency will deviate up to 80MHz (max 120MHz) from the set point (target value).

The linearization kit allows to calibrate this deviation to a level of 0.05%, that is from 4MHz if FSR=8GHz down to 1MHz if FSR=2GHz. For this end, the software lets the laser scan over 1 FSR and records the markers fiber-based etalon generates during the scan. Based on this information, the set point look-up table predistort in the iScan Digital control unit (DCU). Like other settings, the predistortion values can be saved to the non-volatile memory.

Getting started

Set-up, connections and initial operation

1. Set up your iScan as described in the iScan manual

2. Install the laser according to the manufacturer's instructions and connect it to the iScan, following the laser-specific installation guide.
3. Check and make sure that the iScan DCU can scan the laser frequency continuously (i. e. without mode hops) by at least 1.5 FSR while the feedback loop is open (regulator off). See iScan manual for details.
4. Check and make sure that feedback loop is operational and that the regulator parameters (P, I, D and others) are optimized for a good regulation performance. We recommend to use the step-response feature to check the quality of the feedback loop. See the iScan manual for details.

Signal check and adjustment

The signal generated by the fiber etalon must reach a certain level to be used for the calibration. Depending on the available optical power and the coupling efficiency, the sensitivity of the internal photo detector must be adjusted accordingly. If you have an oscilloscope at hand, we recommend to check the signal level before starting the software. Otherwise, you can check it while the software is operating, but this is not that comfortable.

If you want to use an oscilloscope, connect a free channel to the "monitor 1" output of the iScan DCU (you can use "monitor 2" likewise). Set the vertical scale of the oscilloscope to a range of +/-10V DC (that is 2V or 5V per division, typically). Make sure that no 50 ohms termination is active.

Press the button "Monitor" on the front panel touch screen, scroll down to reach the "Monitor X" button and press it to open the list of available signals. Press "Pin4" to select the fiber etalon signal for display on the oscilloscope.

If the laser is on and light is coupled into the fiber, the average monitor voltage displayed on the oscilloscope should have a level of 2…4V. If the laser is not scanning, the signal is constant. Otherwise, an AC component will appear. If the laser is scanning in a linear manner, the signal will be sinusoidal, reaching from zero to almost twice the average value.

If the signal level is significantly higher or lower, navigate to Settings->input settings -> detector settings. Click to the number of "Gain F" and change by turning the knob B to adjust the signal level. (Note that turning the knob while keeping it pressed alters the decimal place.)

The signal must not exceed or come close to the limits of +/-10V. Otherwise the calibration quality will degrade due to clipping. Signal levels below 1V are not recommended.
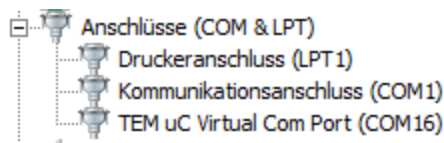
Software installation

The linearization software comes on the USB memory stick delivered with the iScan. You find it in the folder \TEM\LabView\iScan_XXX as iScan_XXXnm.exe, where XXX stands for the wavelength at which the calibration shall take place. For installation, you can simply copy the folder to a destination on your computer.

For operation, you also need the LabView Runtime Engine (Version 2014, 32bit) and the NI-VISA software package by National instruments. You find them in the folder \TEM\LabView on the memory stick. Copy these files to your computer and execute them for installation.

USB connection

Connect your iScan DCU to your computer as described in the iScan manual. Make sure the iScan DCU appears as "TEM virtual COM port" in the device manager:


Software operation

Startup

For remote control and calibration of the iScan, execute the iScan_XXXnm.exe file, where XXX stands for the wavelength at which the calibration shall take place. (For installation, see previous section.)

The program will open 2 windows: The main window iScan_XXXnm.vi and the terminal window TEM_communication.vi. A standard COM port is preset in the upper left corner of the main window:
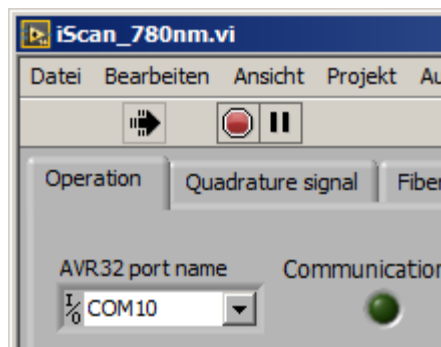
If the DCU is not available at this port (indicated by the dark LED "Communication" being dark), you can either stop the program by clicking the red stop button, or you can select the right COM port in the terminal window:
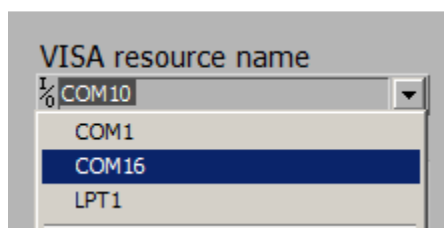
As soon as the USB connection is established, the program reads out all relevant settings from the DCU and enters the "Ready" state:
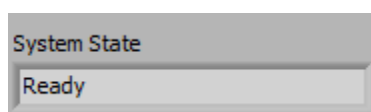

Now you can control many operational parameters of the iScan by the front panel elements organized in tabs on the right hand side of the main window:
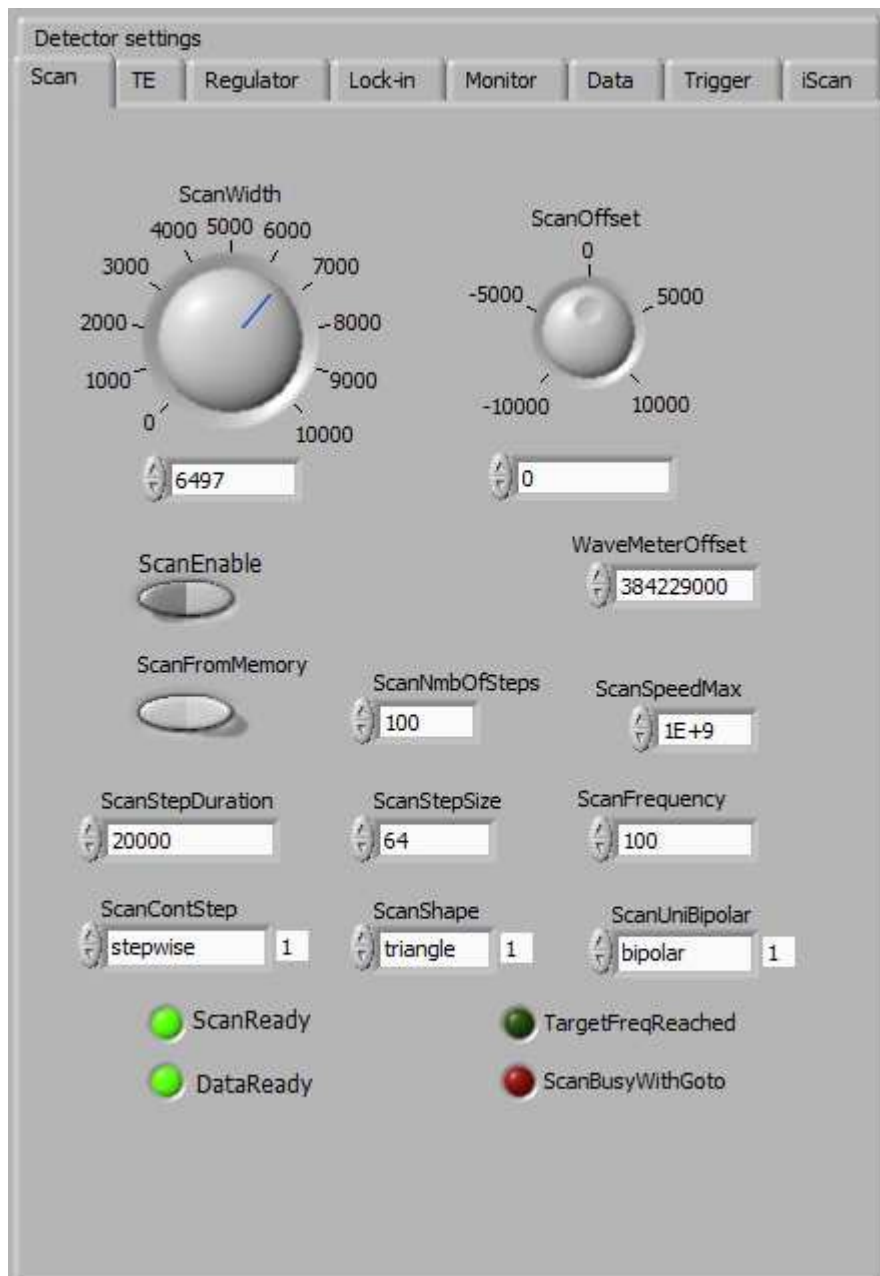
Please note that all frequency related values are given in MHz units, except for the FSR, which is given on kHz in order to obtain a high numerical resolution.

Upon delivery, the iScan is calibrated lock the laser to the frequency given as "WaveMeterOffset":
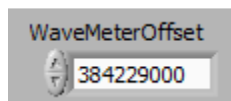

You can close the feedback loop using the switch "RegOnOff" in the "Regulator" tab. A successful locking is indicated by the LED "LockedA" being lit.

Please note that the iScan cannot measure the absolute laser frequency. Therefore the will lock the laser to the nearest frequency value given by "WaveMeterOffset" + n * "FSR", n being an integer number. In order to lock the laser exactly to "WaveMeterOffset", the laser must have a frequency close to that before the loop is closed (switch "RegOnOff" put to "on"). However, if the iScan is combined with some means to determine absolute frequency values (a spectroscopy unit like CoSy, e.g.) an offset is corrected during the calibration. The spectral feature used for this correction must be within a small scan range around the actual frequency. In other words, n must be sufficiently small.

You can adjust the set point for the laser frequency control via the knob "ScanOffset":
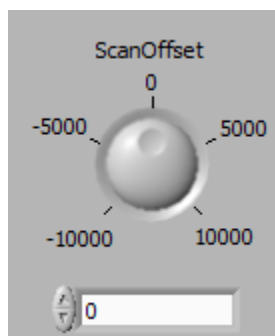
This value adds to the "WaveMeterOffset". In other words, if ScanOffset = 0, the laser frequency equals WaveMeterOffset if the frequency was already close to that when closing the feedback loop.

Calibration process

Start
Whenever the software is in the state "Ready" you can initiate a calibration process by clicking "Calibrate now" in the tab "Operation" on the left part of the main window:
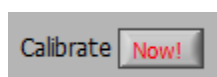

First step: Adjustment of the quadrature signal
In the first step, the software will scan the laser with the feedback loop open (unregulated scan). The aim is to adjust the size and the offset of the iScan quadrature signal as close as possible to a circle:
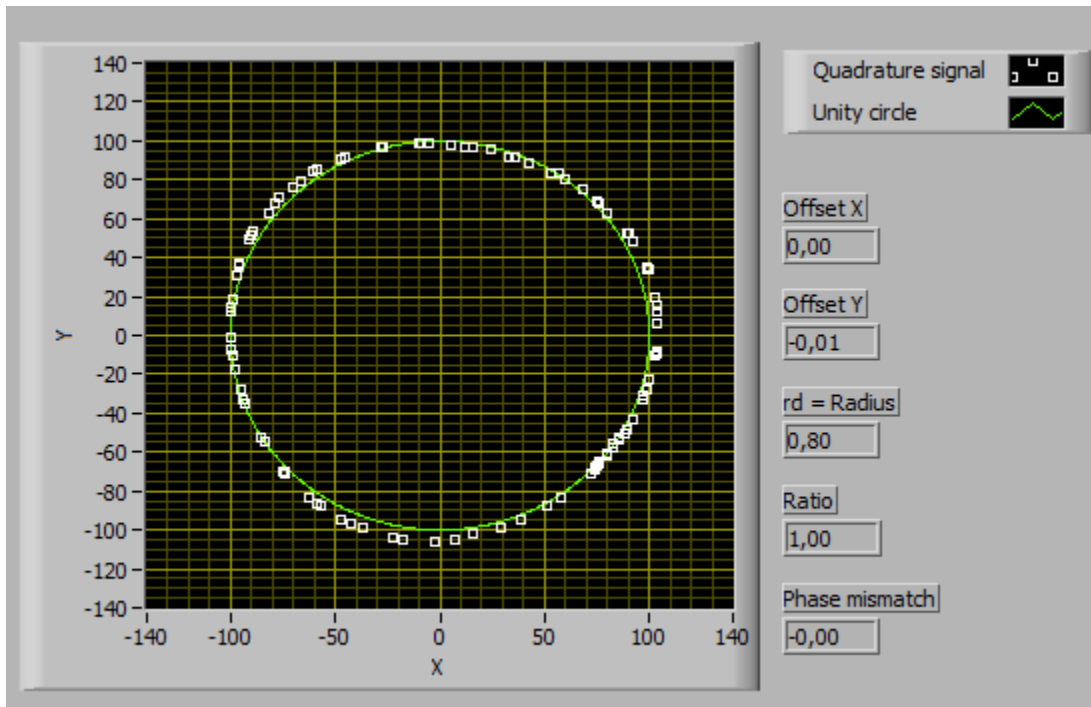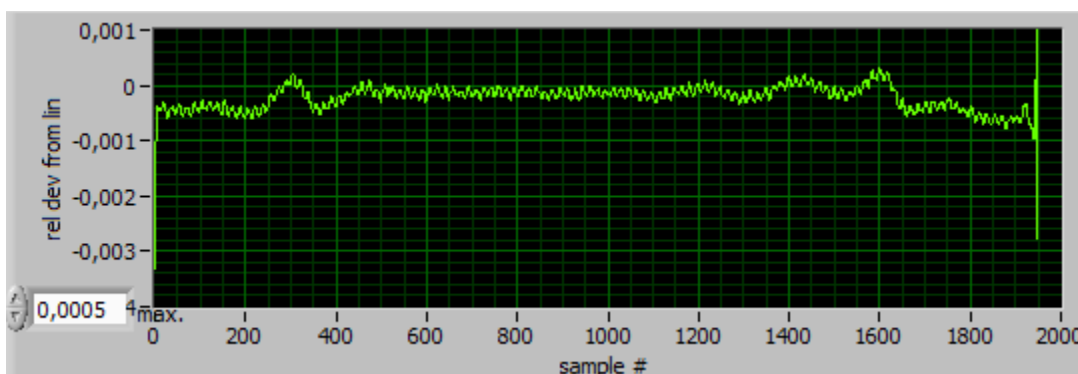
## Second step: Linearization

In the second step, the marker signal from the fiber etalon is used to correct the periodic deviation of the iScan set point. The red trace should look sinusoidal (as did the signal on the oscilloscope in section "Signal check and adjustment" above:
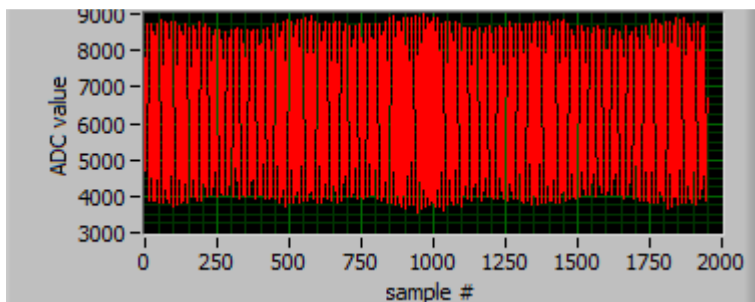
The residual relative deviation from linearity is indicated as green trace:

This calibration step is finished as soon as the trace is within +/- the maximum value (here: 0.0005), and the suggested modification to the look-up table is smaller then the respective maximum (here: 20)
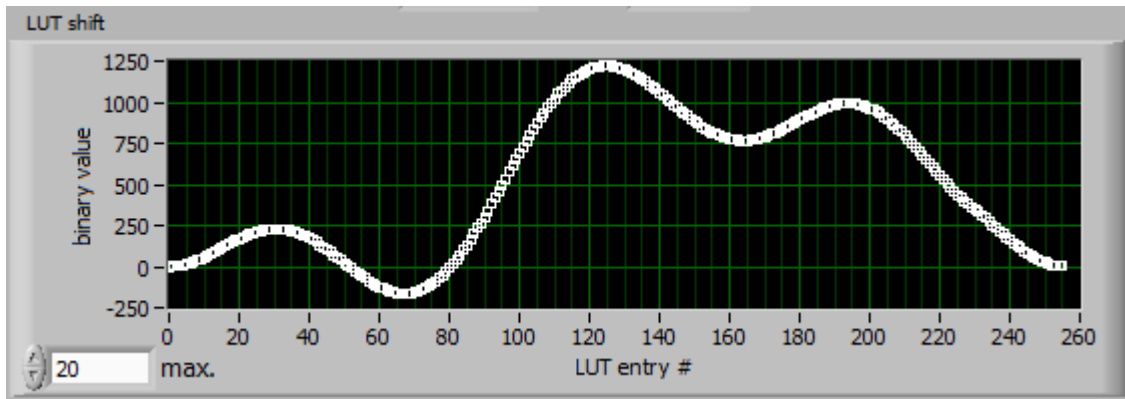
Third step: Absolute frequency reference

If a CoSy signal is available, the program matches the position of the Doppler-broadened absorption line (green line) with the theoretical position (red line) relative to the WaveMeterOffset.
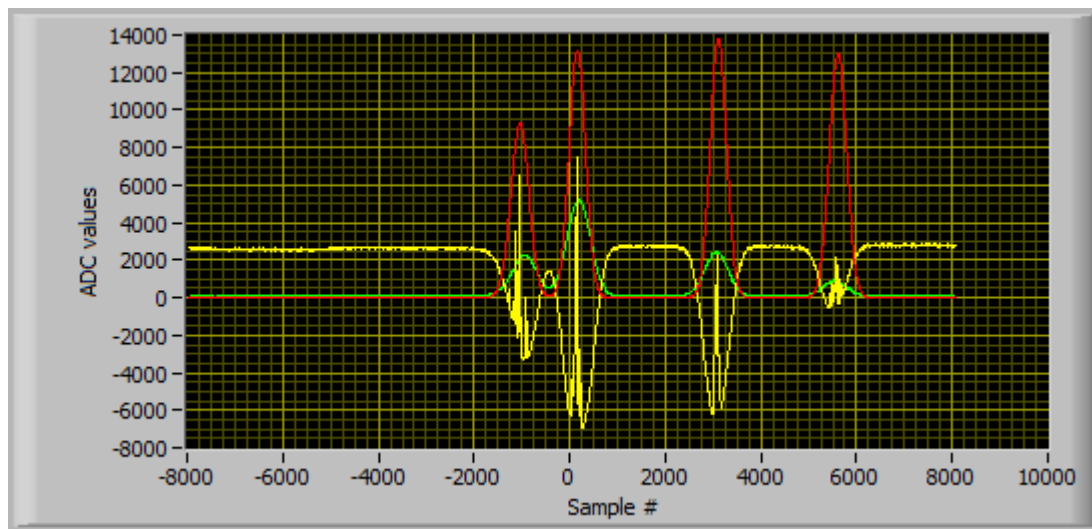

If this was successful, the program matches the position of the hyperfine lines (yellow line) with their theoretical positions (red line) relative to the WaveMeterOffset:
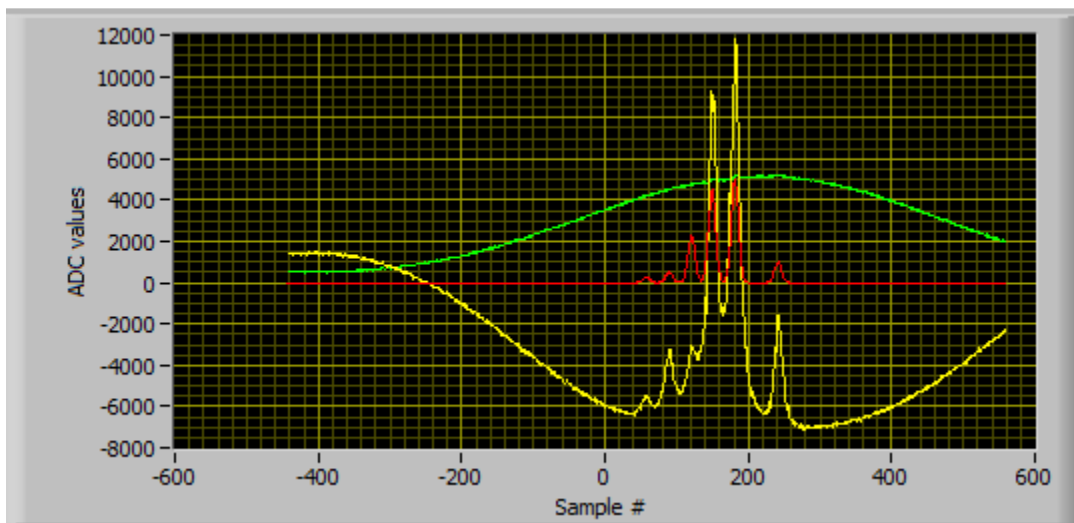
Hint: If you want to calibrate the iScan around a new WaveMeterOffset value, you can choose the new value as "target value" in the operation section:
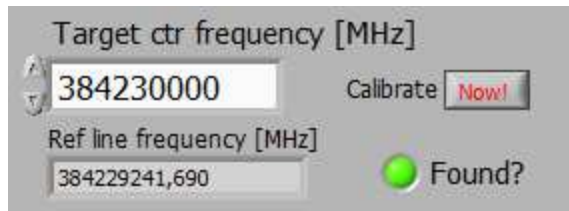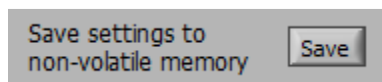
The program will then select a suitable absorption line within +/-1GHz around the target frequency. If none is available, the Calibrate button will be greyed out:
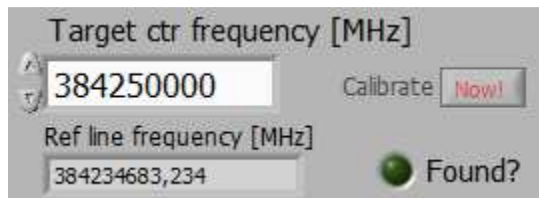
Saving the values

After a successful calibration, we recommend to save all parameters to the non-volatile memory by clicking the button: