Quick Setup Instructions (Offset Phase Lock D2-135)

Please refer to the Quick Setup Instructions for setting up the electronics modules and connecting the Laser Controller to the Lasers.

At this point you should have two lasers temperature stabilized and running at their operating current. The two lasers should be within a few GHz of the same frequency of each other. (If unsure of the laser frequency, you can use a spectroscopy module to get one laser on transition and then temporarily move the spectroscopy module to the other laser to get it near the same transition.)

D2-150 Alignment

This section assumes you are using the D2-150 Heterodyne Module to obtain an optical beat note between two lasers. If you have obtained an optical beat note by other methods, please skip this section.

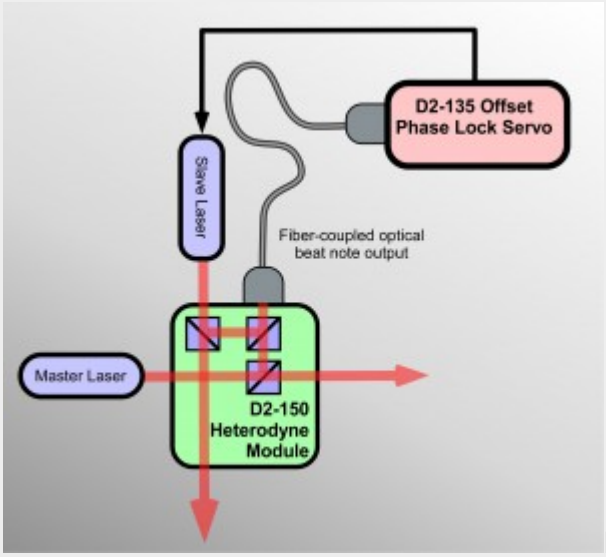


Fig. 1: Schematic drawing of the laser alignment in to the D2-150 Heterodyne Module.

Place the two lasers and the D2-150 as shown in figure 1: the two lasers oriented 90° relative to each other and both pointing at the D2-150. Take the top off the D2-150 and place it such that the beams of both lasers hit the center of the first beam splitter that they encounter. There are 3 adjustable beam splitters in the D2-150: two for aligning one laser, and one for aligning the other laser. In figure 1 the master laser is the laser with only one adjustment because it passes straight-through the second beam splitter on its way to fiber, while the slave laser reflects at 90° off of two beam splitters. It is important to align the laser with only one adjustment stage first (the master laser in the figure).

First Laser Alignment

Use a power meter to measure the power out from the fiber connected to the D2-150. Block the laser that has two adjustments and measure the power from the laser with one adjustment that gets coupled into the fiber. Use the two adjustments on the beam splitter that affects the laser position to maximize the power into the fiber. If you cannot measure any light from the fiber, it is often helpful to put light into the fiber (opposite direction from how the system operates) and see how well that light gets back to the laser. Adjust the same beam splitter so the light is aimed directly at the laser source.

This should get the alignment close enough to measure the power in the fiber to use for further optimization. Aim for 500 µW of power although a few hundred microwatts should be sufficient. <html>The detector in the D2-160 or D2-135-FC can be damaged by more than 1 mW input power, so be careful not to couple in too much light.</html>

Second Laser Alignment

Once you have at least a few hundred microwatts of power from the first laser coupled into the fiber, the next step is to overlap the lasers with two adjustments to the second laser. Unblock the second laser. The last beam splitter has two outputs: one goes to the fiber, the other to an exit port. This port is for alignment and portions of both lasers will pass out of this port. Looking at this output close to the D2-150 and far from the D2-150, one can match the position and angle of the second laser to the first. When doing the alignment, adjust the beam splitter close to the fiber when looking at the beams far from D2-150 and use the other beam splitter when looking close to the D2-150. By iterating adjustments back and forth, you can converge on a nice alignment of the laser. At this point you should be coupling a few hundred microwatts of power from the second laser into the fiber. If you are not, try tweaking the beam splitter closest to the slave laser input beam and then repeat the alignment procedure. Once this is done, you are ready to look for a beat note.

Finding a Beat Note

Plug the fiber into either the D2-160 or D2-135-FC (obsolete). If using the D2-160, use a short RF SMA cable to connect the D2-160 to the D2-135-SMA. Look at the D2-135's Beat Note div/2 monitor on a spectrum analyzer. You should see a beat note at half the frequency difference between the two lasers. You may need to tweak the laser current on one laser to make sure the frequency difference is in range. Once you see a beat note, adjust the laser frequency until the beat note starts to broaden or disappear. When that happens, park the laser where the beat note starts to degrade and tweak the alignment of the 3 beam splitters until the beat note looks good. Repeat until you have the desired frequency range (typically ~10 GHz).

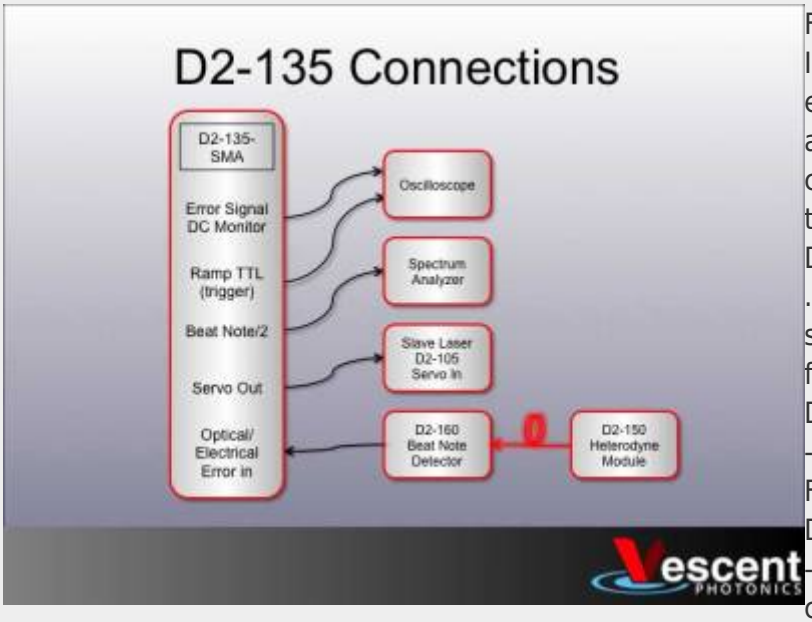


Fig. 3: Initial electrical connections to D2-135. (As shown for D2-135-SMA. For D2-135-FC, connect optical output of D2-150 directly to SC fiber input on face of D2-135.)

D2-135 Locking

Getting a phase lock can be tricky, as the servo feedback must be pretty well optimized to your laser to get a phase lock. The narrower the linewidth of the laser and the higher the bandwidth of the laser, the easier it is to get a phase lock. The first step is to get an error signal with a steep slope at the desired offset frequency and then a basic lock.

Connect the D2-135's Servo Out to the Servo In on your Laser Controller to sweep the slave laser's frequency. (Refer to figure 3 for making electrical connections to the D2-135.) Connect the Ramp TTL on the D2-135 to the trigger on your O-scope and view the Error In Monitor to the O-scope. Set the D2-135 to N=16, VCO Low mode, put the Servo in Ramp mode and by tweaking the laser current, you should see the Error In Monitor look something like what is shown in figure 4.

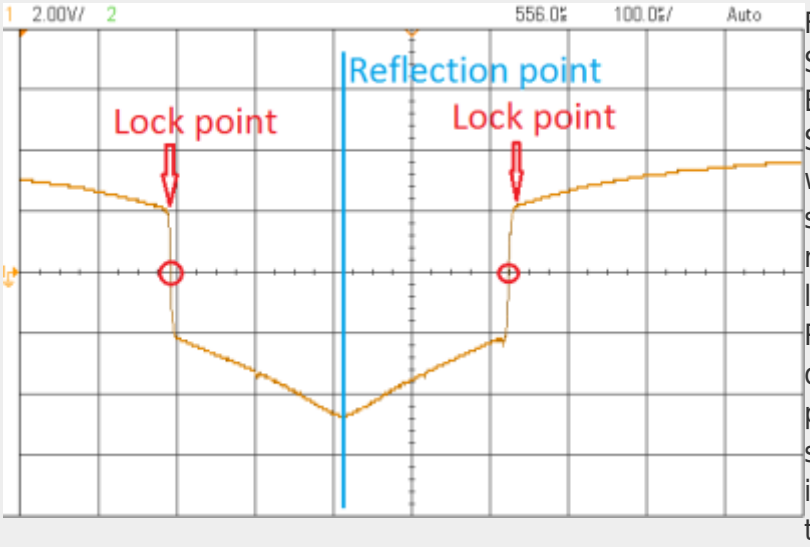


Fig. 4: Sample Error Signal when sweeping one laser. Reflection point shown in blue, two lock point shown in red.

The reflection point on the Error Signal is where the two lasers are at the same frequency. The Error Signal is a even function of offset frequency (Error(Δf) = Error(-Δf)), so there is a reflection point about Δf=0. The sharp slope to the left or right of the Δf=0 point is the lock point and can be adjusted by changing the VCO frequency. Which of the two lock points the laser will lock to will depend on the gain sign. Center the O-scope on one of the lock points and turn down the ramp amplitude. Flip the D2-135 Servo to Lock mode. If the Servo Output jumps to +/-10V, repeat with the opposite gain sign. At this point, you should have a lock that is holding the offset frequency to a specific value. You may be be significantly broadening the laser because the servo is oscillating, but you have a basic lock.

Optimizing the Lock

The first step is to optimize the gain. Look at the Error In Monitor and turn down the gain to minimize the RMS noise on the Error In Monitor. At this point you should be able to see the

beat note with the Beat Note (div 2) monitor on a spectrum analyzer with a 100 MHz span. You can try to further optimize the gain by looking at the beat note monitor and trying to minimize the width of the beat note (or if there is a phase lock, maximize the amplitude of the coherent peak). The next step is to optimize the feedback. It is recommended starting with the ω_{HF} in the off position, ω_I at 16 kHz, and ω_D at 64 kHz. Generally, leave ω_{HF} off and adjust ω_D, ω_I, diff gain and overall gain while monitoring the beat note to see if the lock is getting better as you make adjustments. Look for a narrow peak coming out of the center of the beat note, as shown in figure 5.

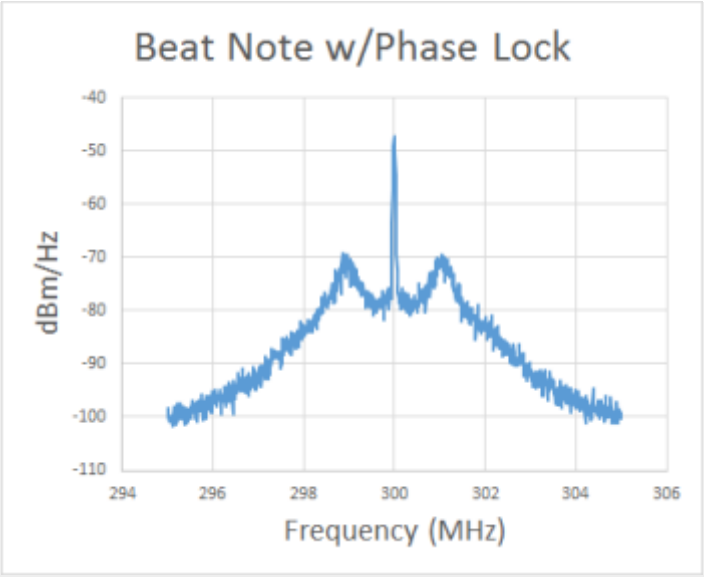


Fig. 5: Beat note when locked with coherent peak showing a phase lock.

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