Jumping the Lock Point of the D2-125 Reconfigurable Servo

The D2-125 Reconfigurable Servo from Vescent Photonics is a flexible PI^2D loop filter servo often used to lock a laser to a known spectroscopic feature for precision optical physics work such as cold atom experiments, quantum cryptography, computing & time keeping, and as a frequency reference. The D2-125 produces a control signal with bandwidth from DC to 10 MHz with a flexible, user-specified transfer function. Additionally, it features an internal ramp generator and an auxiliary servo output for controlling an outer, slow loop. It also provides a modulation/demodulation circuit for locking to the center of the error feature.

A useful feature of the D2-125 is the control the user has over its output and operation mode through the Absolute and Relative Jump inputs. The user can conveniently select the servo lock state and output value, allowing a jump to a new lock point. In this application note, we will demonstrate taking the system from an initial stable lock point through an externally controlled jump to a new spectroscopic feature and then locking the laser to this new transition.

In order to demonstrate this capability, we deployed a Vescent laser system as seen in Figure 1. A D2-005 Linear Power Supply provides DC power rails to all the active components: the D2-105 Laser Controller, D2-210 Saturated Absorption Spectroscopy Module, and the D2-125 Reconfigurable Servo. The D2-105 Laser Controller provides both current for the laser diode (integrated into the D2-100 Laser) and temperature control for the same. Having established operation of the D2-100 at 780.24 nm and ~40 mW of output power, a small portion of the beam (<1 mW) is introduced into the D2-210 Spectroscopy Module. The D2-210 generates an error signal based on the Doppler-free D2 hyperfine spectrum of rubidium which is used as input to the D2-125.

The D2-100 uses Distributed Bragg Reflector technology for wavelength control and tuning. It therefore has no moving parts which makes the locked laser system extremely stable, as is demonstrated by the videos found at this link.[1]

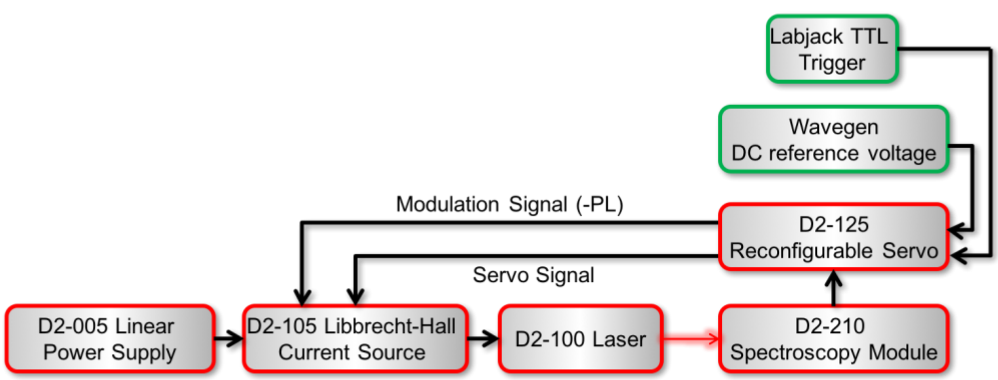

Figure 1. Experimental Configuration.

By using the built-in ramp from the D2-125 Reconfigurable Servo, we are able to sweep the laser over the D2 transitions of Rb as seen in Figure 2. The system is then locked to the F-2 ← F'=3, F'=2 Crossover transition of ^{87}Rb as also indicated in Figure 2.

[1] http://www.vescent.com/products/electronics/d2-125-laser-servo/#Servo_videos

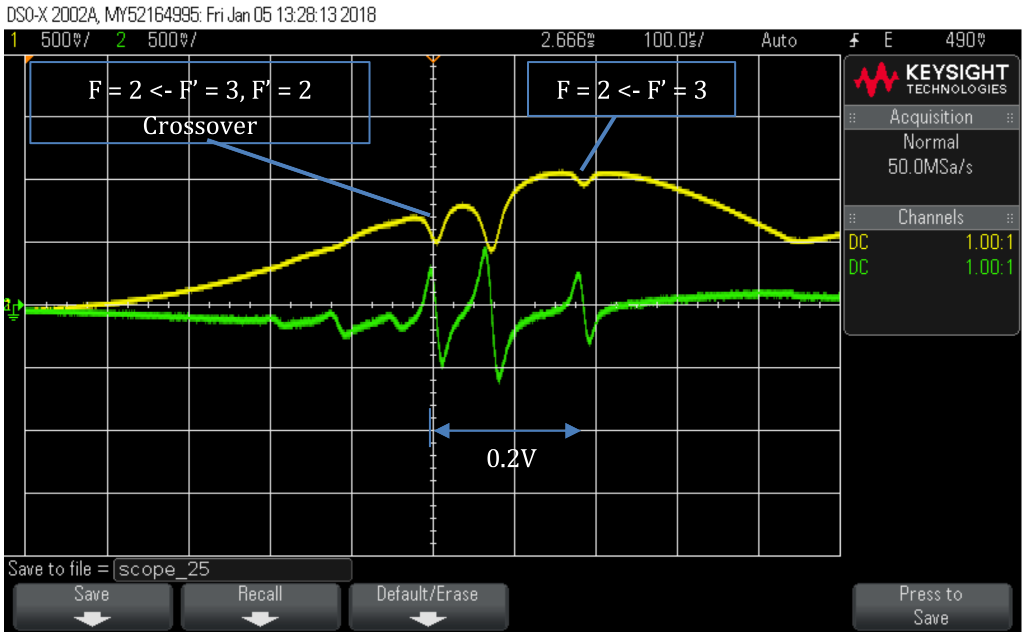

Figure 2. Portion of the D2 spectrum of Rb used in experiment. DC error signal (yellow) and demodulated FM error signal (green).

When a TTL high signal is applied to Absolute Jump TTL input on the rear of the D2-125 Reconfigurable Servo, the dual Integrators are suspended and the Servo Out control signal is set to the negative of the voltage input at the Laser Jump Amplitude Input (also found on the back of the servo). We set this value at -113 mV to match the frequency difference between the F-2 ← F'=3, F'=2 Crossover transition and the F=2 ← F'=3 transition given the transfer function of the Servo Input on the D2-105 Laser Controller (~1 mA/V) and the current tuning of the DBR laser (~-1.3 GHz/mA). When the Absolute Jump TTL is asserted low, the Integrators re-engage at the new set point and relock is achieved on the new transition.

Figure 3 shows the results of this experiment. The yellow trace is the Servo Output and the green is the DC error (both collected from the monitor ports on the front of the D2-125). In section A of the figure, the system is locked to the initial F-2 ← F'=3, F'=2 Crossover transition with the Servo Output roughly at ground. In Section B, the Absolute Jump TTL is asserted high and the Servo Output is deterministically set to the voltage value supplied at the Laser Jump Amplitude Input Port. (There is an inverter with a gain of 2 in between the Laser Jump Amplitude Input and the Servo Output.) From previous observation of the D2 spectrum of Rb, it has been determined that this offset will move the laser from the F-2 ← F'=3, F'=2 Crossover transition to the F=2 ← F'=3 transition. In this portion of the trace, the DC Error fluctuates over a large amplitude as the laser "hovers" open loop over the new transition. In Section C, the Absolute Jump TTL is again asserted low and the Integrators catch lock at the new set point as is indicated by the Servo Output centering about the new lock point.

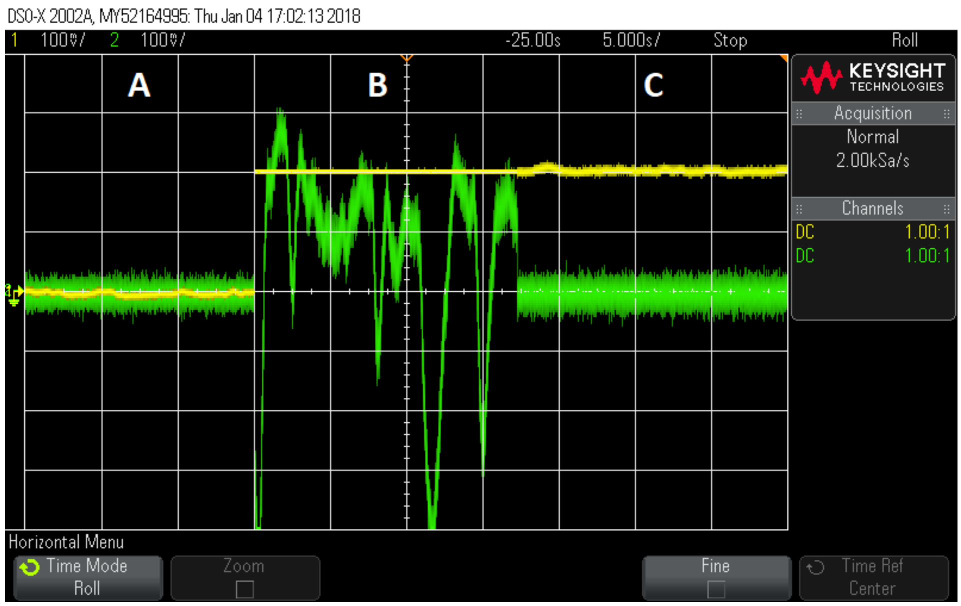

Figure 3. Oscilloscope traces in "roll" mode showing Servo Output (yellow) and DC Error Input (green). Section A: System initially locked to the F-2 ← F'=3, F'=2 Crossover transition. Section B: System free-running with Servo Out held to a controlled value near the center of the F=2 ← F'=3 transition. Section C: System set to lock state at new lock point.

This jump-and-relock process could also be effected by using the Relative Jump mode. It should be noted that this process was most easily successful with lowered gain on the lock loop in comparison to the tightest lock possible.

It takes tens of microseconds for the system to catch lock again after the Absolute Jump TTL is asserted low again. This can be seen in Figure 4 where it took approximately 14 μs to execute a 1 V jump.

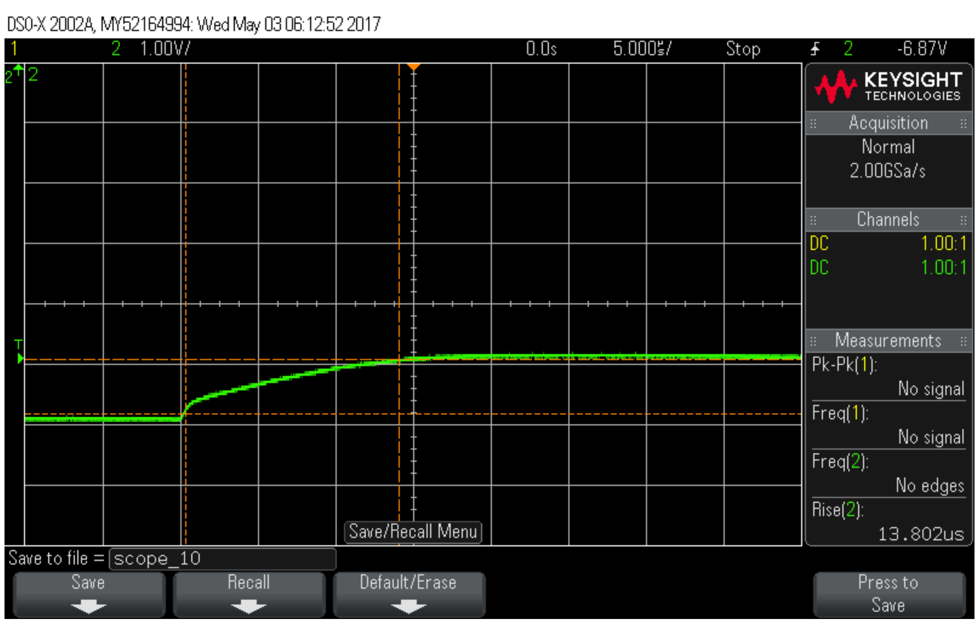

Figure 4. Oscilloscope capture of timing to catch lock

For further information on this or other features of the D2-125 Reconfigurable Servo, contact info@vescent.com.