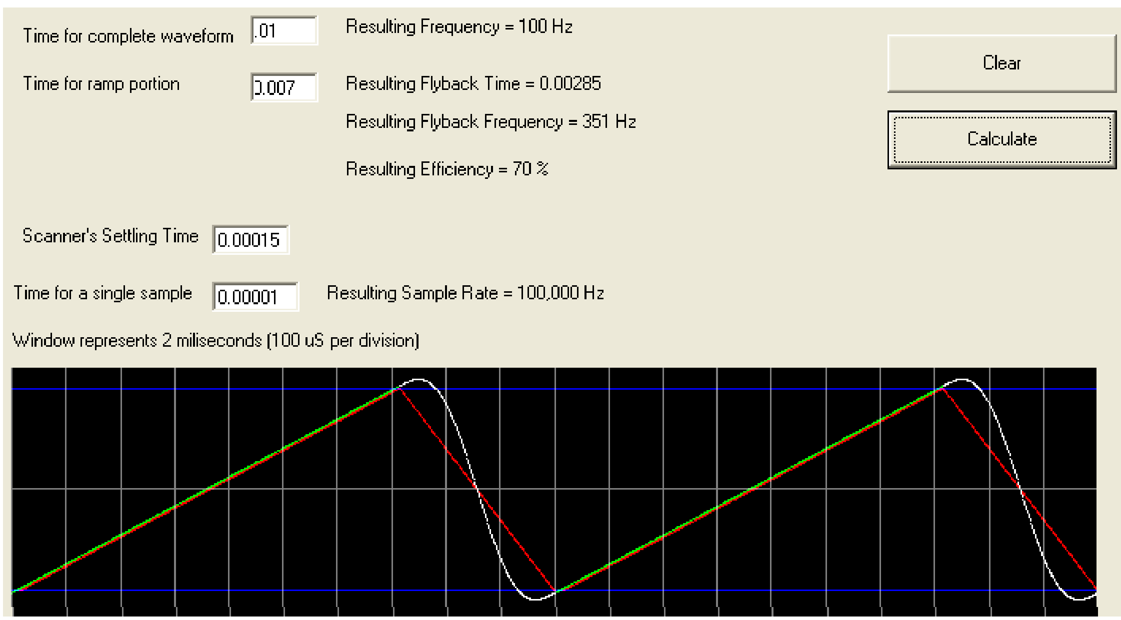
ScannerMAX Saturn 9B scanning 6.2mm beams with sawtooth waves up to 2kHz and sinewaves at 2.5kHz

This is a test of the ScannerMAX Saturn 9B-46S scanner, with a mirror capable of projecting a 6.2mm beam through a 40-degree optical scan angle. The Saturn 9B is available with several coil configurations, including "standard" and "-46S". The –46S version has a coil with lower resistance and lower inductance, which is advantageous for scanning sawtooth waveforms.

The Saturn 9B-46S scanner was driven with a ScannerMAX Mach-DSP servo driver having +/-24V rails. This servo driver is capable of driving two scanners (dual axis driver) and has a compact package. For convenience and for low heat dissipation by the servo driver, it is designed to have a single-ended power amplifier. This means that the power amplifier can only deliver approximately +/-21 volts to the galvo coils, but it also means that heat generated by the power amplifier is generally less than half of that of an H-bridge configuration.

To ensure the +/-21V maximum output voltage capability wasn't exceeded, a cycloid-type flyback was used with the sawtooth. This generally imparts a modified sinewave onto the retrace portion of the waveform, instead of a simple linear ramp. This minimizes resonances, while also minimizing flyback time. To generate the cycloid-type flyback retrace waveforms, a custom program was written, which allows the user to specify the waveform "cycle time" as well as the "ramp time". The program also allows the user to specify the scanner's settling time, and will automatically increase the amplitude of the waveform to compensate for the natural low-pass-filter rolloff of a scanner/servo system. A picture of the program, and the cycloid-type flyback is shown below.



The Mach-DSP servo driver has accompanying Application Software that runs on a Windows-based PC. The software is capable of monitoring all parameters of the scanner during operation. The software also includes a built-in oscilloscope function. This comes in handy as it can be used to measure virtually any quantity of the overall scanning system.

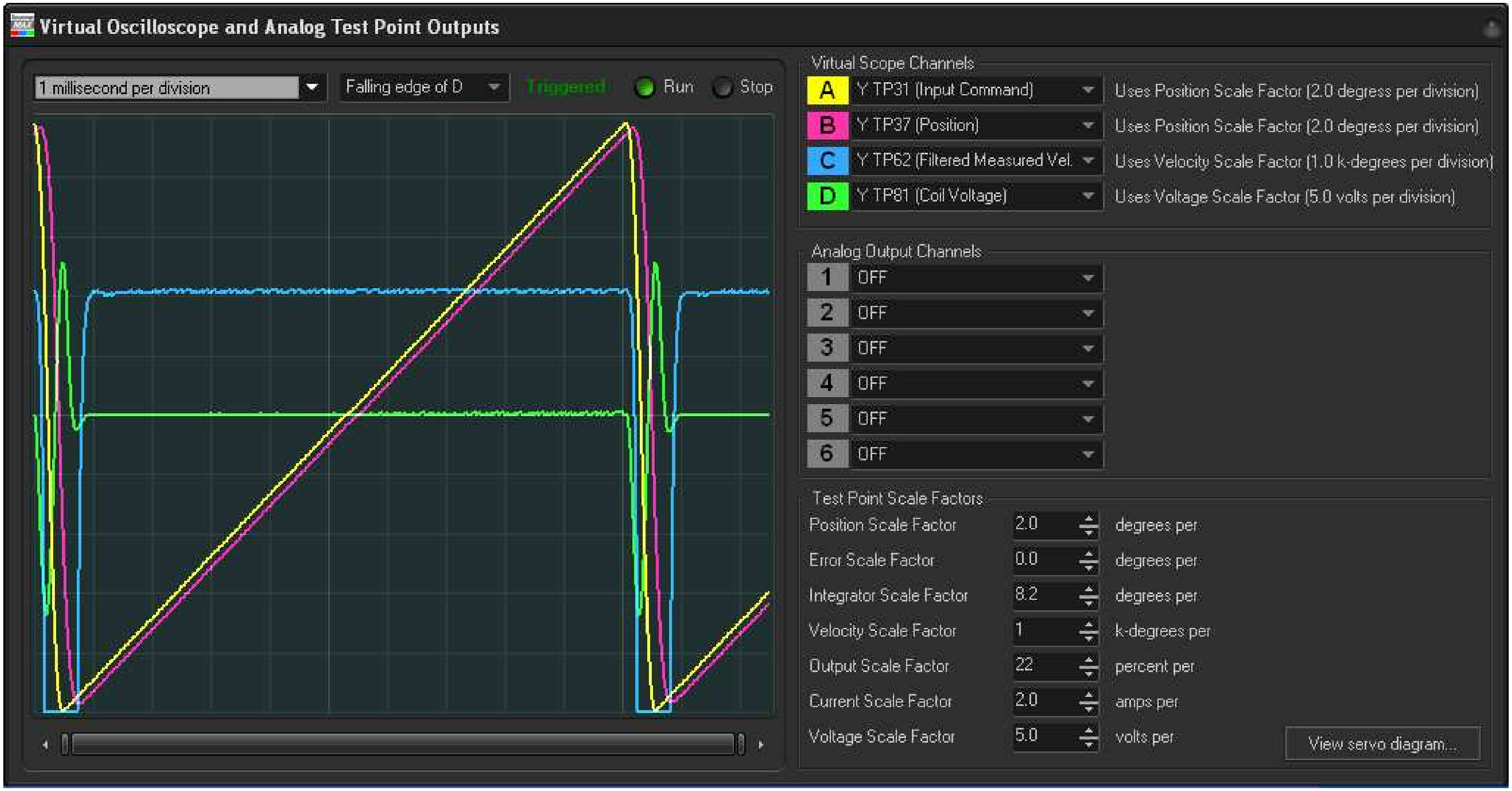
All screen shots that follow show four separate channels being measured. The yellow trace shows “Input command”. The pink trace shows “Position”. (Both Input and Position are in mechanical degrees, thus, optical scan angle is double that shown in the traces). The blue trace shows the “velocity” (first derivative of position). The green trace shows the coil voltage.

For all of the testing, we drove the input command signal using the special program mentioned above.

Tunings used for the 40-degree-optical scan angles (up to 300Hz) was a PD tune with bandwidth of 2.8kHz, step time of 250 microseconds, and 130 microsecond command-to-position (tracking) delay.

Tunings used for the smaller scan angles (up to 2500Hz) was a PD tune with bandwidth of 4.3kHz, step time of 180 microseconds, and 100 microsecond command-to-position (tracking) delay.

<u>100 Hz, 20 degrees mechanical peak to peak (40 degrees optical)</u>

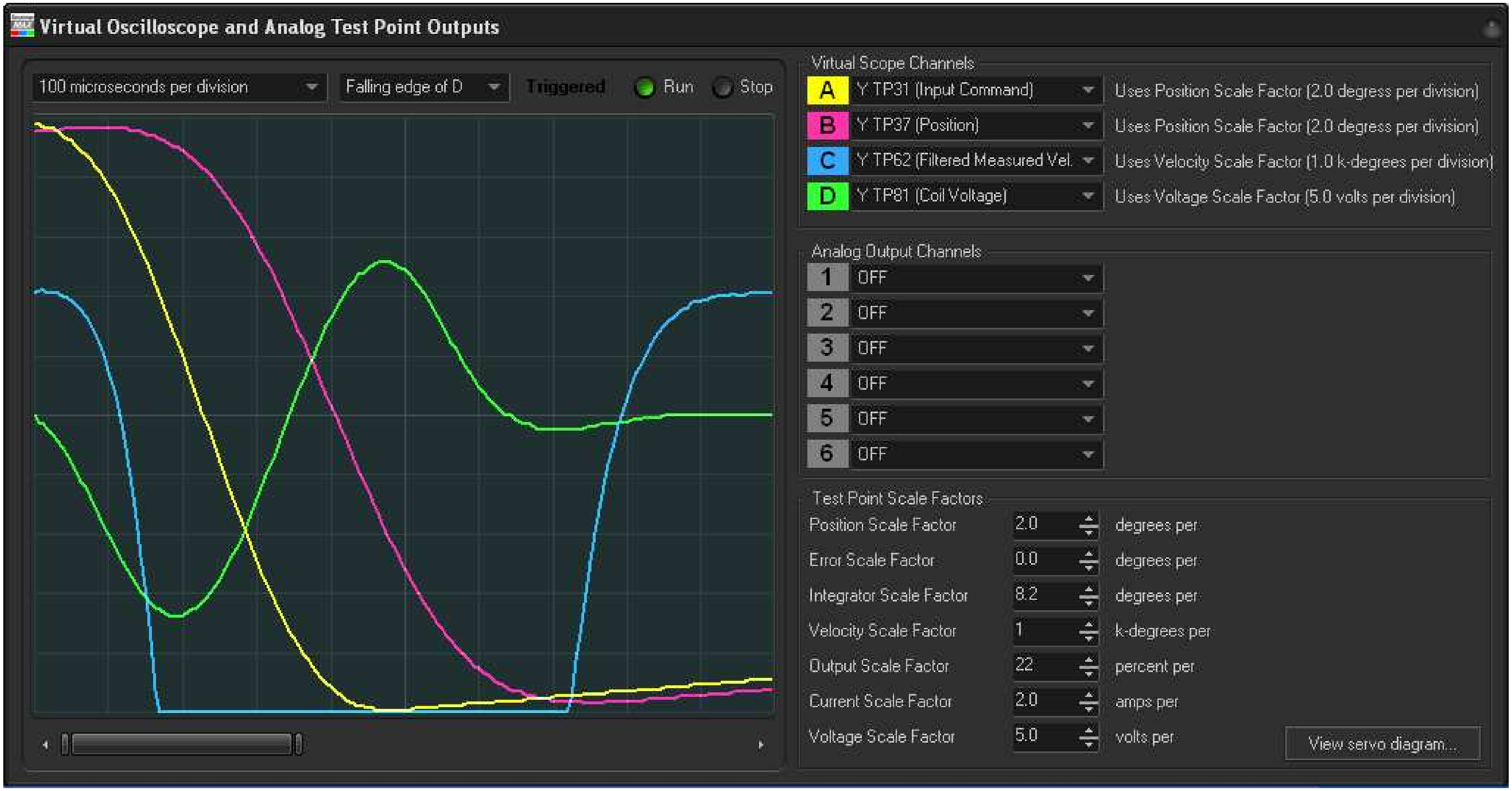


Cycloid retrace program was set for 9.35 millisecond “ramp time”, and a corresponding 650 microsecond retrace time.

Power consumption is 0.4 Amps from each of + and –24V power supply; 19.2 watts electrical power
3.2 watts of heat generated by the scanner while scanning
6 watts of heat generated by the power amplifier portion of the servo driver

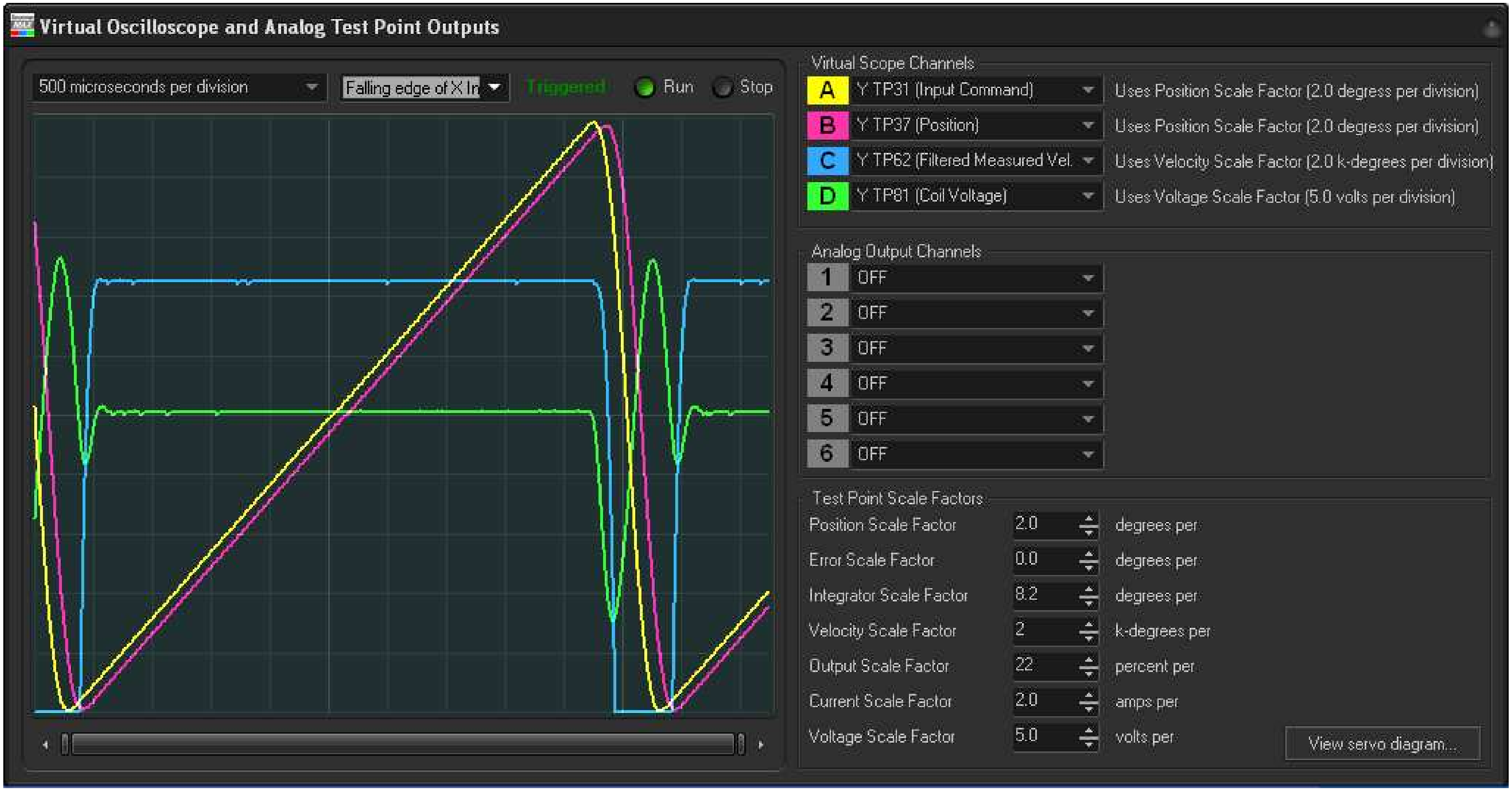
Close up of falling edge of command.

Notice that the command input has a sinusoidal shape to it, and the position waveform follows the input quite nicely. This uses the “cycloid” method of retrace, similar to how cam-following is optimized.



Actual retrace is approximately 850 microseconds

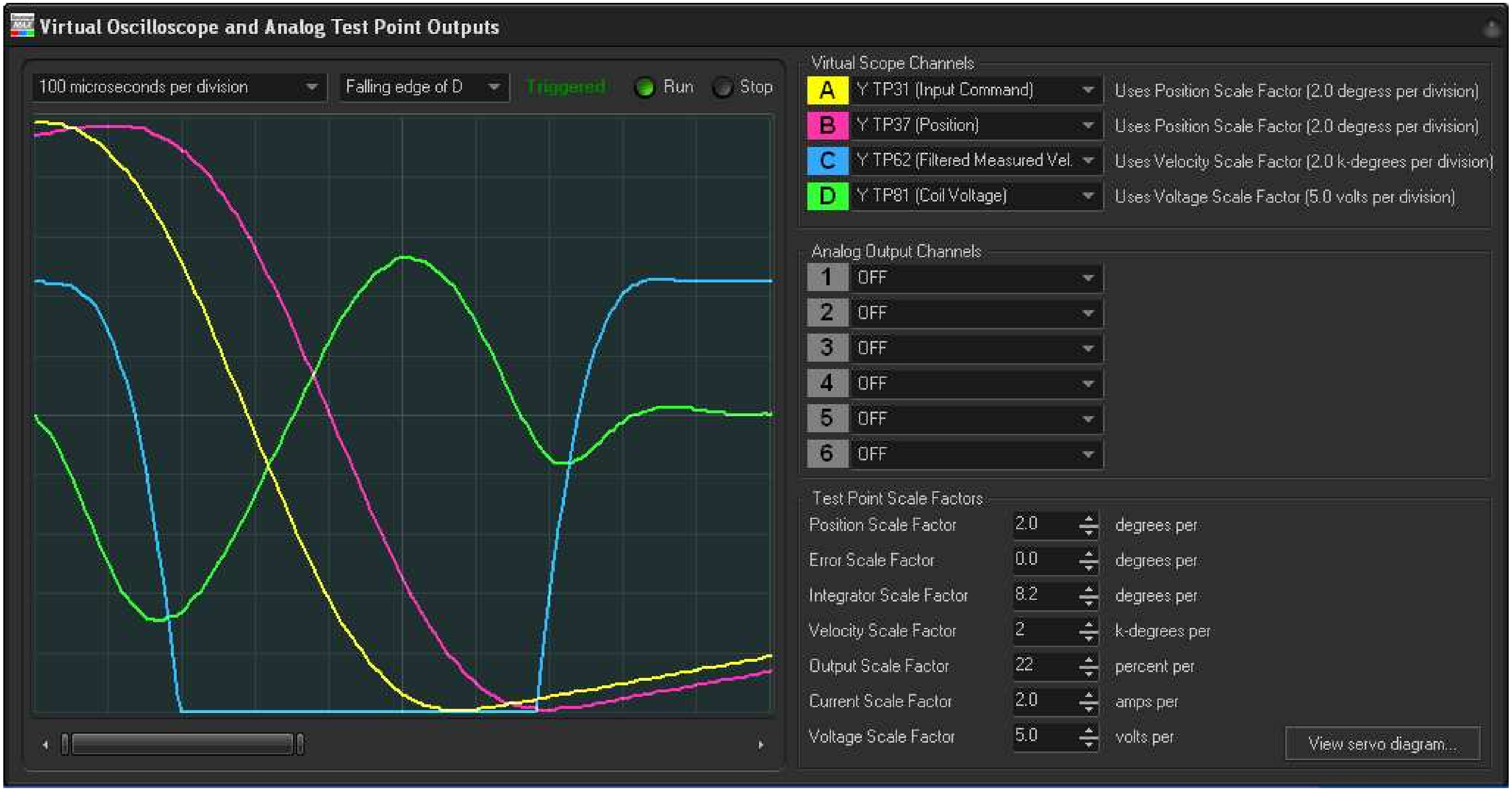
200 Hz, 20 degrees mechanical peak to peak (40 degrees optical)



Cycloid retrace program was set for 4.33 millisecond “ramp time”, and a corresponding 670 microsecond retrace time.

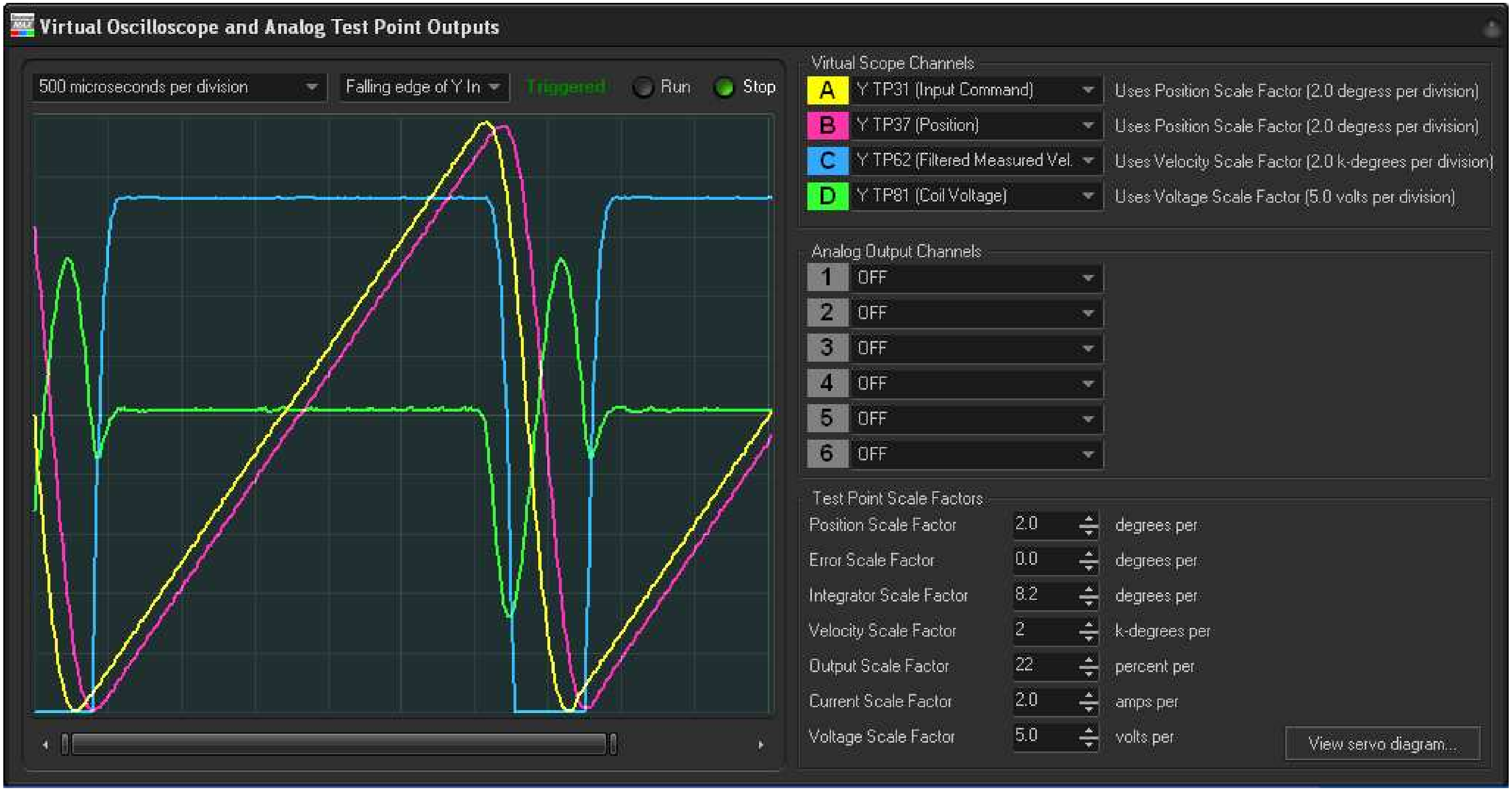
Power consumption is 0.61 Amps from each of + and –24V power supply; 29.6 watts electrical power
7 watts of heat generated by the scanner while scanning
11 watts of heat generated by the power amplifier portion of the servo driver

Close up of falling edge of command.



Actual retrace is approximately 750 microseconds

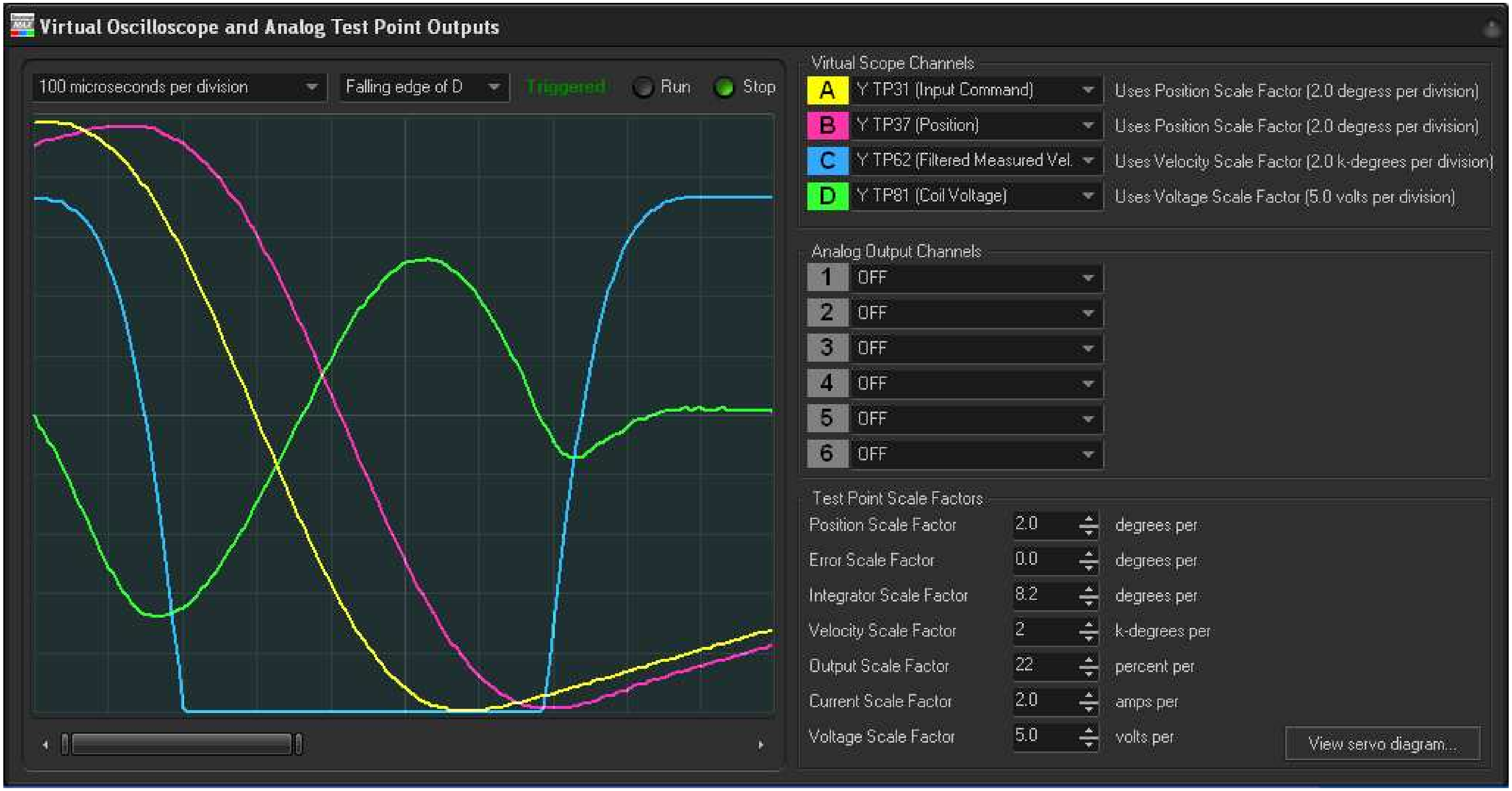
300 Hz, 20 degrees mechanical peak to peak (40 degrees optical)



Cycloid retrace program was set for 2.6 millisecond “ramp time”, and a corresponding 733 microsecond retrace time.

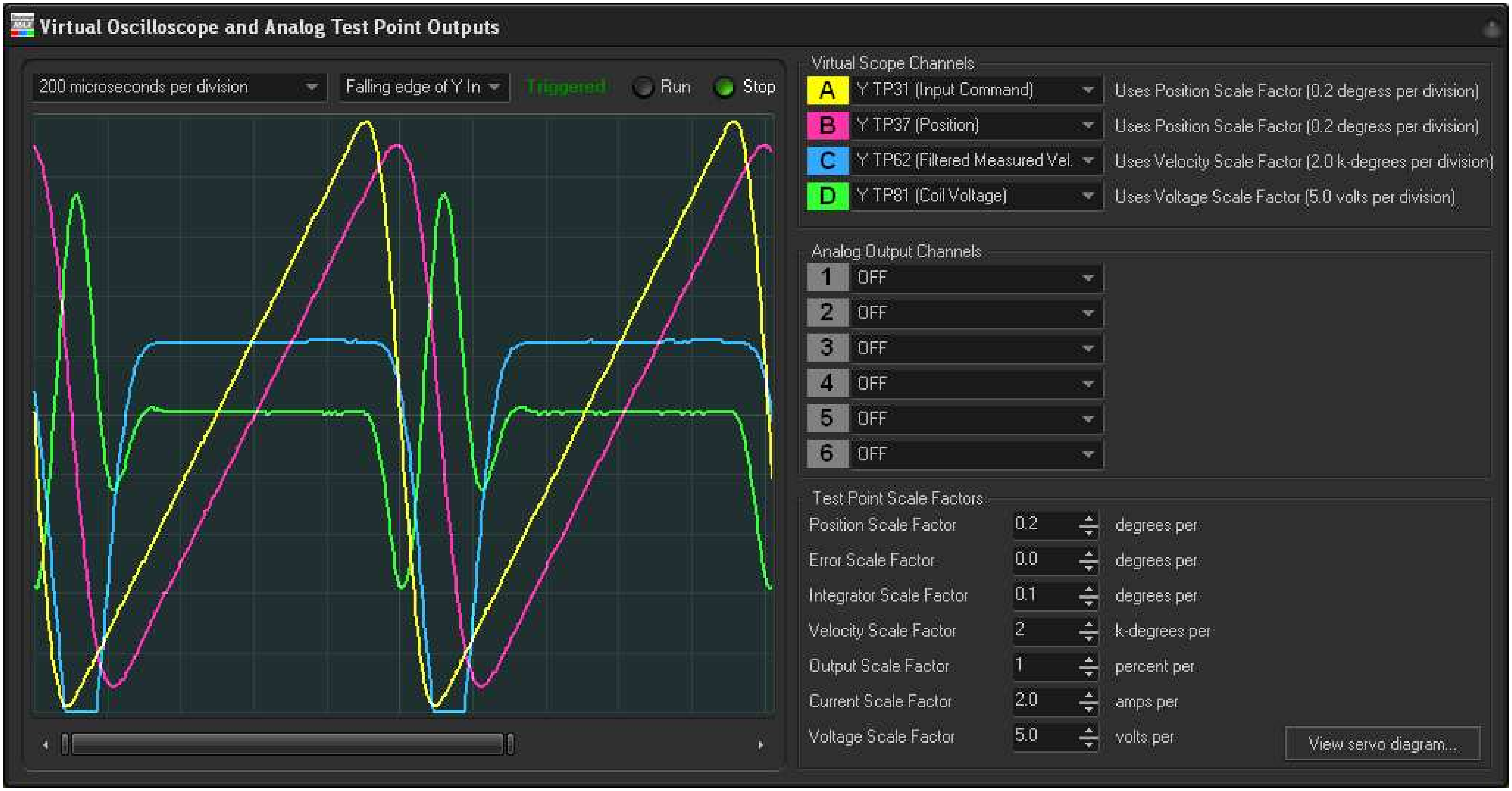
Power consumption is 0.84 Amps from each of + and –24V power supply; 40.7 watts electrical power
12 watts of heat generated by the scanner while scanning
19 watts of heat generated by the power amplifier portion of the servo driver

Close up of falling edge of command.



Actual retrace is approximately 800 microseconds

1000 Hz, 2 degrees mechanical peak to peak (4 degrees optical) Command Input; >1.9 degrees mechanical position

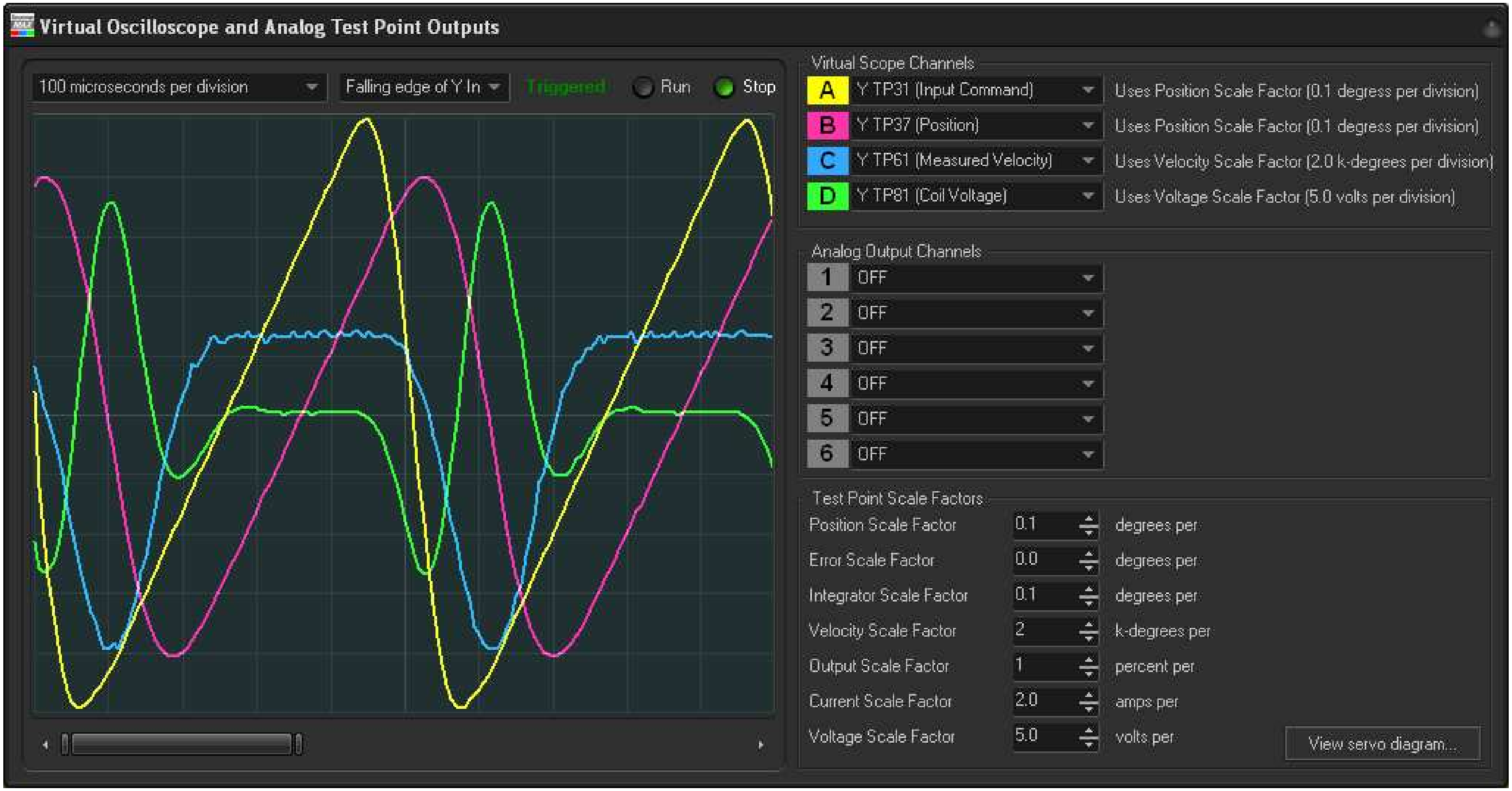


Cycloid retrace program was set for 760 microsecond “ramp time”, and a corresponding 240 microsecond retrace time.

Power consumption is 0.7 Amps from each of + and –24V power supply; 34.1 watts electrical power
4 watts of heat generated by the scanner while scanning
20 watts of heat generated by the power amplifier portion of the servo driver

Actual retrace time is approximately 350 microseconds.

2000 Hz, 1 degrees mechanical peak to peak Command Input; 0.8 degrees mechanical position



Cycloid retrace program was set for 330 microsecond “ramp time”, and a corresponding 170 microsecond retrace time.

2500 Hz, 1 degrees mechanical peak to peak (2 degrees optical) Sine Wave Input; > 0.8 degrees Position Output

Power consumption is 1.28 Amps from each of + and –24V power supply; 62 watts electrical power
8 watts of heat generated by the scanner while scanning
45 watts of heat generated by the power amplifier portion of the servo driver

Conclusion:

This test generally shows how the Saturn 9B can be used to scan 6.2mm beams with sawtooth waveforms for imaging applications such as scanning microscopes.

Given the power requirements and heat generated by both the scanner and servo driver, all of these waveforms could be scanned for a virtually indefinite period.

Note that while scanning small angles at 2kHz or higher, it is certainly a good idea to intersperse such scanning with much lower frequency, full-field scanning so that the lubrication in the bearings is continually being distributed.