<u>ScannerMAX Saturn 9B scanning 650Hz and 1325Hz at several scan angles</u>

This is a test of the ScannerMAX Saturn 9B scanner with our standard 8mm Y mirror. This particular Y mirror has the capability of scanning a 8mm beam over a 40-degree optical angle.

Based on the customer request, this testing is being done at 3.75 optical degrees, 7 optical degrees, and 14 optical degrees peak to peak. Since these angles are much smaller than the 40-degrees that the standard mirror set is capable of, it means that beams larger than 9 mm could be reflected by this mirror set.

The Saturn 9B is available in several coil configurations, including “-46S”, “-56S” and “Standard”. The difference is the number of turns and diameter of wire used in the stator. The “–46S” version has the lowest coil impedance (only 1.1 ohms and 125uH) so – ordinarily, it would provide the best dynamic performance for this kind of application. However, testing was done using both the “Standard” and –46S versions and there not much of a perceivable performance difference.

The Saturn 9B scanner was driven with ScannerMAX Mach-DSP servo driver having +/-24V rails. This servo driver is capable of driving two scanners (dual axis driver) and it is in a compact package. HOWEVER, 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.

According to our testing, we are able to accomplish the desired 1325Hz at 3.75 optical degrees, and also 650Hz at both 7 degrees as well as 14 degrees optical as requested by the client. For this particular application the limitation was not scan frequency, scan angle or even temperature, but rather the limitation is one of “scan efficiency” or perhaps better known as “flyback time” or “retrace time”.

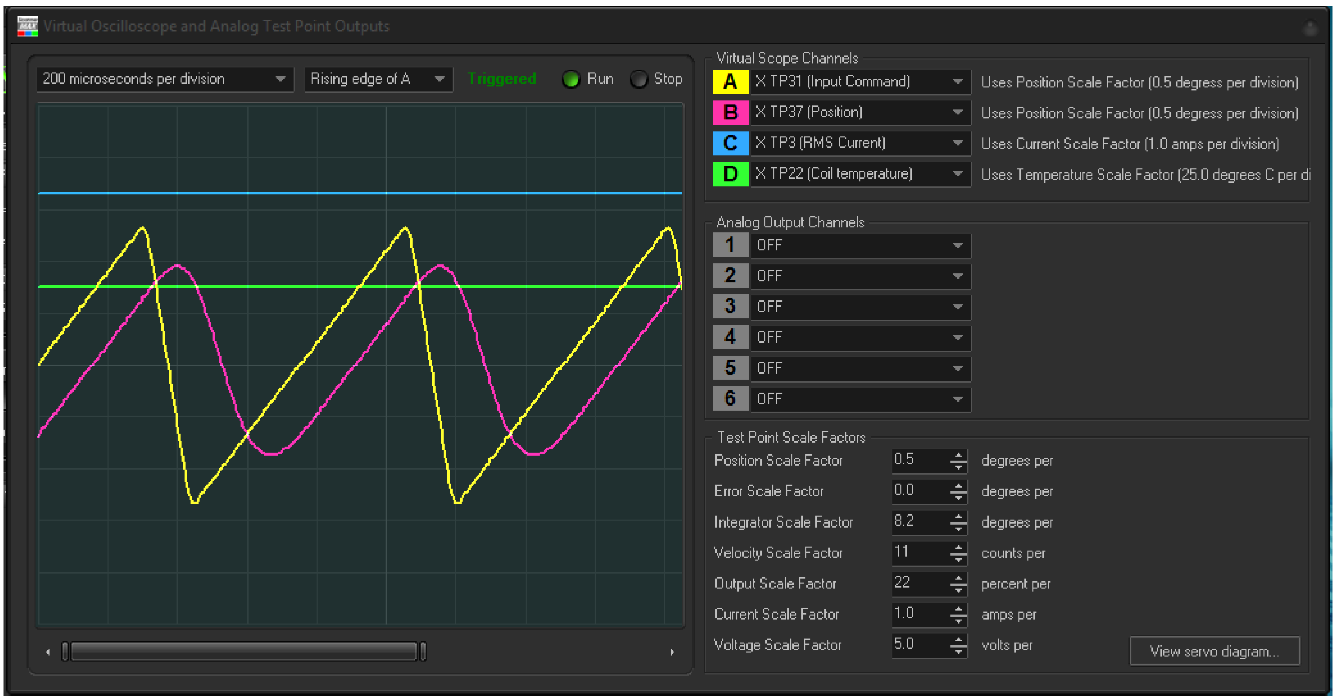
The Mach DSP has a built-in oscilloscope function. This comes in handy as it can be used to measure virtually any quantity of the overall scanning system. For example, the screen shot below shows four separate channels being measured. The yellow trace shows “Input command”. The pink trace shows “Position”. (Both Input and Position are in mechanical degrees, thus, optical scan angle is double that shown in the traces). The blue trace shows the RMS current being driven into the scanner. The green trace shows the coil temperature.

For all of the testing, we drove the input command signal using a function generator capable of generating ramp waveforms with any desired frequency and “symmetry”. You will notice that the input command signal has higher amplitude than the position signal. This is common, since all servo drivers act like low-pass filters and have some “rolloff”. The rolloff could be adjusted if desired.

1325Hz at 3.75 degrees optical

The scope screen shot below shows the results of 1325Hz (roughly 755 microsecond period) sawtooth waveform. Here the input command signal waveform has 17 percent symmetry (12 percent of 755 microseconds is roughly 128 microseconds). Clearly the position signal (pink trace) has a longer retrace than 128 microseconds. Based on the fact that the scope is showing 200 microseconds per horizontal division, we estimate retrace time is 280 microseconds or so.

In any event, you can see the waveform below. Around 475 microseconds is spent in the “trace” portion of the waveform, and around 280 microseconds is spent in the “retrace” portion.

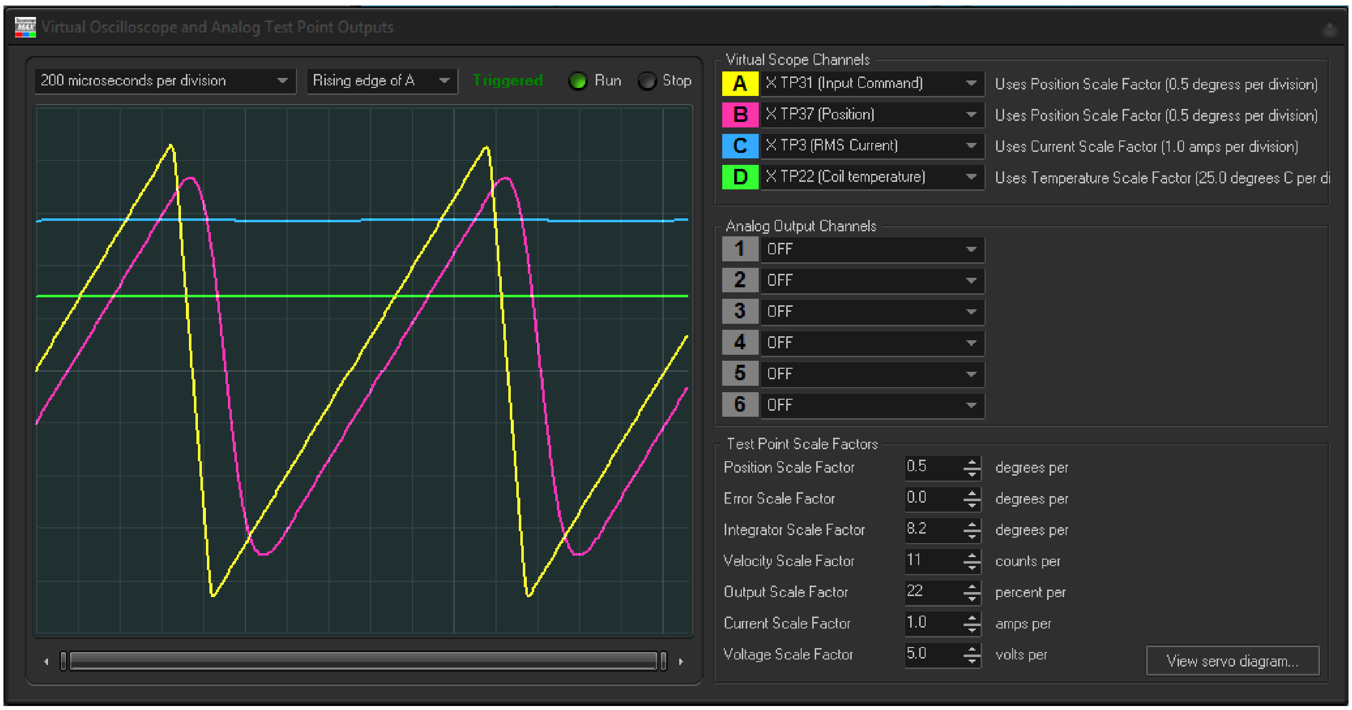


The oscilloscope shows that the RMS current being driven into the scanner is roughly 3.3 amps and coil temperature is only around 35 degrees. Note that at this current, the scanner will be dissipating 13 watts of heat, which is certainly manageable. Power required from the power supply is around 1.9 amps from each of the +24V and –24V supply rails.

650Hz at 7 degrees optical

Below you will see another scope screen shot. This time the testing was done at 650Hz (a bit more than 1.5 millisecond period) and 3.5 degrees mechanical (7 degrees optical peak to peak). The function generator was set for 12% symmetry (185 microseconds), although the "retrace" time of the actual position signal appears to take approximately 280 microseconds or so.

In this case the "trace" portion of the wave takes approximately 1250 microseconds, while the "retrace" portion takes approximately 280 microseconds.

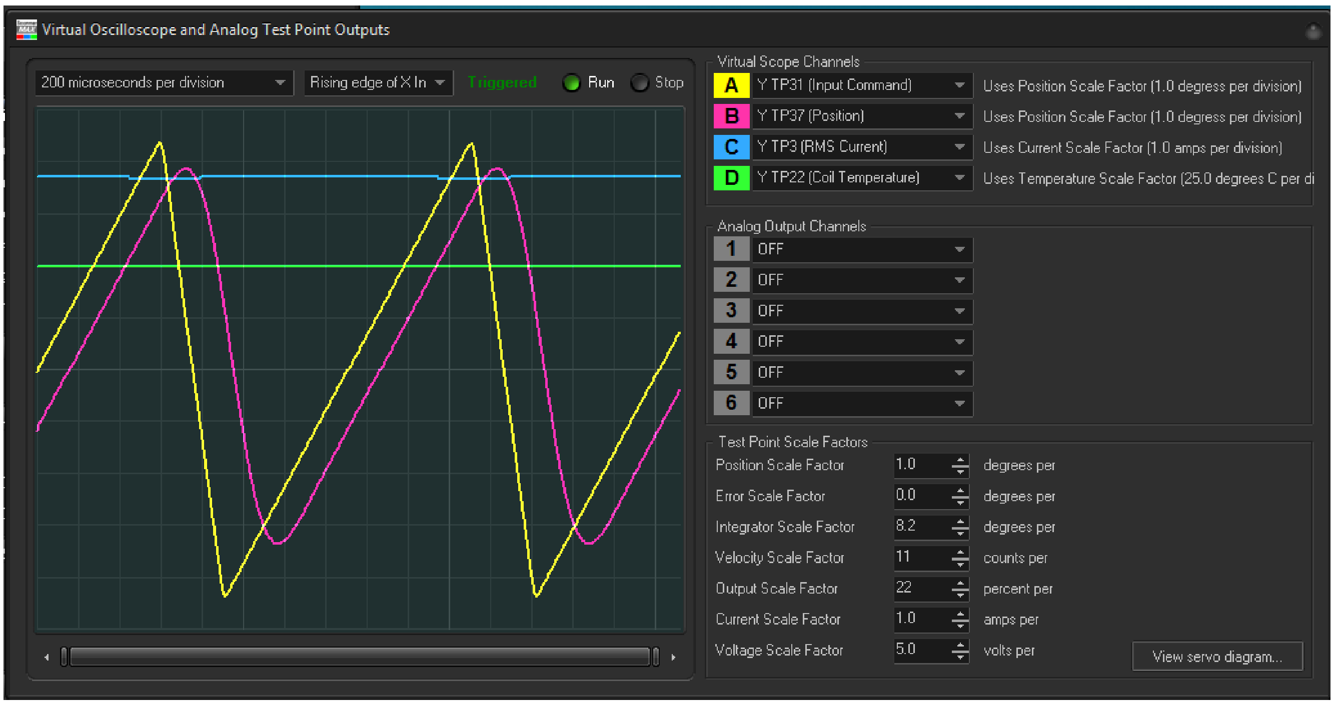


In this case, the coil current is 2.9 amps RMS and coil temperature is around 32 degrees C. The scanner will be dissipating 10 watts, and power required from the power supply is around 1.6 amps per rail.

650Hz at 14 degrees optical

Below you will see another scope screen shot. This time the testing was done at 650Hz and 7 degrees mechanical (14 degrees optical peak to peak). The function generator was set for 20% symmetry (308 microseconds), although the “retrace” time of the actual position signal appears to take approximately 450 microseconds or so.

In this case the “trace” portion of the wave takes approximately 1088 microseconds, while the “retrace” portion takes approximately 450 microseconds.

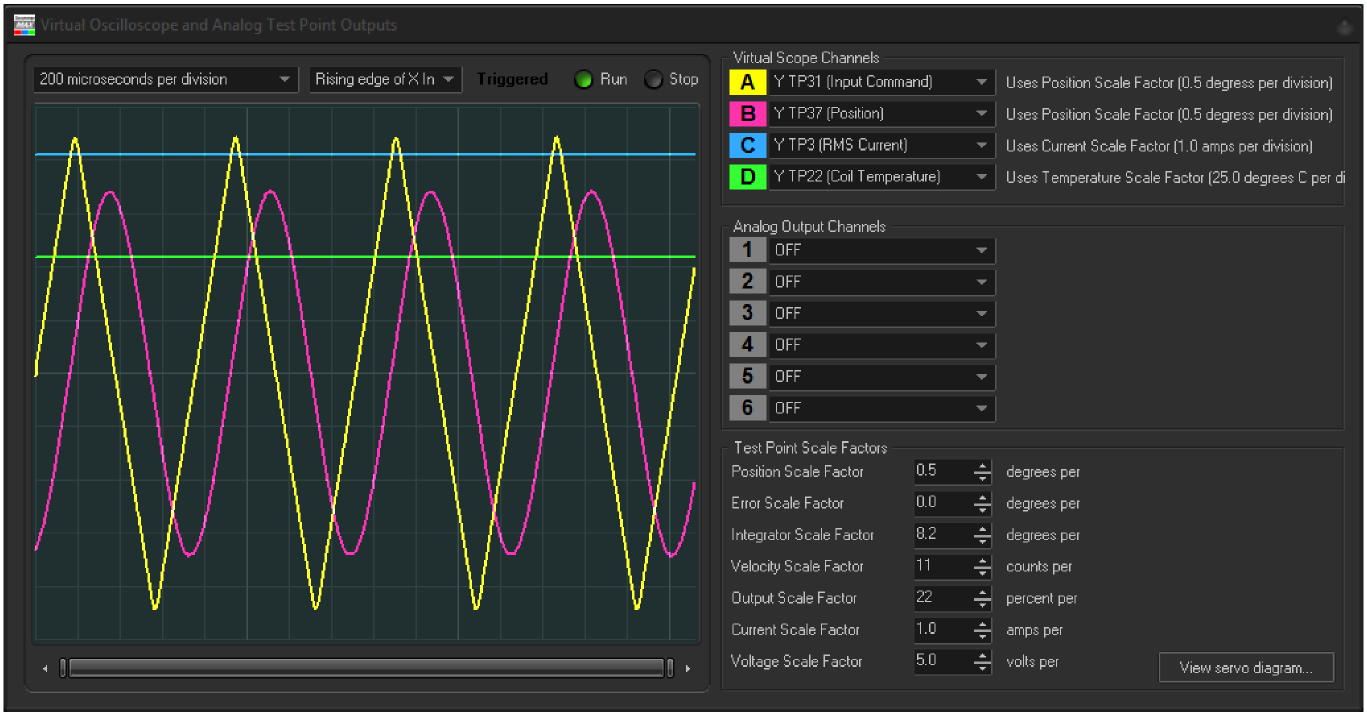


In this case, the coil current is 3.8 amps RMS and coil temperature is around 50 degrees C. The scanner will be dissipating 26 watts, and power required from the power supply is around 2.2 amps per rail.

1325Hz triangle wave at 7 degrees optical

Below you will see another scope screen shot, with the amplitude still at 3.5 degrees mechanical peak to peak (7 degrees optical), and with the “symmetry” set for 50% (triangle wave). In this case we set the function generator for 1325Hz.

This is about the highest practical frequency for a triangle wave at this angle and with our standard 8mm mirror set. Even at this frequency, the triangle wave is somewhat rounded.



In this case we see that the RMS current being driven into the scanner is around 4.1 amps, and coil temperature is around 55C (assuming the scanner body is 30C). The scanner will be dissipating 30 watts, and power required from the power supply is around 2.25 amps per rail.

Conclusions

It is clear that heating of the scanner will not be a problem for this application, given the waveforms above. Retrace time is respectable, and can be reduced somewhat further with the use of +/-30V power supply rail voltages. The heat at the scanner is quite manageable, but due to the very low coil impedance, heating of the servo driver was noticeable because of the low coil resistance and inductance of the scanner. Therefore the servo driver will need to be heat sinked very well to conduct generated heat to the laser equipment chassis.

The scanner and mirror configuration used for this testing (Saturn 9B with 8mm / 40-degree mirrors) was one that we happened to have handy for a quick test based on an informal customer inquiry. A customized mirror set that is designed for this small scan angle would deliver better performance than the standard mirror set used during this test.