ScannerMAX Saturn 5B and 9B, scanning triangle waves at 600Hz and 800Hz

This is a test of the ScannerMAX Saturn 5B and Saturn 9B scanner with our standard 5mm X-Y mirror set. This particular Y mirror has the capability of scanning a 5mm beam over a 60-degree optical angle on both X and Y axis. Moreover, this particular mirror set uses the same inertia for both X- and Y-axis mirrors. Therefore the results below would be identical for X or Y axis.

A customer asked us if we are able to scan a triangle wave with 800Hz frequency at 40 degrees optical, using our Saturn 5B. As you will see, the answer is unequivocally yes. However, this simple “yes” may not really be the answer that the customer is looking for. Unlike an electronic instrument like a function generator or oscilloscope, an optical scanner cannot turn around immediately, and thus it cannot achieve a constant velocity over the entire 40 degrees of a triangle wave. A certain amount of time is needed on each end of the triangle-wave to decelerate the mirror and turn around and accelerate in the other direction.

After demonstrating that the Saturn 5B can indeed scan a triangle-wave pattern at 40 degrees, we will then redefine the problem to ask the question – what would be needed to achieve 40 degrees of actual constant velocity scan? We will separately ask the question – what is the maximum scan angle that can be achieved at 800Hz if constant velocity is desired.

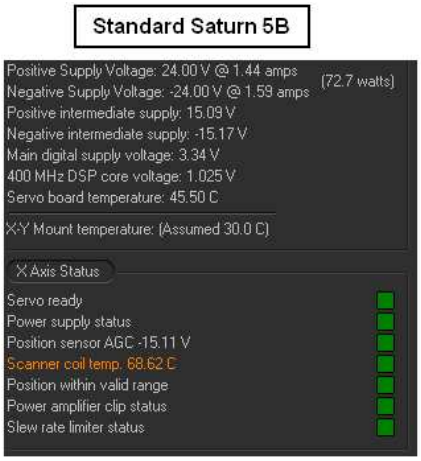
The Saturn 5B and Saturn 9B scanners were driven with ScannerMAX Mach-DSP servo driver having +/-24V rails. This servo driver is capable of driving two scanners (dual axis driver) and it is in a compact package. For convenience and for low heat dissipation by the servo driver, it is designed to have a single-ended power amplifier. This means that the power amplifier can only deliver approximately +/-21 volts to the galvo coils.

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. 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 “velocity” (first derivative of position). The green trace shows the coil voltage.

For all of the testing, we drove the input command signal using a function generator capable of generating triangle-wave waveforms. You will notice that the input command signal often 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 depends on the scanner tuning, and thus, the –3db bandwidth of the servo system.

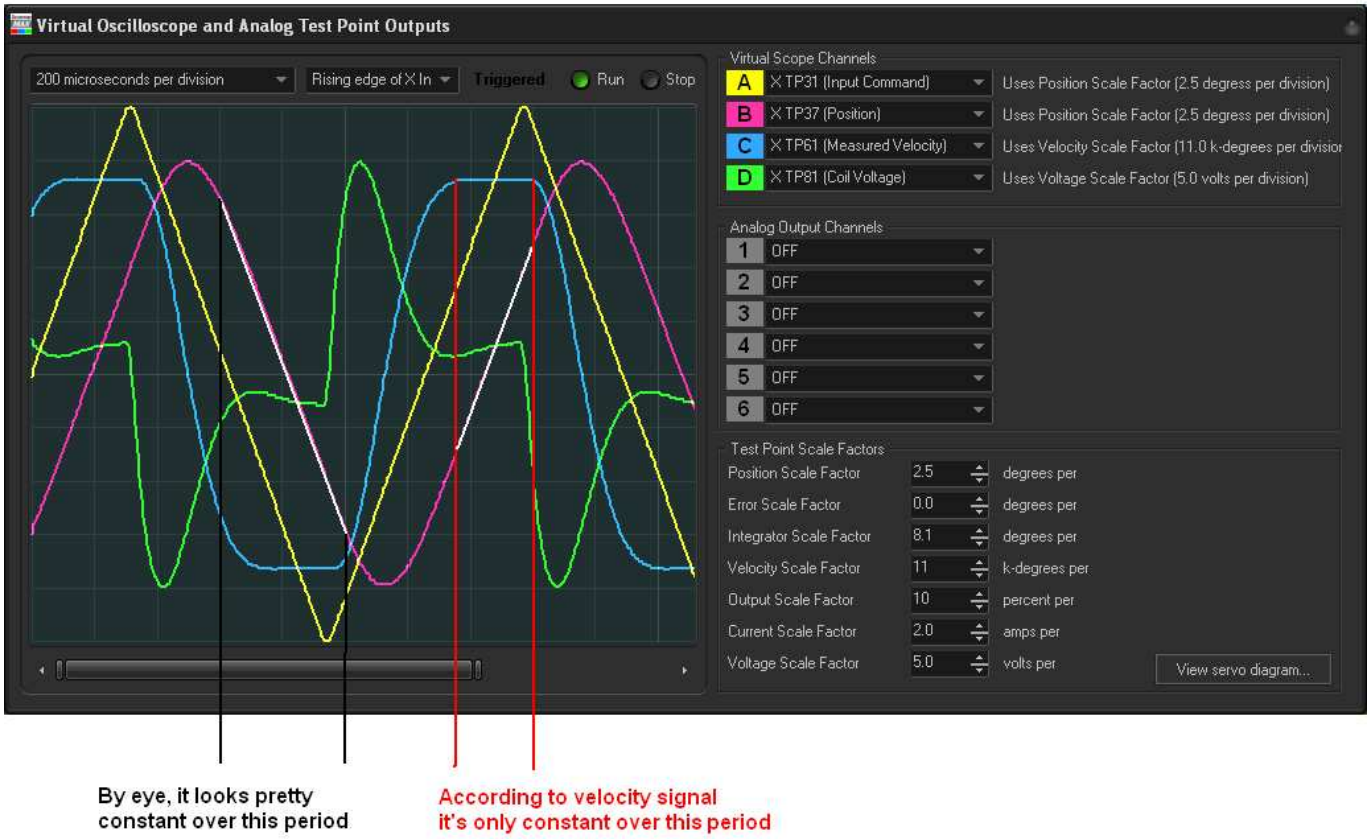
800Hz triangle wave at 40 degrees optical peak-to-peak

The scope screen shot below shows the results with a 800Hz triangle waveform scanning 40 degrees optical peak-to-peak, and using a standard triangle-wave command input. Note that the command input is 50-degrees peak-to-peak, and yet the scanning only achieves 40 degrees peak-to-peak. This is because – in order to prevent saturation of the power amplifier, relatively low servo-gains must be used. Also note that out of the 40 degrees optical peak-to-peak scanning of the mirror, the velocity of the mirror is only constant for approximately half of this scan angle.



Scanner dissipates 39 watts

Power amplifier dissipates 28 watts



By eye, it looks pretty constant over this period

According to velocity signal it's only constant over this period

Electrical Power Consumption and Coil Temperature for the scanning described above

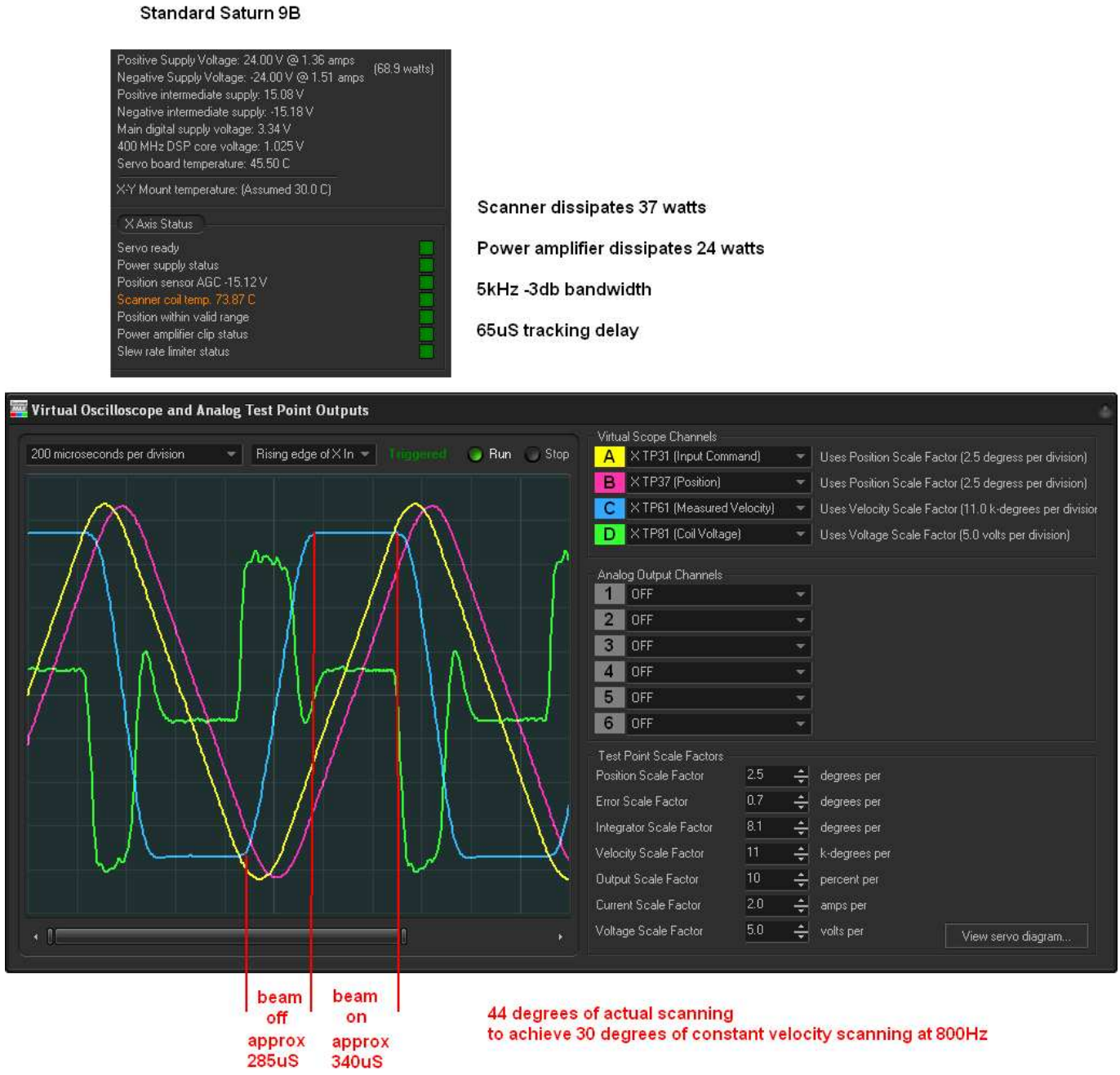
The Mach-DSP PC Application also allows for the monitoring of electrical voltage and current (and resulting electrical power) as well as the coil temperature, and various other system-health-related parameters.

As you can see in the screen shot above, with the 800Hz triangle wave signal input as shown above, the electrical power consumption is 72.7 watts and coil temperature reaches around 69 degrees C, assuming the body of the scanner is maintained at 30 degrees C.

To accomplish this scanning, the Saturn 5B scanner itself will be generating 39 watts of heat, and the power amplifier portion of the Mach-DSP will be generating 28 watts of heat, all of which the customer will need to remove. This heat is generated for the portion of time that the scanner is performing this scanning action. Once scanning action ceases (for example during idle periods), the heat generation also ceases.

800Hz triangle wave at 30 degrees optical peak-to-peak (44 degrees of actual scanning)

With our standard Mach-DSP with single-ended power amplifier, it turns out to be impossible to achieve 800Hz triangle wave scanning at 40 degrees peak-to-peak, while maintaining constant velocity throughout the scan. (It would be possible using a Mach-DSP with H-bridge, but power consumption and heat dissipation both increase dramatically, perhaps beyond the level the customer wants to deal with…) However, by switching to our Saturn 9B scanner, and also by using a rounded triangle-wave command instead of a standard triangle-wave command input, we are able to achieve optical scanning of 30 degrees optical peak-to-peak at 800Hz. This is shown below.



Using the Saturn 9B and our standard 5mm mirror set, actual scan amplitude of 44 degrees is needed to accomplish 30 degrees with constant velocity.

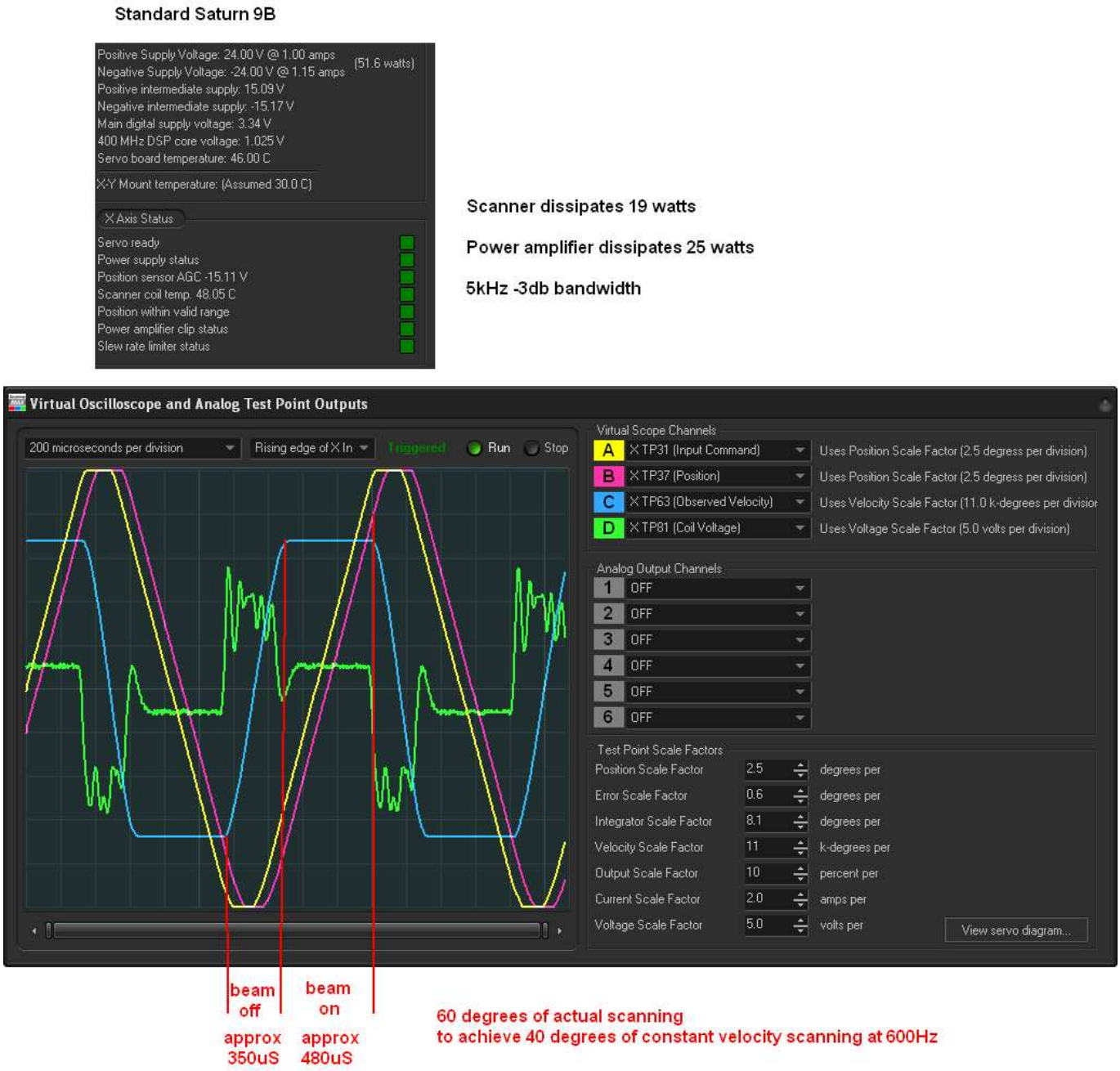
Electrical Power Consumption and Coil Temperature for the scanning described above

As you can see in the screen shot above, with the 800Hz triangle wave scanning at an actual scan angle of 44 degrees optical peak-to-peak, the electrical power consumption is 68.9 watts and coil temperature reaches around 74 degrees C, assuming the body of the scanner is maintained at 30 degrees C.

To accomplish this scanning, the Saturn 9B scanner itself will be generating 37 watts of heat, and the power amplifier portion of the Mach-DSP will be generating 24 watts of heat, all of which the customer will need to remove.

600Hz triangle wave at 40 degrees optical peak-to-peak

If 40 degrees optical peak-to-peak scanning is needed with constant velocity, this is possible by reducing the frequency to 600Hz. Although not visible in this screen shot, a rounded triangle wave command signal is also used here.



Using the Saturn 9B and our standard 5mm mirror set, actual scan amplitude of 60 degrees is needed to accomplish 40 degrees with constant velocity.

Electrical Power Consumption and Coil Temperature for the scanning described above

As you can see in the screen shot above, with the 600Hz triangle wave scanning at an actual scan angle of 60 degrees optical peak-to-peak, the electrical power consumption is 51.6 watts and coil temperature reaches around 48 degrees C, assuming the body of the scanner is maintained at 30 degrees C.

To accomplish this scanning, the Saturn 9B scanner itself will be generating 19 watts of heat, and the power amplifier portion of the Mach-DSP will be generating 25 watts of heat, all of which the customer will need to remove.

Conclusions

Using a ScannerMAX Saturn 9B, along our standard Mach-DSP driven with +/-24V power supply, and our standard mirror set configured for scanning 5mm beams through a 60-degree optical scan angle, we are able to meet the customer's demands. Electrical power consumption is reasonable. The customer will need to take care to manage the heat generated by both the servo driver and scanner.

A customized mirror set that is designed for the smaller scan angle would deliver better performance, with less heat and lower power consumption compared with the standard mirror set used during this test.

An entire article is available that covers the **Use of Galvanometer Laser Scanners for Raster Imaging Applications**. This article goes into great lengths to describe various scan scenarios, scanner tuning for raster applications, and why the rounded triangle wave is beneficial. Be sure to request this article from the ScannerMAX division of Pangolin.