ScannerMAX Saturn 1B scanning a 1kHz pattern with a 3mm beam at 8 degrees

This is a test of the ScannerMAX Saturn 1B scanner with the standard ScannerMAX 3mm mirror set, being driven by our ScannerMAX Mach-DSP servo driver.

The scanning waveform essentially creates a “plus sign” shaped projection, which is accomplished using a pair of modified sawtooth waveforms. For this particular application, the “plus sign” pattern projection would desirably be refreshed 1000 times per second. However, due to the “two phase” nature of the X and Y waveforms, the rise-time and fall-time of the each of the X and Y waveforms corresponds to the equivalent of a 1.67kHz sawtooth waveform for each axis.

The scanning being performed in these tests uses only a 8 degree scan angle, although the standard 3mm mirror set being used in this test is capable of scanning up to 60 degrees optical. Therefore somewhat better performance could be derived from a mirror set customized for the 8-degree angle. Alternatively, a slightly larger beam could be used on this stock mirror set.

The Saturn 1B is available in several coil configurations. The “standard” coil configuration was used for this test. If lower power supply voltages are desired (for example +/-15V), then our Saturn 1B-80S coil configuration might be a better choice. This would result in less heat being generated by the scanners because the KM (a measure of how a motor generates motion while not generating heat) is higher in the –80S coil configuration. Nevertheless, it’s not the best choice in all cases, and so each application must be examined and considered separately.

For convenience and for low heat dissipation by the servo driver, the Mach-DSP uses a single-ended power amplifier – not an H-bridge as is the case for some of our competitors. As it turns out, this particular application can not benefit from an H-bridge anyway, and if an H-bridge were used with the same power supply voltages, then the heat generated by the servo driver would be four times that seen in this report.

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 shots below show four separate channels being measured. In the most important screen shots, the yellow trace shows “X Input command” and the pink trace shows “Y Input Command”. The blue trace shows “X Position” and the green trace shows “Y Position”. (Note that Input and Position are in mechanical degrees, thus, optical scan angle is double that shown in the traces).

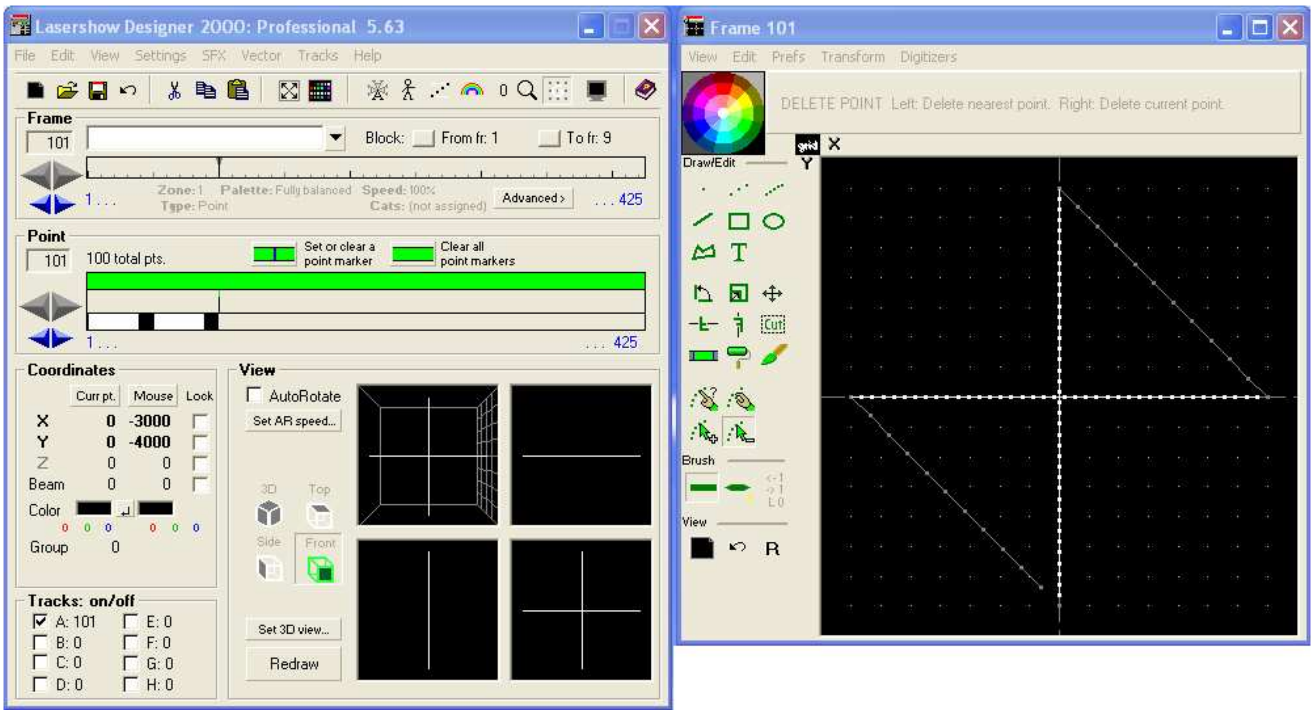
For all of the testing, we drove the input command signal using our graphic software, which is capable of generating the required “plus sign” shape, which is essentially created by a pair of modified sawtooth waveforms.

“Plus sign” pattern generation

For this testing, the plus-sign pattern is being generated by Pangolin’s LD2000 software.

The point output rate (aka “sample rate”) was set to 100,000 points per second.

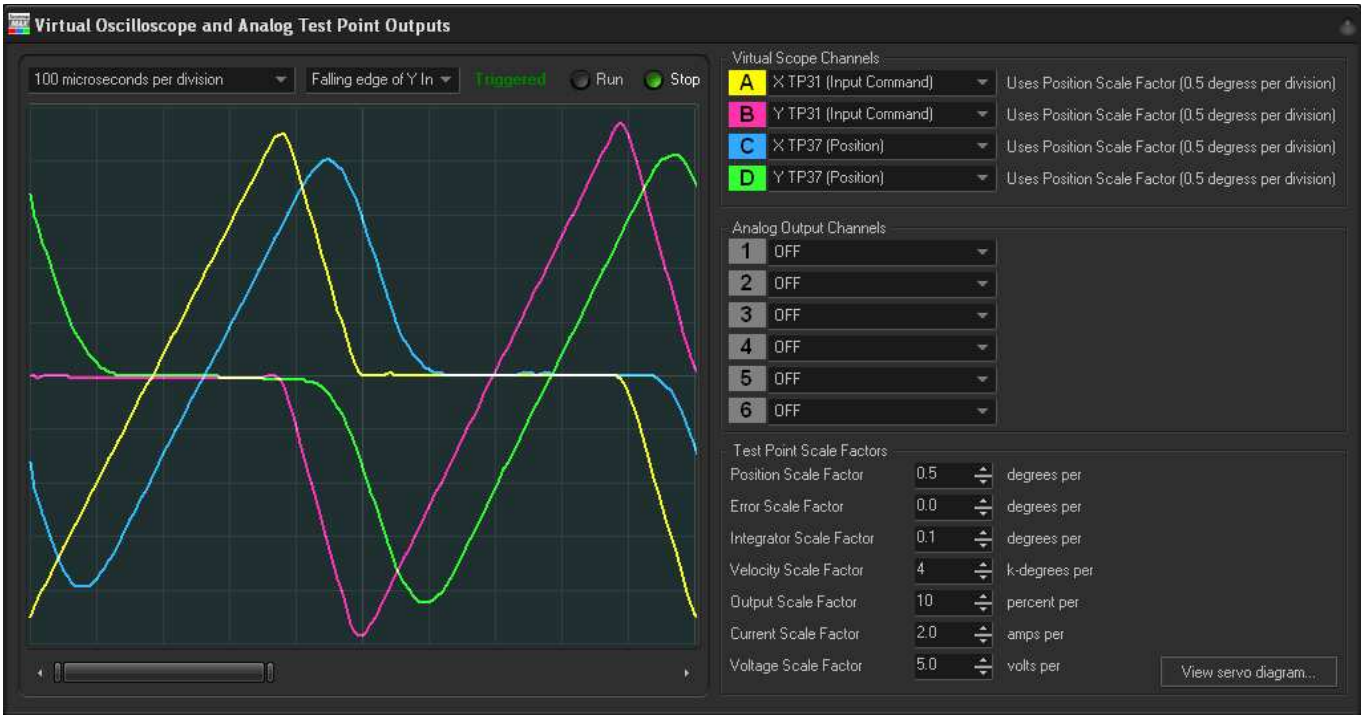
There are 40 points in each “trace” portion, and 10 points in each “retrace” portion. With the entire pattern being defined in a total of 100 points, it means that the refresh rate for the pattern is 1000 refreshes per second.



Note that no “wait states” (aka “corner points”) were used in this particular pattern.

Sawtooth input with no “wait states”

The scope screen shot below shows the results. This was using our standard “60K” tuning, which corresponds to a small signal bandwidth of 5kHz.

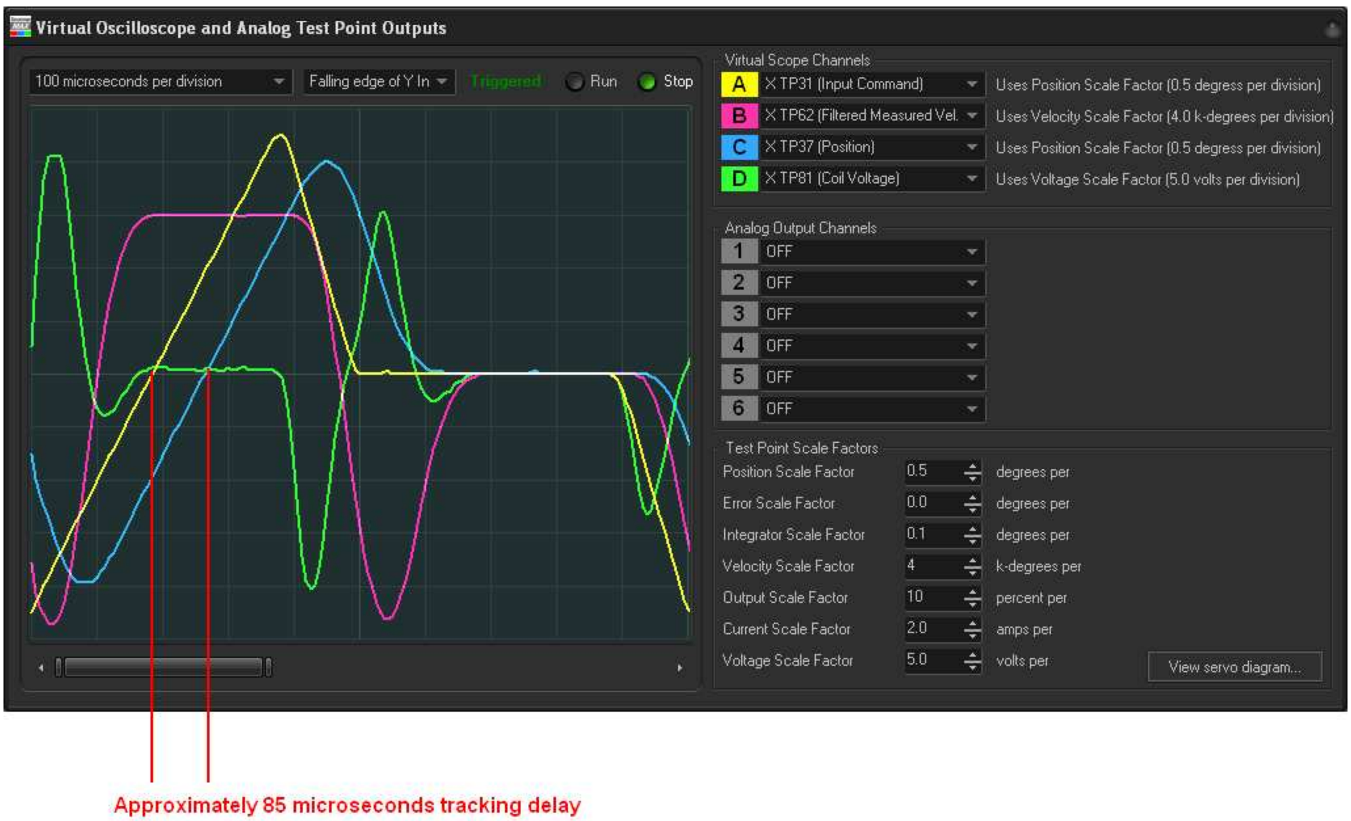


It can be seen that the X and Y input command waveforms (yellow and pink traces) are larger in amplitude than the X and Y position waveforms (blue and green traces). This is because the servo system acts as a low-pass filter (5kHz low-pass with this particular tuning). This also essentially means that the resulting position waveforms are “rounded” when compared the command waveforms.

The scope screen shot below shows only the X axis, but in this case the pink trace corresponds to scanning velocity, and green trace corresponds to coil voltage.

It is handy to look at scanning velocity and make sure that it is flat (constant velocity), during the “trace” portion of the waveform. This also helps to evaluate amount of time spent transitioning between “trace” and “retrace”.

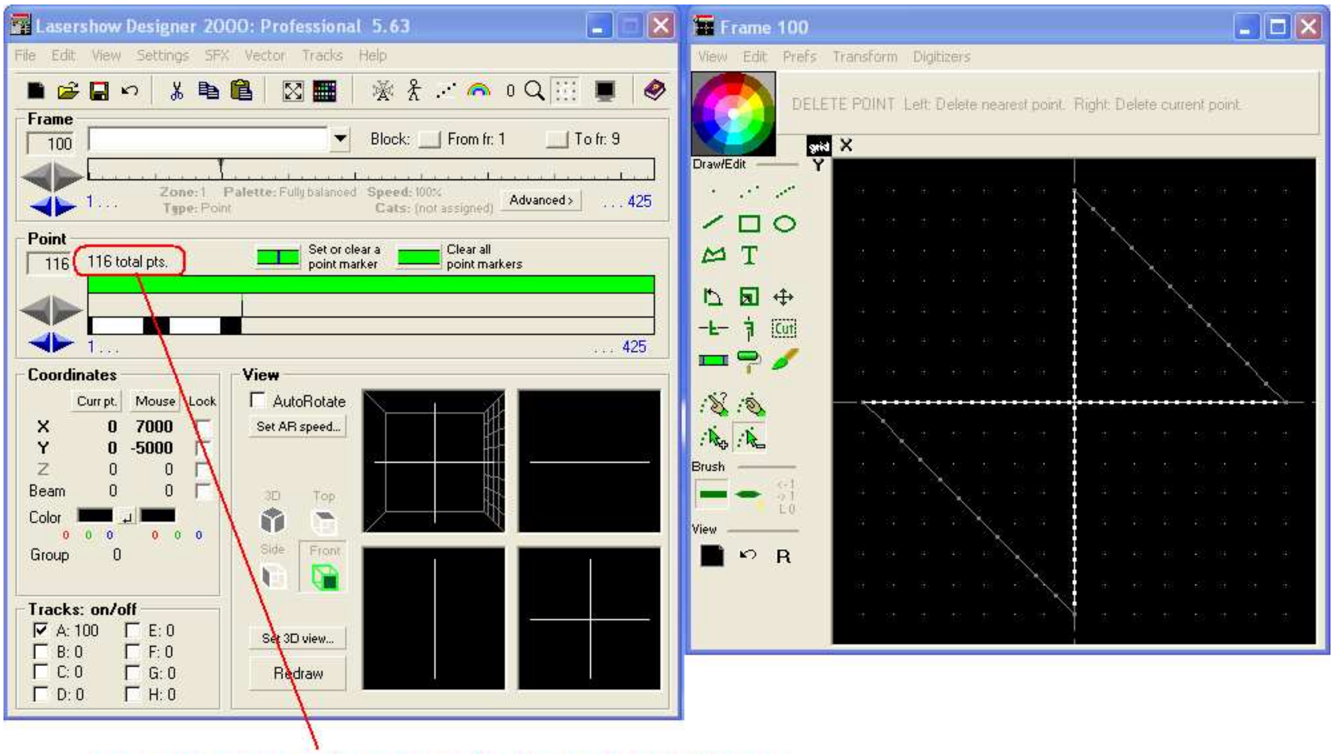
The green trace shows that the coil voltage is already clipping against the power supply rails, and thus no greater performance could be had with this particular waveform and this particular tuning.



Better performance by adding "wait states"

The data points were adjusted in LD2000, providing an additional 4 "wait states" at each corner.

Note that in this case, the actual slewing of both the "trace" and "retrace" remain the same, but now the entire scan pattern takes just a bit longer.

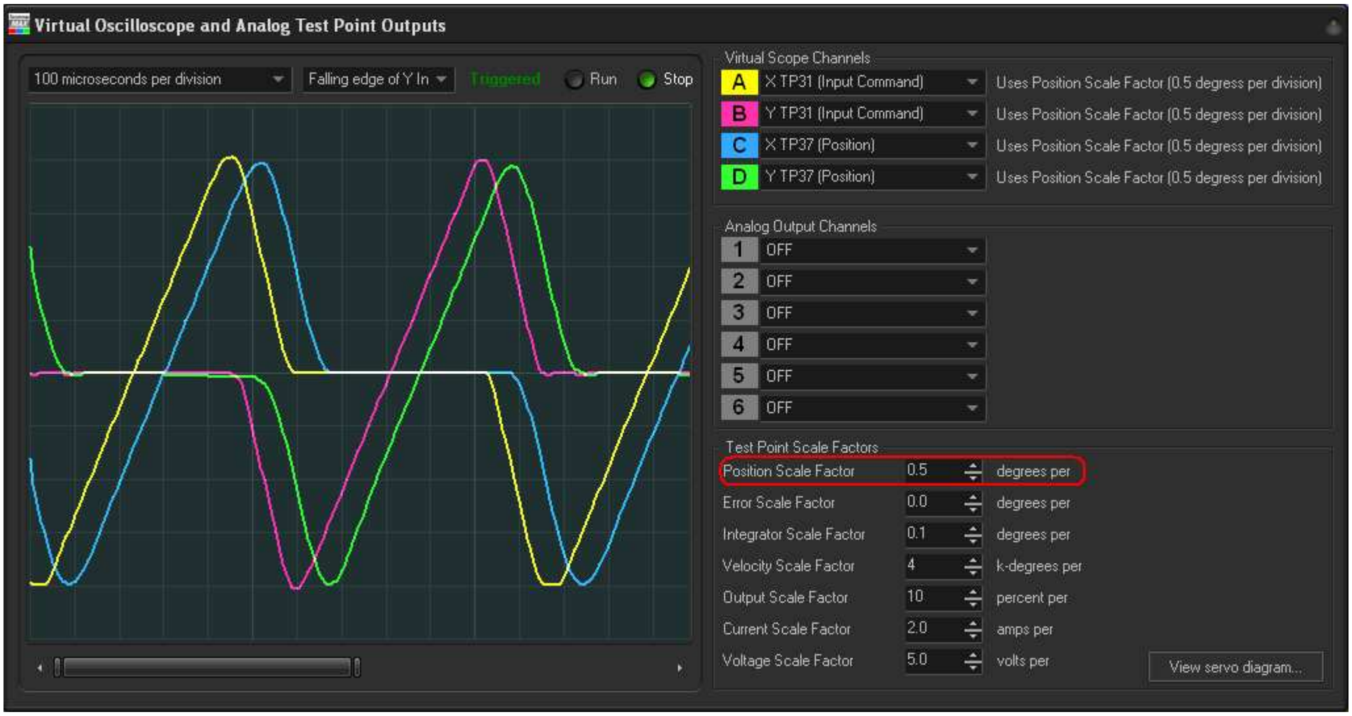


With "wait states" added, at a point output rate of 100,000 points per second, the whole pattern now requires 1.16mS

Sawtooth input with "wait states"

The scope screen shot below shows the improved results with "wait states" added. (Servo tuning was also changed, as explained further below.)

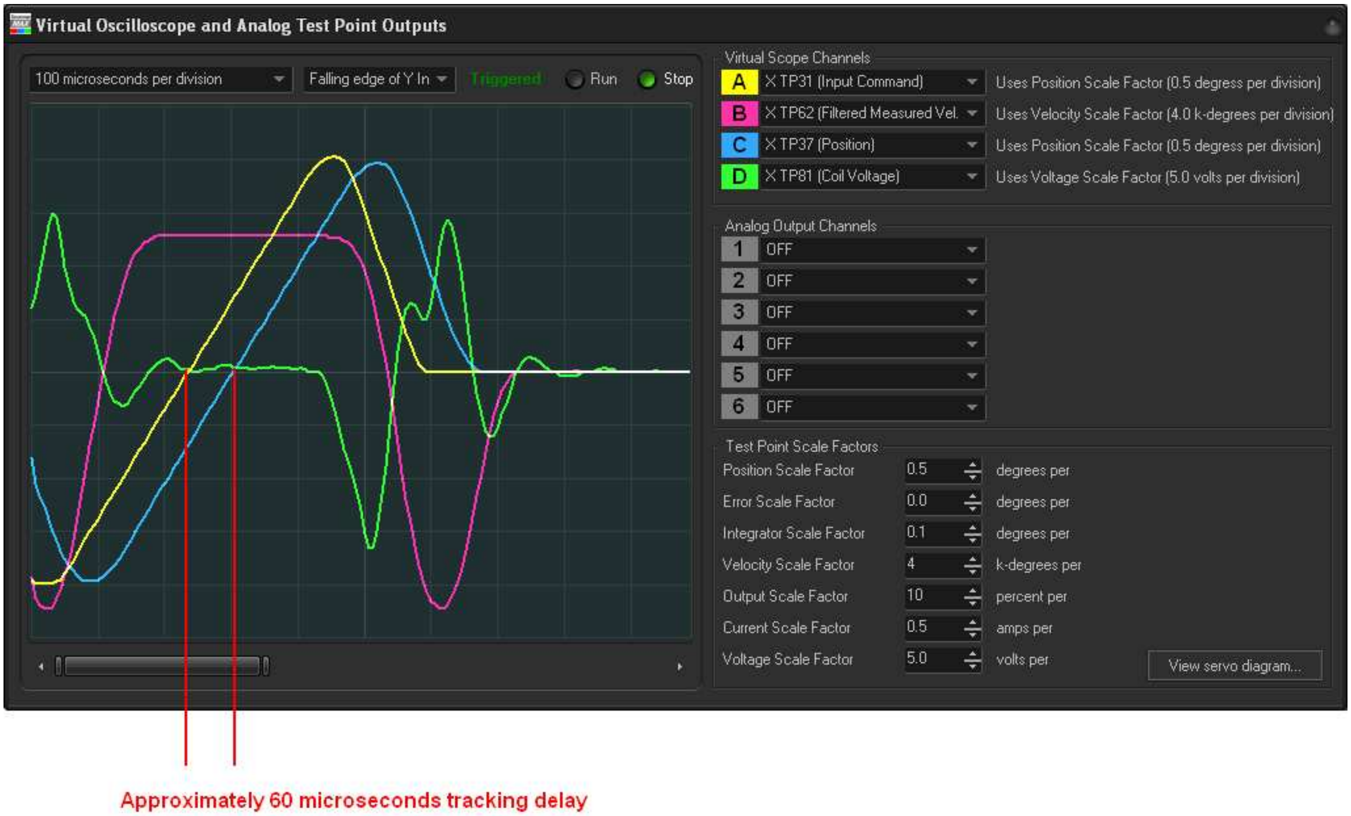
Note that the Input and Command waveforms don't really show a "flat top" nature of the wait-states. This is because the Mach-DSP servo driver has a 20kHz low-pass anti-aliasing filter at its front end, and because of this, it naturally creates some rounding action on high-frequency input command signals.



Unlike the first set of tests, it can be seen that the X and Y input command waveforms (yellow and pink traces) are much closer in amplitude than the X and Y position waveforms (blue and green traces). This is because the servo system acts as a low-pass filter, but the servo gain was increased, raising the small-signal bandwidth of the servo system. Clearly in this configuration, although "wait states" were added, the resulting position waveforms are far less "rounded" than they were in the configuration above.

The scope screen shot below shows only the X axis, but in this case the pink trace corresponds to scanning velocity, and green trace corresponds to coil voltage.

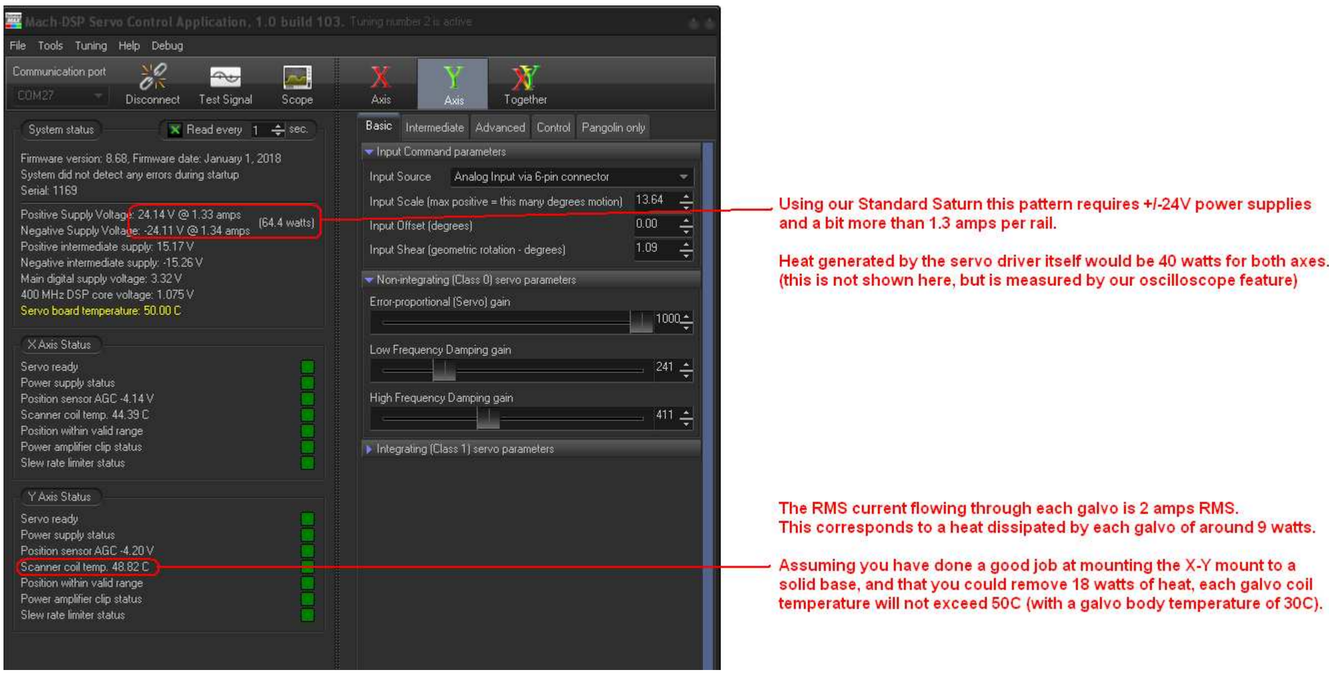
Thanks to the wait states being added, the green trace shows that the coil voltage is no longer clipping against the power supply rails. This allowed servo gain and damping to be increased, which increased the small-signal bandwidth of the system. Tracking delay was also reduced from around 85 microseconds to around 60 microseconds.



As seen with the built-in Dynamic Signal Analyzer feature of the Mach-DSP, the Small signal bandwidth is now around 7.5kHz, which is certainly very high for any galvo scanner.

Power supply requirements and heat generation

The Mach-DSP also continually monitors power supply requirements and heat generated by both the servo driver and scanners, all in real time. Below is a screen shot of the main window of our Mach-DSP software.



For the performance seen immediately above, +/-24V power supplies are required when using the Standard Saturn 1B. Power supply current is 1.33 amps per rail, which corresponds to an overall power supply requirement of 64.4 watts of electricity.

The servo driver has a Class AB power amplifier stage. When creating this particular plus-sign-shaped projection at 1000 refreshes per second, the servo driver will need to dissipate a total of 40 watts of heat.

The RMS current flowing through each galvo was almost exactly 2 amps. Given the 1.8 ohm (cold) coil resistance of the standard Saturn 1B, heat generated by each scanner is 9 watts.

As long as there is sufficient metal to which both the servo driver and X-Y scanner mount can be bolted, heat should be tolerable.

Conclusions

It is clear that standard Saturn 1B will perform well in this particular application. It is also clear that modifying the sawtooth waveform providing “wait states” improves the results of the servo driver and scanner, while also reducing heat generated by the scanner as well as power supply requirements.

Heating of the servo driver and scanners is certainly manageable, but the customer will need to take care in the mounting of both the servo driver and the X-Y scanner mounting block.