ScannerMAX Compact 506 scanning various steps using our 10mm Y-axis mirror

This is a test of the ScannerMAX Compact 506 scanner with our standard ScannerMAX 10mm Y-axis mirror, being driven by our Mach-DSP servo driver. This report is generated in response to a customer inquiry about the time to execute small steps with this configuration.

To give some background information, the Compact 506 is a tiny scanner. It is no larger than the tip of your finger. It was designed to be a low-cost, lightweight, and versatile scanner. We stock mirror sets in apertures ranging from 3mm up to 10mm, and our customers routinely use the Compact 506 to drive their own mirrors greater than 1-inch (25mm) in diameter.

Below is a picture of the Compact 506 with our 10mm Y-axis mirror, along with a credit card for a size reference. The scanner with mirror weighs less than 13.5 grams!

The Compact 506 scanner itself can be purchased for $175-$200 in quantity of 1 piece. Competitors' galvos that are intended for 10mm scanning applications are typically many times the size, many times the weight, and many times the cost of our Compact 506.

It should be understood that the Compact 506 was intended to be a versatile scanner, not a high-performance scanner. For applications requiring the utmost performance, we offer our Saturn-series of scanners, which offer the highest performance in the industry. However, the increased performance comes along with an increase in cost, size and weight.

Note that although this report concentrates on only small steps, the mirror attached to this scanner is capable of moving a 10mm beam through a 40-degree projection angle. Therefore if the application can tolerate a smaller mirror, step times can be faster.

The Mach-DSP used in this report was powered by our standard +/-24V power supply, which we also offer for sale.

Built-in tools

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 three separate channels being measured. In the most important screen shots, the yellow trace shows “Y Input command”; the pink trace shows “Y Position”; and the blue trace shows “Y Position Error”. Note that Input and Position are in mechanical degrees, thus, optical scan angle is double that shown in the traces. Also note that the Position Error is shown as 1/100th of a degree of error per division.

Step-time versus rise-time: Beware of how companies specify and may exaggerate claims!

There are, unfortunately, a variety of ways in which “step times” are quoted by some galvo manufacturers. Some companies use the equivalent of “rise time”, which would be the time that the position signal takes to go from 10% of the move to 90% of the move. This is of course a much much shorter amount of time than the true “step time”, which we believe extends from the very beginning of the move until the time that the mirror comes to a complete stop. Because of the variety of methods that manufacturers use to describe “step time”, we are showing the oscilloscope screen shots below so you can judge for yourself. For ease of visualization – since Position Error is shown at 1/100th of a degree per division, below we note the time to settle to within 1/100th of a degree of the final position.

Servo types and tunings

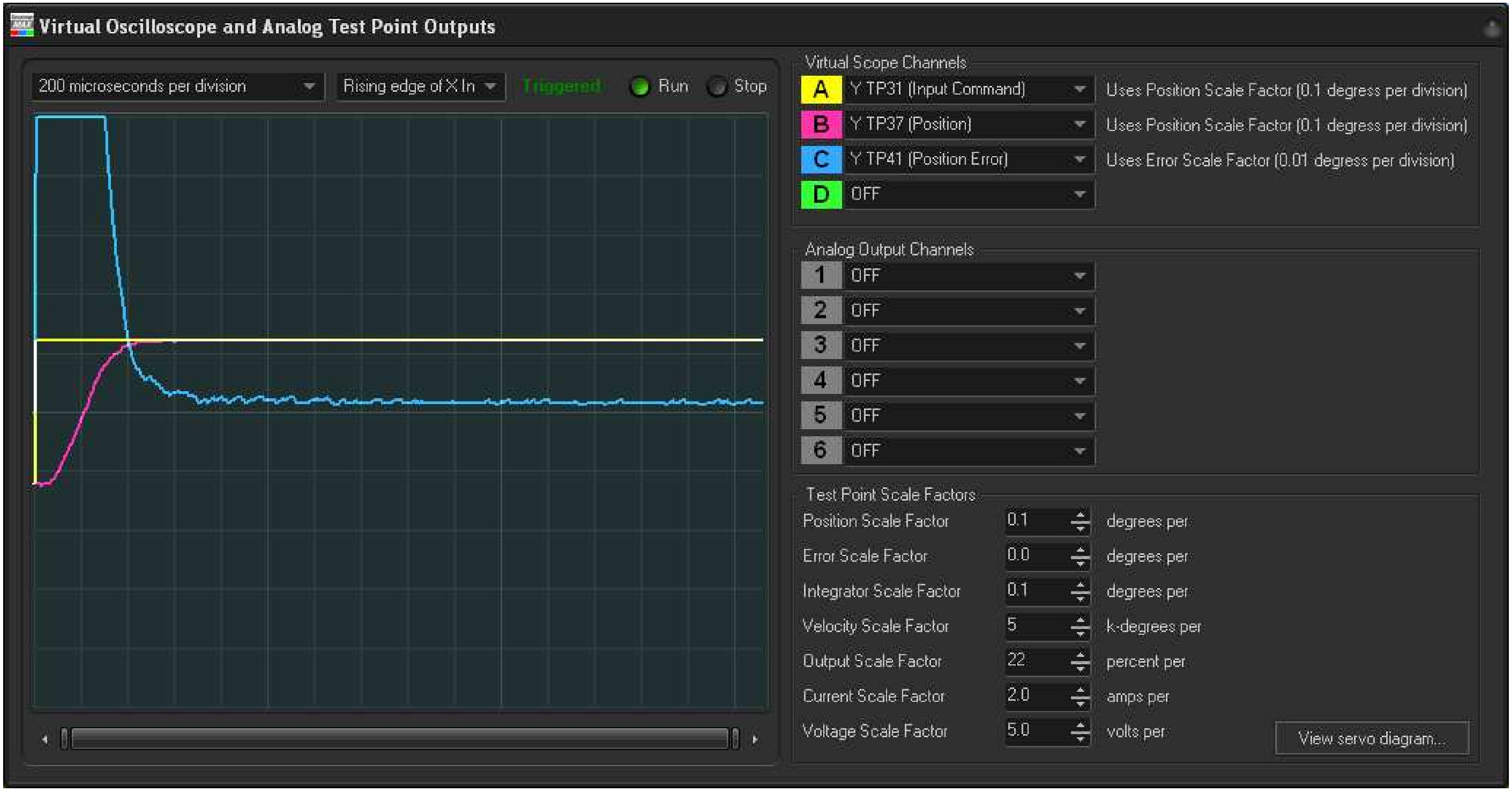
There are a variety of servo drivers. Most of the servo drivers that serve the galvanometer scanner industry are simple analog servo drivers, that implement what’s called “PD” servo control laws. PD stands for Position and Derivative, which is a simple and robust way of driving galvo mirrors. Unfortunately PD has the drawback of allowing some amount of steady-state error to exist. This generally means that the mirror will never truly achieve the commanded input position. For applications that do not require absolute position accuracy, PD may be fine.

In order to completely eliminate the steady-state error, an integrator may be added into the control loop. This is referred to a PID, indicating Proportional, Integral, and Derivative, however most servo drivers used on galvanometers do not use the classic PID construction. Instead, most implement an alternative called PDF (Pseudo Derivative Feedback), which allows the integrator to be operated a high gain, to drive the steady-state error to zero much more quickly than the classic PID approach. Nevertheless, PDF servo tuning is generally at least a bit slower than PD tuning, and therefore there is a tradeoff between speed and absolute accuracy.

There are yet other controller types. PDF can be extended with a feed-forward term, to create something called PDFF. Some companies also offer servo drivers that use state-space methods. The Mach-DSP can implement PD, PID, PDF and PDFF control laws.

The first few pages below show the results with PD tuning. The last few pages show the results with PDF tuning.

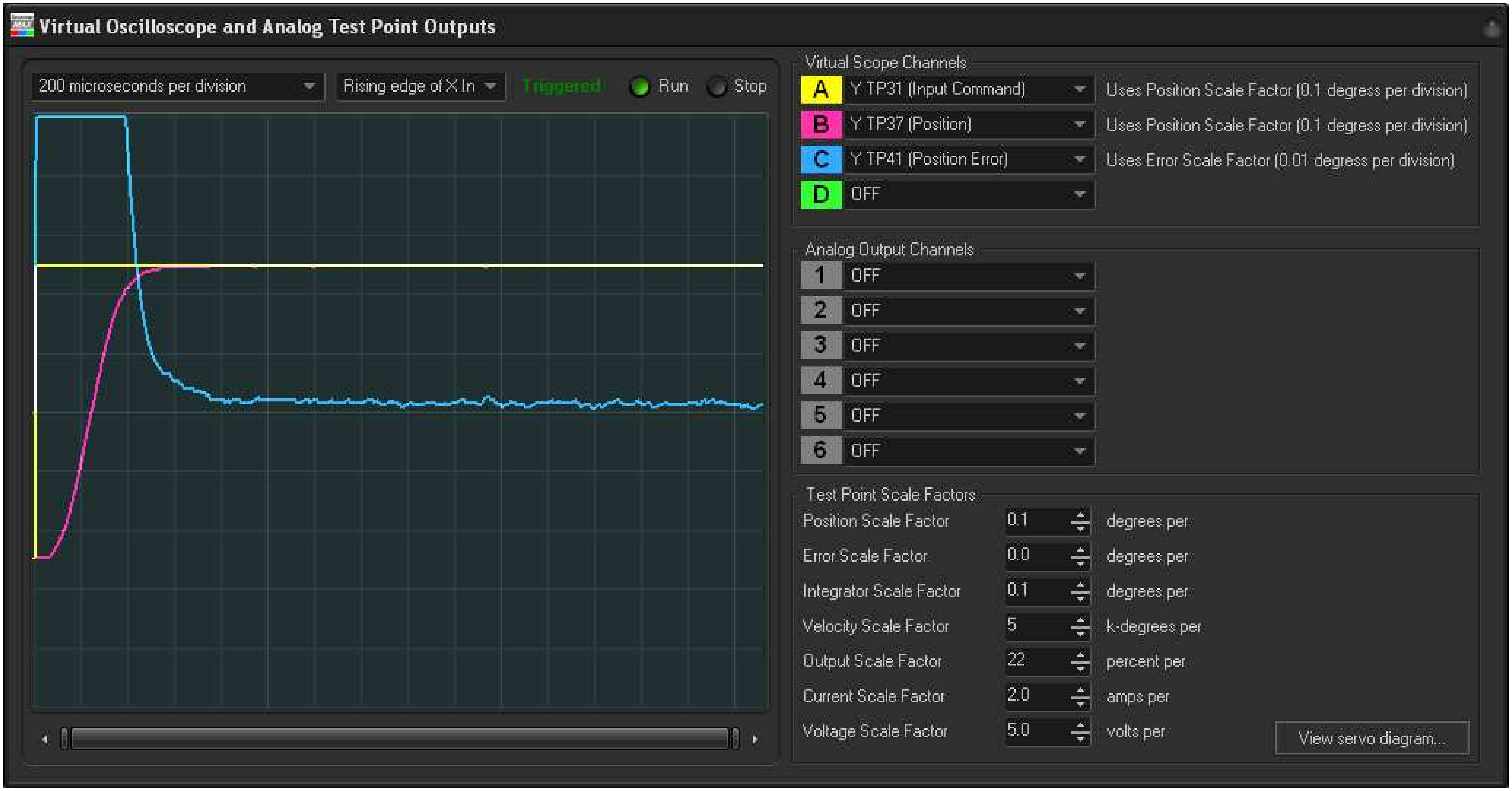
0.25 mechanical degree (0.5 degrees optical) step, with PD servo tuning



Position is settled to within 1/100th of 1 mechanical degree (0.01 degrees) within 400 microseconds. Since the step is 0.25 mechanical degrees, 0.01 degrees represents 4% of the 0.25 degrees, or 96% of the full step.

Note that since this tuning uses PD control laws, there is a small steady-state error of approximately 0.002 degrees, which is less than 1% of the 0.25 degree step size.

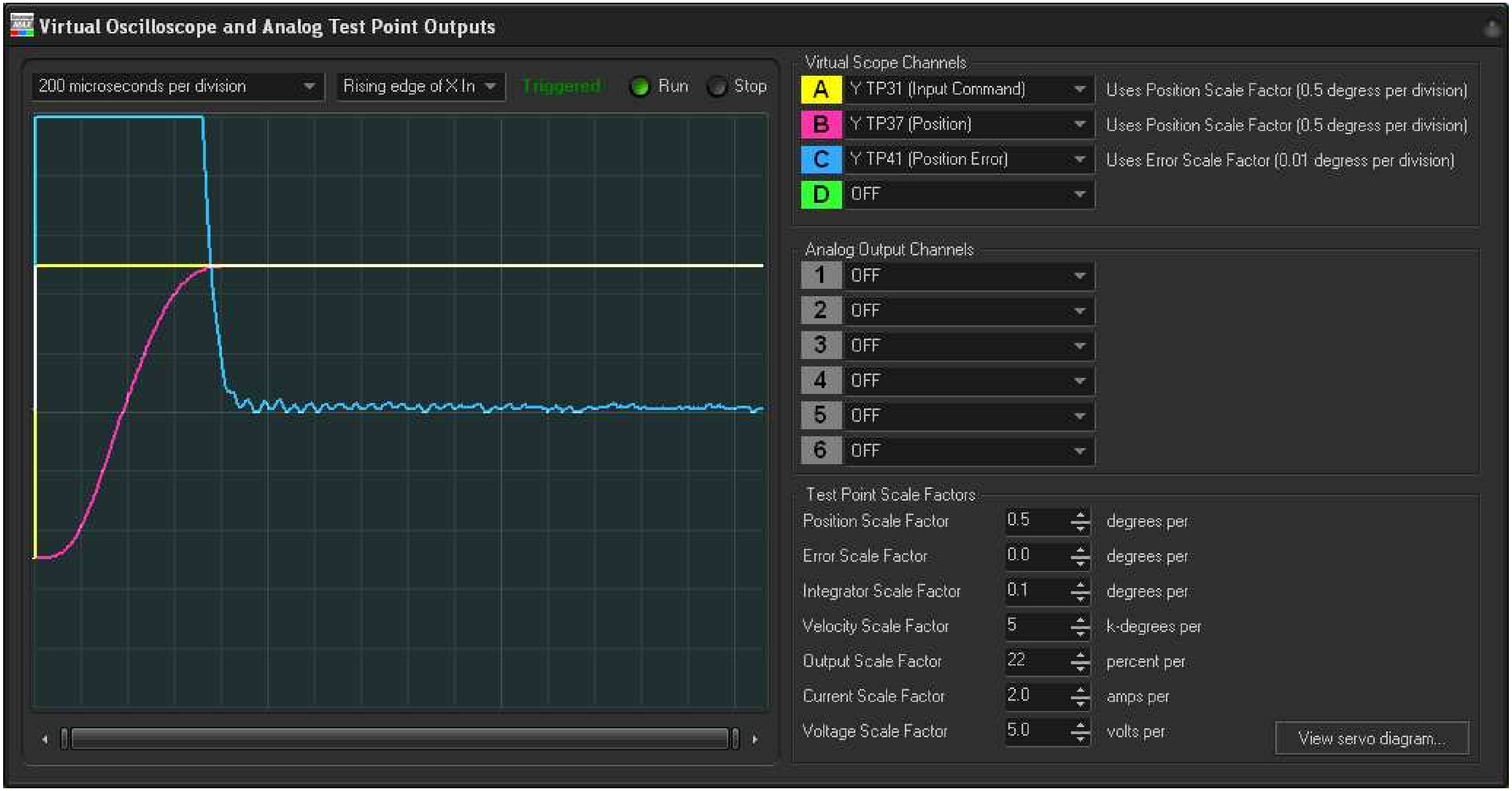
0.5 mechanical degree (1 degrees optical) step, with PD servo tuning



Position is settled to within 1/100th of 1 mechanical degree (0.01 degrees) within 500 microseconds. Since the step is 0.5 mechanical degrees, 0.01 degrees represents 2% of the 0.5 degrees, or 98% of the full step.

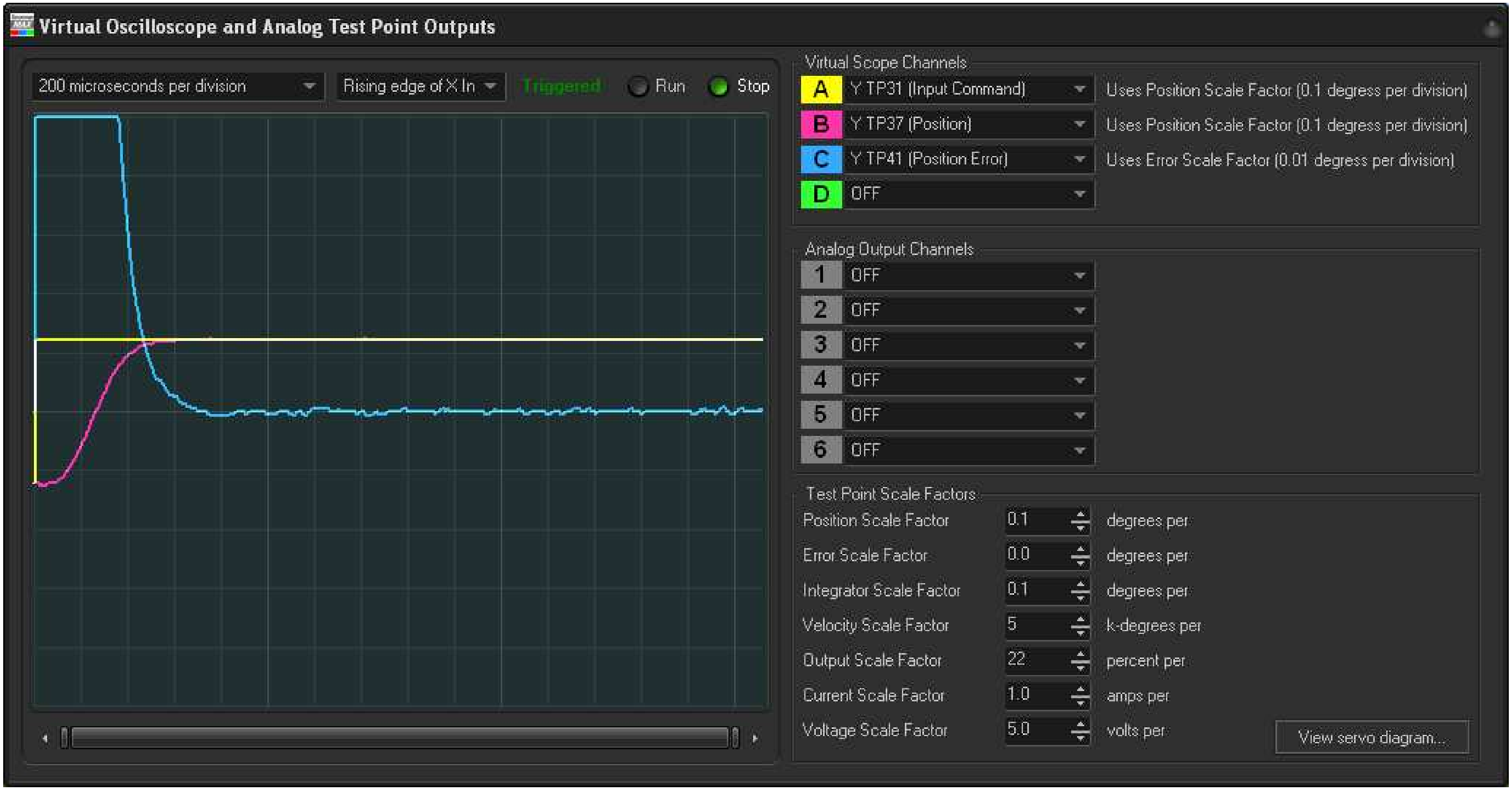
Note that since this tuning uses PD control laws, the small steady-state error of approximately 0.002 degrees is present, just as it was in the case above.

2.5 mechanical degree (5 degrees optical) step, with PD servo tuning



Position is settled to within 1/100th of 1 mechanical degree (0.01 degrees) within 800 microseconds. Since the step is 2.5 mechanical degrees, 0.01 degrees represents 0.4% of the 2.5 degrees, or 99.6% of the full step.

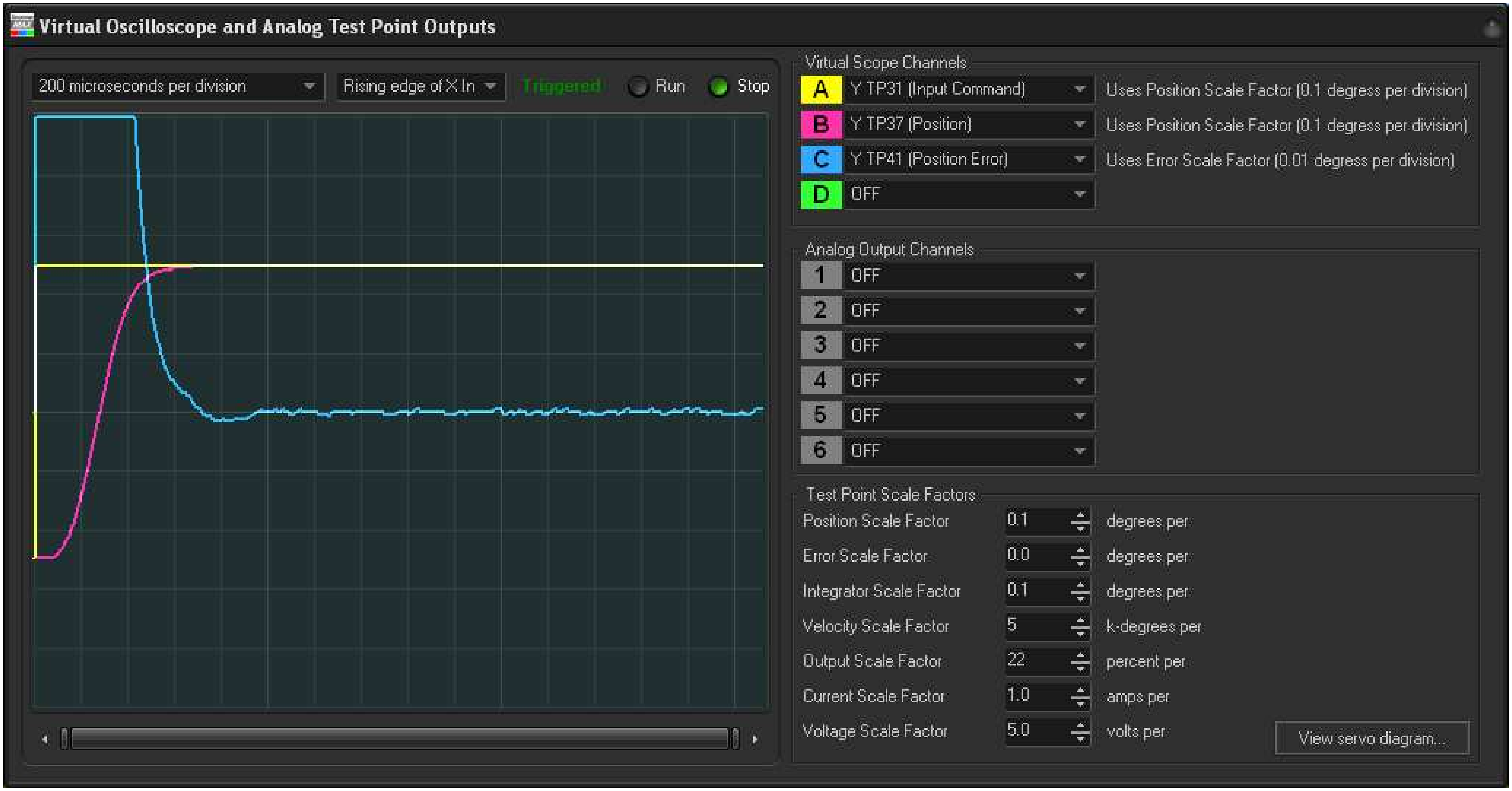
0.25 mechanical degree (0.5 degrees optical) step, with PDF servo tuning



Position is settled to within 1/100th of 1 mechanical degree (0.01 degrees) within 500 microseconds. Since the step is 0.25 mechanical degrees, 0.01 degrees represents 4% of the 0.25 degrees, or 96% of the full step.

Note that since this tuning uses PDF control laws, there is no steady-state error.

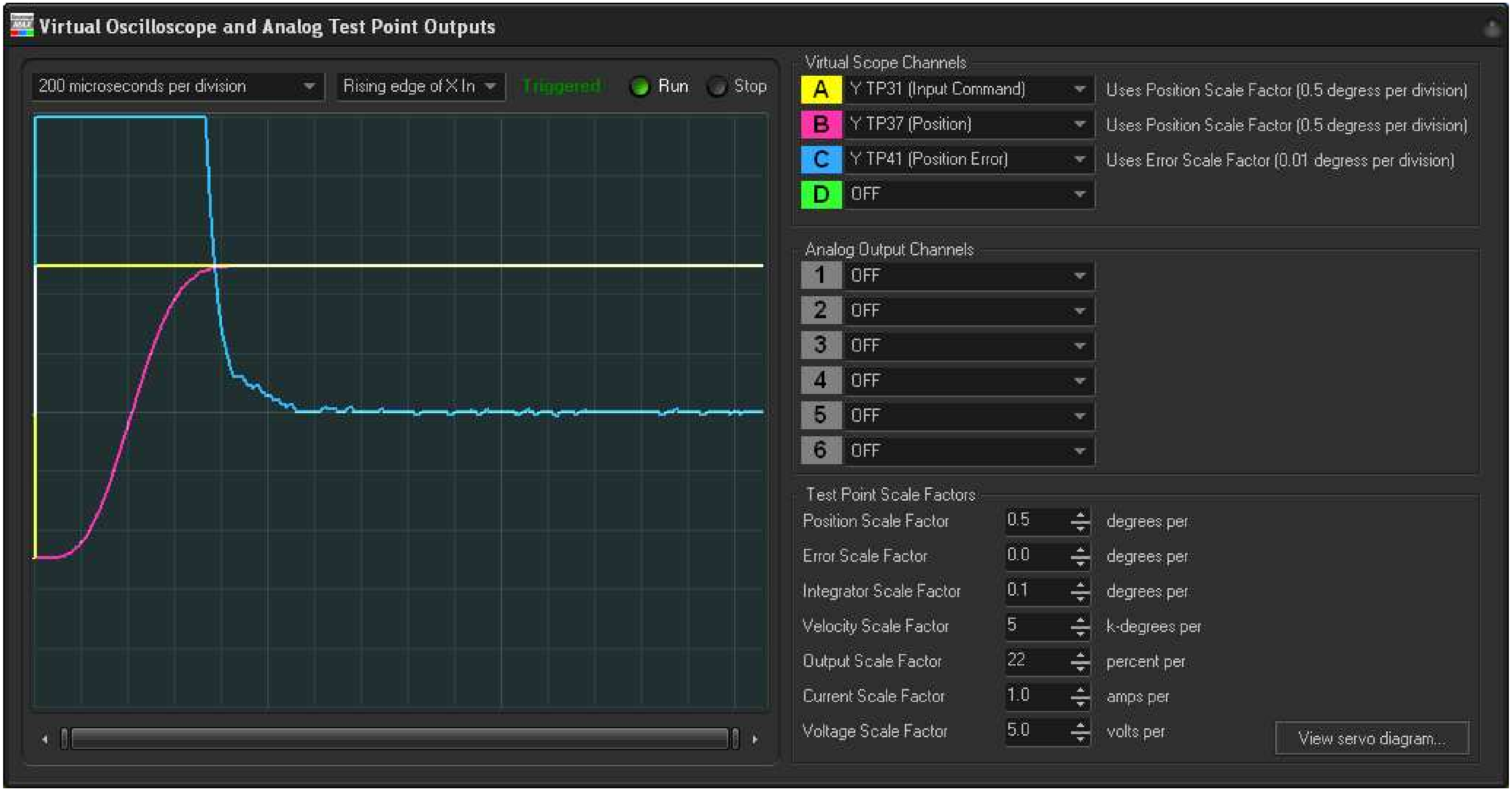
0.5 mechanical degree (1 degrees optical) step, with PDF servo tuning



Position is settled to within 1/100th of 1 mechanical degree (0.01 degrees) within 550 microseconds. Since the step is 0.5 mechanical degrees, 0.01 degrees represents 2% of the 0.5 degrees, or 98% of the full step.

Note that since this tuning uses PDF control laws, there is no steady-state error.

2.5 mechanical degree (5 degrees optical) step, with PDF servo tuning



Position is settled to within 1/100th of 1 mechanical degree (0.01 degrees) within 825 microseconds. Since the step is 2.5 mechanical degrees, 0.01 degrees represents 0.4% of the 2.5 degrees, or 99.6% of the full step.

Note that since this tuning uses PDF control laws, there is no steady-state error.

Conclusions

The ScannerMAX compact 506 is a tiny, versatile scanner that can be used to drive a wide variety of mirrors. Performance is generally acceptable for most applications, and given the small size and very low cost, the Compact 506 has found its way into a wide range of cost-sensitive applications including hand-held medical instruments, point-of-purchase displays, 3D printers, laser “cleaning” (paint removal), and autonomous vehicles.

The step times shown above are for +/-24V power supplies. Step times would be somewhat longer if the power supply voltage is reduced.

Complete information about the Compact 506, including datasheets, 3D CAD files and mount drawings can be found on the ScannerMAX web site at: www.ScannerMAX.com

A video, showing what’s included with a typical Compact 506 package along with the Mach-DSP servo driver and associated PC application software can be found on YouTube here: https://youtu.be/fEpQRhSgly8

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The Compact 506 is manufactured by the ScannerMAX division of Pangolin Laser Systems, Inc. a 34-year-old company having offices in the United States, Central Europe and Mainland China. Pangolin manufactures and licenses several lines of optical scanners, as well as software, laser projection systems and a laser diode ESD protection semiconductor called LASORB.

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