Scanning For Photonics Applications

1 - Introduction

The nPoint LC.400 series of controllers have several internal functions for use with raster scanning. A traditional raster scan can be generated via the simple Raster Scanning GUI as explained in Section 2. Additional raster scanning patterns can be generated via the arbitrary scan capability of the controller. This provides complete flexibility for the type of scanning pattern, which leads to decreased time to complete a scan.

The LC.400 controllers can also record up to 8 streams of internal data simultaneously, including voltage measurement from the BNC analog inputs. In this case, the analog inputs can be disabled for position command functionality while retaining recording capability. This is useful in applications that benefit from correlating stage sensor readings with measurements such as fiber alignment intensity. The internal recording function can sample every 24 microseconds. The rate can be adjusted to record for longer periods of time for a given buffer size. Sensor and BNC analog input values are recorded with 20 bit resolution.

In the following sections the NPXY60Z20-257 stage has been used to demonstrate the various raster scanning modes.

2 - Traditional Raster Scanning

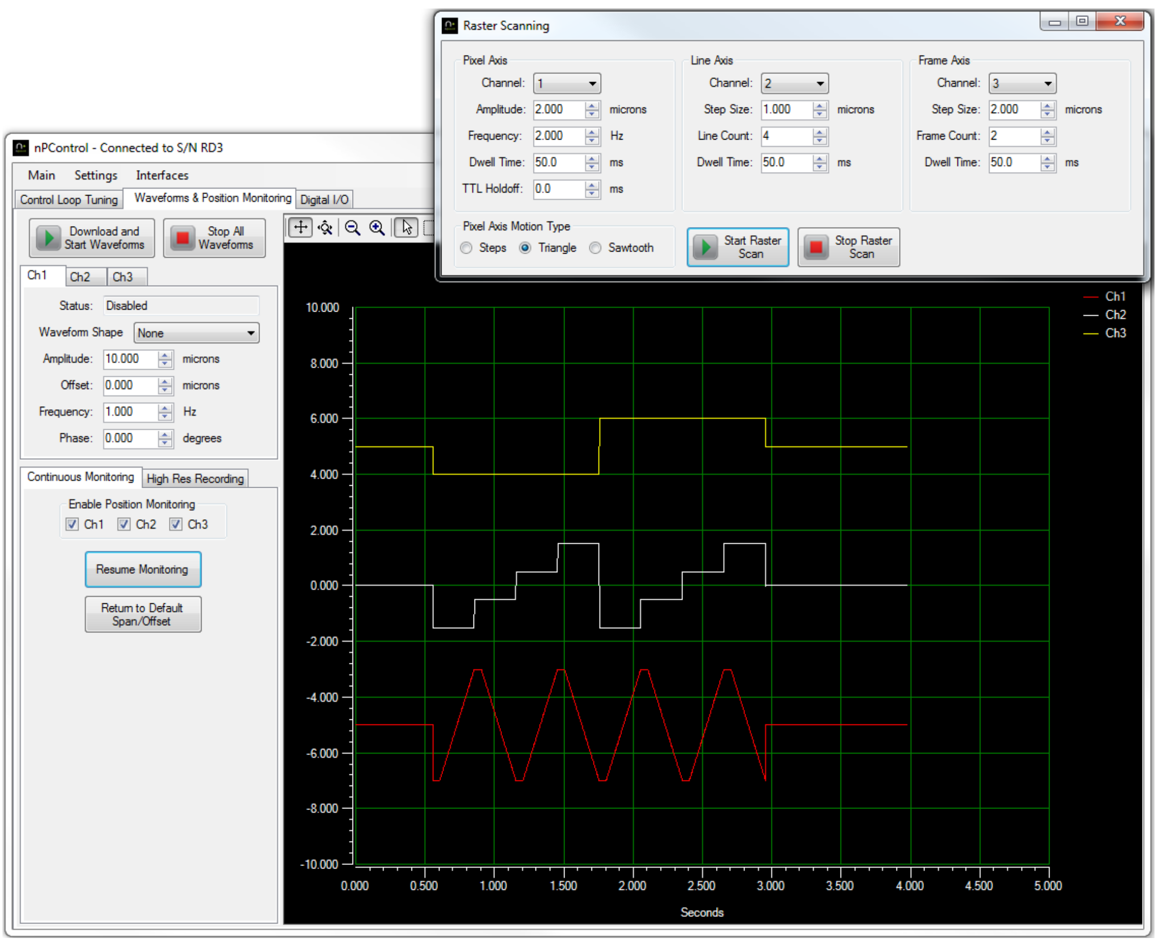

Figure 1 - Raster scanning with constant velocity in the fast axis. The Pixel Axis is red, the Line Axis is white, and the Frame Axis is yellow.

Traditional raster scanning can be run either from the nPControl PC software, or from the user's own programming application. Typically the fastest mode is for the pixel axis to scan a triangle waveform, and for data to be collected in both directions. The line axis steps each time ½ period of the pixel axis waveform completes. A dwell time can be used to allow the stage to settle each time the line axis steps.

2.1 - Traditional Raster Scan with the NPXY60Z20-257 stage

The unloaded resonant frequency of this stage is approximately 780 Hz. The control loop bandwidth can be tuned for a 240 Hz control loop bandwidth and settling time of 3.65 milliseconds (+/- 2% of step size is considered settled).

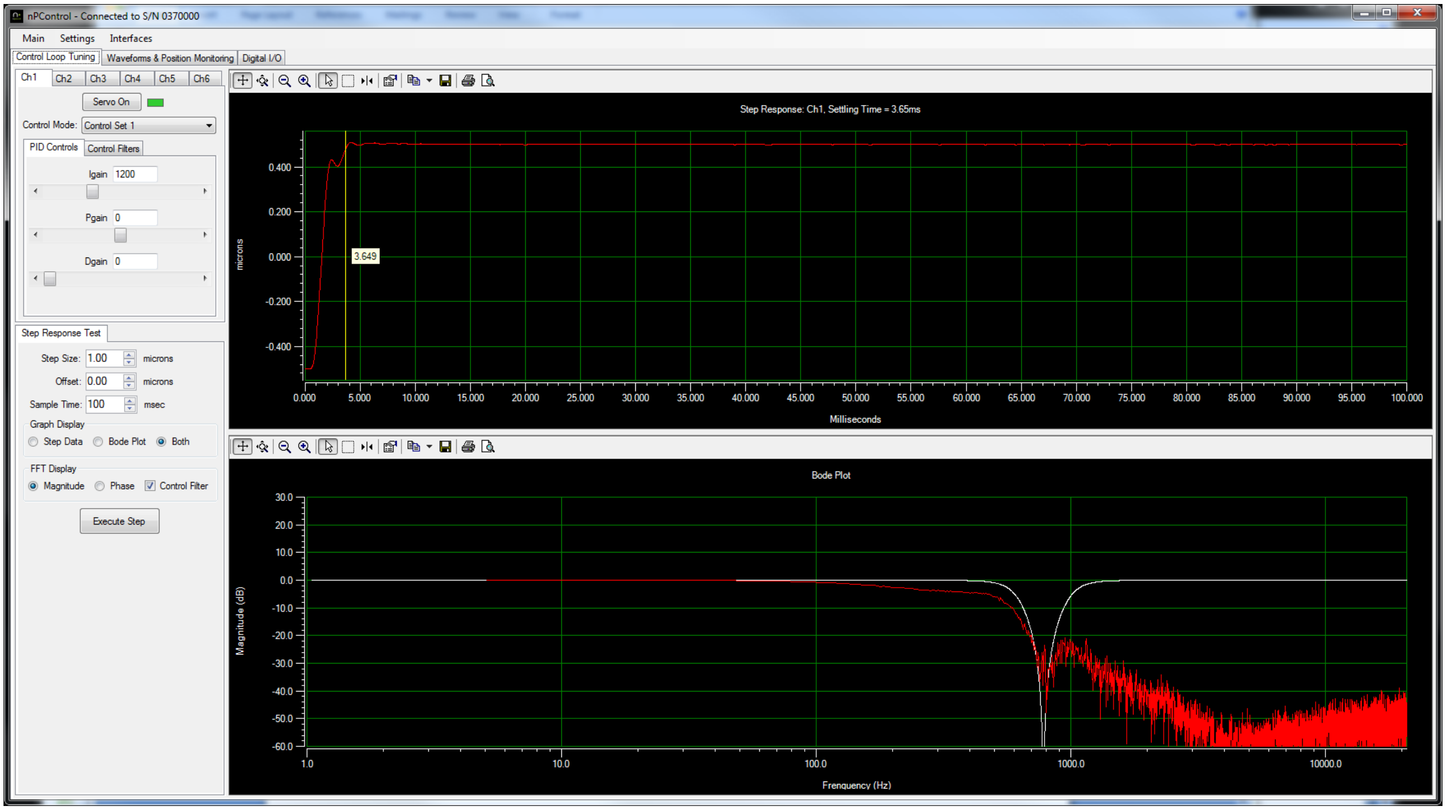

Figure 2 - NPXY60Z20-257 step response.

With a typical 100 mA piezo drive controller (more current drive capability is optional), this stage is able to scan a 50 micron by 50 micron area with a 40 Hz triangle waveform for the pixel axis.

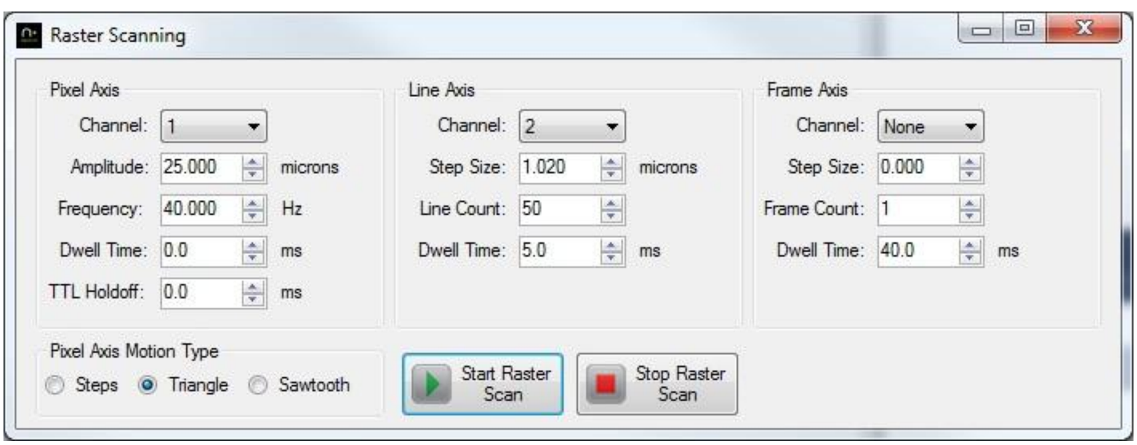

Figure 3 - Example raster scan parameters for a 50 x 50 micron scan.

Scanning this area with 50 lines gives a step size of 1.02 microns in the line axis (50 microns/49 steps). 5ms dwell time is used at the beginning of each line to let the stage settle. The raster scan completes in less than 1 second.

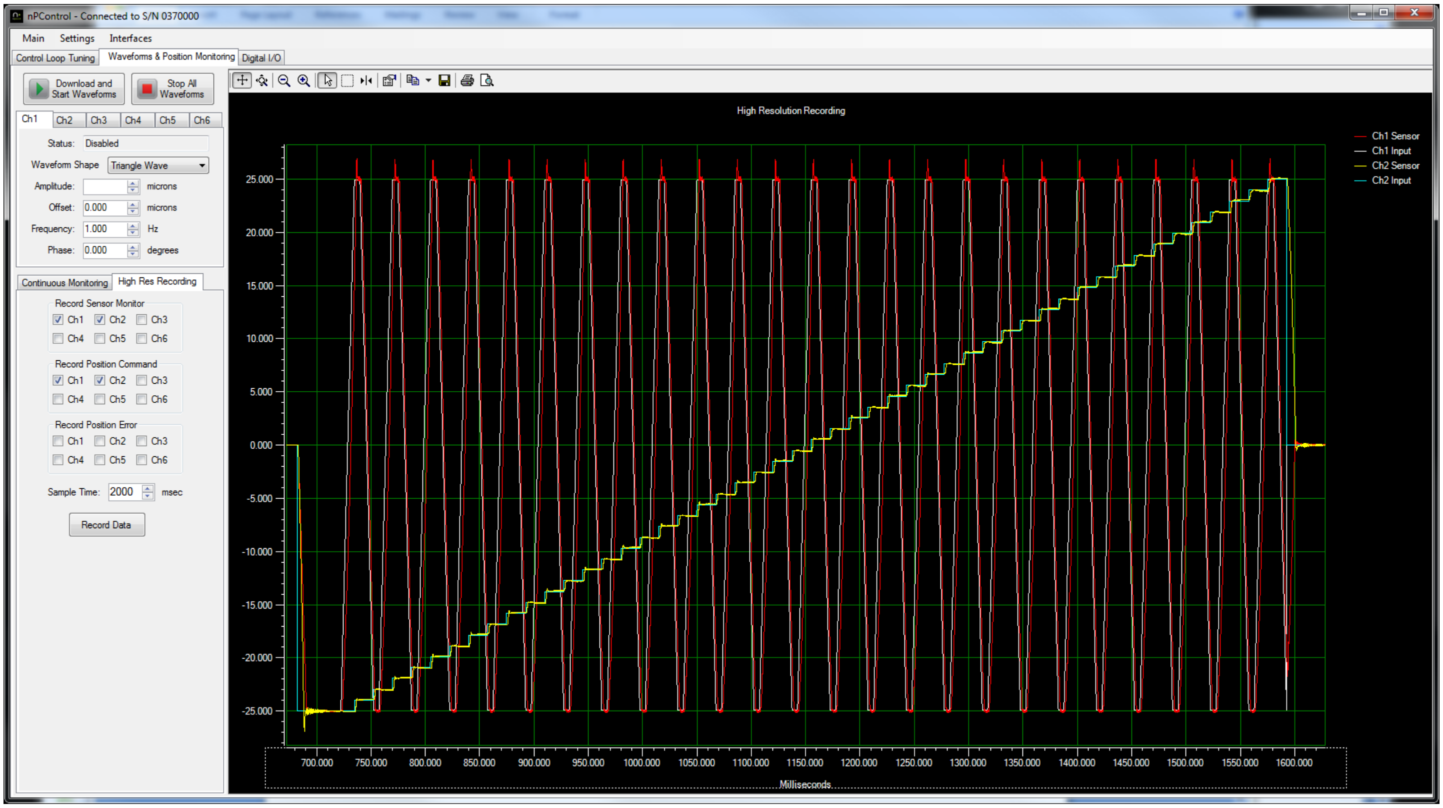

Figure 4 - 50 x 50 micron 40 Hz triangle raster scan completed in less than 1 second.

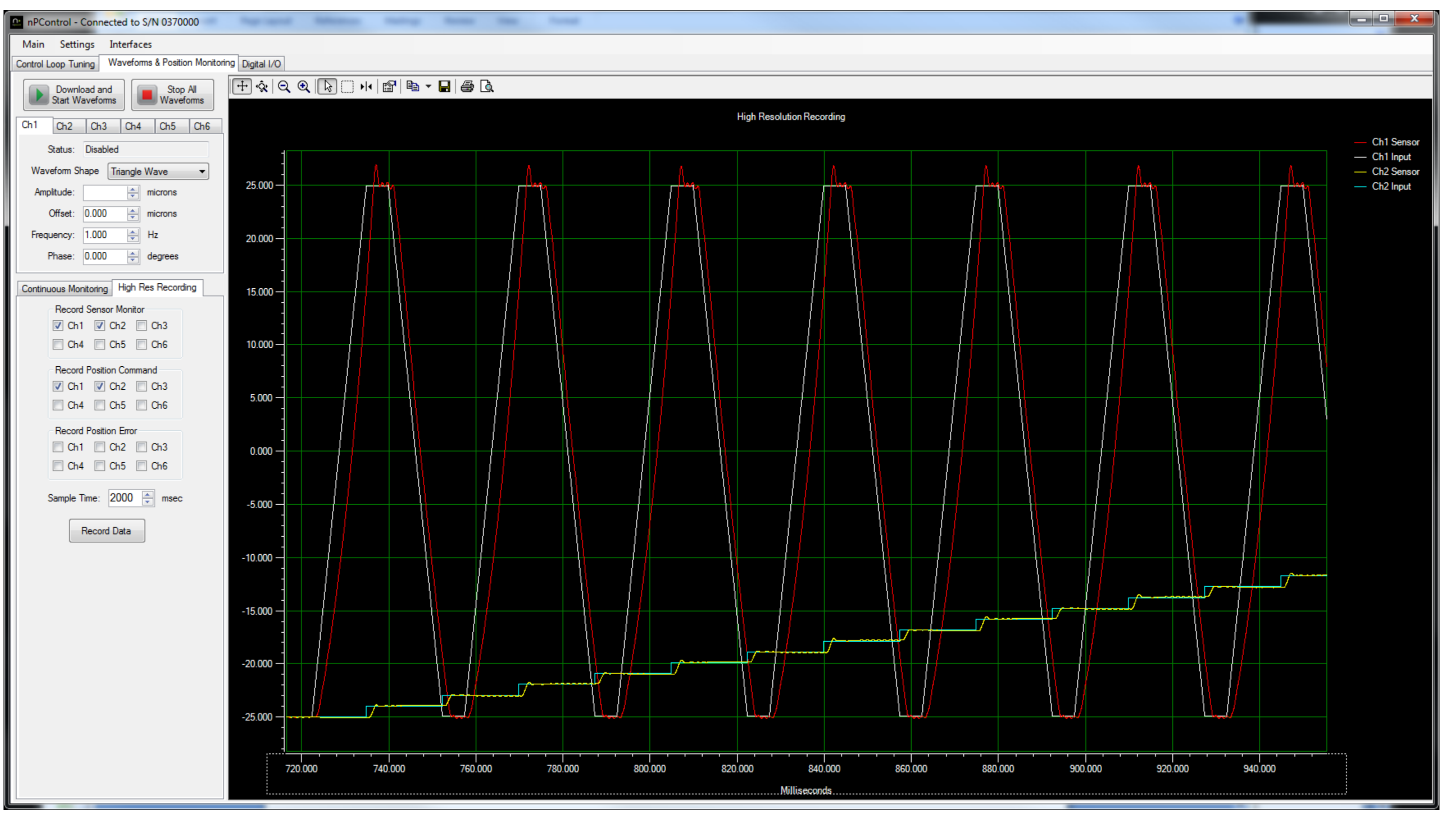

Figure 5 - Zoomed in section of a 50 x 50 micron 40 Hz triangle raster scan.

When plotting the X sensor reading vs. Y sensor reading for the center 40 microns of the fast axis and 50 microns of the line axis, there is good scan line spacing and coverage of the scan area.

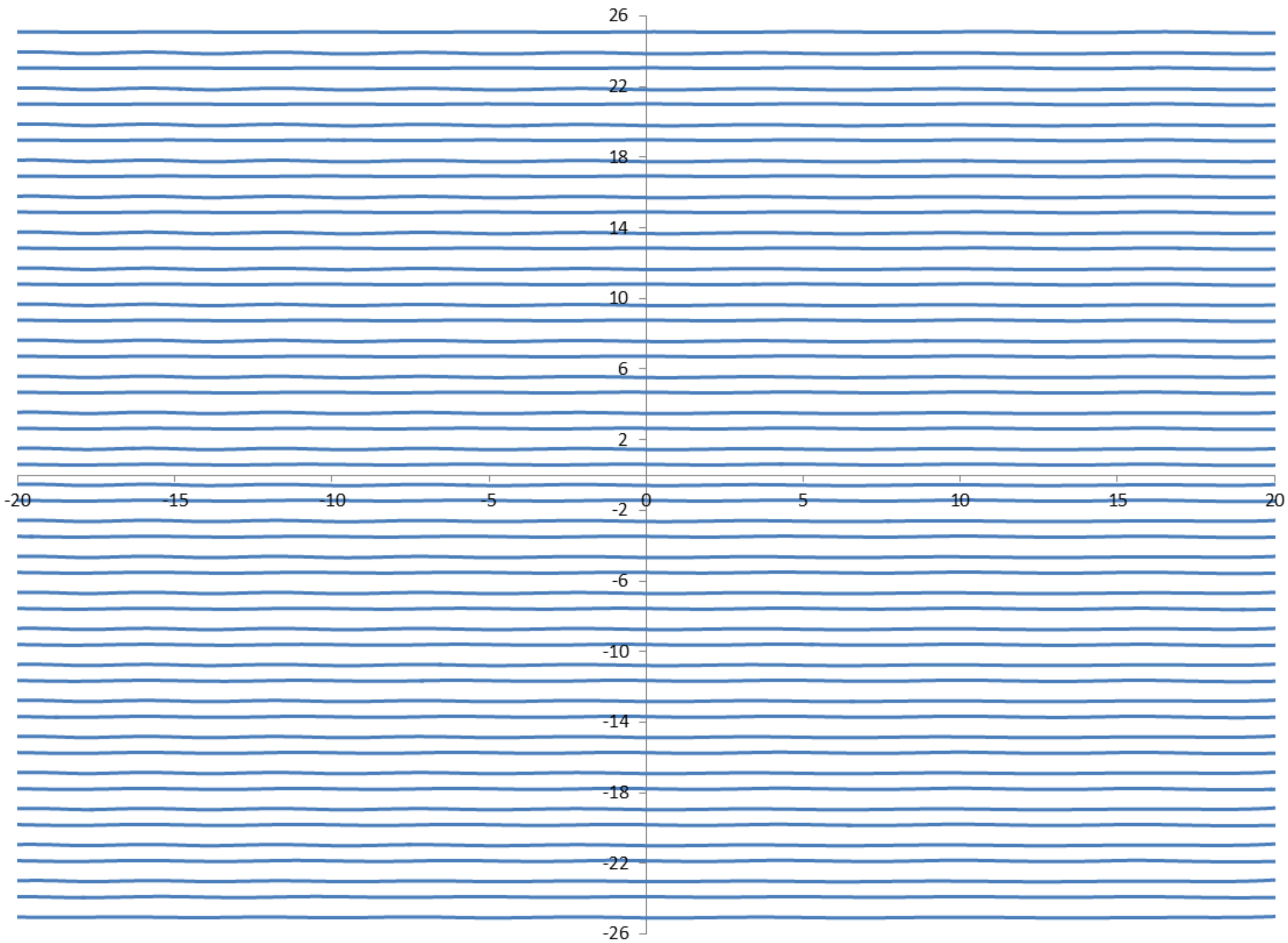

Figure 6 - The blue lines represent X vs. Y sensor data for a 40 x 50 micron section of the 40 Hz triangle raster scan.

3 - Arbitrary Scanning

nPoint LC.400 series controllers have internal buffers for storing arbitrary waveforms for each axis. The internal controller buffers hold 2 seconds of data per channel when specifying a position for each 24 µsec interval. However, the output interval can be adjusted to multiples of 24 µsec for longer waveforms. For example, this functionality allows programming of scan shapes with smooth turn-around motion. This avoids exciting mechanical resonances. nPoint provides a programming example that uses a sine wave in the fast axis and a single, constant velocity ramp in the slow axis. The scanning behavior of the XYZ stage under this condition is shown in the next section.

3.1 – Arbitrary sine-ramp scan with the NPXY60Z20-257 stage

The unloaded resonant frequency of this stage is approximately 780 Hz. The control loop bandwidth can be tuned for a 240 Hz control loop bandwidth and settling time of 3.65 milliseconds (+/- 2% of step size is considered settled).

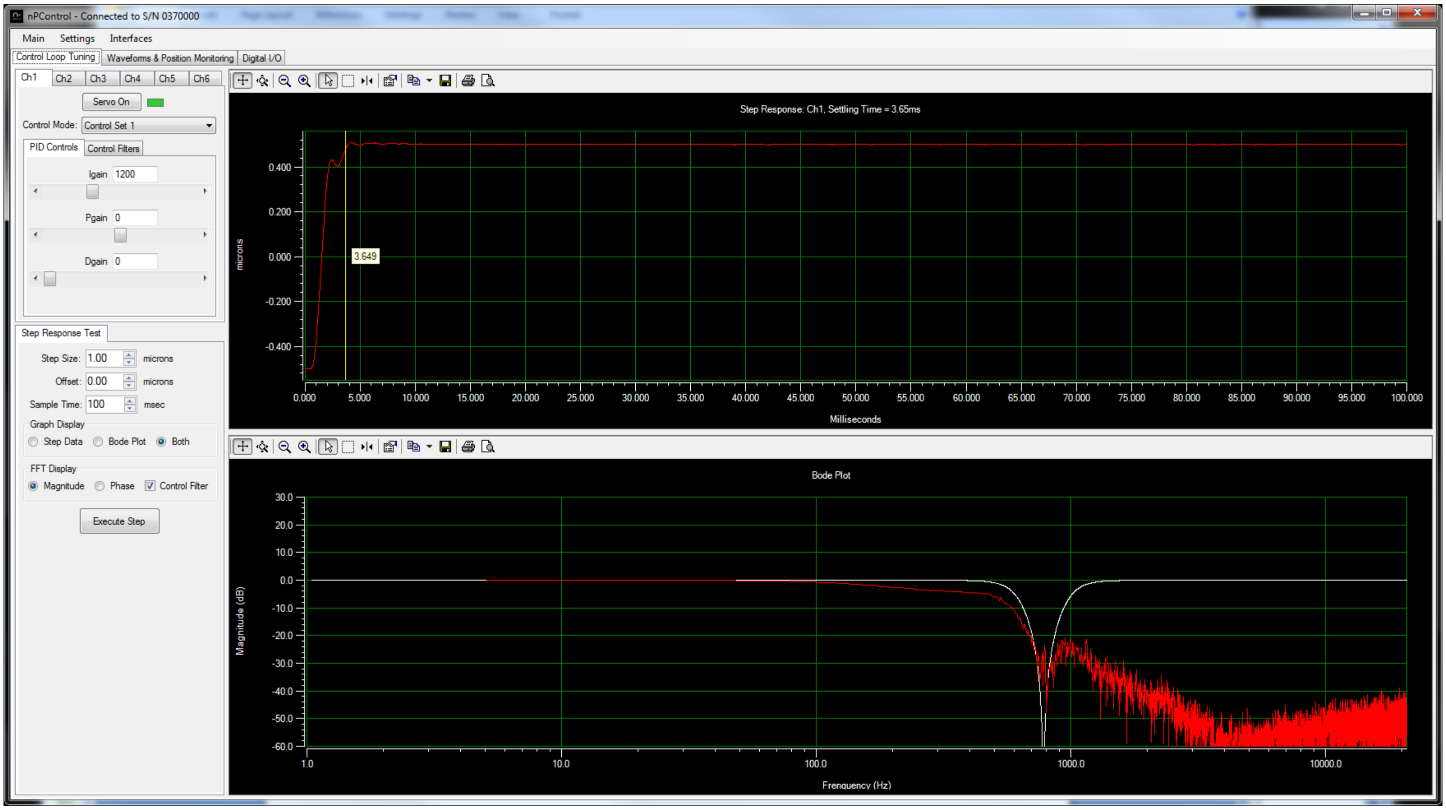

Figure 7 - XY60Z20 Step Response.

With a typical 100 mA piezo drive controller (more current capability is optional), this stage is able to scan a 50 micron by 50 micron area with a 40 Hz sine waveform for the fast axis. Since this mode of scanning does not require dwell time at the end of each line the overall scan time is reduced. With 50 lines this scan completes less than 700 milliseconds.

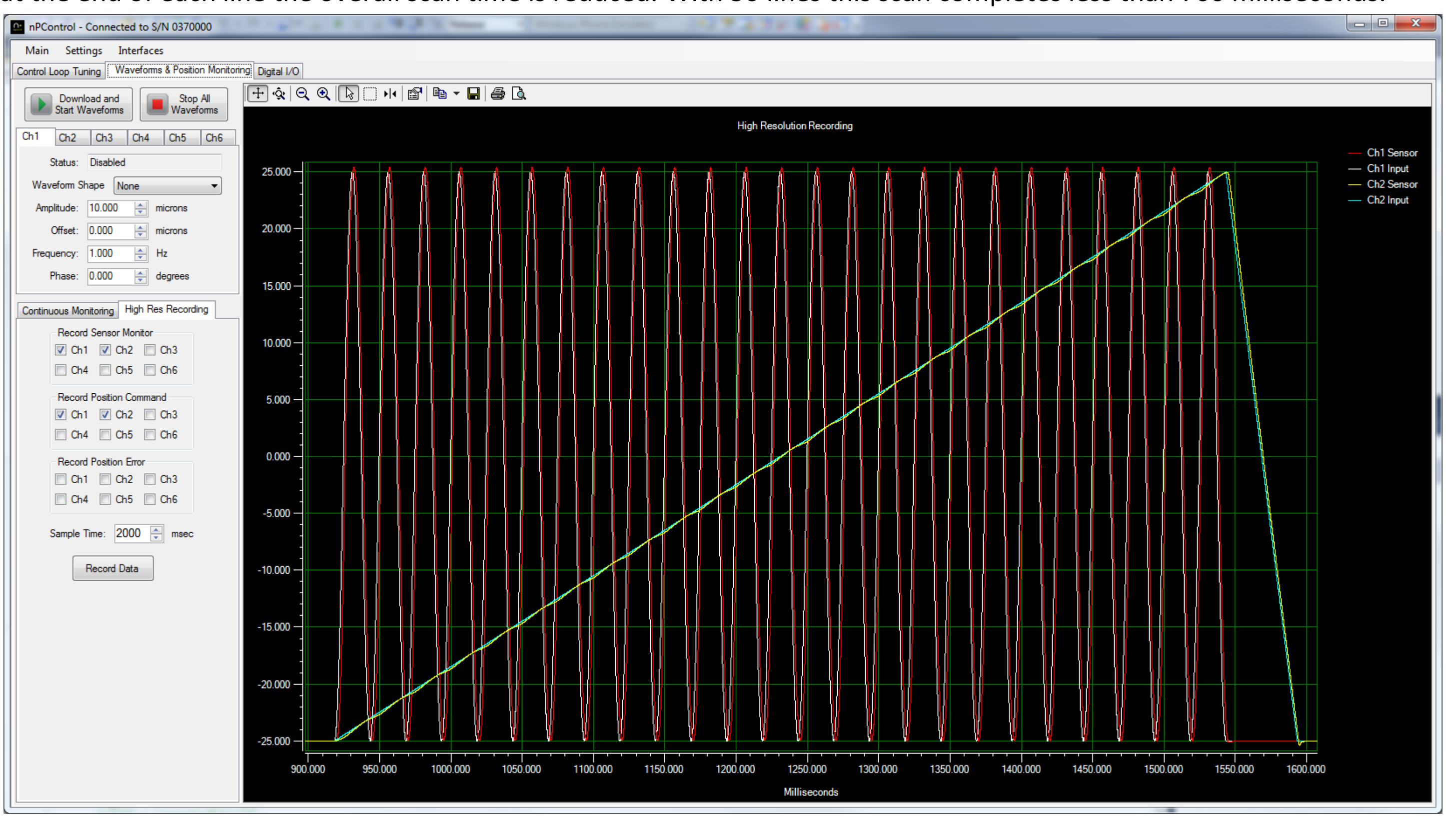

Figure 8 - 50 x 50 micron 40 Hz sine wave scan completes in 700 ms.

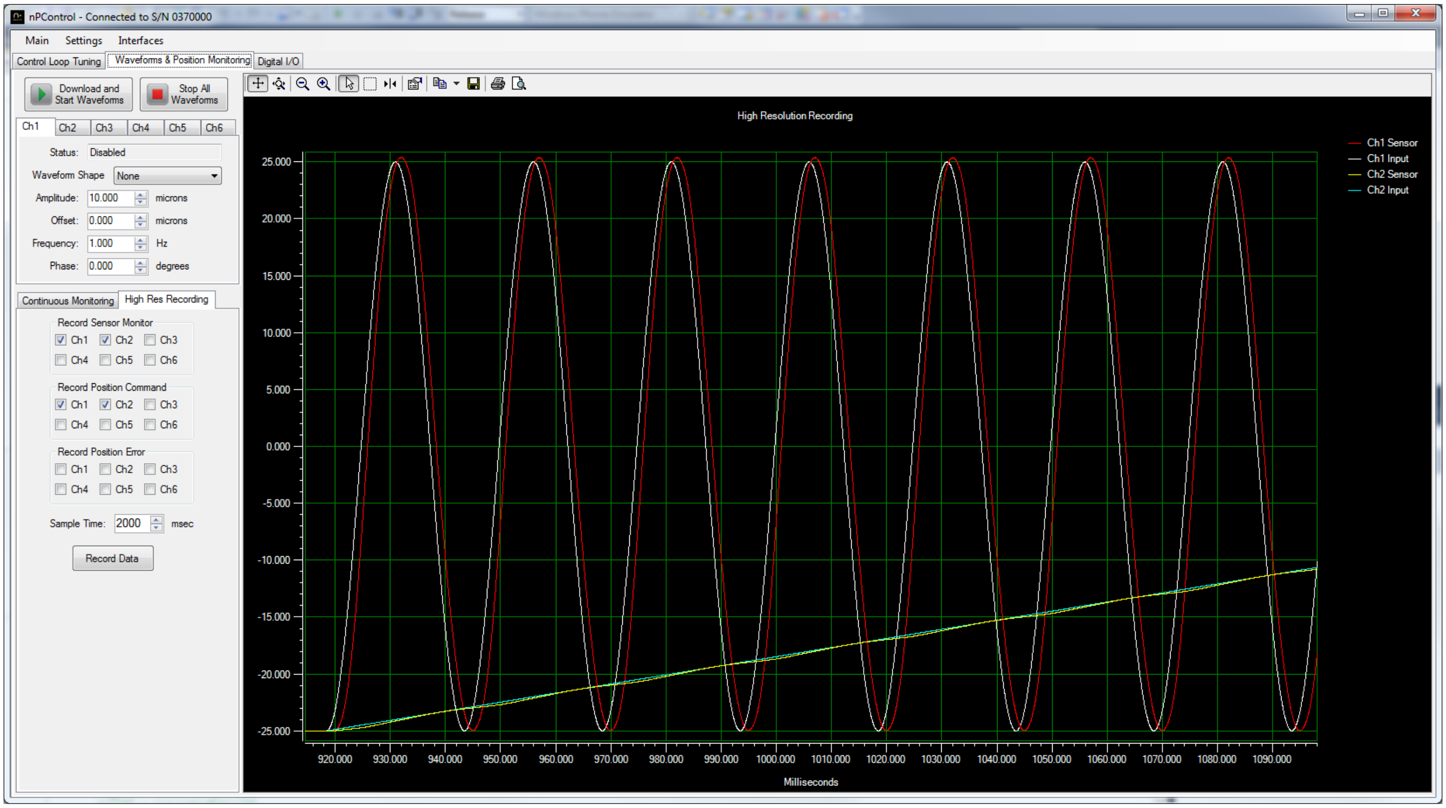

Figure 9 – Zoomed in section of a 50 x 50 micron 40 Hz sine wave scan.

When plotting the X vs. Y sensor recording for the 50 x 50 micron 40 Hz sine wave scan, data at the edges of the fast axis can be included and the scan provides good coverage of the scan area.

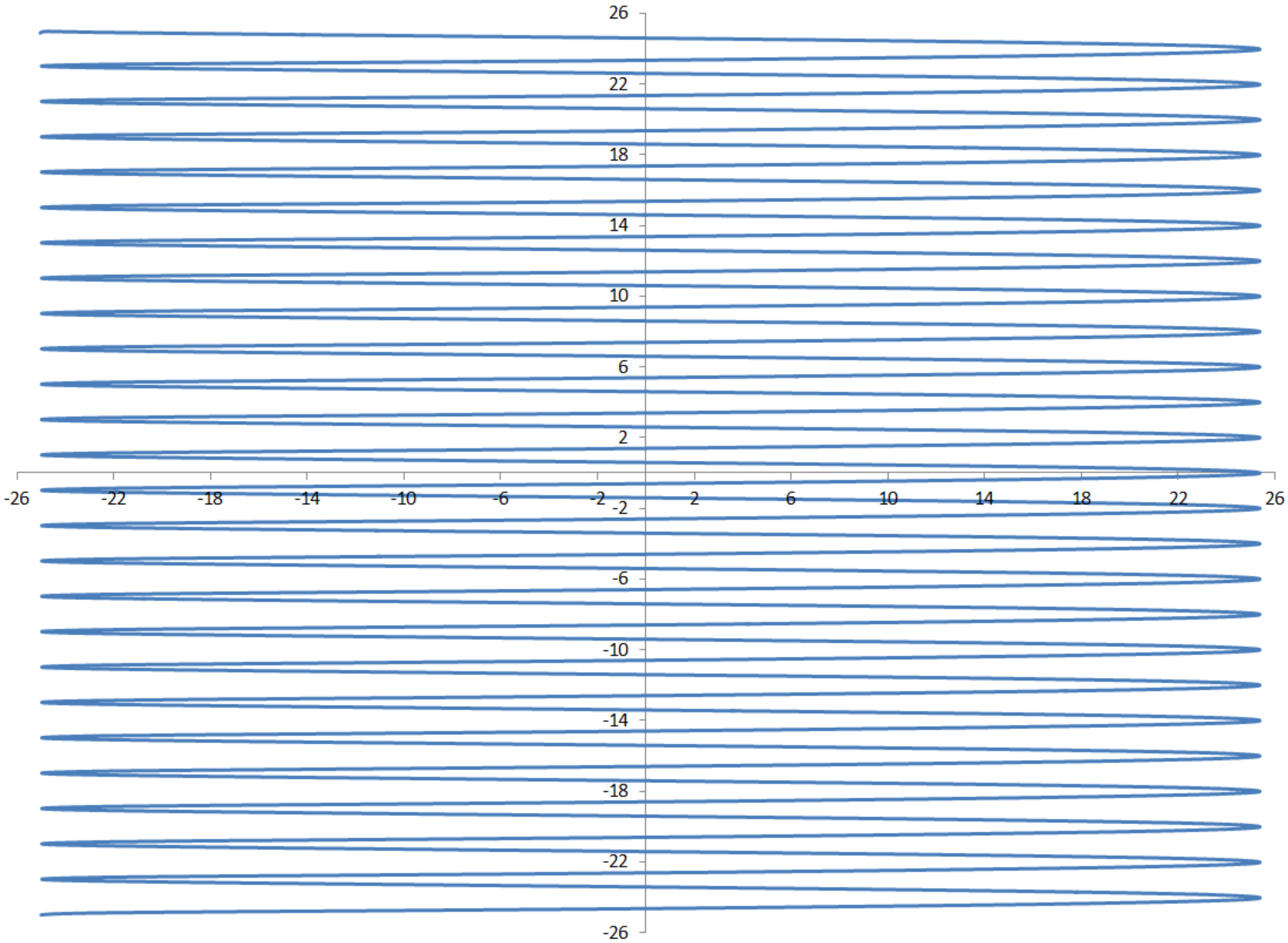

Figure 10 - The blue line represent X vs. Y sensor data for a 50 x 50 micron section of the 40 Hz sine wave scan.

3.2 – Spiral scan with the NPXY60Z20-257 stage

The unloaded resonant frequency of this stage is approximately 780 Hz. The control loop bandwidth can be tuned for a 240 Hz control loop bandwidth and settling time of 3.65 milliseconds (+/- 2% of step size is considered settled).

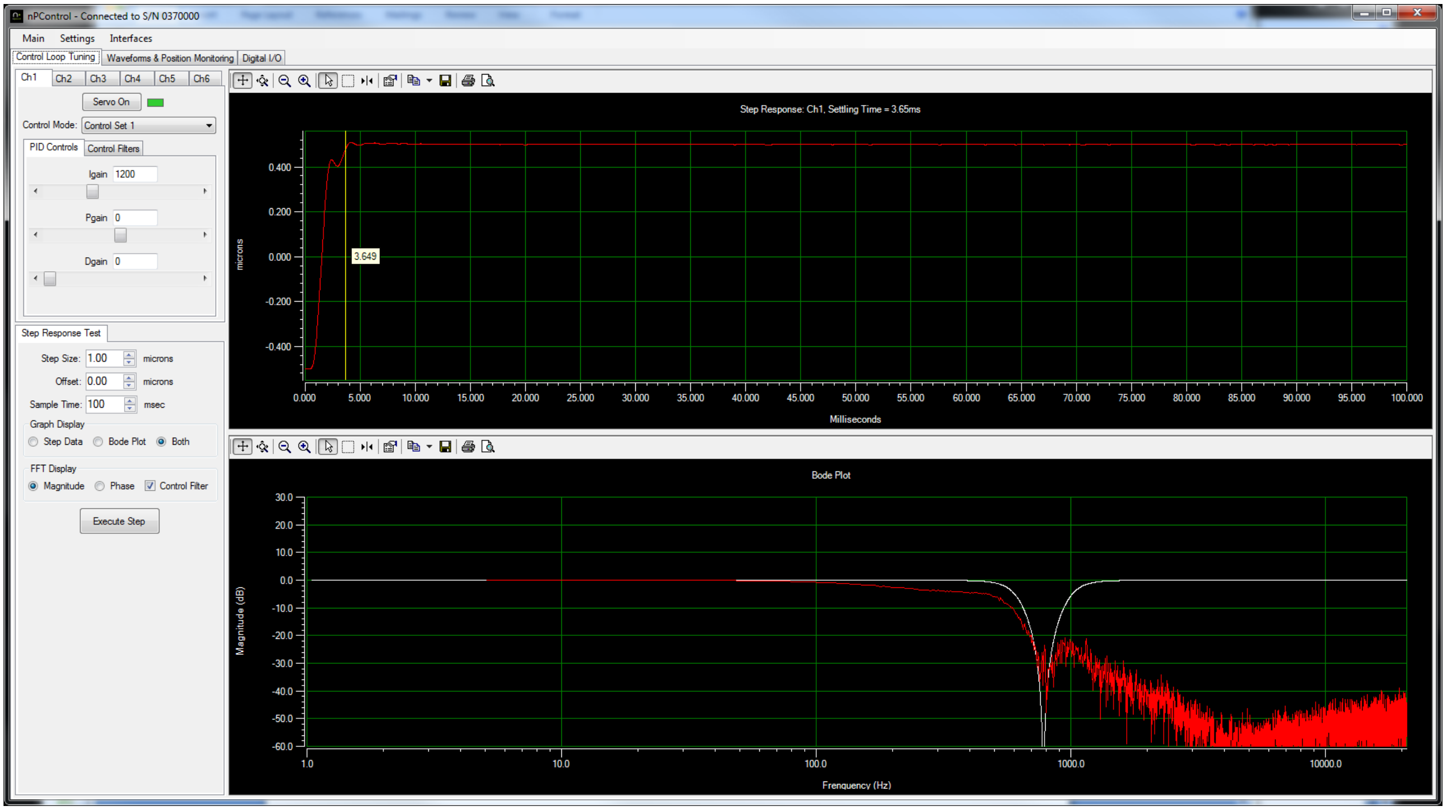

Figure 11 - XY60Z20 Step Response.

With a typical 100 mA piezo drive controller (more current capability is optional), this stage is able to scan a 50 micron diameter area at 40 Hz. With 1 micron spacing this scan completes in less than 700 milliseconds.

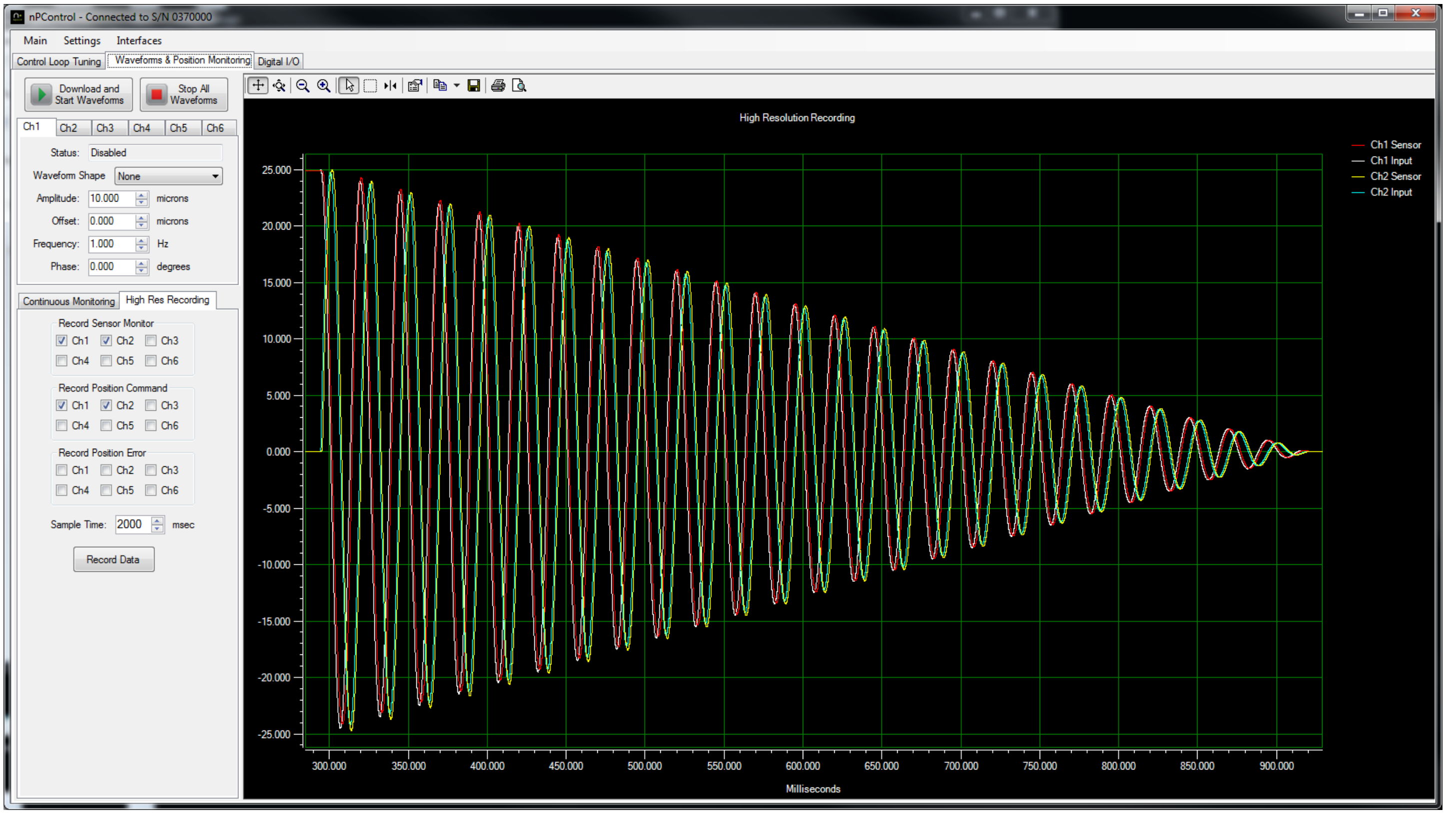

Figure 12 – A 40 Hz 50 micron diamater spiral scan completes in less than 700 ms.

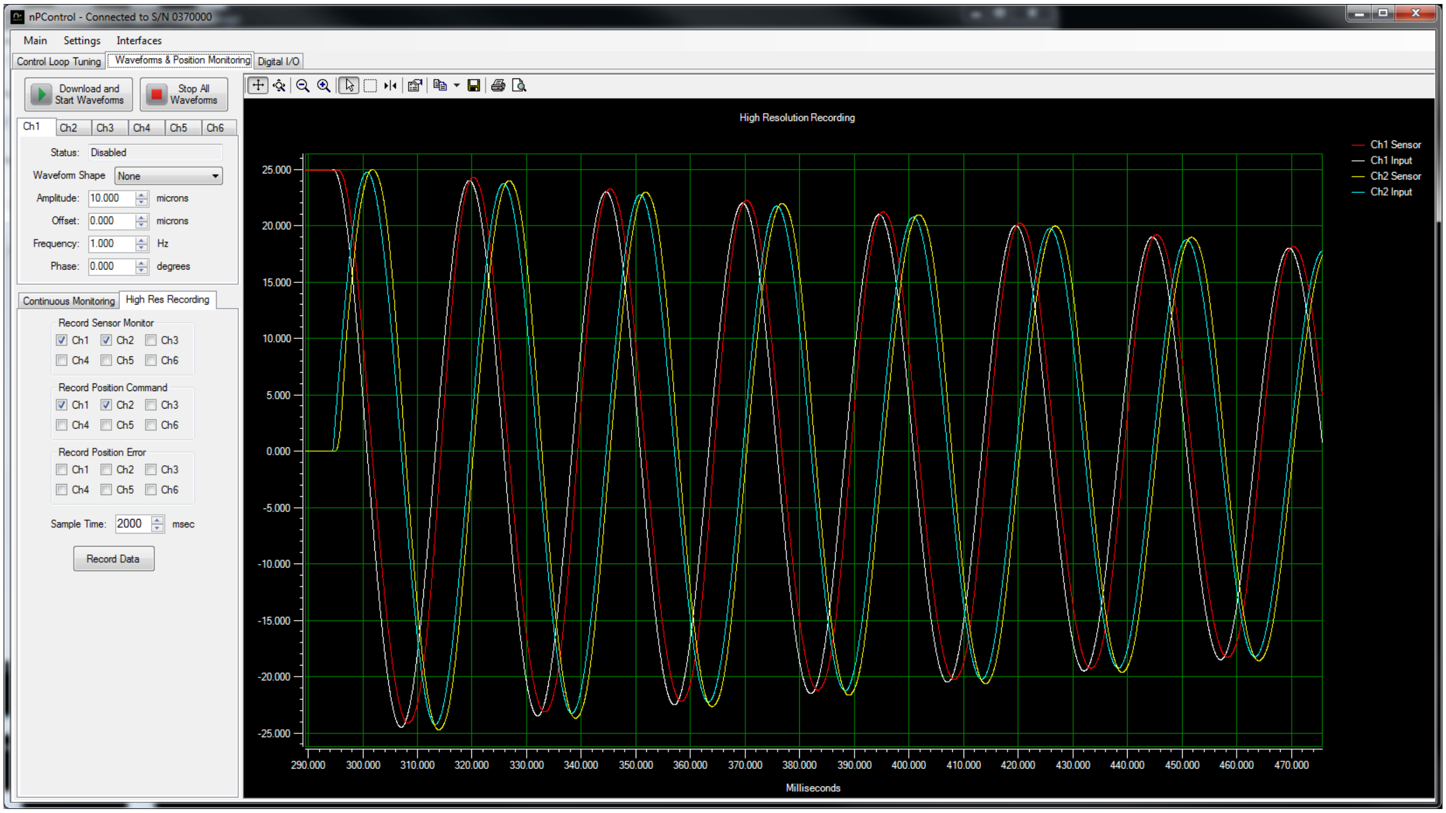

Figure 13 - Zoomed in section of a 50 micron diameter 40 Hz spiral scan.

When plotting the X vs. Y sensor recording for the 50 micron diameter scan area, this scan type provides even line spacing throughout the scan area.

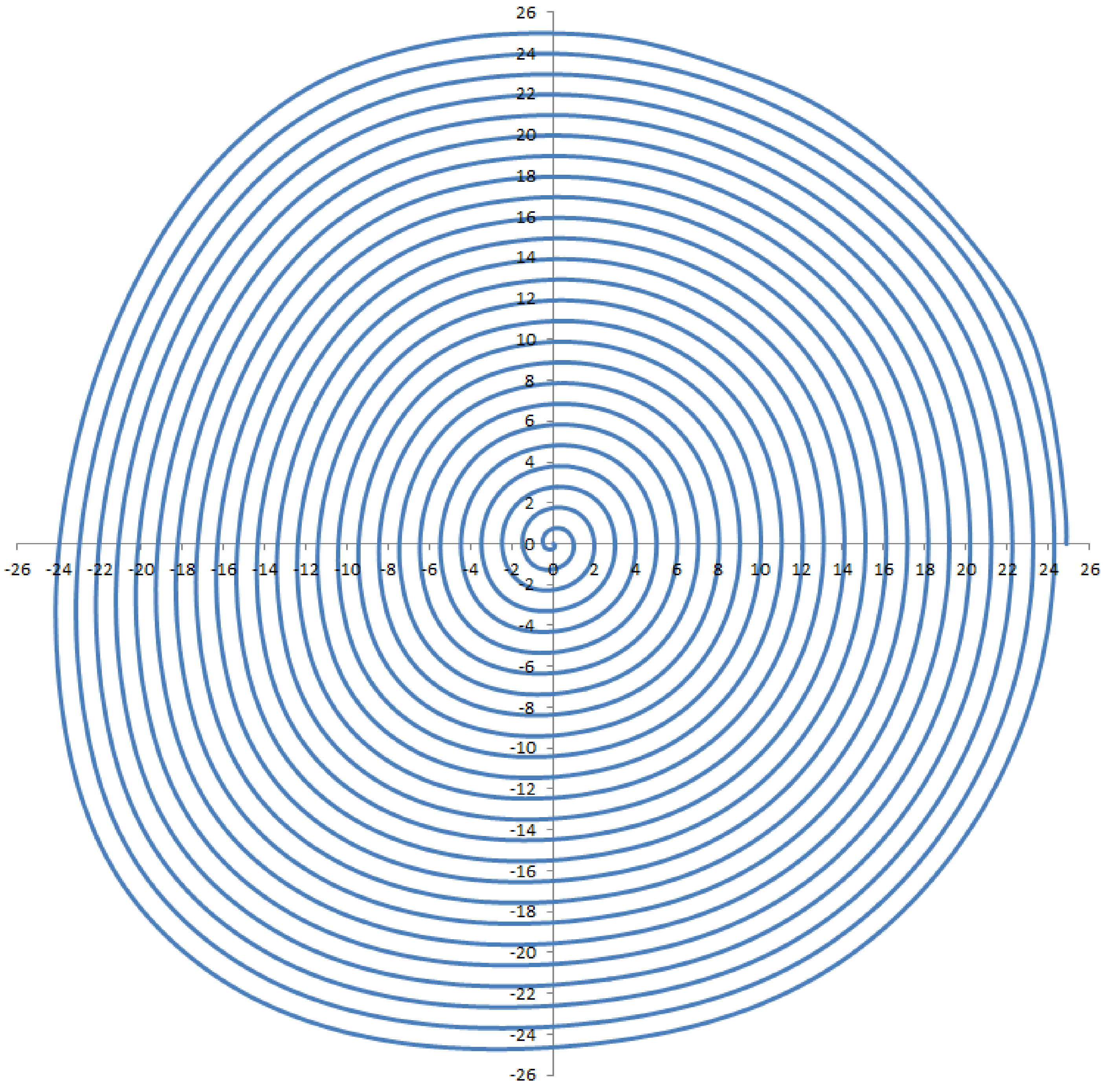

Figure 14 - The blue line represent X vs. Y sensor data for a 50 micron diameter 40 Hz spiral scan.

If a controller with 200 mA driver option is used, this stage is able to scan a 50 micron diameter area at 80 Hz. With 1 micron spacing this scan completes less than 350 milliseconds.

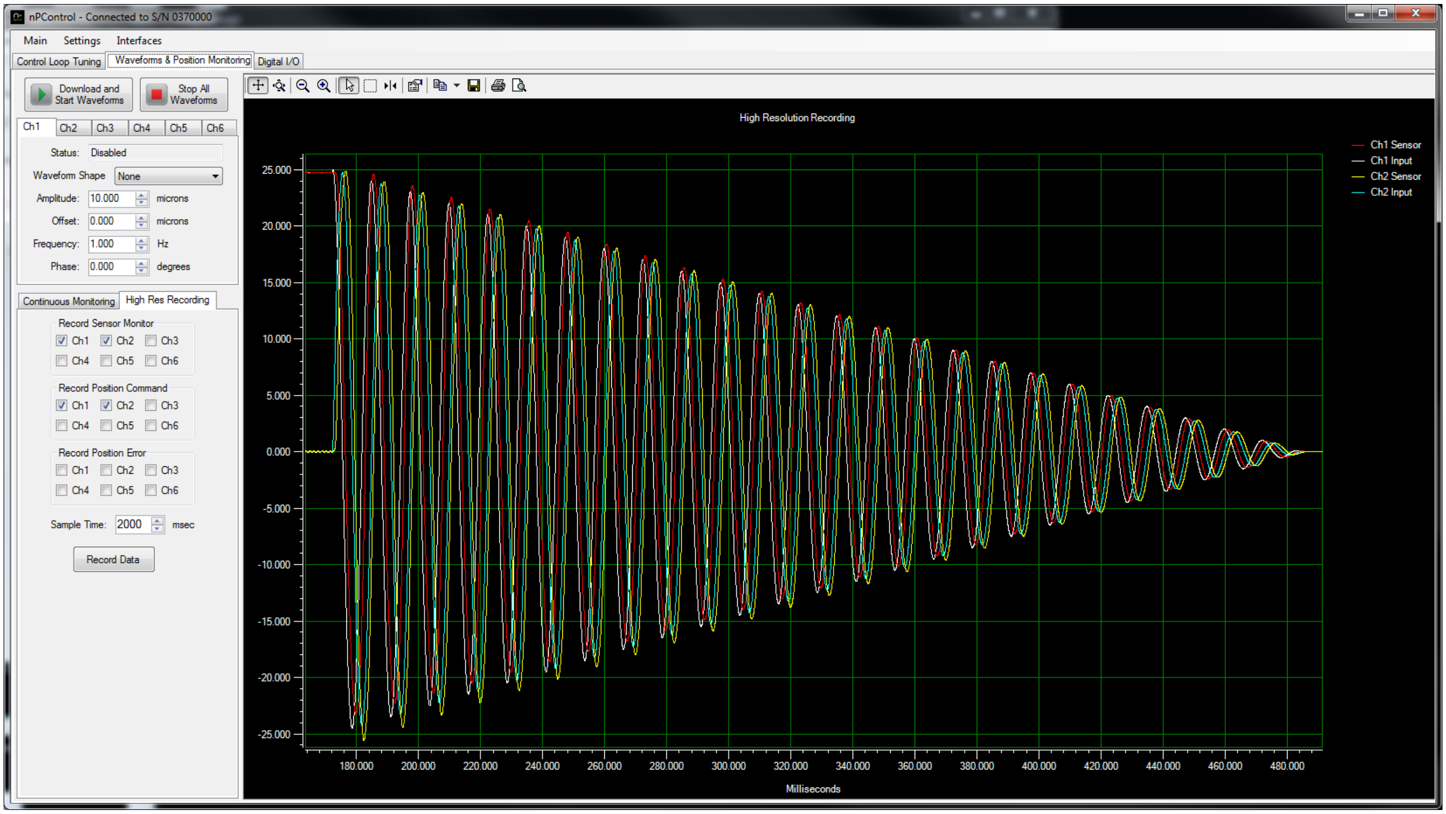

Figure 15 - A 40 Hz 50 micron diamater spiral scan completes in less than 350 ms.

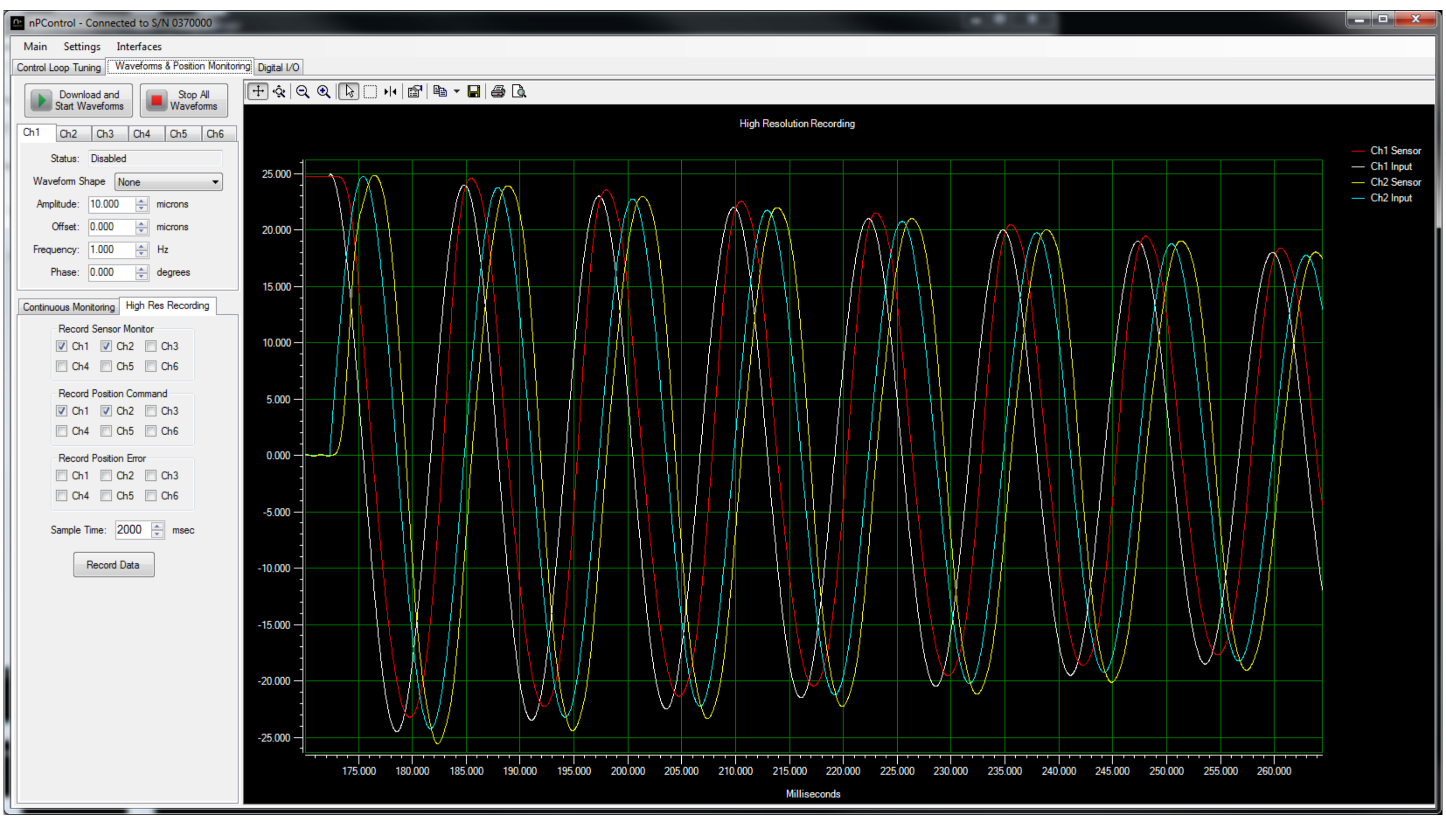

Figure 16 - Zoomed in section of a 50 micron diameter 80 Hz spiral scan.

When plotting the X vs. Y sensor recording for the 50 micron diameter 80 Hz scan area, there is some distortion of the shape but line spacing provides reasonable coverage.

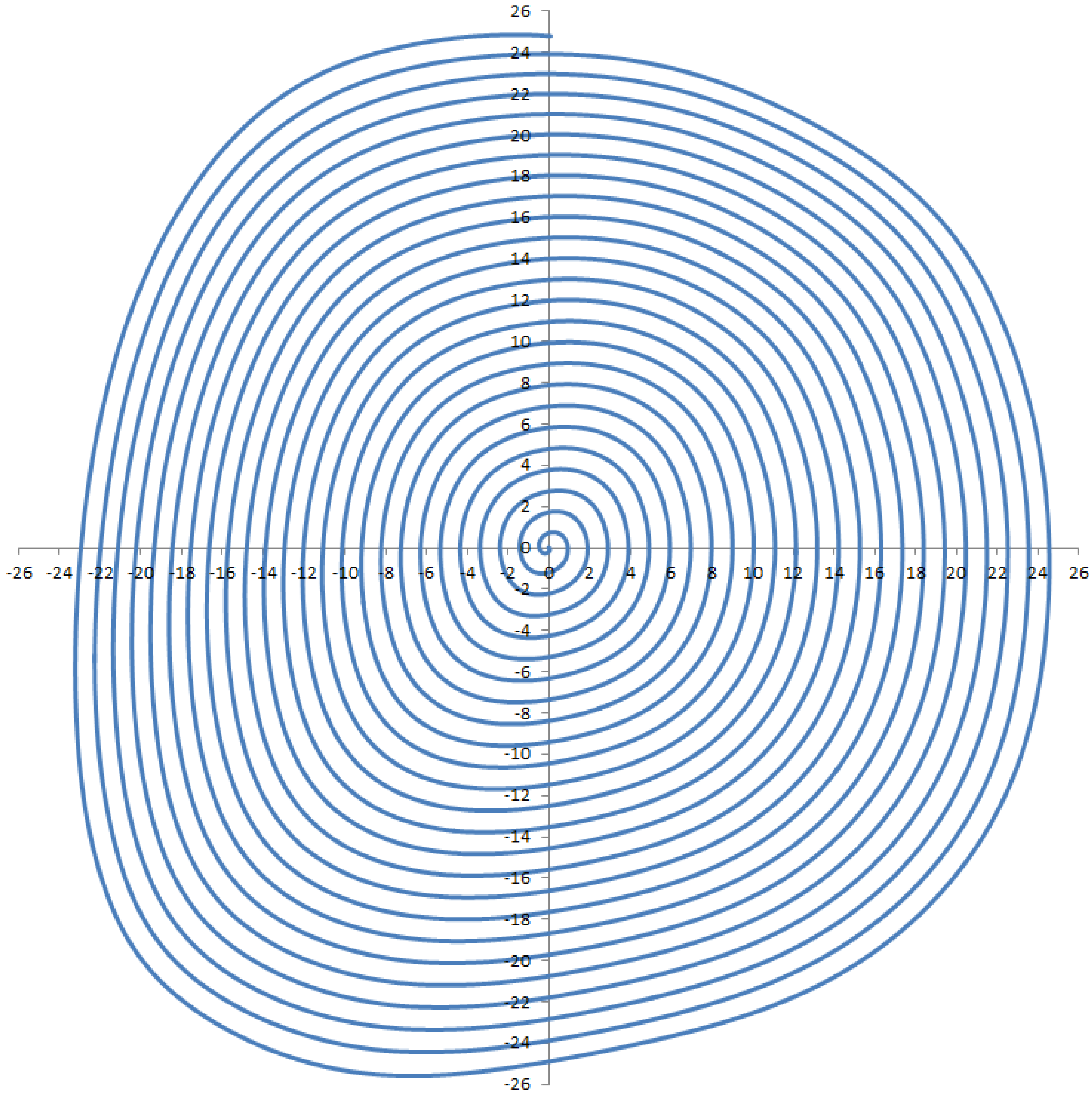

Figure 17 - The blue line represent X vs. Y sensor data for a 50 micron diameter 80 Hz spiral scan.

4 – Controller Internal Recording

The LC.400 controller can record up to 8 internal data streams with simultaneous samples every 24 microseconds. Each of the 8 recording memory buffers can hold 2 seconds of data when sampling at full speed. The sample rate can be reduced to any multiple of 24 microseconds in order to record for longer periods of time, or reduce the size of the data set transferred to the PC. For example if the sample rate were set to every 240 microseconds, the controller can record 8 simultaneous data streams for up to 20 seconds.

When using a digital positioning function to scan the nPoint stage, the position command functionality of the BNC analog inputs can be disabled so that they can be used to record external signals. The BNC analog inputs and nPoint stage position sensors are sampled at 20 bit resolution. Using this method can eliminate an external data acquisition device to sample the LC.400 BNC sensor monitors, or eliminate complex TTL synchronization.

Recorded data buffers are transmitted to the PC at a rate of approximately 173k samples per second via USB. For example if sampling every 240 microseconds for 1 second, each buffer of 4167 samples would take approximately 24 milliseconds to transfer from the LC.400 controller to the PC.

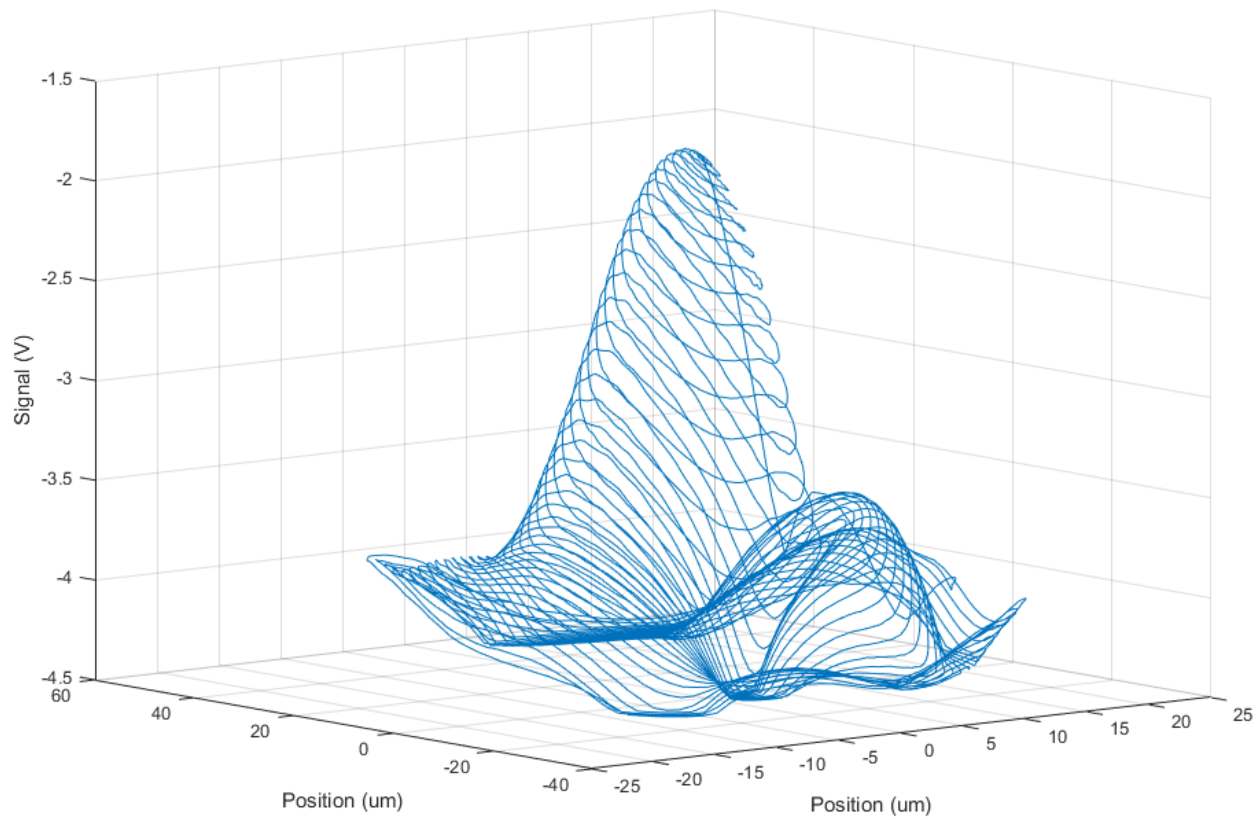

Figure 18 - 3D plot of Optical Power recorded via the LC.400 BNC analog input vs. Stage Position

5 - Programming Examples

```
Private Sub btnStartRecording_Click(sender As System.Object, e As System.EventArgs) Handles btnStartRecording.Click
    Try
        btnStartRecording.Enabled = False
        setInteger(Addresses.numSamplesToRecord, Convert.ToInt32(Math.Round(numNumberSamples.Value)))  'set number of samples to record
        setInteger(Addresses.recordPointer1, Addresses.ch1BaseAddress + Offsets.digitalPositionCmd)  'set pointer 1 to Ch1 Position Command
        setInteger(Addresses.recordPointer2, Addresses.ch2BaseAddress + Offsets.digitalPositionCmd)  'set pointer 2 to Ch2 Position Command
        setInteger(Addresses.recordPointer3, Addresses.ch1BaseAddress + Offsets.digitalSensorReading)  'set pointer 3 to Ch1 Sensor Reading
        setInteger(Addresses.recordPointer4, Addresses.ch2BaseAddress + Offsets.digitalSensorReading)  'set pointer 4 to Ch2 Sensor Reading
        setInteger(Addresses.recordPointer5, Addresses.ch1BaseAddress + Offsets.analogInput) 'set pointer 5 to Ch1 Analog In
        setInteger(Addresses.recordPointer6, Addresses.ch2BaseAddress + Offsets.analogInput) 'set pointer 6 to Ch2 Analog In
        setInteger(Addresses.recordPointer7, 0)  'don't record anything
        setInteger(Addresses.recordPointer8, 0)  'don't record anything

        setInteger(Addresses.recordingDivisor, Convert.ToInt32(Math.Round(numCyclesPerSample.Value, 0))) 'set cycles per sample

        setInteger(Addresses.startRecording, 1) 'Start the recording
        tmrCheckForRecComplete.Enabled = True
    Catch ex As Exception
        MsgBox(ex.Message, MsgBoxStyle.Exclamation, "Error")
    End Try
End Sub
```

Figure 19 - Sample of VB.NET programming example code

Visual Studio 2010 programming examples are provided to assist customers in developing their own PC applications. The USB drivers provided for the LC.400 controller are compatible with Windows, Linux, and Mac OS X. The driver functions can be called from a wide variety of development environments for C++, C#, VB, Java, Python, Labview, etc.

To open and run the example projects, Visual Studio 2015 Community Edition can be downloaded for free from Microsoft.

Programming examples are provided for stepping traditional raster scans, scanning traditional raster scans, a sinewave-ramp arbitrary scan, and internal synchronized recording.

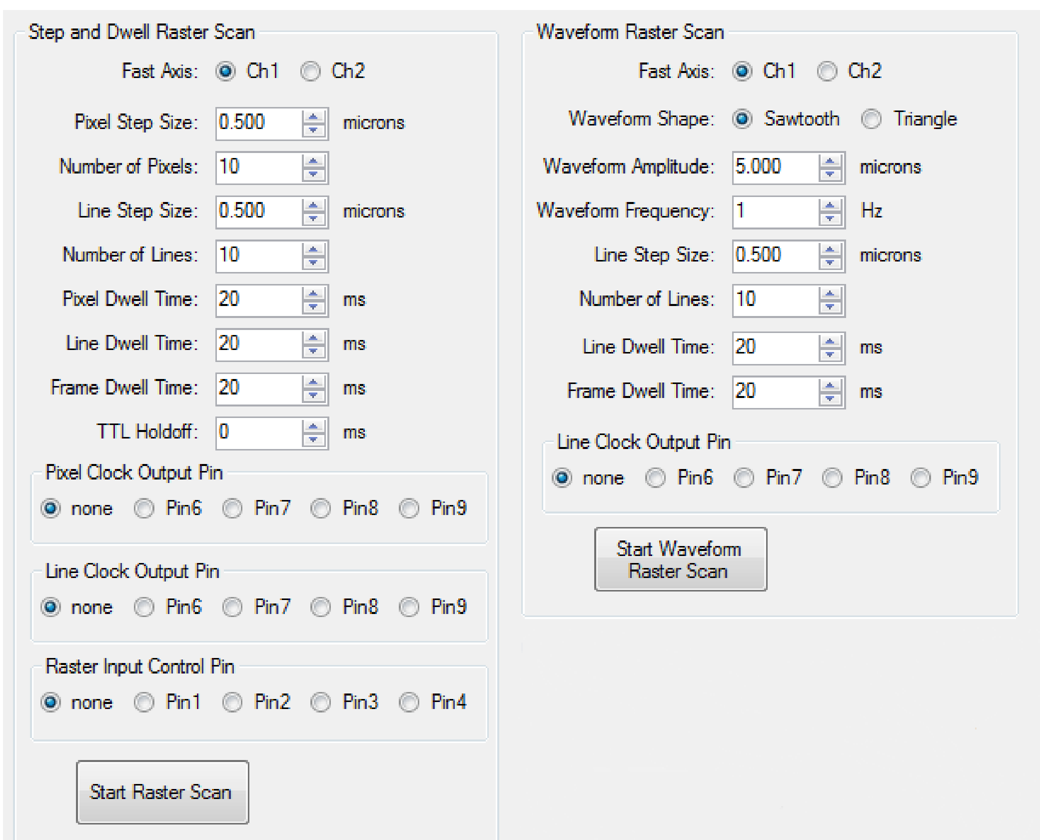

Figure 20 - Traditional stepping or scanning raster scan programming example user interface

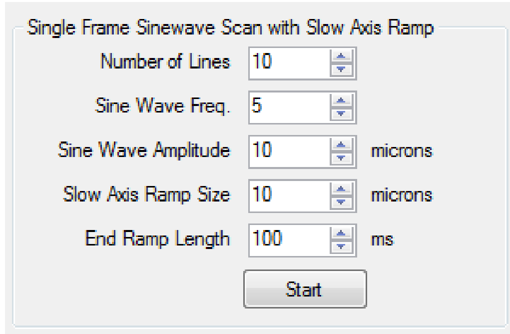

Figure 21 - Arbitrary sinewave-ramp scan programming example user interface

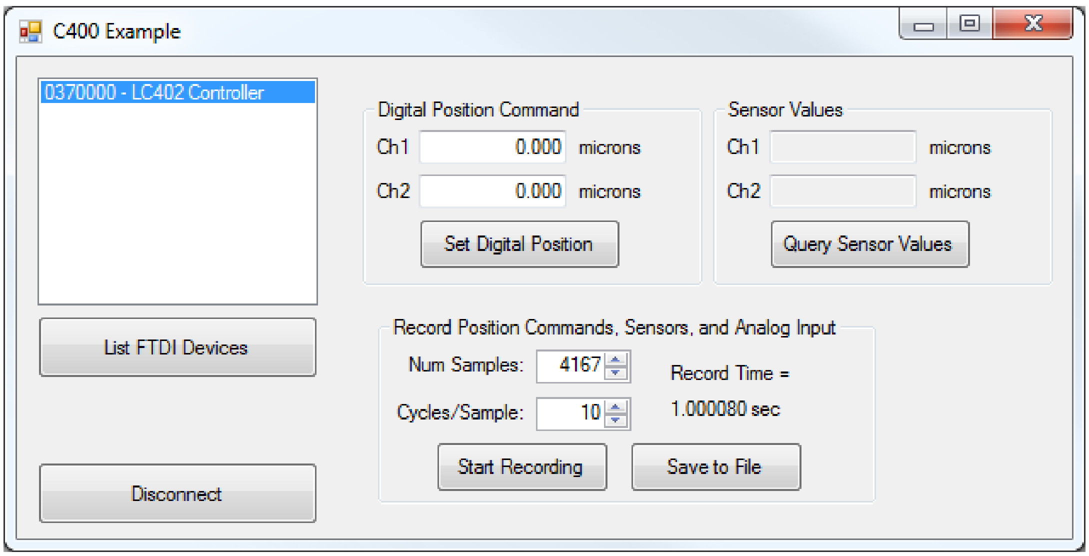

Figure 22 - Internal recording programming example user interface