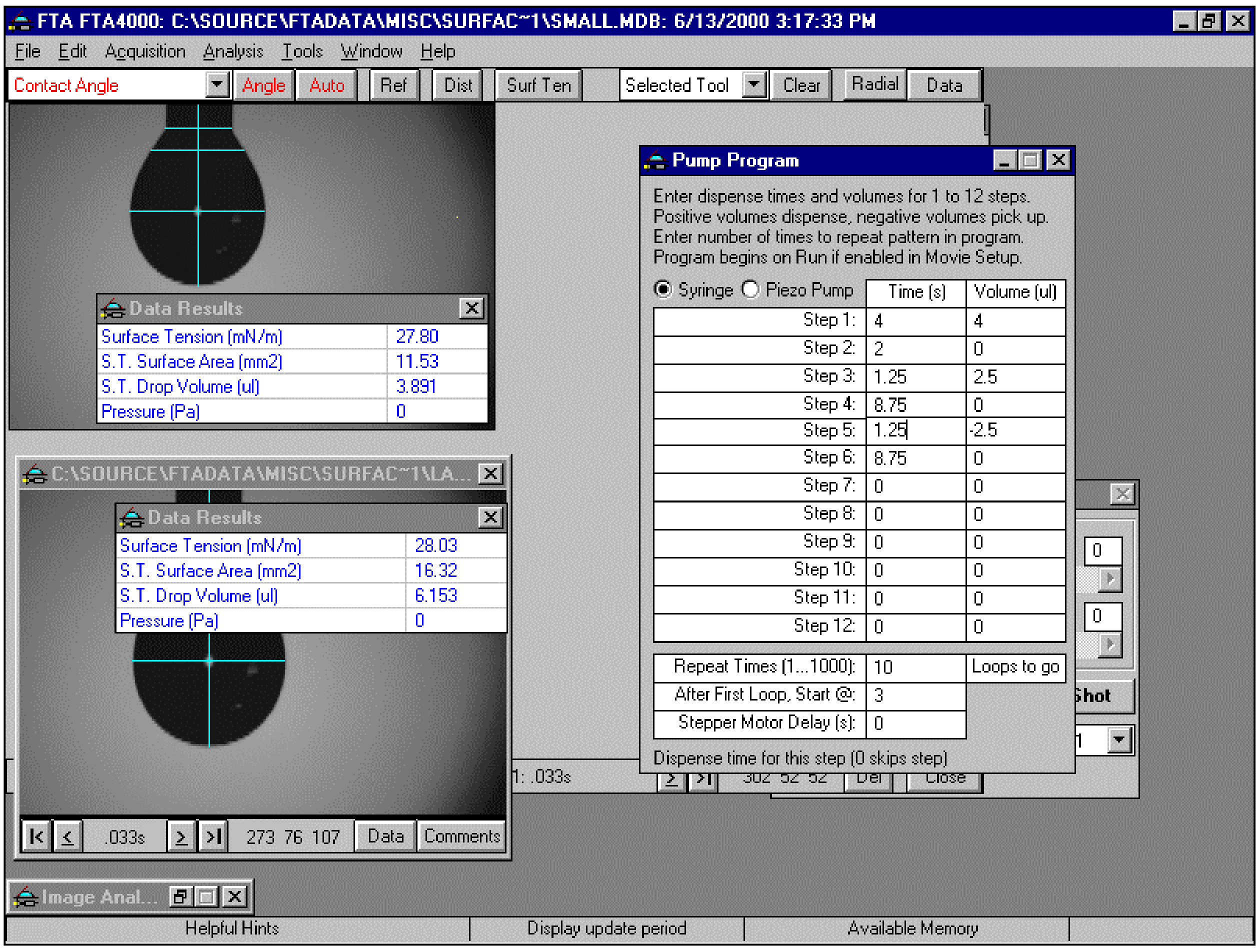
First Ten Ångstroms **ApplicationNotes**

Pump Programming

November 14, 2000

FTÅ systems with stepper motor driven syringe pumps can be programmed to generate complex volume or surface area waveforms in time. This note illustrates two waveforms.

Square Wave



A simple square wave program.

Step 1. forms initial drop. This presumes no droplet present before beginning. Depending on how you clear the previous drop, the 4µl volume will require tweaking. The goal was to start with a 4µl drop, something slightly more than your "small" drop. This drop is formed at 1µl per second; we may be able to go faster, but this is affected by needle size and fluid characteristics (tendency to run up needle, viscosity, etc.).

465 Dinwiddie Street • Portsmouth, Virginia 23704 • 1.757.393.1584 Fax: 1.757.393.3708
http://www.firsttenangstroms.com

Step 2. wait for drop to settle. This time can be adjusted or set to zero for no wait.

Step 3. expand drop to 6.5µl total (increment = 2.5µl.). We have requested 2µl per second rate. May be able to go faster (see note in Step 1).

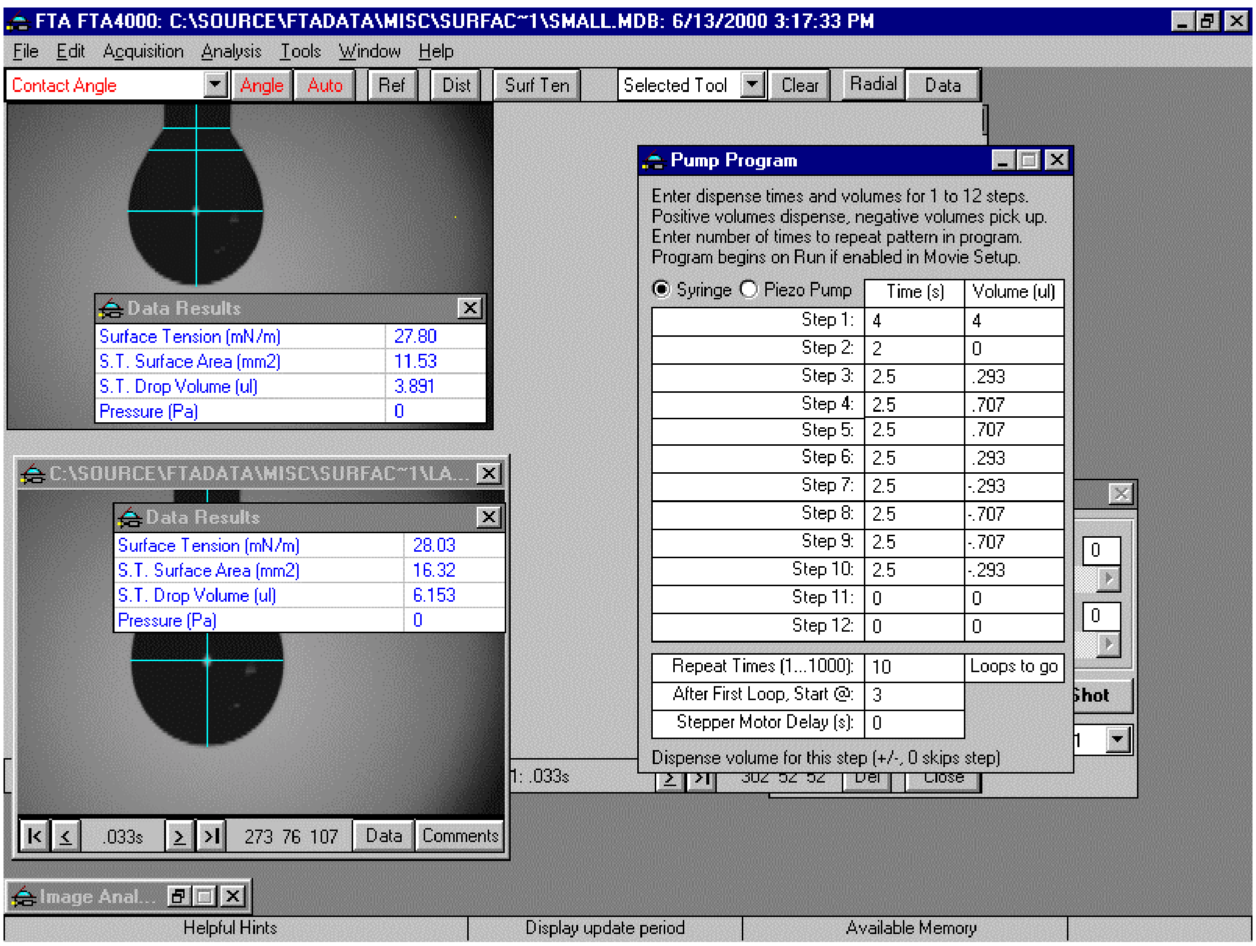
Step 4. rest for 8.75 seconds at expanded state.

Step 5. retract back to 4µl at 2µl per second.

Step 6. rest for 8.75 seconds at retracted state. This gives a total period of 20 seconds.

Subsequent steps, down to 12, are skipped because they have zero time. Upon hitting Step12, the program loops back to Step 3 and does this 10 times.

Sine Wave



The sine wave program is setup to mimic the square wave. It will have a 20 second cycle. The sine wave is synthesized by a piecewise linear approximation in steps 3-10. There are more efficient approximations, but this one is easiest to understand and does well in practice. We use equal time divisions ($8 \times 2.5s = 20s$). Each time division represents 360 / 8 = 45°. The sine of 45° = .707. For simplicity, we set the peak amplitude of the sine wave = 1 and the peak-to-peak = 2µl. So the volume at 45° is .707µl. Since the peak is 1µl., the increments are 1 -.707 = .293µl. and .707µl.

Because we are starting at the *minimum* volume in Step 3, the increment for Step 3 is +.293µl. The minimum volume occurs at 270°, where the sine = -1. Step 3 corresponds to 270°.

Step 1. expand initial drop, as before.

Step 2. wait for stabilization, if desired.

Step 3. starts at 270°, sine = -1. Increment towards 270 + 45 = 315° where sine = -.707.

Step 4. starts at 315°, sine = -.707. Increment towards 315 + 45 = 360 = 0° where sine = 0. This gets us to 4 (initial volume) + 1 = 5µl.

Steps 5-8. covers 0 to 180°.

Steps 9-10. covers 180 to 270°, the beginning at sine = -1.

Understanding this, you can see that Steps 4 and 5 and Steps 8 and 9 could be combined into +1.414 and -1.414µl's, respectively, over 5 seconds each, for a simpler and smoother running program.

Triangle Wave

As you desire to run faster, you will find that a triangle wave is a satisfactory approximation to a sine wave when fluid viscosity starts to "smooth" the flows. The triangle that would correspond to the above example is

3:	10s	2µl
4:	10s	-2µl

Notice it has only two steps. This runs fast because the pump is not being reprogrammed as often (each reprogramming takes some fraction of a second, hence some dead time).

Finally, since we *measure* the actual drop volume and surface area, any imperfections in the excitation do not really hurt us.

465 Dinwiddie Street • Portsmouth, Virginia 23704 • 1.757.393.1584 Fax: 1.757.393.3708
http://www.firsttenangstroms.com