First Ten Ångstroms

FTA SI-640 High Speed Camera Installation and Use

Last updated November 14, 2005

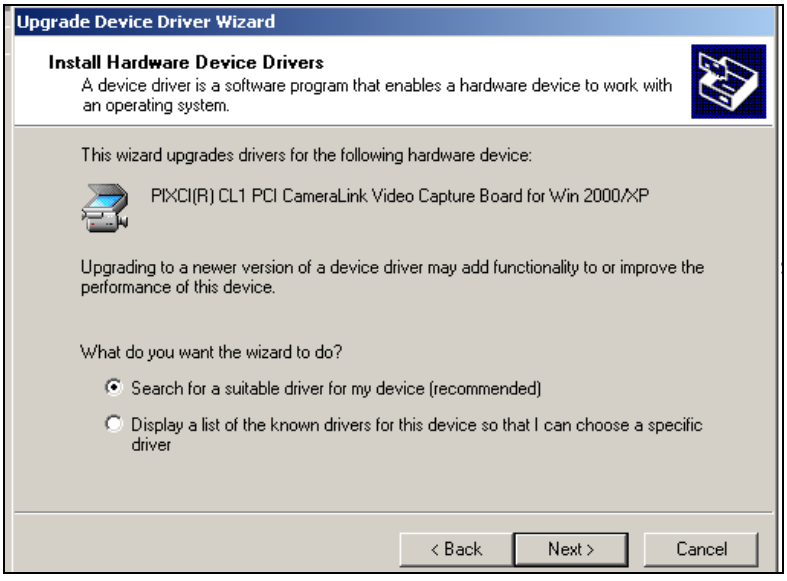
Installation

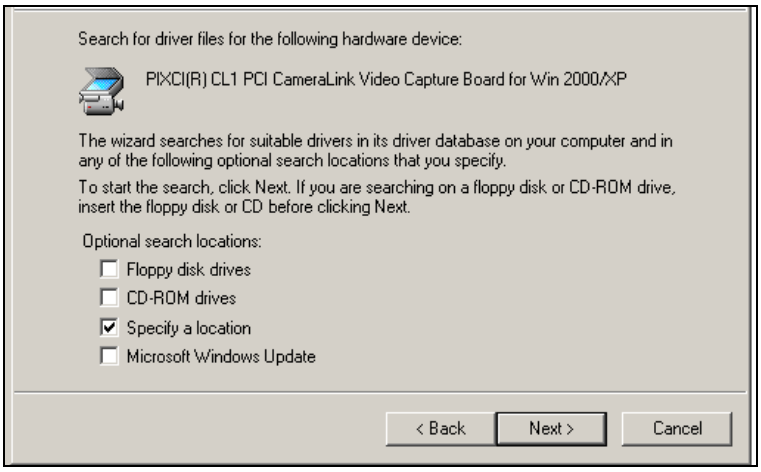
The required drivers are included with the standard Fta32 Video distribution, so no separate folders exist on the CDROM or the FTA website. For the easiest installation, follow this order:

- do not put the Epix frame grabber in the system until you have installed Fta32 Video
- install Fta32 Video, the main application program
- install the Epix frame grabber in a PCI slot and connect the camera cable
- when the system boots next, *Found New Hardware* will automatically run

The Found New Hardware wizard will ask for "inf" and "sys" files. Direct the wizard to the Fta32 Video directory. The default location is C:\Program Files\Fta32. The requested files will be

EPIXXCW2.INF
EPIXXCW2.SYS



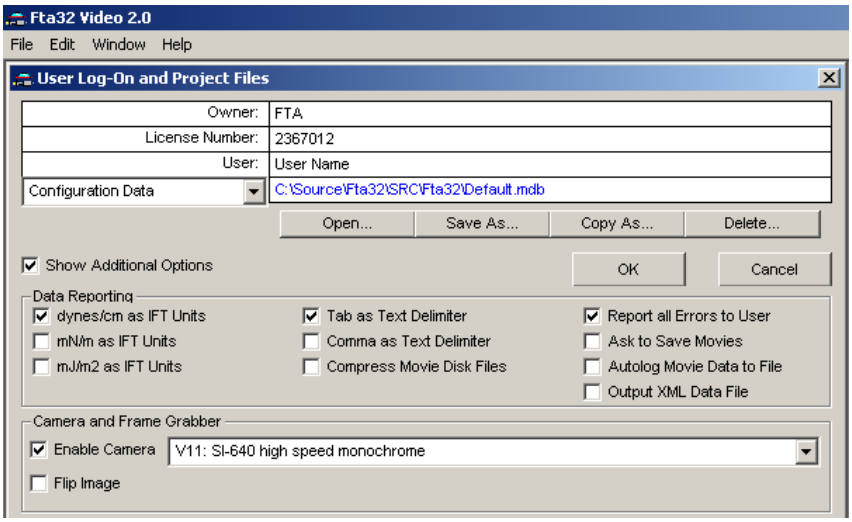


For your information, the DLL used is XCLIBWNT.DLL. All of these will be present in the Fta32 Video folder.

This camera does not have a demo program. Instead, use the main FTA software.

On the LogOn screen, select

V11: SI-640 high speed monochrome



Capabilities

The camera uses a Camera Link interface to the frame grabber. This interface provides real transfer rates of 80M byes per second, which is considerably faster than USB2 cameras. The height of the captured image can be varied and this provides different frame rates when running as fast as possible. At slower frame rates, the entire VGA (480 line) image is transferred. Since

you will have only a partial image at the fastest rates, the image can be panned (moved up and down) to position it at the point of maximum interest. To make using the camera easier, pre-selected rates and images sizes can be chosen from the Video | Capture tab. These are described in the following table.

Approximate Frames/sec	Exact Period (s)	CCD Exposure (s)	Image Lines	Max Movie Frames*	Movie Capture Timing Method
2000	505µ	488µ	58	450	fixed buffer, continuous
1250	816µ	800µ	95	275	fixed buffer, continuous
1000	1017µ	1000µ	119	219	fixed buffer, continuous
800	1262µ	1245µ	148	176	fixed buffer, continuous
500	2019µ	2002µ	238	110	fixed buffer, continuous
250	4048µ	4m	480	109	fixed buffer, continuous
200	4980µ	4m	480	54	fixed buffer, continuous
125	8084µ	4m	480	54	fixed buffer, continuous
100	10.0m	4m	480	54	fixed buffer, continuous
80	12.5m	4m	480	54	fixed buffer, continuous
50	20.0m	4m	480	54	fixed buffer, continuous
25	40.0m	4m	480	any number	RAM; skip one 20ms frame
16.6	60.0m	4m	480	any number	RAM; skip two 20ms frames
12.5	80.0m	4m	480	any number	RAM; skip 3 20ms frames
10	100m	4m	480	any number	RAM; skip 4 20ms frames
8.33	120m	4m	480	any number	RAM; skip 5 20ms frames
5	200m	4m	480	any number	RAM; skip 9 20ms frames
2.5	400m	4m	480	any number	RAM; skip 19 20ms frames
2	500m	4m	480	any number	RAM; skip 24 20ms frames
1.25	800m	4m	480	any number	RAM; skip 39 20ms frames
1	1000m	4m	480	any number	RAM; skip 49 20ms frames
0.833	1200m	4m	480	any number	RAM; skip 59 20ms frames
0.5	2	4m	480	any number	RAM; skip 99 20ms frames
0.25	4	4m	480	any number	RAM; skip 199 20ms frames
0.2	5	4m	480	any number	RAM; skip 249 20ms frames
0.125	8	4m	480	any number	RAM; skip 399 20ms frames
0.1	10	4m	480	any number	RAM; skip 499 20ms frames

Approximate Frames/sec: The clock generator in the camera can generate only specific frequencies and these do not generally match "even" frame rates. The approximate frames per second (fps) rates are easy-to-remember values.

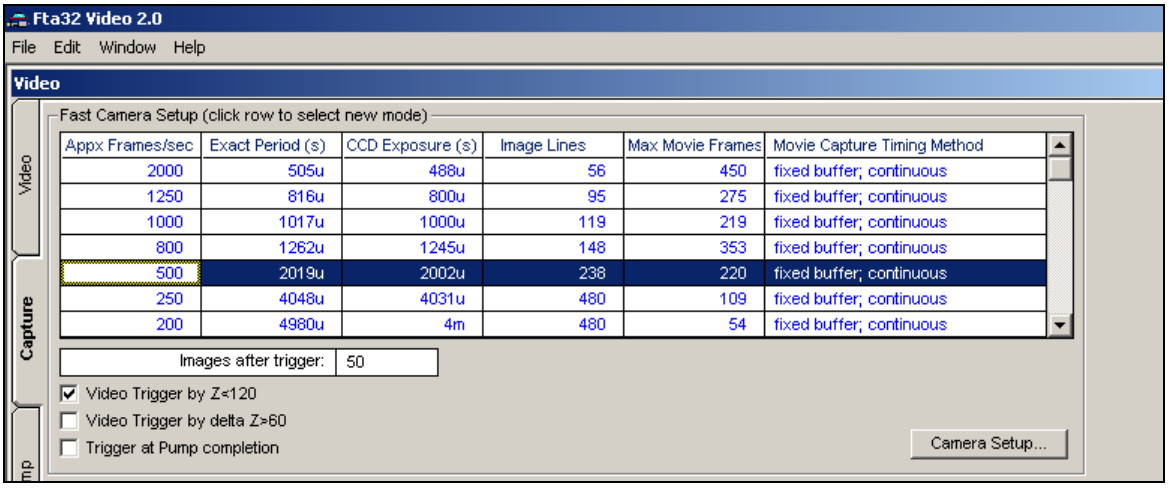
Exact Period: This is the actual frame period for each rate. These rates periods are within 2% of the theoretical period for the selected frame rate, and most are within 1%. The very fastest rate is also subject to a calibration for each camera (discussed later). The values in this column are used to time Movie frames.

CCD Exposure: "Exposure" refers to the time in each frame that the sensor actually collects light. At the fastest frame rates, you want, and need, all the light you can get, so the exposure starts out as much as is allowed for the frame period. The exposure period can not exceed the frame period. At slower frame rates, you can collect more light than you can use. In an attempt to keep fast and slow rate images of similar brightness, the exposure is limited to 4 milliseconds from 250 frames per second and slower.

Image Lines: The highest frame rates are achieved by transferring only a portion of the frame and using the available time to transfer several of these instead of one complete, large frame.

Max Movie Frames* and Movie Capture Timing Method: Frames rates of 50 frames per second and faster can not reliably be transferred by Windows. This is not an issue with the Live preview image, since the eye can't follow changes much faster than 30 per second anyway. But we do need to capture Movies at faster rates. Therefore, we store all of the frames of a fast Movie in a special buffer memory, then move them over to Windows as time allows later. That's why the final column changes at 25 frames per second. At 25fps and slower, you can transfer directly to Windows and you can have as long a Movie as you wish. At the faster rates, the Movie is captured in this special buffer first. The buffer has a fixed size that limits Movie length in the fast capture mode. The fastest frame rates have smaller image and therefore more of these images can fit in the buffer. *How to make the buffer larger is discussed later*. Slow Movies are captured using the 50fps setup and skipping, or throwing away, enough images that the remaining images are spaced in the desired fashion. For example, skipping every other frame gives us a 25fps Movie.

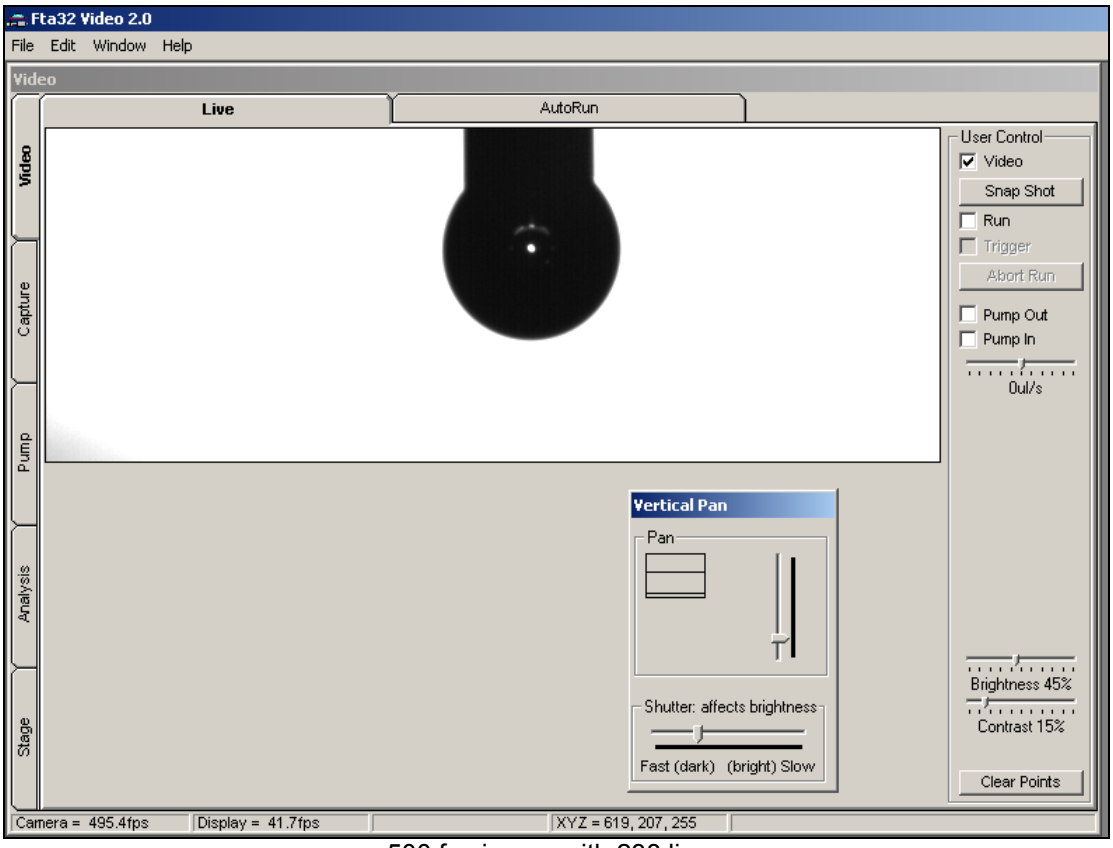
Camera modes are selected by clicking on a row in the table on the Capture tab.



Pan, Brightness, Contrast, and Shutter Time

This camera functions a little differently than other cameras you may have worked with. First, there are three controls that affect brightness and contrast, and the vertical pan control to set the region of interest when you are running less than a full frame.

Brightness: Sets the black level for the image. This is the brightness of "dark" portions of the image, like the needle in the example image below. It is rarely set above 50%. Determine the gray scale value for any point by the XYZ control and readout in the lower status bar. Place the cursor over the point to be read.



500 fps image with 238 lines.

Contrast and Shutter: Contrast is the amplification applied to the image after the A/D converter on the sensor chip. All other things being equal, you want as little amplification as possible, because amplification increases noise, but you want enough that the brightest portions get to full white (255). Make this adjustment with the Shutter control all the way to the right (unlike what is shown in the illustration). The Shutter control allows the full exposure, as shown in the preceding camera mode table. All it can do is reduce the exposure from the allowable maximum, which is the full frame time. The differences between Contrast and Shutter are

- Shutter is the *time* the image sensor is sensitive to light each frame period.
- Contrast is the electronic *gain* applied to the sensor signal.

The adjustment procedure is

1. select the mode, which sets the frame rate and image size.
2. start with Brightness = 50%.
3. start with Shutter to full right.
4. increase Contrast until bright portions of image are indeed bright, but no more.
5. because the Contrast control is coarse, you may find no “happy medium.” Go on to the next upward setting so the bright areas are fully white.
6. back off on the white brightness by reducing the Shutter, i.e., moving it to the left.
7. adjust Brightness if necessary.

The above image purposefully had the shutter reduced until some portion of the bright background was no longer fully saturated at 255. This area is seen in the lower left-hand corner.

You can easily estimate the actual shutter time:

- when the shutter is at the full right, it is the value shown in the table, from a minimum of 488μs to a maximum of 4ms.

- when the shutter is not at its full right, it will be the fractional value of the exposure shown in the table. Notice the shutter slider displays a number, from 0 at the left to 4000 at the right, when it is dragged. The number will be the fraction of the available exposure: (slider / 4000) × max exposure for this format. A short shutter time is useful in preventing motion blur in the image.

Pan: The pan control will move the region of interest up and down when the image is less than full height. Move the slider up to move the region of interest up. In the above illustration, it is set in the lower middle of the range.

Camera Setup Calibration

The fastest clock mode is calibrated for each camera. This clock is used for all frame rates where only a partial image is available. Each camera is calibrated at the factory and the correct code is placed in the ConfigFile, typically default.mdb. Normally there is no reason to ever change this. Nevertheless, the code is made visible in case it needs to be changed. The *Camera Setup…* command button on the Capture tab provides this. The code is not human readable. The code selected for your camera will affect the fastest clock rate slightly (typically less than 1%). The grid on the Capture tab is not changed to reflect your code; instead it shows the typical value, 505μs. The code is chosen for the best quality of image at the fastest rate. The code takes effect the next time the image is resized or the program is restarted. If you have obvious ragged blackness on the right-hand side of the image, from top to bottom, the code is wrong.

Max Movie Frames Buffer Size

Fast capture is implemented by directly writing images into a pre-allocated buffer in RAM. This buffer is allocated when Windows starts, whether or not the Fta32 program is used. The default value is 16M bytes, a small portion of the typical 512M byte, or more, RAM in new computers. The default allocation gives you the maximum Movie lengths shown in the grid table. However, you can easily have a buffer ten times this size, giving you Move lengths ten times the table values.

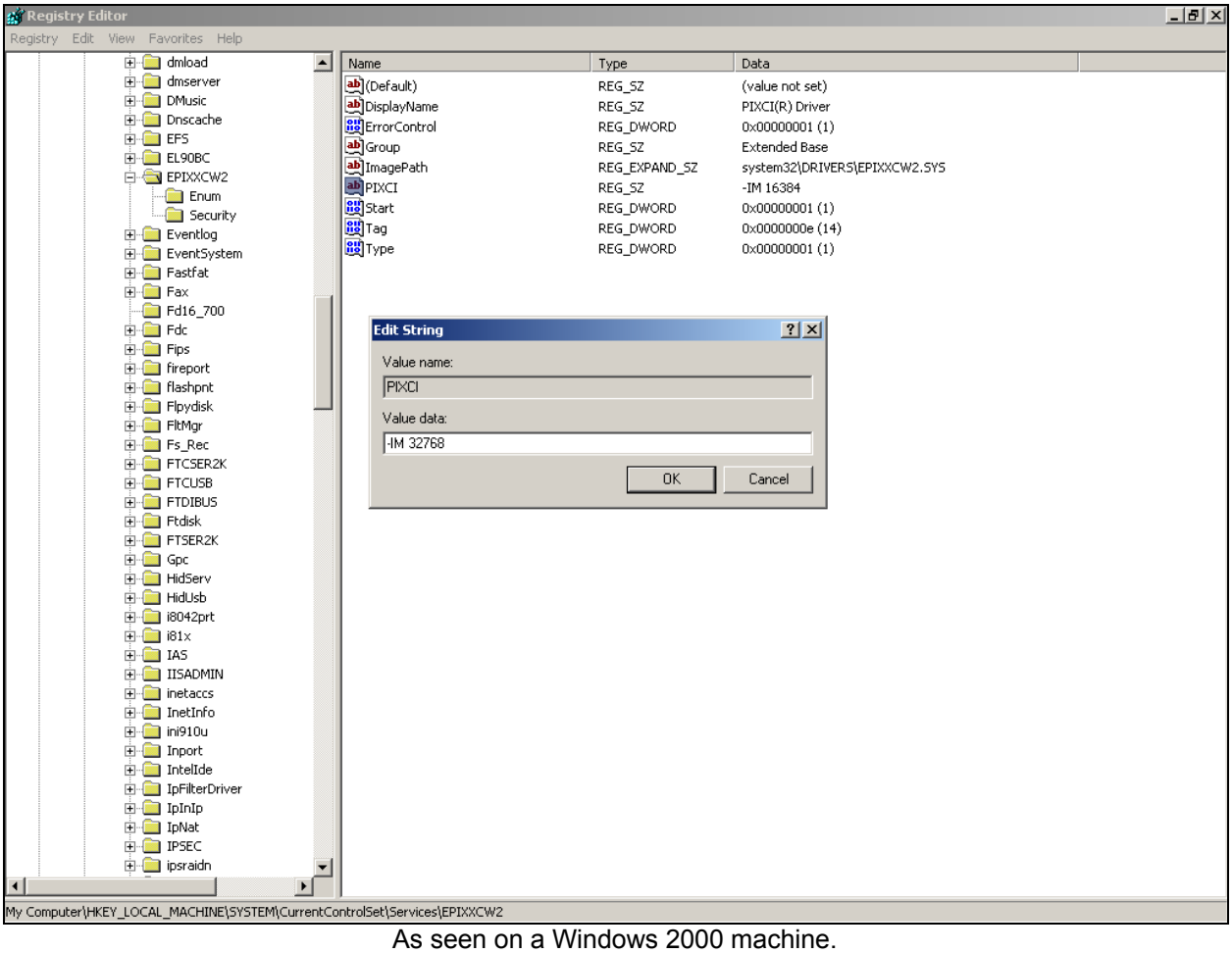
You change the buffer size by editing the Windows registry. If you have not done this before, you may want to ask someone who has or your IT support person. The procedure is outlined below. You only need to do this once, as it is stored.

1. Click Start | Run and type in “regedit” in the Open box. This will open the Registry Editor.

2. You will see an Explorer-like display of the “keys” in the registery. Click down to find

   HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\EPIXXCW2
   PIXCI = <DriverConfigurationParameters>

   Right click PIXCI in the right panel to *Modify* (edit) the –IM value. The initial value will be 16384. This is the megabytes of pre-allocated storage. The example shows it doubled to 32768 megabytes. You might wish much more. The new value takes effect after a restart.



As seen on a Windows 2000 machine.

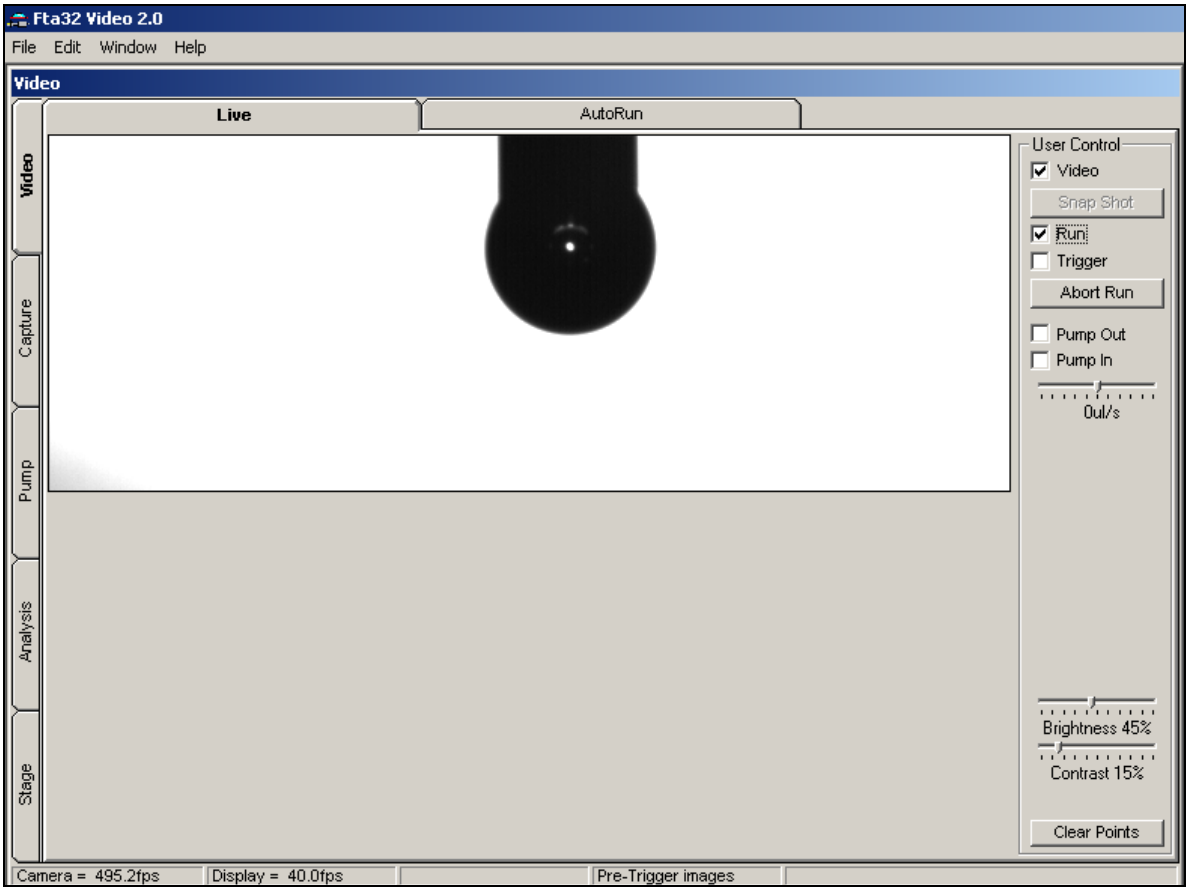
When you select a camera mode in the Capture tab, the *Max Movie Frames* value will be updated to what is currently available.

Capturing Movies

Movie acquisition is similar with the SI-640 to other FTA systems, but there is one critical difference: while the Trigger starts the final acquisition, the number of pre-trigger images is fixed at nominally 5. Instead, the method is

1. Enter the number of images desired on the Capture tab. In the illustration on page 4, 10 images were requested.

2. Click Run to perform the basic setup for acquiring the Movie. When the system is ready, the annotation *Pre-trigger images* will appear in the lower status panel, as illustrated on the next page.



Pre-trigger images appears indicating ready for Trigger.

Now you can click *Trigger* for a manual trigger or have the image processing generate a video trigger. The driver purposefully captures about five images before the trigger, to account for the delay in Windows of recognizing the condition of a trigger request. This allows you to see an image or so *before* the trigger, as the example movies will illustrate.

Camera, Display, and Movie Frames Per Second

There are three flavors of frame rate:

Camera: This is the current measured rate of images being generated by the camera. The rate is determined by measuring the time required for the camera to generate 1000 images. Because of the coarseness of the Windows timer, plus the uncertainty of when the software will inspect the timer, there is an uncertainty of ±1 images in the count. You will notice the last digit of this rate will bounce in time.

Since 1000 images are required to make a calculation, the time required at slower rates can be quite long. For example, at 50fps, 20 seconds are required. If you change format, it will take some time to correctly update the frame rate. You should expect that the measured Camera rate to be approximately the reciprocal of the "Exact Period" time in the grid table. If the grid shows 505μs, for example, you would expect 1/505μs = 1980fps. This measured rate is to give you comfort that the camera is running as expected.

Display: This is the measured rate at which new images are displayed by Windows. For frame rates above 50fps, you can expect Windows to be slower than the camera. The missing images for the Live screen are discarded and lost. Movies, however, capture everything they are supposed to. When running slower than 50fps, the camera sends all images through to the Windows display, even though not all will be used in a Movie. So here the reverse is true: the display is faster than the ultimate Movie.

Movie: Images in a Movie are given time stamps according the Exact Period values in the table. This is more accurate than the Windows timer, as discussed above. Whatever the camera rate is, we know it is constant because it is crystal controlled.

Illumination

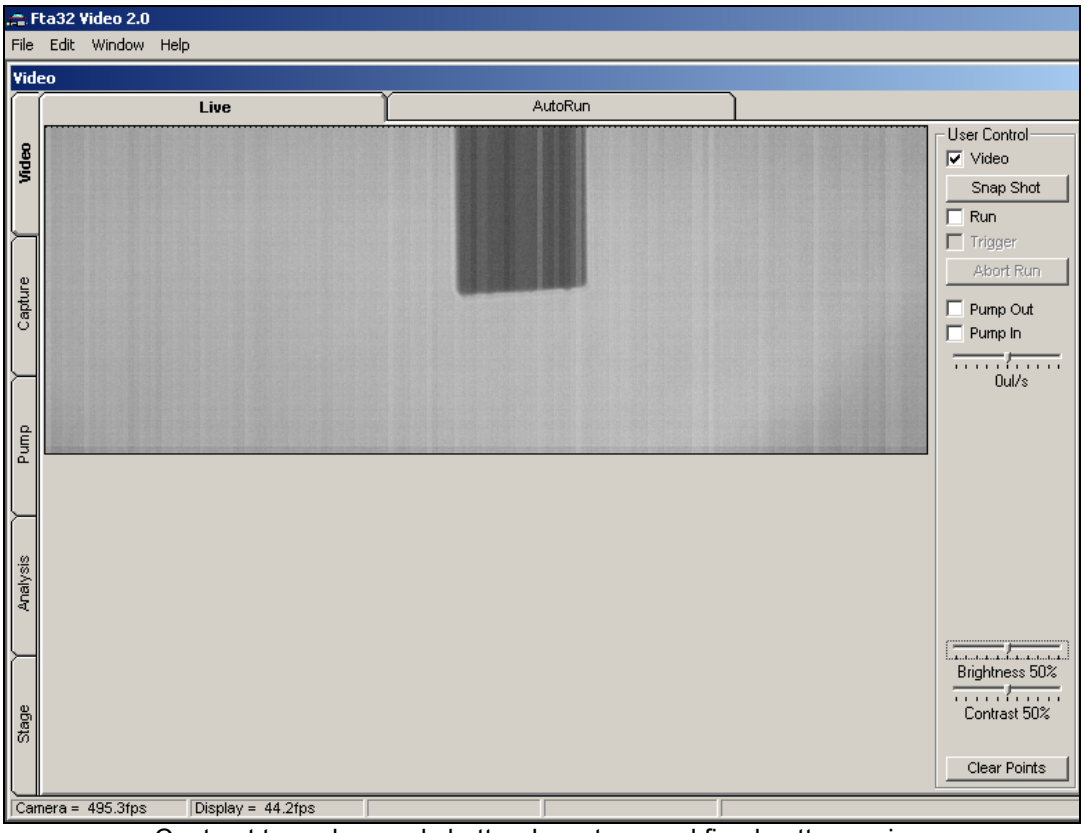
Bright illumination is required because of the short exposure time at the higher frame rates. The standard FTA illumination for this camera uses a 12V, 5W halogen bulb (Osram 64111). Certain systems have adjustment screws on the light box that position the bulb so the illumination can be in the centered on the region of interest.

Because the field of view is restricted at high frame rates, you may wish to use a lower magnification than normal so that you maintain a reasonable field of view. This is contrary to intuition. A lower magnification (→ larger field of view) also provides more light for the image.

Image Noise

All cameras have noise in one form or another. In this type of camera, it is different from the "salt and pepper" or "snow" found in ordinary RS170 cameras. This camera shows what is

called fixed pattern noise, which are vertical lines in a poorly lit image. The following image purposefully shows this.



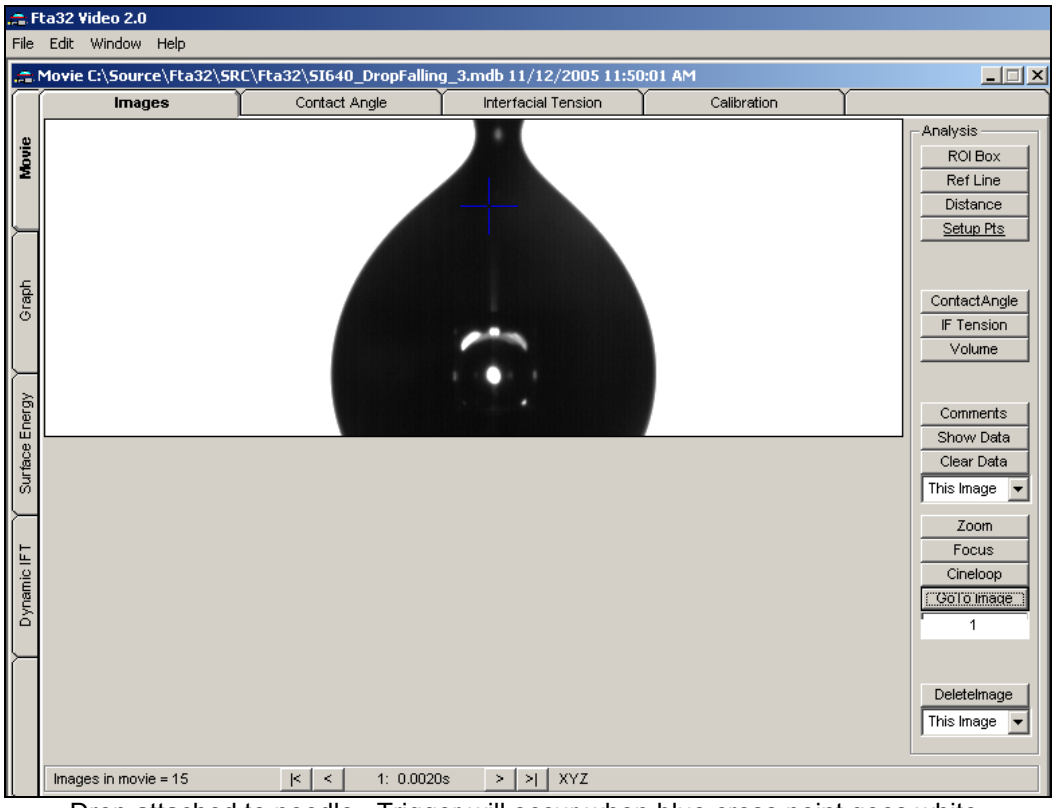
Contrast turned up and shutter down to reveal fixed pattern noise.
Avoid this by running just enough Contrast and a higher shutter value.

Running Other Programs While Fast Video On

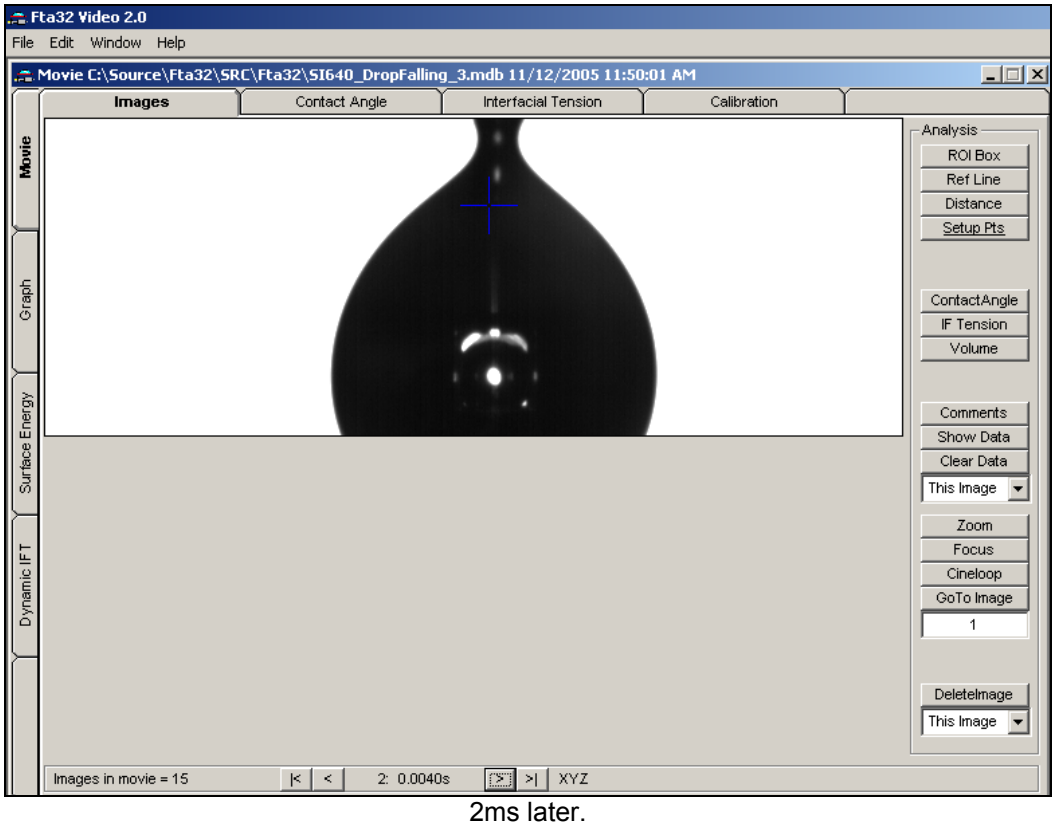
Basically you can not take the focus away from the camera any length of time or else it will stall and you must restart the Fta32 program. If you want to do something else, say run Word, then uncheck Video before switching to the other program.

Example Movies

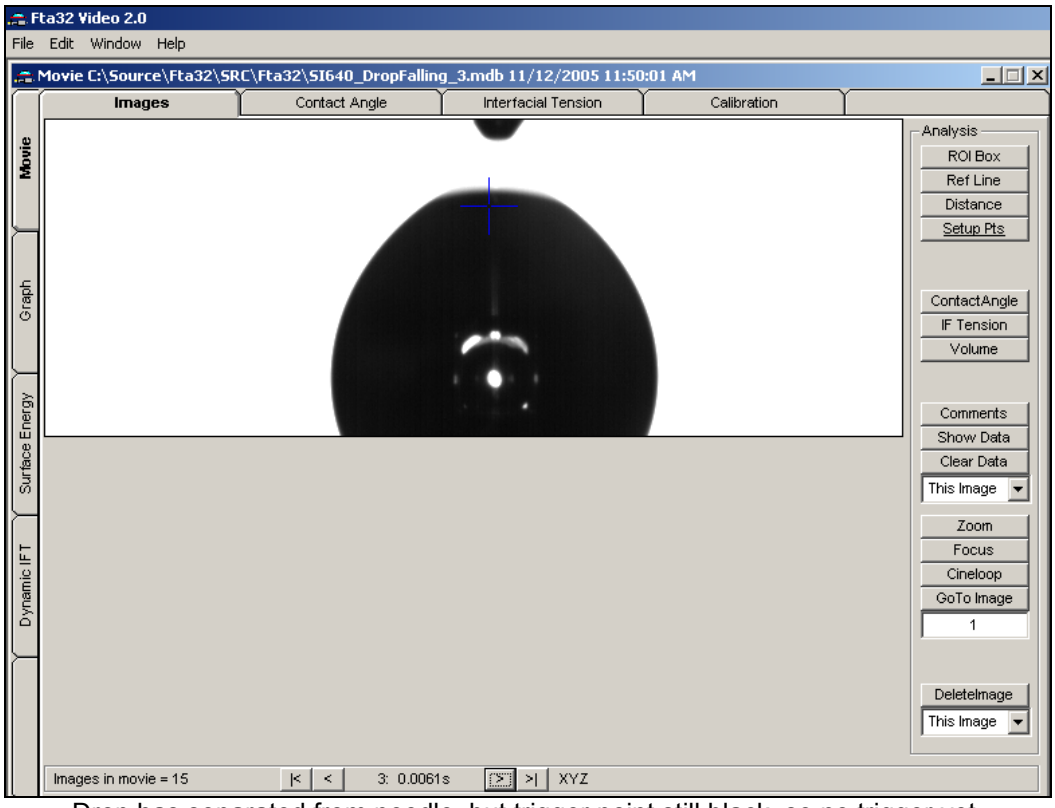
Two examples will be shown: a drop detaching from a dispense needle and falling free and a sessile drop detaching onto a surface via the touch-off method. In both cases a Video Trigger was used (see checkboxes in screen image on page 4). The first movie, the falling drop movie, is triggered by the trigger point changing gray scale, in this case from black to white. The second, the sessile drop touch-off, is triggered by the trigger point going dark. Six frames are shown from each movie. Both were taken at 500fps, so there is 2ms between images. The optical magnification was ×1 in both cases. The needle was a 27GA (406µm diameter).



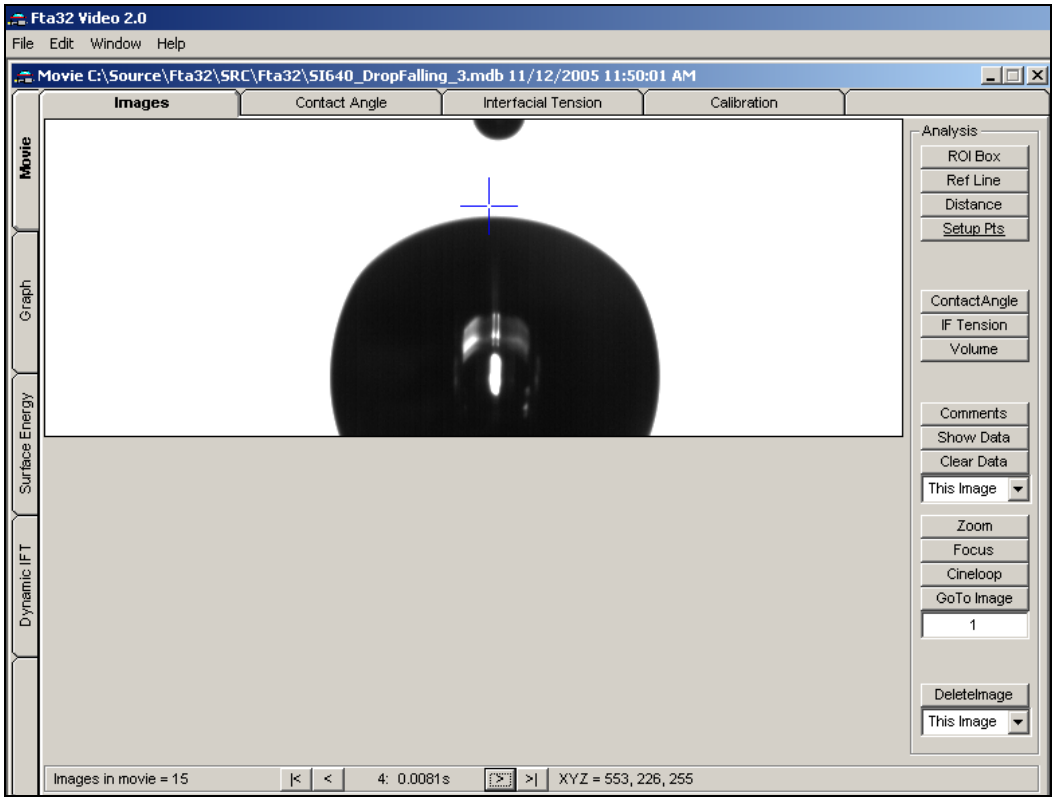
Drop attached to needle. Trigger will occur when blue cross point goes white.



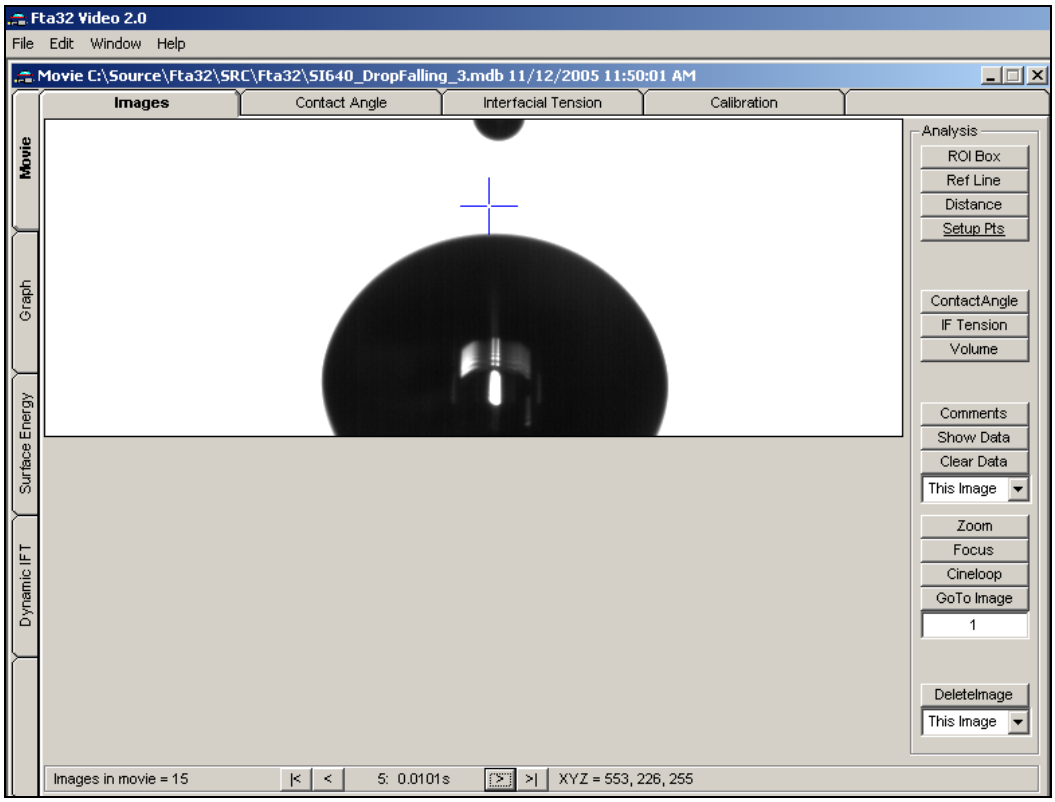
2ms later.



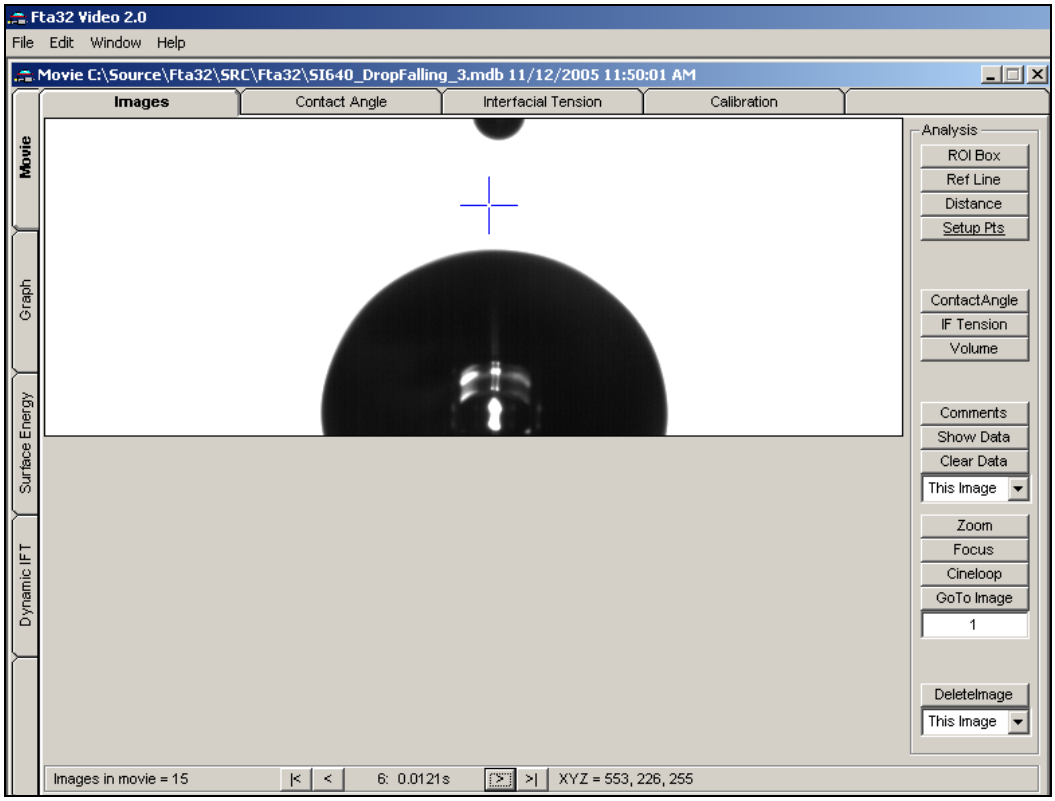
Drop has separated from needle, but trigger point still black, so no trigger yet.



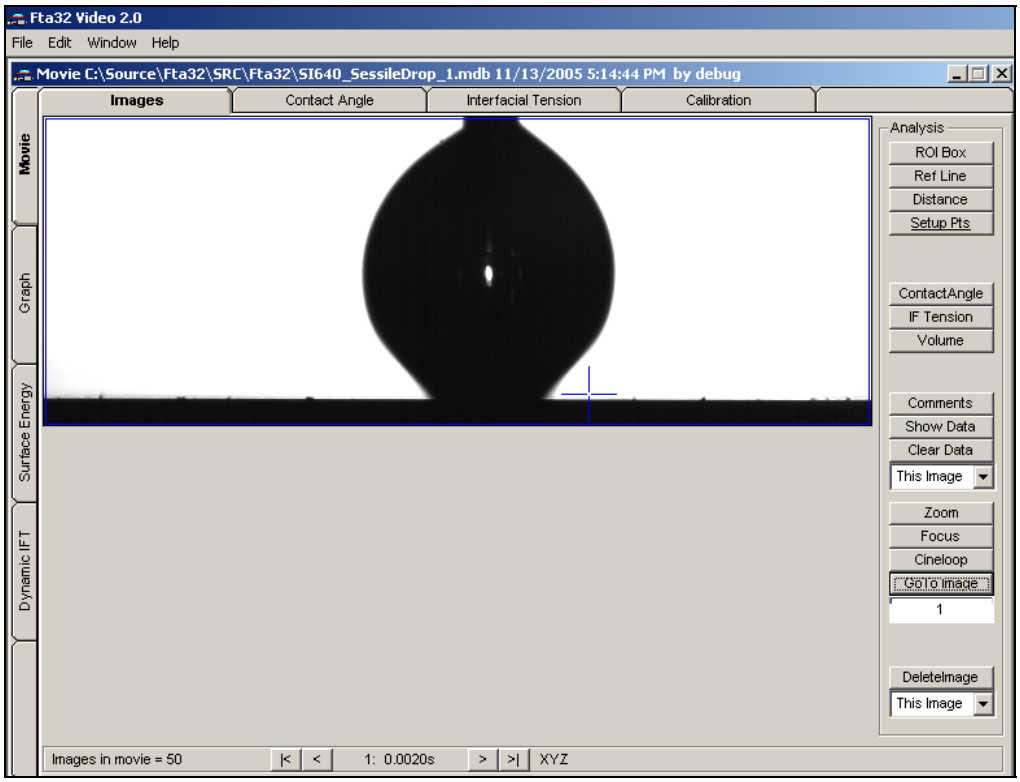
This is the frame that the video trigger generates the trigger. The cross is now white.



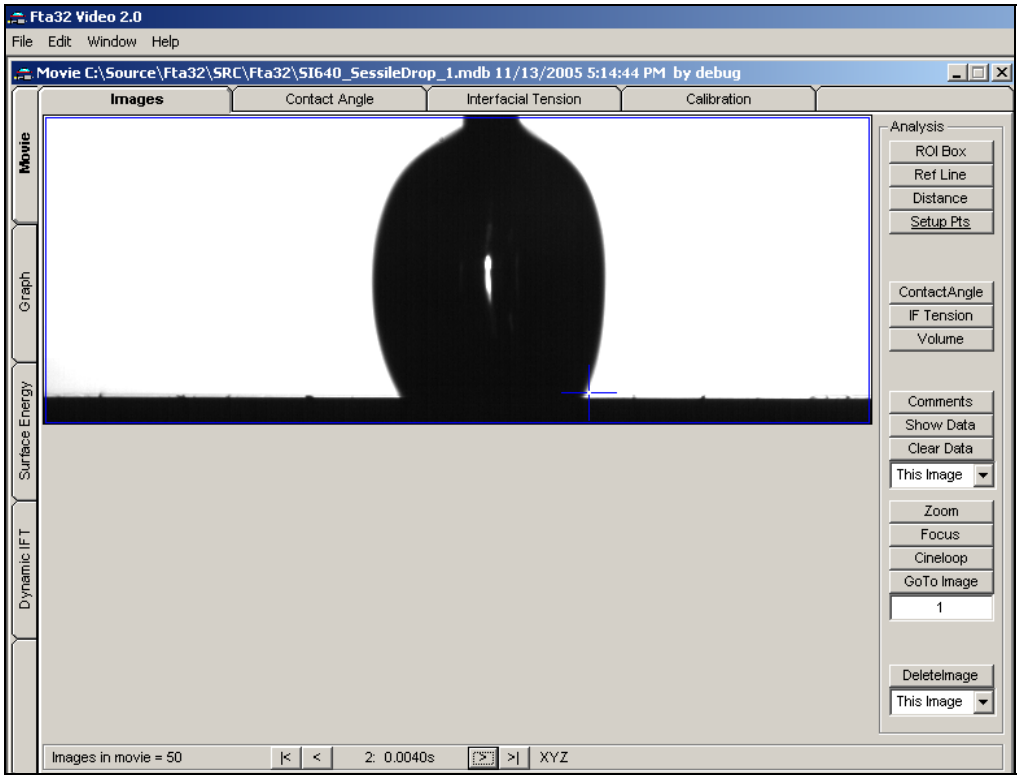
Notice top of drop has moved very little in 2ms since last image.



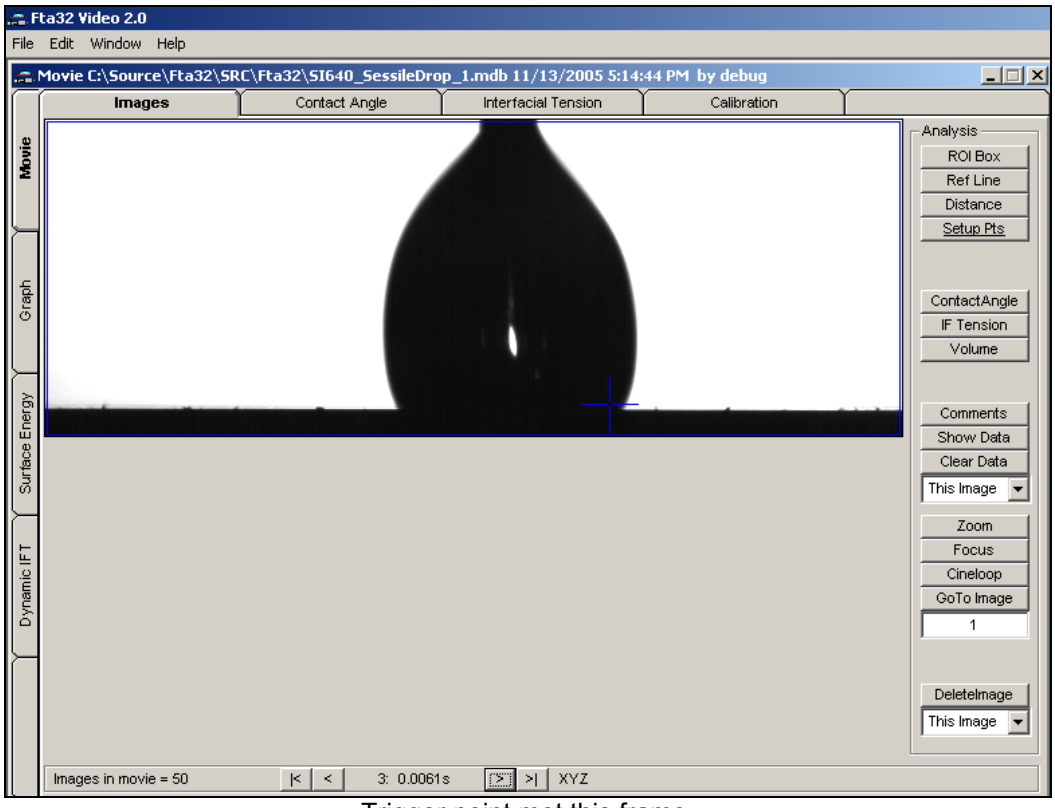
Drop starts noticeable movement down.



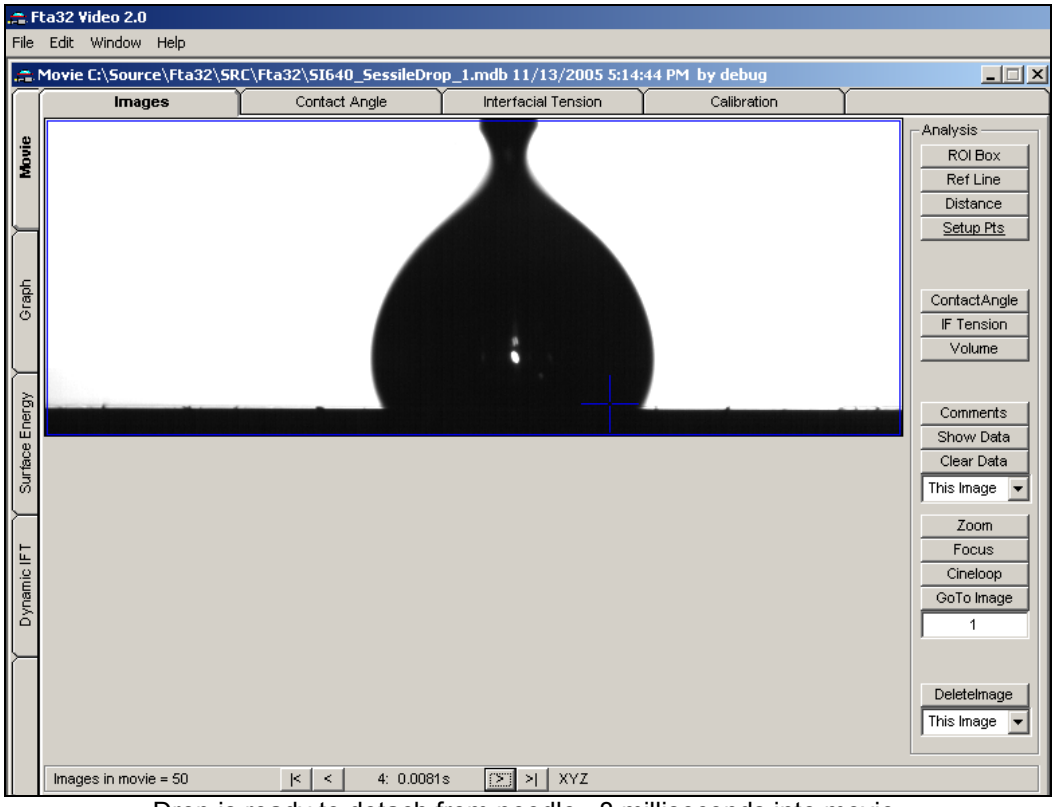
Sessile drop Movie. The previously spherical pendant drop has just touched the surface. Initial spreading distorts drop.



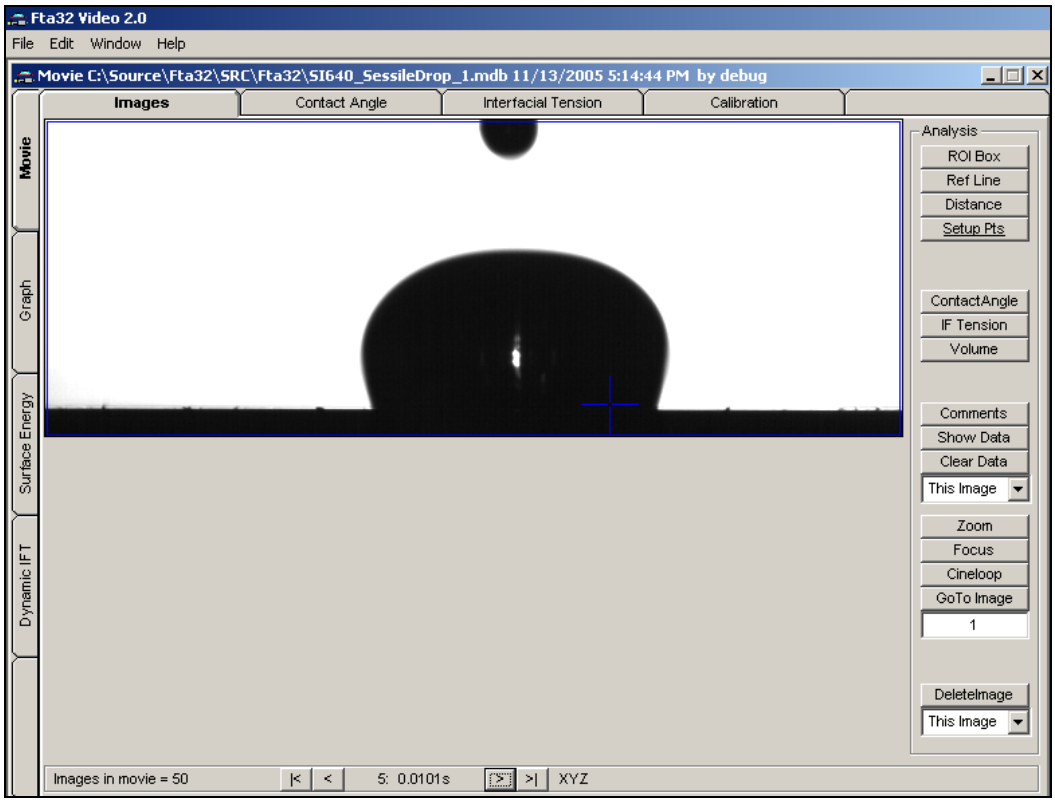
Drop continues to spread. Trigger point not yet met.



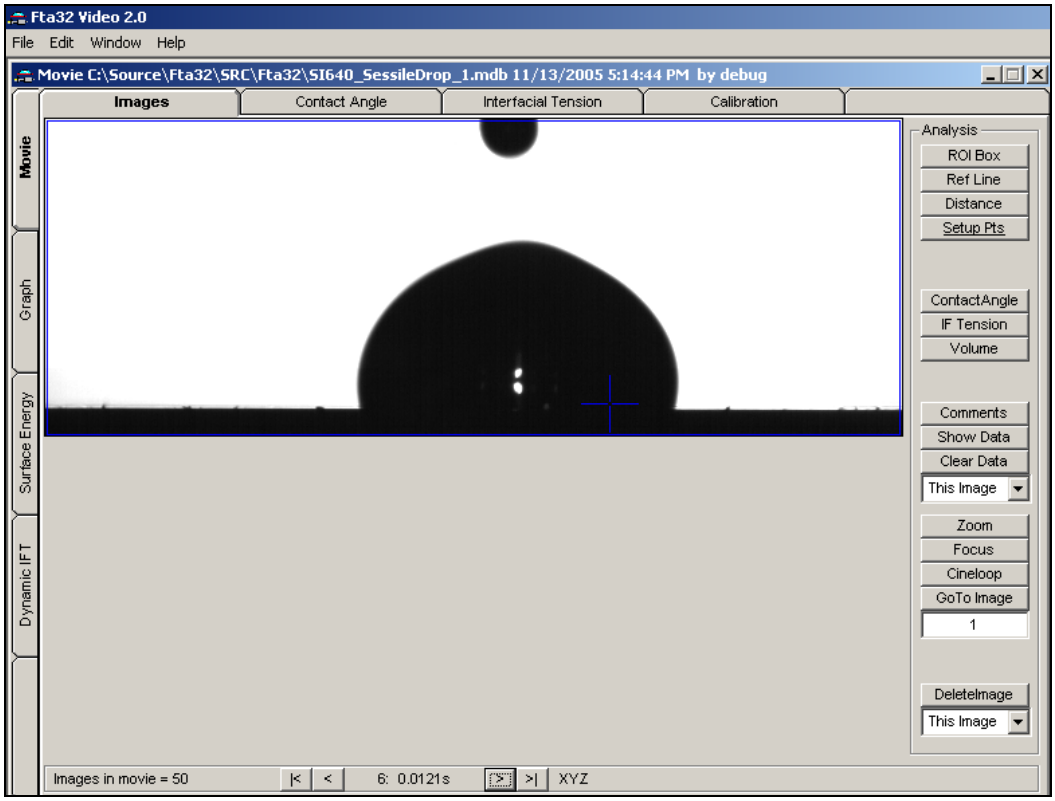
Trigger point met this frame.



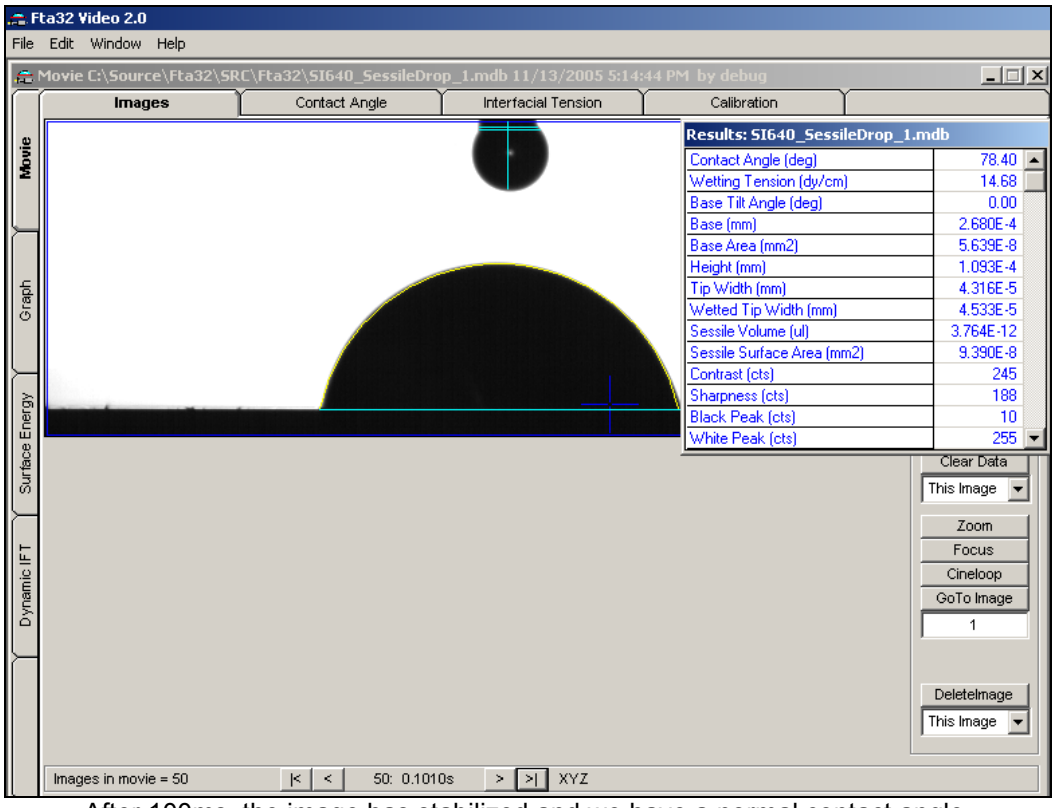
Drop is ready to detach from needle. 8 milliseconds into movie.



Drop again distorted by detachment.



Drop continues to spread on solid surface.



After 100ms, the image has stabilized and we have a normal contact angle.

External Hardware Trigger

The Fta32 software provides a real time image processing based trigger for Movies. If you desire a electronic hardware trigger, please consult FTA. It is possible to provide a TTL interface to a user-provided signal which will trigger Movies. This interface requires an additional PCI slot to bring the connector out. There is a charge for the interface and its software.

An example of its utility would be when droplets are fired at the surface by some external dispense mechanism. The advance warning of the external signal would make high speed capture easier.

Frame Grabber Board

For additional information on the frame grabber employed with this camera, see

http://www.epixinc.com/products/pixci_cl1.htm

File: SI640CameraInstallationAndUse.doc