SVM340 Synchronized Video Microscope
User's Guide

Table of Contents

1. INTRODUCTION

The SVM340 is an inverted fluorescence microscope with built-in video camera, fluorescence filter, pulsed Light-Emitting Diode (LED) illuminator, motorized *x-y* traverse and focusing actuator. It can directly image fluorescent or non-fluorescent samples on a standard video monitor or video recorder.

In addition, the SVM340 includes an advanced programmable synchronization unit with four inputs and three outputs for synchronizing image acquisition to external events.

The basic functions can be controlled by the front panel controls or through the uScope application software included with the instrument.

1.1 New in uScope™ Version 1.04

Version 1.04 of uScope™ software includes a number of new features and improvements to existing features:

Macropixel intensity probes
The macropixel probe is a rectangular intensity probe that can be subdivided into discrete sections for spatially-resolved intensity measurements.

Expanded Time lapse options
The Time lapse option lets you select the frame rate frequency to allow video taken over a long period of time to be compressed to a small file and played back at increased speed. The latest version of uScope also allows you to apply snap shot settings (i.e. flash settings, averaging, black and white level adjust) to the time lapsed video, essentially compiling a series of snap shots into a time lapsed video.

Some other relatively new features (implemented in v1.026) include:

Snap-shot settings
The snap-shot feature lets you create a single image consisting of an average of one or more consecutive images.

Motion Limits
Motion limits on the XY stage are useful if you have installed a device on the SVM (i.e. a chipholder) that may interfere with the stage at its preset limits.

Video compression
Though uScope does not have built-in compression it can now use video compressors that are installed on your computer. To add compression functionality, you need to download and install a “codec.” A compatible codec will also need to be installed on anything that plays the video.

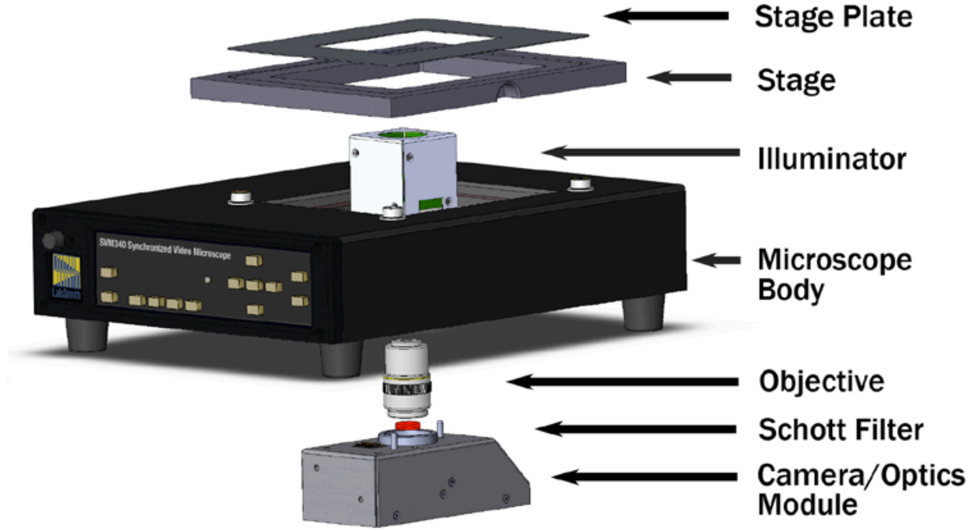
Deinterlacing
Improvements have been made to the deinterlacing method and to the Deinterlace Settings dialog box.

Buffering
Improvements have been made to the method by which video is buffered to RAM memory. The newest version of uScope software uses video buffering for the video recorded live (not from the pre-trigger buffer) so that this video is also saved without dropping frames.

Recording a video
Improvements have been made to the interface for recording pre- and post-trigger video.

Distance indicator
The Distance Indicator allows you to measure features on your image.

1.2 Package contents



The basic SVM340 includes the following items:

- Microscope body + 4 standoffs (feet)
- B&W optics module
- 4-channel illuminator (typically Blue)
- 10X objective
- Delrin sample stage
- standard stage plate (50 mm x 75 mm opening)
- external video capture device
- power, RS232 and S-video cables
- uScope software installation disk
- user's manual

The following optional items may also be included, if ordered

- additional optics module (i.e. Color, EPI)
- additional illuminators
- 4X or 20X objective
- integrated breadboard sample stage

- chip viewing sample stage (two openings to fit most standard microfluidic chip sizes)
- internal video capture card
- Schott glass filter with foam washer
- Schott glass filter kit (includes 8 filters and 2 foam washers)

If any parts are missing or damaged, please contact your local dealer or LabSmith immediately.

1.3 Basic functions

The SVM340 combines an inverted fluorescence video microscope with a programmable synchronizer and software for on-line image acquisition, processing and storage. You can use the instrument in several ways:

- As a stand-alone video microscope. Connect the video output from the SVM340 to an analog video monitor or VCR through the BNC or the S-video outputs on the rear panel. You can now focus, traverse and adjust illumination intensity by the controls on the front panel while observing the image on the monitor.
- As a software-controlled video microscope for automatic or manual acquisition of video sequences, using the on-line image processing and storage capabilities of the uScope application.
- As an integrated part of a complex experiment, synchronizing pulsed illumination, image acquisition and external devices in response to up to four trigger input signals.

In each of these modes, you can use microscope objectives with magnification from 4X to 20X, and acquire and store the video output on standard analog video storage hardware. With the uScope application, you can directly store the video data on computer disk as .avi files and perform advanced real-time video processing.

1.4 Computer requirements

The uScope software is designed to stream digitized video sequences directly to disk, so it is recommended that the computer fulfills the following minimum requirements:

- Windows XP, Vista or Windows 7 or newer
- USB2.0 port for the external video capture device or a PCI slot for the internal video capture card
- RS232 port for communication or USB2.0 port and a RS232-USB adapter
- minimum of 1 GB of RAM (4-8 GB recommended)
- 80 GB hard disk with 12 ms access time (500-1000 GB recommended).

The SVM340 microscope includes a VGA-resolution analog CCD camera which outputs a standard RS170 monochrome or NTSC color composite video signal. The video signal is digitized by a DirectX9.0 compliant PCI video capture card or USB2.0 video capture peripheral, capable of digitizing and storing uncompressed VGA resolution video on disk.

Many PC video input devices include on-board image compression hardware, converting the video stream into various compressed video formats. Image compression standards like MPEG are designed for general visual imagery and may not be suitable for all types of imagery occurring in microfluidics device diagnostics, e.g., the images of isolated small particles as recorded in Particle Image Velocimetry (PIV) experiments. The ability to record uncompressed video is therefore an important feature of the hardware and software included with the SVM340.

Uncompressed video streams naturally take up more bandwidth and use more computer processing power for display and storage, so a powerful computer is recommended. When used on a newer standard PC with moderately fast CPU and disk speed, uncompressed video sequences can usually be stored on disk in real time. If used on slower computers, frames may be lost during recording. Slower computers may also exhibit a perceptible delay between an imaged event and its appearance on the computer display.

Also, a large hard disk is recommended for storage of video data. A color video signal will typically generate 1.6 GB per minute and thus quickly consume hard disk space.

1.5 Installing the software

1.5.1 Installing the video capture card and/or drivers

A video capture card or peripheral USB capture device is required to view and record the video signal on your computer. If you purchased one of the devices through LabSmith, a separate instruction manual with the installation instructions and driver disk will be included with the device. It is always a good idea to check with the manufacturer's website to make sure you have the latest drivers.

If you have purchased a RS232-USB adapter you will also need to install the drivers for this device. Again, the disk with drivers and instruction manual will be included with the product.

Your computer may need to be restarted after the video capture or RS232 adapter drivers have been installed.

1.5.2 Installing uScope

If your computer does not already have DirectX9.0 or greater installed you will need to install it before running uScope. DirectX9.0 is free and available directly from Microsoft's website. Most computers will already have this software installed.

To install uScope, run setup.exe and follow the on-screen directions.

2 SVM340 HARDWARE

The following section describes how to set up your SVM and how to use it independent of the uScope software.

The SVM340 is shipped with the feet removed to protect the unit during shipping. They must be installed on the unit before an optics module is inserted.

Note: The SVM uses a sheet metal chassis to minimize weight, size and cost. The sheet metal chassis occasionally can have a slight warp that causes it to rock when the feet are attached. The feet are designed to have some adjustability to accommodate for this unevenness. This warp does not affect the function of the SVM due to the kinematic design of the focus stage.

2.1 Illuminator module

The illuminator module consists of four independent LED channels. Two of the channels (A and B) have 8 LEDs each and two channels (C and D) have 4 LEDs each.

Available LED colors include:

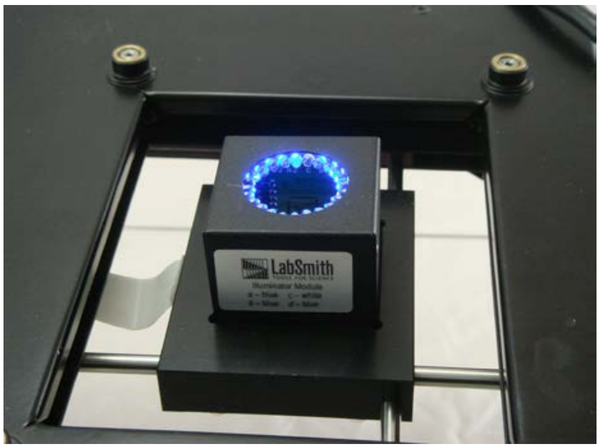
Color	**Wavelength range**
Blue	464-476 nm
Green	520-535 nm
Red	615-636 nm
Yellow	585-595 nm
White	

Standard illuminator modules:

Name	**Channel A**	**Channel B**	**Channel C**	**Channel D**
LED-B	Blue	Blue	White	Blue
LED-G	Green	Green	White	Green
LED-R	Red	Red	White	Red
LED-Y	Yellow	Yellow	White	Yellow
LED-W	White	White	White	White
LED-X	Blue	Green	White	Red

LabSmith can provide customized illuminator modules with any combination of LED channels.

The illuminator module can be removed from the traverse from the top by pulling the module upwards.



Illumination module installed in SVM340

Note: When reinserting the illuminator module, take care that the connector pins are all correctly inserted in the receptacle without bending or damaging the pins. Also take care not to apply excessive force. Support the camera module from below with your hand when inserting the illumination module and press from below to ensure the traverse mechanism is magnetically seated.

2.2 Optics module

The optics module is attached to the traverse by magnetic holders and can be removed by tilting the SVM340 on its side and gently pulling the module down from below the SVM340 body until it comes free.

Important!	Turn off power to the SVM340 before removing or inserting an optics module.

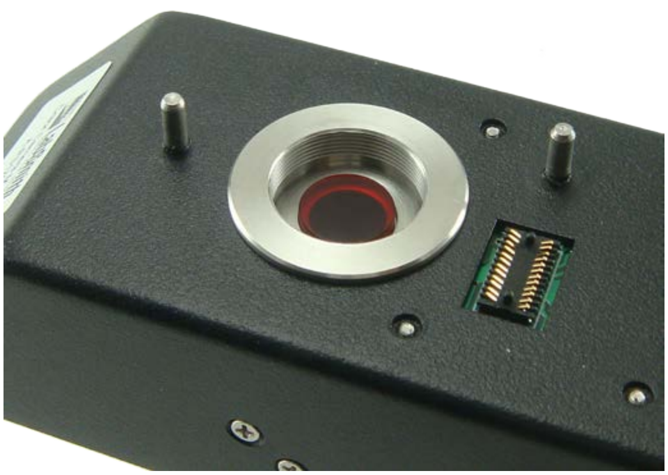
Optics module

Note: When removing or inserting the optics module, take care not to apply excessive force since this may damage the traverse mechanism and compromise traverse accuracy.

2.3 Microscope objective

The microscope objective is a standard DIN type objective with 160 mm conjugate image distance. To replace the objective, remove the camera module and unscrew the objective. The SVM340 supports objectives with magnifications from 4× to 20×. Objectives with higher magnification generally have insufficient stand-off distance to clear the illuminator LED's and can only be used with an external illuminator module or other external light source.

WARNING: Dust particles can enter the optics module when the objective is not installed. Removal or changing of the objective should be done in a clean environment when possible. We recommend that a piece of tape be placed over the objective opening if the optics module will be stored without the objective installed.



Fluorescence filter installed in an optics module; note: filter washer is placed on top of filter

2.4 Fluorescence filter

The fluorescence filter can be installed in the B&W and Color camera modules. The filter is installed by removing the objective and carefully placing the filter in the recessed opening. A compliant washer (provided with the filter) is placed over the filter to keep it secure under the objective.

Note: The EPI camera module is supplied with pre-installed fixed filters that cannot be removed.

2.5 Base stand

SVM340 front panel

2.6 Front panel controls

Many SVM340 features are accessible through the uScope software. will go through the uScope application software. You can also, however, access some important functions directly from the front panel.

The Power button and Power LED are located in the upper left corner of the front panel. When the power is turned on, the LED will flash green and red while the system runs its initial tests, and turn green when the tests have passed.

Site-Light These buttons toggle between SITE mode and LIGHT mode. When the SITE button is lit, the four storage buttons A–D represent four different stored positions, and the keypad controls the traverse movements. The focus buttons moves the objective up and down for focusing.

When the LIGHT button is lit, buttons A–D represent the four

LED channels, and the keypad up and down buttons control the intensity of the LED banks selected by the A–D buttons.

A–D In SITE mode, the buttons A–D represent four stored settings of the traverse and focus positions and LED intensities.

To recall a stored position, select SITE mode and press and release a storage button. The traverse will move to the location and set the four LED intensities to the values of the stored settings.

To store a traverse position, press one of the storage buttons and hold it down a few seconds until the button light goes off. This will store the current traverse position and the LED settings in the selected storage cell.

Note: There are a total of 10 preset positions available on via the uScope software.

In LIGHT mode, the buttons A–D represent four LED channels, labeled A-D. The 24 LEDs in the illuminator module are divided into four channels, which can be controlled individually. When a LED bank is selected, the corresponding button lights up. One or more LED banks can be selected simultaneously by pressing the one or more of the A–D buttons.

Note: When an EPI Optics Module is installed in the SVM, the EPI illumination is controlled using front panel button D. In this case illuminator channels B and D are both controlled by front panel button B.

Keypad In SITE mode, the four buttons will move the traverse in the *x* and *y* directions. Pressing a button will start the traverse motor at low speed, and after about two seconds motor speed slowly ramp up to high speed. Pressing the button briefly allows single stepping of the traverse.

Pressing the center button (Stop) will immediately stop any traverse movement which may be in progress.

When in LIGHT mode, the up/down keys will increase/decrease the intensity of those LED banks which are selected by the A–D buttons. One or more of the LED banks can be controlled simultaneously.

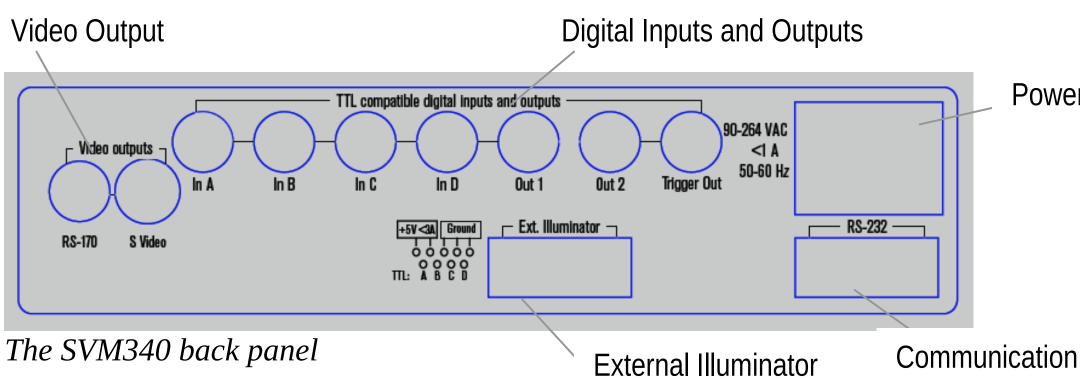
Pressing the center button (Stop) with switch off all selected LED banks.

Focus up/down These buttons will move the focus motor up or down to focus the image. The focus motor will start at slow speed and then ramp up to high speed.

Lock indicator The lock indicator LED on the front panel is green when the SVM340 is in position.

The Lock indicator LED turns red when the SVM340 is in motion, e.g. while the traverse is moving to a preset.

2.7 Back panel connections



The SVM340 back panel

Power Plug the power cable from the back of the SVM340 into a 90 – 240 VAC power outlet.

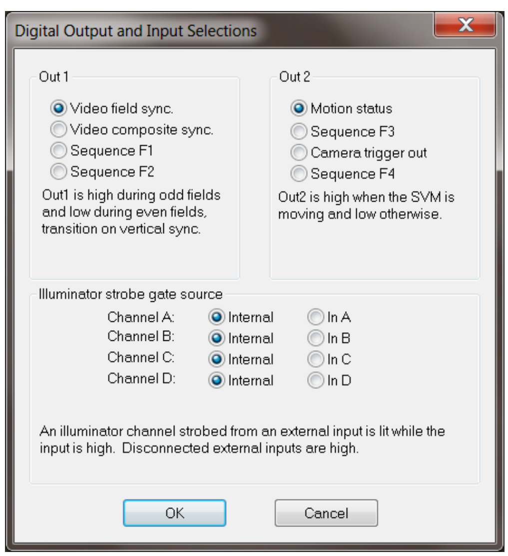
Communication The female 9-pin D-sub connector is for RS232 communications. This link allows the SVM340 to receive programming and commands from an external controller, e.g., a computer running the uScope application or LabView through the provided serial cable. A USB/RS232 converter can be used for computers without an RS232 port.

Video Output

The video signal is typically output via the S-video connector. An analog video capture card (included with the SVM340) is used to connect the S-video to your computer. It is generally recommended to use the S-video for best image quality. A BNC (RS-170) output is also provided for use with monitors without S-video input.

Digital Inputs and Outputs

The four digital inputs and three outputs on BNC connectors provide TTL level communication with external equipment. The inputs can be used to control or strobe the four LED illuminator channels or to trigger more advanced behaviors. The outputs are selectable and include video timing information, motion status information, and several advanced programmable flags. The inputs and outputs are set from the menu SVM>Digital Outputs & Inputs:



Digital Output and Input Window

The inputs could be connected to digital experiment controllers like the LabSmith LC880, interlock switches, sensors, or other external devices, and the outputs connected to other apparatus to facilitate real-time control and automation.

External Illuminator

This male nine-pin D-sub connector provides 5 V DC power and pulse signals to drive 4 external illumination sources with settings similar to the four-bank led module.

Pin connections

1	5 V DC (max 3 A)
2	Chassis Ground (0 V)
3	Chassis Ground
4	Chassis Ground
5	Chassis Ground
6	LED A drive (TTL)
7	LED B drive (TTL)
8	LED C drive (TTL)
9	LED D drive (TTL)

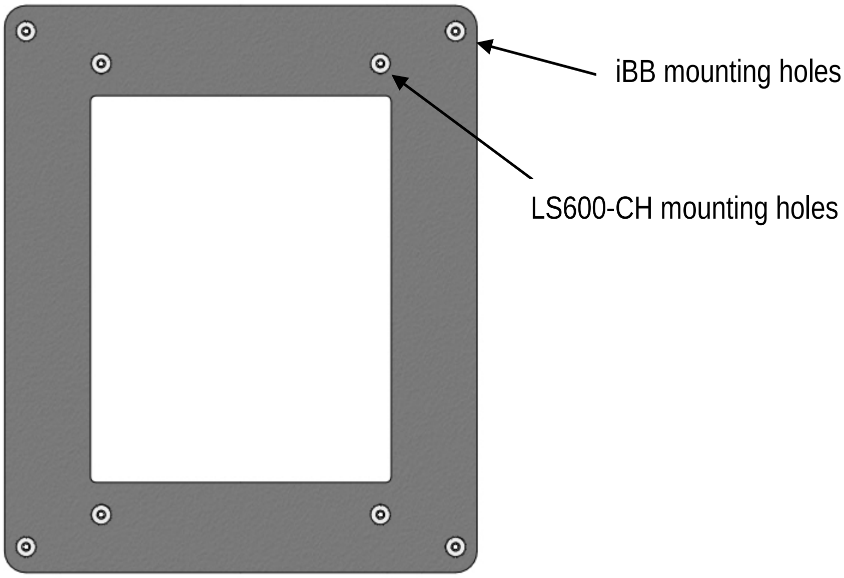
The light intensity of the SVM340 LEDs is controlled by pulse width modulation with a frequency synchronized to the video signal. Full light intensity means an illumination duty cycle close to 100%.
LED drive outputs A–D are negative logic, i.e., TTL level is high when LEDs are off.

2.8 Microscope stage

The SVM340 is fitted with a replaceable microscope stage, attached to the main body of the instrument by four magnetic locks. To remove the stage, simply pull the stage gently up until it releases. The stage top is a polished stainless steel plate, which can be machined to provide application-specific mounts for the fluidic device, electrodes, fluid hoses or other fittings.

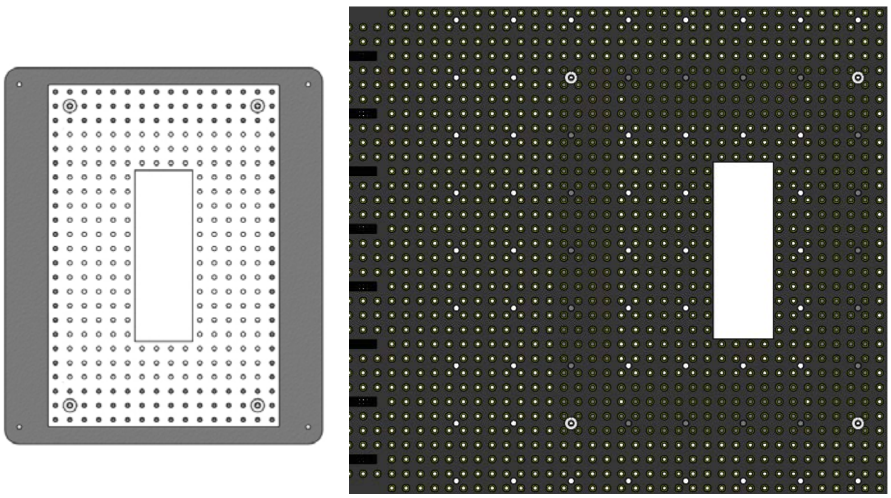
Removing the microscope stage

LabSmith also offers an integrating sample stage (A-SVM-Stage-BB) that can be used to couple the SVM340 microscope to one of LabSmith's breadboards (iBB or LS600-CH).



Integrating Delrin sample stage

The breadboard is mounted onto four screws installed on the Delrin stage. The inner stage mounting holes are used for the LS600-CH, the outer mounting holes are used for the iBB.



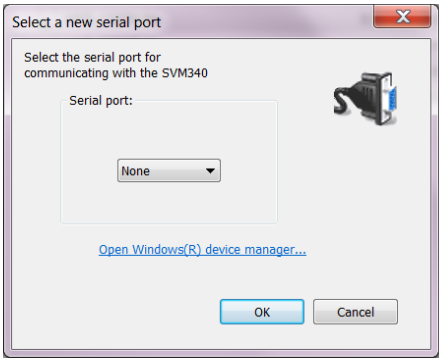
Integrating Delrin stage shown assembled with LS600-CH (left) and iBB (right) breadboards

3 uSCOPE SOFTWARE

The uScope software lets you set the functions of the SV340 and control the video acquisition and on-line processing. It also allows you to recall and process stored video files. uScope runs on any PC with Microsoft Windows XP operating system or later.

Note:	The uScope application makes extensive use of the DirectX software, which is provided by Microsoft Corp. and installed independently of uScope. If you have installed a local language version of Windows XP, DirectX will install in the same language. Consequently, some of the dialog boxes shown below may appear in the language of your windows installation.

When the uScope software is started a dialog box will pop up that says "Select a new serial port". Select the COM port that the serial connector is connected to and click OK. This dialog will keep popping up until you succeed in communicating with the SVM or you click Cancel (then you work offline and uScope does not try to send commands to the SVM).

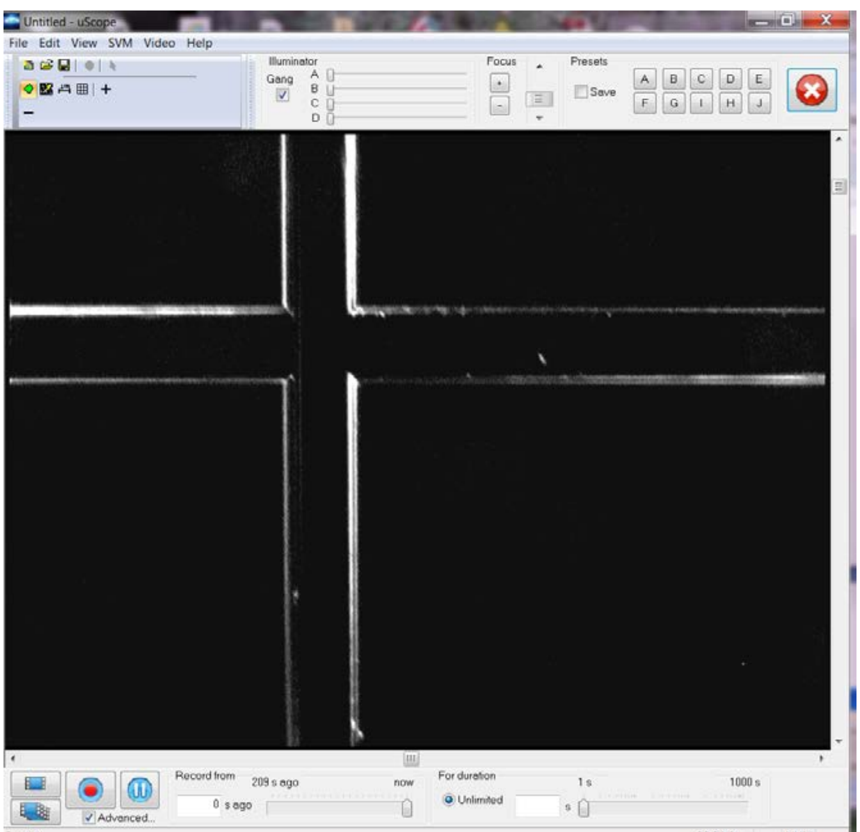


Communications settings dialog box

Note: Some functions are available with the SVM in offline mode. Manipulation of the stage (x, y, and z) and illuminator settings can be accomplished via the front panel. Images can be viewed and recorded with the SVM operating offline, however real-time measurements (PIV and Intensity probes) are disabled.

The uScope main window shows the video display (live or saved) as selected in the Video menu. The following controls are also available:

- probes
- illumination
- focus
- x-y traverse
- presets
- video recording

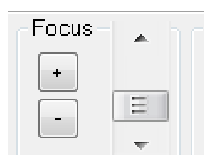


uScope main window

X-Y Traverse. The position indicators to the right and below the video display indicate the position of the *x-y* traverse and can be used to move the traverse. The X-Y traverse has a motion range of 50 mm by 75 mm.

The traverse can also be adjusted using the keyboard arrow keys. Holding down the shift-key while using the arrow keys slows the traverse to allow fine adjustment.

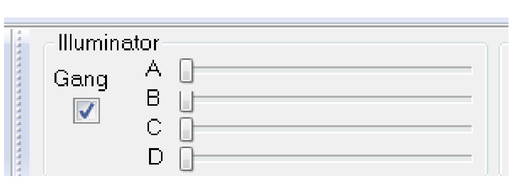
Focus. The focus indicator slider bar is located at the top of the main window. The slider bar can be used to adjust the focus, while the + and – buttons to the left of the bar are used for fine adjustment. The focus can also be adjusted using the Page Up and Page Down keys on the keyboard.



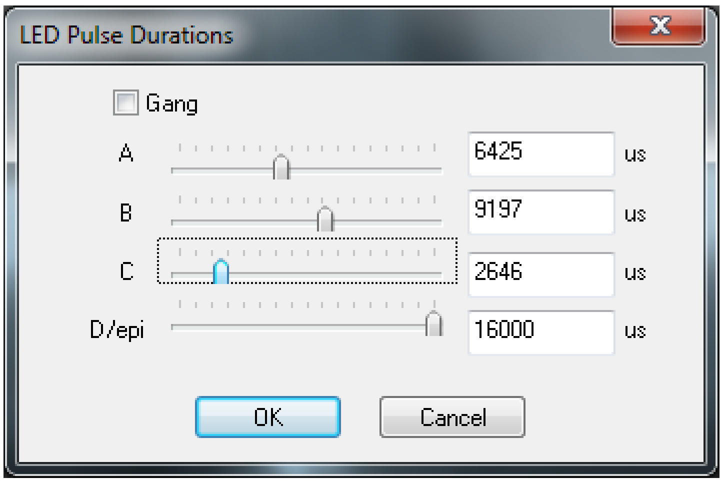
Illumination. The LED illuminator channels strobe during each image frame. The Illuminator control is used to adjust the strobe duration of each channel, effectively altering the LED intensity.

For certain applications it may be useful to temporarily reduce the motion limits of the x, y, or focus. The motion range can be reduced by selecting *SVM>Motion Limits…* from the main menu. Modification of these limits may be useful if you have installed a device on the SVM (i.e. a chipholder) that may interfere with the stage at its preset limits.

The channels can be adjusted using the controls along the top of the main window, or by pulling up the LED Pulse Durations window (SVM>LED Settings...).



uScope main window controls



LED Pulse Durations dialog box

When an EPI optics module is installed the forth slider controls the EPI illumination and channel D is controlled with the Channel B slider/button.

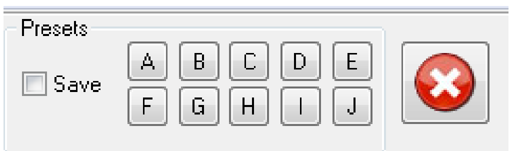
The maximum time duration that can be entered for the pulse duration is dependent on the camera frame rate, and is equal to 1/f.

Checking the Gang box will cause all LED banks to be adjusted simultaneously when one slider is activated.

Note: The Illuminator scroll bars do not update when the illumination is changed via the SVM front panel. If the front panel will be used for illuminator control, we recommend first setting all illuminator slider bars to the maximum setting to allow the full range of illuminator control.

More details on illuminator timing can be found in the Video and Illumination Timing Section below.

Presets. The presets panel allow saving and restoring up to ten traverse (x, y, and focus) positions and illumination settings in storage cells A–J. Clicking a button will load the stored preset and adjust traverse position and LED illumination to the stored values. Checking the Save box first will store the current setting in the selected storage cell. Sites A-D can also be saved and accessed from the SVM front panel.



To stop the traverse, click the Stop Motion button  or the center button on the front panel keypad (the SITE button must first be illuminated).

For descriptions of **video recording** and **probe functions**, see sections 5 and 6 below.

3.1 usc files

The uScope software saves the instrument and video settings in a file with .usc extension. To open a uScope file, choose File>Open, then locate the file on your hard drive. You can also choose from recently opened files at the bottom of the File menu.

3.2 Online and offline operation

uScope can work in both online and off-line mode. When on-line, it communicates with a SVM340, controls its functions and accepts live video signals from a DirectX compliant video capture card.

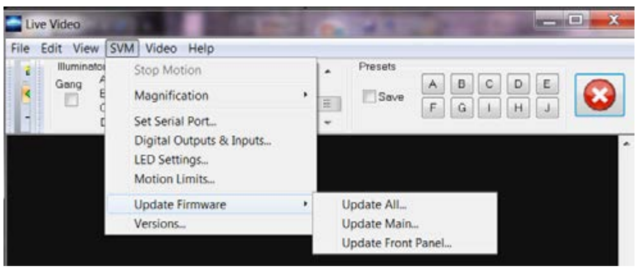
When off-line, uScope can open a stored video file for playback and further processing. uScope will go into off-line mode whenever it fails to locate a SVM340 on the selected serial port.

3.3 Upgrading firmware

The firmware is the software stored inside the SVM340 in non-volatile memory and controls the internal functions of the instrument, such as traverse movements, front panel lamps and buttons, and back-panels inputs and outputs. The firmware is included in the uScope application package and can be loaded into the SVM340 from within the uScope software.

To upgrade firmware to the latest version:

1. Download the newest version of uScope from www.labsmith.com and install on your computer following the installation procedure described in the introduction.
2. Connect and turn on the SVM340 and start up the uScope application on the PC.
3. In online mode, choose SVM>Update Firmware>Update All

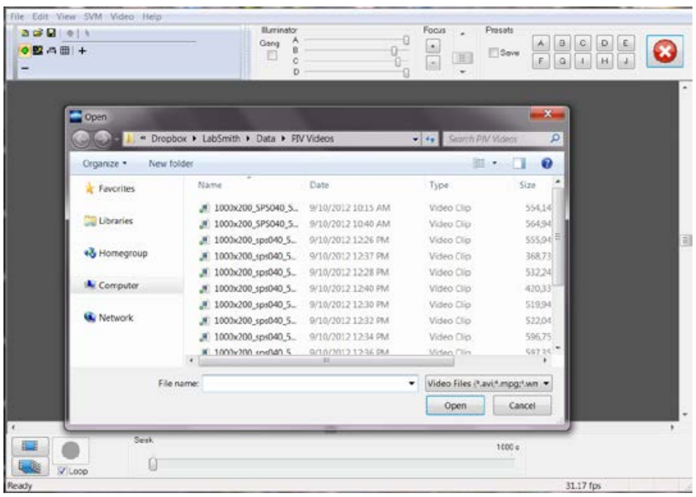


4. Click OK when the update dialog box appears
5. Wait while the firmware is updated. You can follow the progress in the status bar at the bottom of the uScope main window.
6. When the progress indicator reaches 100%, the upgrade is completed.

Important: Do not turn off or disconnect the SVM340 or the PC while the upgrade is in progress. This may result in loss of communication with the instrument that requires LabSmith assistance to resolve.

4 uSCOPE VIDEO PLAYBACK AND PROCESSING

When the uScope software is opened the main window below will appear.

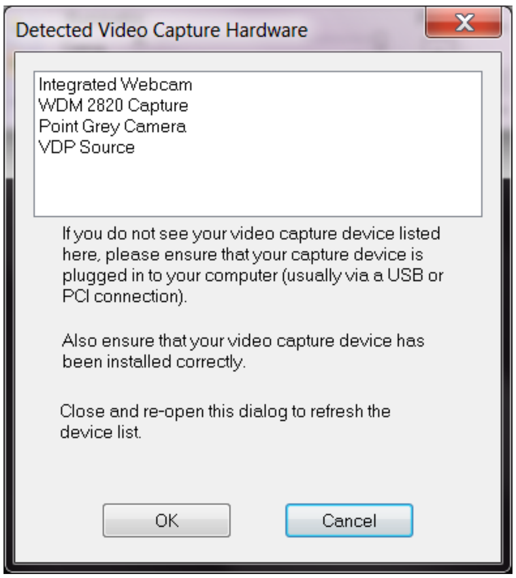


To playback or process a saved video, open the AVI file you want to view.

To capture or process a live video, click cancel in the “Open” dialog box, and then click Video>Capture/Process Live Video.

4.1 Video options set-up

The uScope software will attempt to connect to the most recently used capture device. If that device is not found, the “Detected Video Capture Hardware” window will pop up. Or select Video >Video Capture Device to open this window.



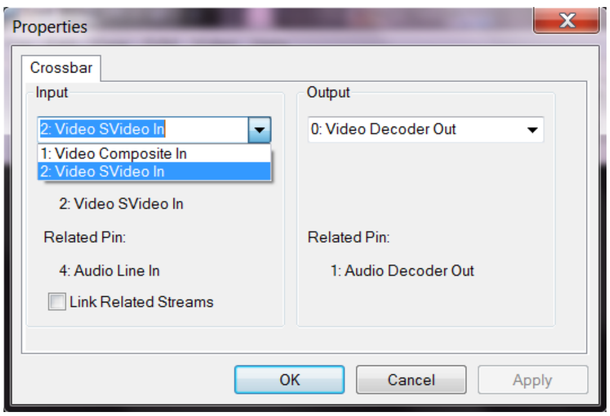
Click on the appropriate video capture device. Video capture devices sold by LabSmith include:

- StarTech capture device (SVID2USB2) is listed as: WDM2821
- Imaging Source capture device (DFG/USB2 PRO) is listed as: DFG/USB2pro
- Hauppauge internal video card is listed as: Hauppauge WinTV Capture

Note: If your video capture device is not listed in the Detected Video Capture Hardware Window, ensure that the device drivers are correctly installed and the capture device is plugged into a USB port on the computer.

Make sure that either the BNC composite or S-Video connector output of the SVM340 is connected to an input of the Hauppauge card, and select the relevant input connector through the Input connector box. Click Video >Physical Input Connector and select the correct input and ouput:

if using an S-Video cable select SVideo In (typical)
If using the BNC connector select Video Composite



Physical Input Connector selection box

You do not have to worry about the audio options since they are not currently used for the uScope application.

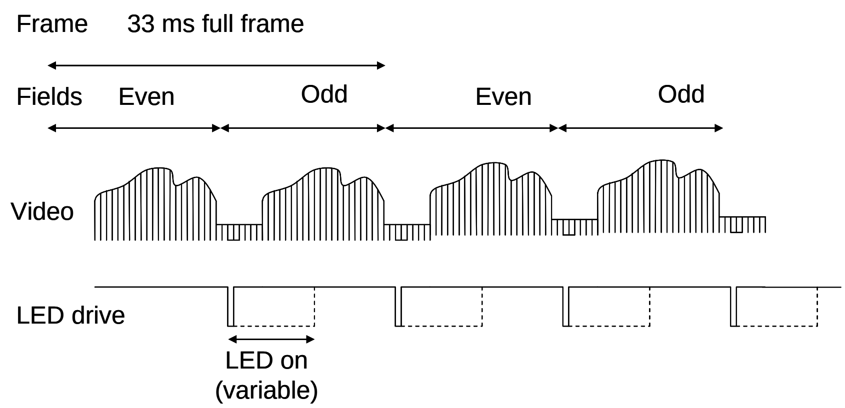
At this point you should see live video on your screen.

To set the video frame size you can click Video>Video options>Video frame format. Select 320×240 for low-resolution images and 720×480 for full-resolution images. Do not change the color space (whatever comes up, normally RGB24, is correct).

Note:	The DirectX video controls dialog boxes are of general nature and allow settings incompatible with the SVM340. Do not change the Video Standard (NTSC_M)

4.2 VIDEO AND ILLUMINATION TIMING

The master clock for the SVM340 is provided by the video signal timing. The CCD camera outputs video in standard RS170 format (NTSC in the color version), which is an analog, interlaced format compatible with standard analog video monitors or video recorders.



Timing sequence of the illumination in relation to the video signal

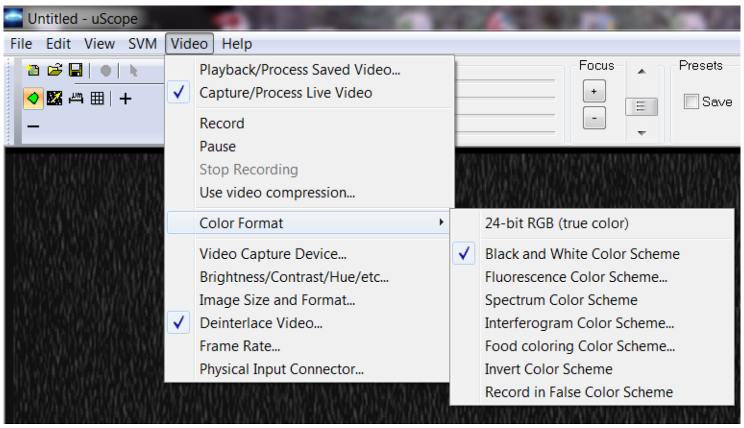
The RS170 interlaced video signal is composed of two fields, called even and odd fields, each containing every second line of the image. The interlaced format was defined in the early days of television to avoid flickering TV images. The even field contains lines 0, 2, 4, …524 and the odd field lines 1, 2, …525. The field frequency is 60 Hz, with one even and one odd field adding up to a full video frame each 33.3 ms, corresponding to 30 Hz frame frequency.

To ensure that all lines of the video signal are equally illuminated, the LED's flash twice during an image, once in every field. The LED pulse starts in the frame blanking period, and its width can be varied from 0 to near 100% of a field period, 16.6 ms.

Due to the interlaced readout of the camera sensor, images of fast moving objects, which move a noticeable distance during the 16.6 ms between two consecutive fields, may appear jagged at the horizontal edges. See section below for a discussion of the implications and tools to control the interlacing effect.

4.3 Color format set-up

The SVM340 can be fitted with either a grayscale (B&W) or color camera module. The uScope software provides many options for viewing and recording images.



uScope video imaging options

24-bit RGB (true color)

Used for true color images. The user should note that color video data takes up 8 bits each for the red, blue and green colors, and thus consumes three times as much disk space and processing time as the B&W video. If color images are not needed, the color optics module can be used in B&W mode to save disk space.

Black and White Color Scheme

8-bit greyscale images (provides 256 gray scale levels)

False Color Display

The uScope software also provides several options for false color display for the 8-bit (black and white) images.

- Fluorescence Color Scheme
- Spectrum Color Scheme
- Interferogram Color Scheme
- Food Coloring Color Scheme

The reason for using false color display is that it is sometimes difficult to distinguish 256 different gray levels on a standard computer monitor. Converting shades of gray into colors can significantly enhance visibility of small differences in gray scale value.

Invert Color Scheme If checked the selected color scheme will be inverted (i.e. Black and White Color Scheme will invert black and white pixels. Like the false color schemes, this option is used to enhance visibility.

Record in False Color Scheme If checked, videos or snap shots will be recorded in the selected false color scheme. If not checked the false color scheme will be used for viewing only, and the video will be recorded in standard black and white.

5 VIDEO RECORDING

One of the main features of the uScope application is the ability to record long, unbroken video sequences without compression. These video sequences are stored in standard AVI format, so that they can later be viewed by Windows Media Player or other video playback software, off-line processed by uScope or other video processing software, compatible with the AVI standard.

To enable uncompressed video recording, uScope makes use of a double buffering system, described below. The buffering scheme also enables pre-trigger recording, enabling you to store a video of what happened before the trigger instant.

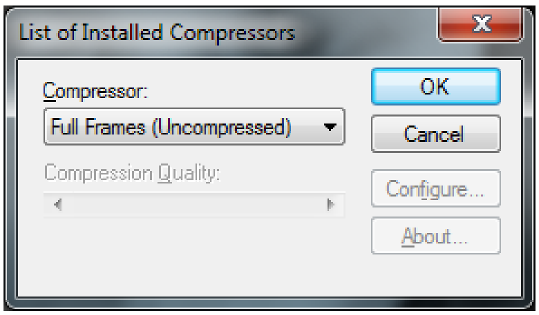
5.1 Video compression

uScope can use video compressors that are installed on your computer, but does not have any built-in compression. To add compression functionality, you need to download and install a “codec.” A compatible codec will also need to be installed on anything that plays the video.

All codecs are not equal. Some compress well. Some compress fast. Avoid over-compressing the data. The compression occurs when the video is being captured, so it cannot be “undone” if the results are not desirable. If you plan to perform PIV on your data we recommend using a lossless compression. The best-quality video compression takes time. It is often best to save videos with minimal or lossless compression and later post-process them.

The uScope software contains links to video compression codecs we recommend (Help>Help install video compressors...).

To save a video with compression, select Video>Use Video Compression… and the following dialog box will pop up.



List of Installed Compressors dialog box

Select the desired compressor from the drop down box. The options listed in the configure dialog box will depend on the installed compressor. Questions regarding specific compressor settings should be directed to the compressor distributor.

5.2 Recording speed

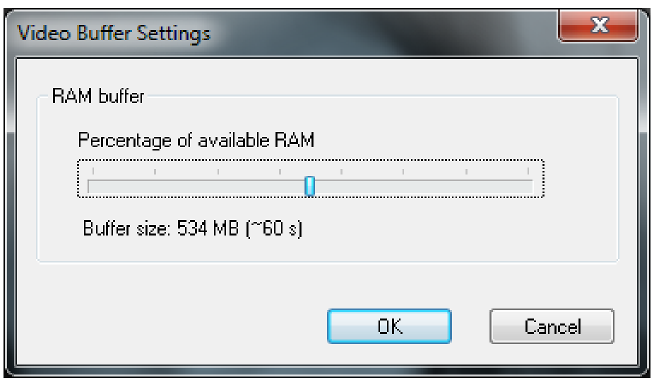
A standard monochrome RS-170 video signal converts into a digital data rate of 8.9 MBytes/s, which can easily be read into PC RAM memory in real time. It is also within the capability of modern, fast computers to write to hard disk in real time at this data rate, provided the computer is not overloaded by simultaneously executing other disk or CPU intensive tasks.
Color NTSC video signals convert into a data rate of 26.4 MBytes/s, which can readily be written to RAM memory in real time, but may be too high to write to hard disk in real time. In that case, some frames scattered throughout the video sequence are lost, resulting in a stored video sequence with time intervals of 33.3 ms between most images, but with 66.6 ms, 99.9 ms or some other multiple of the base frame interval between some individual images.

Such lost frames are called dropped frames. Video sequences with dropped frames are not suitable for accurate time history analysis, since it is difficult to know afterwards exactly where frames are missing.

5.3 Buffering

The SVM’s uScope software uses buffering to capture images without dropping frames. uScope stores digitized video date in a cyclic RAM buffer simultaneous with the display. Buffering also allows the user to selectively record events after they occur. For instance, to catch a particular particle or droplet passing through the field of view, the user can set uScope to start recording from a number of seconds before the record button is pressed and then wait to start recording until the event has been observed.

The duration of the buffered video sequence depends on the amount RAM set aside for the buffer. The more RAM installed in the computer, the more buffer space can be set aside without slowing down other tasks. The initial buffer size is set to half the available RAM, but you may want to adjust the buffer size get longer pre-trigger video sequence duration. Buffer size is specified in The View>Video Buffering settings menu.

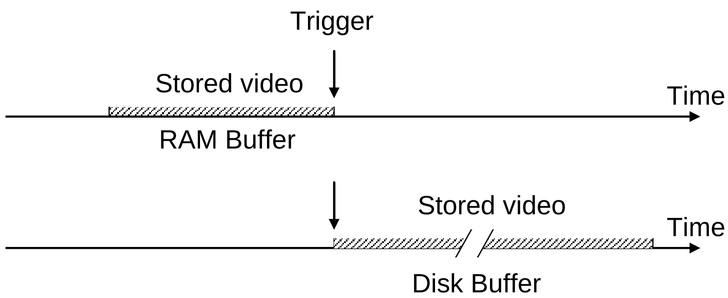


Video Buffer Settings dialog box

Note: Choosing the 24-bit option for recording video (Video>Color Format>24-bit RGB (true color) requires 3-times the buffer RAM of all other video options.

5.4 Pre- and post trigger recording

The figure below illustrates the effect of the buffer size on the pre- and post trigger recording durations.

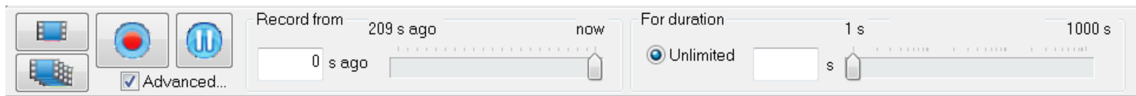


Pre-trigger (top) and post-trigger (bottom) recording

For pre-trigger recording, you save the video sequence occurring before the trigger, stored in the RAM buffer. With post-trigger recording you save the video sequence occurring immediately after the trigger and temporarily stored in the disk buffer. The disk buffer is normally larger than the RAM buffer.

5.5 Recording a video

To record a video, set the time in the *Record from* box to the desired number of seconds or drag the slider bar between now and the maximum buffer size. This sets the time duration recorded from the pre-trigger buffer.



Then either set the *For Duration* time, or leave it as Unlimited. The duration time represent the total video duration (pre-trigger buffer + post trigger record time). If Unlimited video duration is used, the video will record until the record button is pressed again. The total duration of the video will be the buffer time plus the newly recorded time (the time the video button is depressed).

Note: uScope software now uses buffering for the video recorded live so that this video is also saved without dropping frames.

5.6 Snap-shot settings

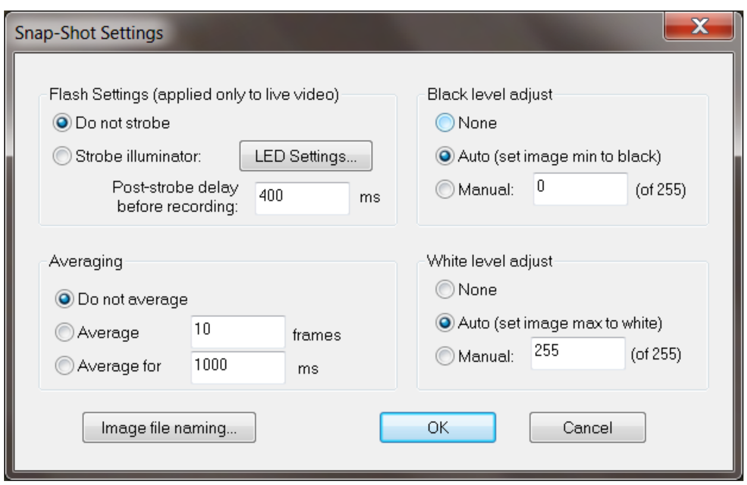
A snap-shot is a single image consisting of an average of one or more consecutive images.

Snap-shots are taking by pressing the  or  button, both located in the lower left hand corner of the main window.

 Takes a snap-shot using the predetermined frame averaging and other options specified in the Snap-Shot Settings (see below)

 Takes a snap-shot and frame averages until the button is pressed again. All other options specified in the Snap-Shot Settings (other than Number of frames to average) are maintained.

Snap-Shot Settings. The dialog box is opened from View> Snap-Shot Settings.



Snap-Shot Settings dialog box

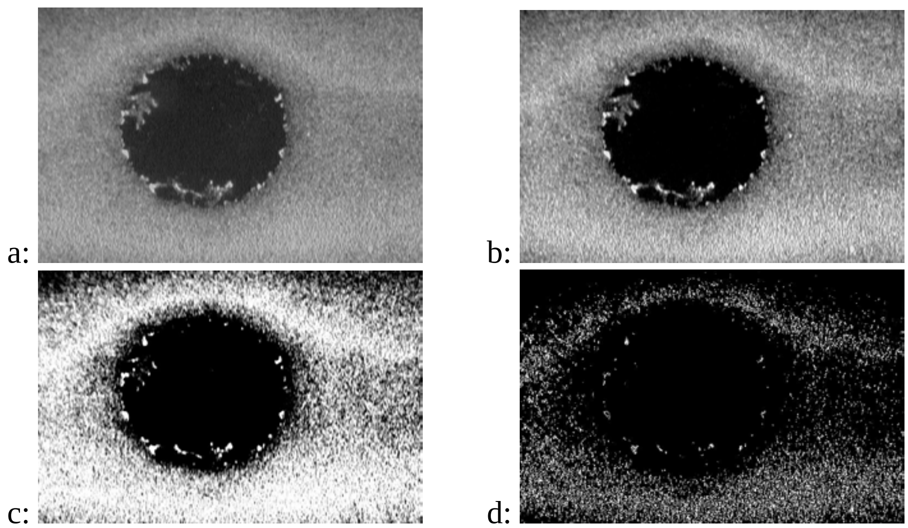
Averaging. Options include

Do Not Average:	Snap-shot will only include one frame. Use this setting if you have motion and are trying to capture particle images.
Average *x* frames:	Number of consecutive frames averaged to form a single snap-shot.
Average for *x* ms:	Number of ms averaged to form a single snap-shot.

If you have a little to no motion, increasing the number of frames or time will improve your signal to noise ratio (for static images the signal to noise ratio will improve by approximately the square root of the number of frames averaged).

Black and White level adjust. Use these values to change limits of the video spectrum. In the full color spectrum 0 represents black and 255 represents white. If this range is reduced everything below the set black level will appear black and everything above the set white level will appear white.

None: No black or white level adjust
Auto: image minimum is set to black / maximum set to white
Manual: set minimums (black) and maximum (white) to desired level.

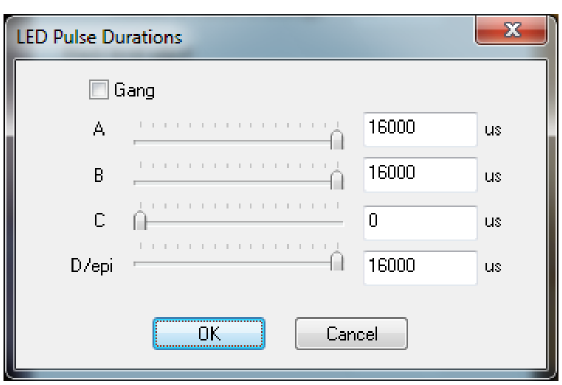


Black and white level adjust example. a: No adjustment; b: black 50 / white 200; c: black 100 / white 150; d: black 150 / white 150

Flash Settings

Do not strobe: Illuminator will not change when snapshot is taken.

Strobe illuminator: Illuminator settings will change when snapshot is taken. Selecting LED Settings button opens the LED Pulse Durations dialog box, where the snap-shot illuminator settings can be selected. After the snap-shot is complete the illuminator will switch back to the original settings.

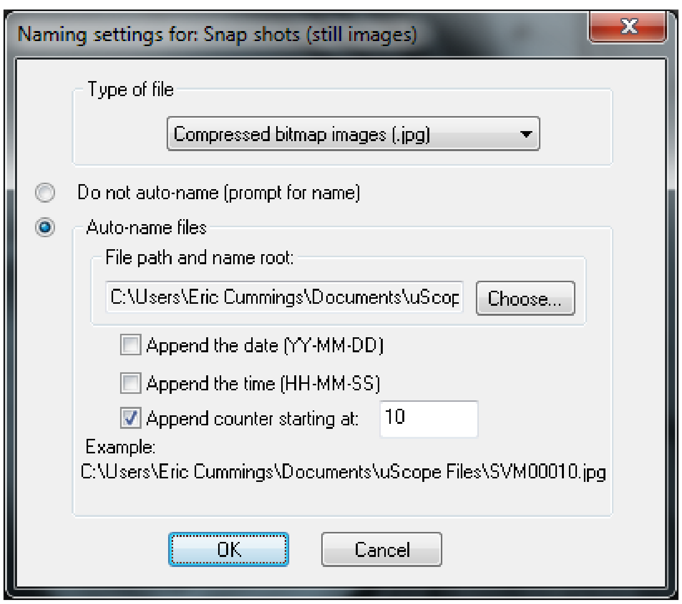


LED pulse duration dialog box

This function is useful to prevent photobleaching or heating of your sample. With this option the illuminator is typically turned off or very low prior the snap-shot.

Post-strobe delay before recording. Choose the number of frames to skip after the snap-shot button is selected and before it takes the photo.

File naming. This option allows you to set the default for the type of file, compressed (jpg) or uncompressed (bmp) and the naming. The files can be autonamed or you can choose to be prompted each time to choose the file name. This window can also be access from File>Snap Shot File Saving…



Naming settings for snap-shots

5.7 Deinterlacing

The camera built into the SVM340 runs in standard RS-170 (monochrome) or NTSC (color) video format at a fundamental frame rate of 30 Hz. As discussed in section 4.1, the full video frame is composed of two interlaced fields at a field frequency of 60 Hz. This means that every second line of a full image is recorded at a time 16.6 ms later than the other half of the lines. As a consequence, fast-moving objects will be recorded with a slight horizontal blur, which is caused by the image segment in the even lines being shifted slightly from the image segment in the odd lines.

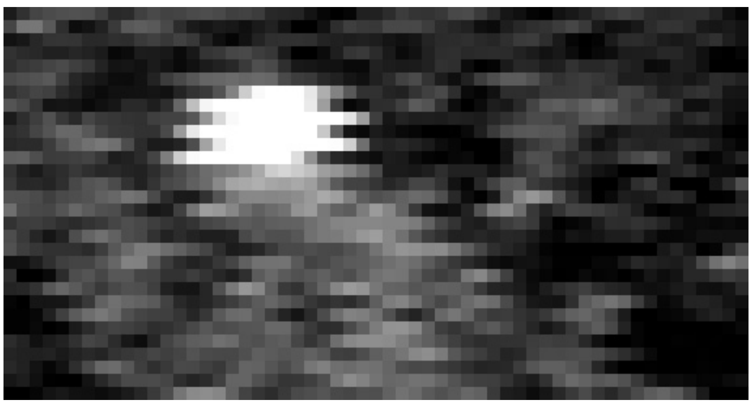
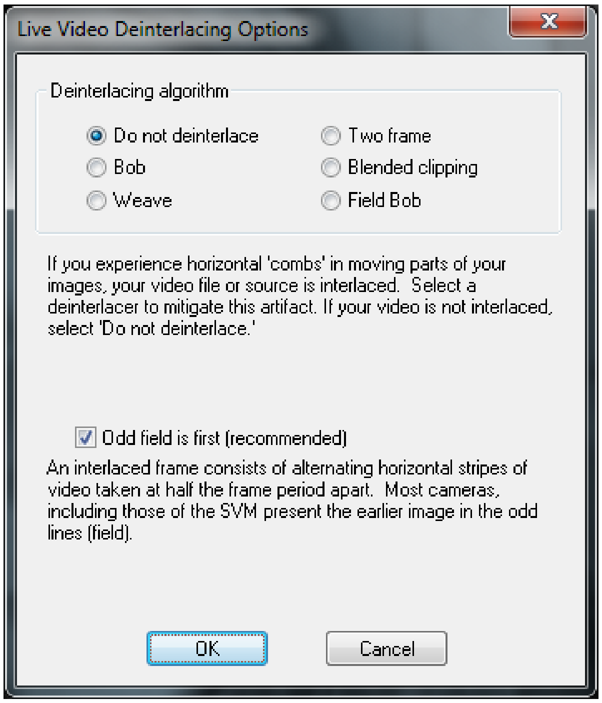


Image of a horizontally moving particle recorded with the SVM340 interlace camera

Zooming in on such a fast-moving particle reveals the jagged edges caused by the interlace camera format.

To reduce the effects of the interlacing, uScope includes deinterlace filters, which will reduce the visual appearance of the blurring caused by the interlacing by various algorithms. The delinterlace method is selected in the Video>Deinterlace Video options dialog box.



Live Video Deinterlace Video options dialog box

The best deinterlace filter depends on the nature of the video image and should be chosen by experimentation. A brief description of the three most common algorithms is given here.

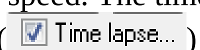
Weave. This method uses three fields in the calculation and works well on slow moving material but tends to fail on fast moving material.

Bob. The basic bob algorithm uses the most recent field and fills in the lines between by interpolation. This method detects weaving artifacts in the current image it uses bob to get rid of them. This method has a tendency to bob rather too much and gives poor results on fine static images.

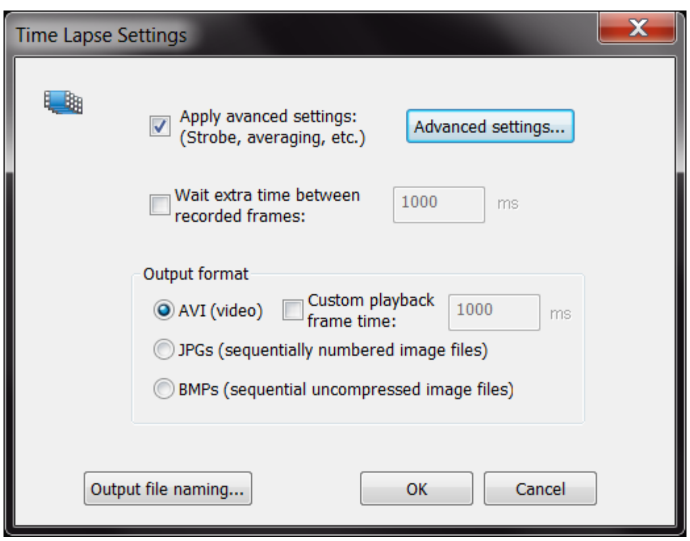
Two-frame. This method uses the current frame and the last two to determine whether to bob or weave a given pixel. This gives better results on both stationary and moving images than the above two methods but uses more CPU.

Although the deinterlace filters improve the visual appearance of the video, they are not always effective for scientific imagery. All filters are based on some form of interpolation between frames under the assumption that scene motion is continuous between frames. When the movies are analyzed by various algorithms, the effect of the deinterlace filter on the result will be algorithm-dependent.

5.8 Time lapse

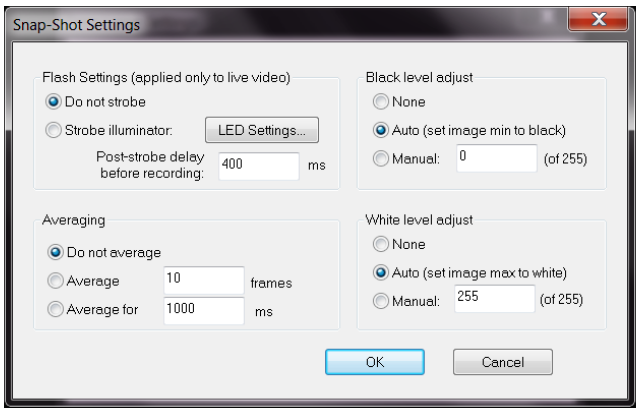
The Time lapse option is used to select the frame rate frequency to allow videos taken over a long period of time to be compressed to a small file and played back at increased speed. The time lapse options are set by clicking on the Time lapse… button(

) at the bottom left side of the main window. The Time Lapse Settings dialog box will appear.



Time Lapse Settings dialog box

Clicking on the Advanced Settings button will bring up a window that is identical to the Snap Shot Settings window.



Advanced Settings for Time Lapse

Note: the settings selected in this window will only be applied to the video recordings, the snap shot settings will not change.

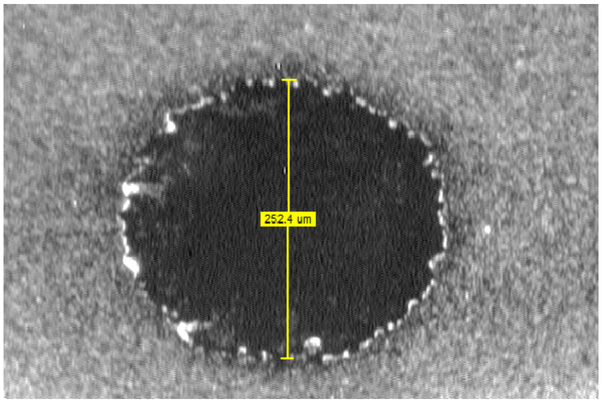
The time between images in a time lapse video is dependent on the averaging time + the wait time between recorded frames. For example, for a recording rate of 30 fps, if you set the averaging to 15 frames and then set the wait time to 1 second, then the apparent increase in speed for the video is 45X (15 frames averaged + 30 frames skipped).

For live video recording, advanced time lapse settings also allow you to control the illuminator strobe to synchronize with the time lapse rate.

5.9 Distance indicator

The Distance Indicator feature allows you to measure features on your image. To create an indicator:

1. Click the **Distance Indicator** toolbar button  to highlight the button.
2. With your mouse curser over the image, right click on the mouse and select New Probe. Click on the image to insert the indicator. The ends of the indicator can then be moved (click and drag) to the desired locations.



Distance indicator probe

Note: The distance calculation is based on the magnification setting for the objective. If the magnification setting is incorrect the distance will be incorrect. If you are evaluating a saved image you will need to know what magnification was used and adjust the magnification at SVM>Magnification>….

Distance Indicator display data can be selected by selecting the probe, then right click and select Properties. The following dialog box will appear.

Distance/angle Indicator Properties dialog box

6 PROBES

uScope has sophisticated real-time probe capabilities that allow users to monitor image properties like color, intensity, variation and video properties like inferred motion (e.g., particle image velocimetry) in real time. These real-time measurements can be recorded to disk and can trigger real-time actions. uScope can support as many probes as your computer's processor can handle.

The two types of probes that can be made in uScope are the Velocity (PIV) probes and Intensity probes.

6.1 Velocity (PIV) probes

uScope software makes it easy to create probes to monitor flow characteristics. Each probe can have its own properties; probes are almost always square, though it is possible to extend the probe in one direction to increase signal-to-noise ratio along that axis.

TIP: When learning how to use uScope's PIV probes it is useful to start with a stable particle flow, or a movie of a stable flow.

6.1.1 Setup

1. Connect the SVM to the computer and turn on both.
2. Launch uScope software.
3. Prepare the microfluidic channel. Fill it out with the buffer and introduce a sample of polystyrene fluorescent particles.
4. Adjust focus, illumination and flow characteristics.

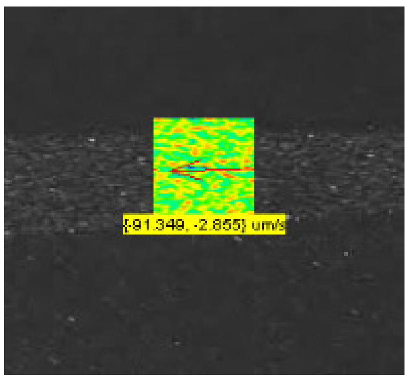
Alternately, you can also open an existing flow movie by choosing **Video** > **Process Saved Video** Creating velocity probes.

6.1.2 Creating a PIV probe

To create a probe:

1. Click the **Velocity Probe** toolbar button  to highlight the button.
2. With your mouse curser over the image, right click on the mouse and select New Probe. Bring the mouse to the center point for the new

probe and left click the mouse to place the probe. A probe such as the one below will appear.



New probe showing correlation field, vector arrow and real time velocity as text

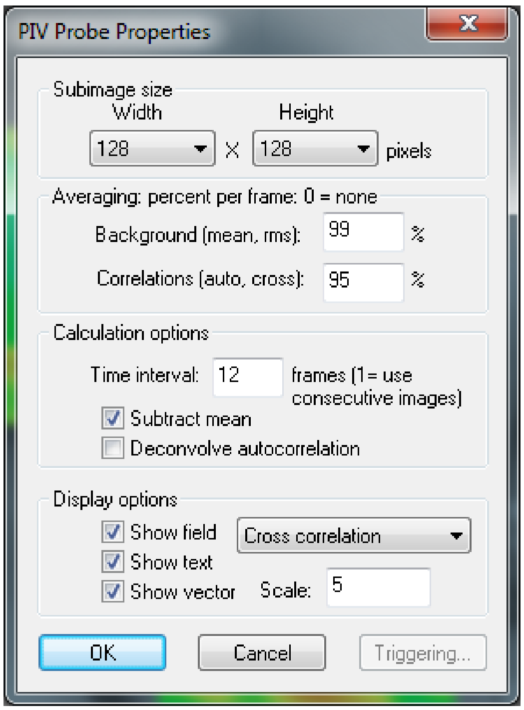
3. Repeat step 2 to create as many probes as desired.
4. Once created, the probes can be moved by clicking and holding the mouse button over the probe and dragging it to the desired location.
5. Click the + and – toolbar buttons to make the probes more or less transparent. The software will continue to calculate velocity at these locations even if you make the probes completely invisible.
6. To remove a probe, right click on it and choose Delete.

When you first create a probe uScope will experimentally determine the fastest FFT algorithm to use. This process may take up to 60 seconds to complete, at which point the software will begin calculating velocity at the location.

When you create a probe it will take on the properties of the last probe you altered. Once created, you can change each probe's properties individually.

6.1.3 Velocity Probe Properties

1. Double-click on a probe to open the **PIV Probe Properties** dialog box. You can also right-click on the probe and choose **Properties** to open the dialog box.



PIV Probe Properties dialog box

2. Select the **Width** and **Height** of the probe window, the area over which statistics will be calculated. Some guidelines for setting the probe window size are:
    a. Probes should typically be the same size in both x and y directions.
    b. Smaller probes require less processing power, so use smaller window sizes to run more probes simultaneously.
    c. Increasing the probe size will improve the signal-to-noise ratio; decreasing the size will increase spatial resolution.
    d. If the probe is located in a region of fast flow, the probe size must be large enough that the correlation does not fall beyond the window. The **Cross Correlation** field (see below) can be an aid in setting the size.

Note: If you cannot achieve sufficient signal-to-noise ratio with a required probe size you may need to adjust the illumination, particle feed, etc.

If the probe is in an area of steady flow then increasing time averaging may also help.

3. The **Averaging percent per frame** values help separate the useful flow information from the background data by weighing the previous frames of data versus the current frame. The default values of 95% are acceptable for most flows. Some guidelines for setting the percentages are:
    a. The **Background (mean)** percentage determines how much of the image field is considered “background” based on its steady presence over multiple frames. Increasing this value increases the amount of information that is ignored, such as stuck particles. Check the **Subtract Mean** box (see below) to apply this calculation and remove the data.
    b. Decreasing the **Correlation** value improves time resolution; increasing the value improves noise control.

4. The **Calculations Options** control how the flow parameters are calculated:
    a. Enter **1** in the **Time interval** box to calculate cross correlation for every sequential pair of frames. Enter **2** to use every other frame, **3** for every third frame, etc. This option is useful for examining very slow flows.
    b. **Subtract Mean** subtracts the background (non moving) data from the flow calculations. The amount of data that will be subtracted is based on the **Background %** value (see above).

Note: If the probe is located in an area of very slow flow then subtracting the background could delete active particles.

    c. **Deconvolve Autocorrelation** is an advanced option for high precision measurements. This option deconvolves the cross correlation by the autocorrelation, which can remove the effects of blur and particle size such that each particle is treated as a single point. It is most useful when the signal-to-noise ratio is extremely high.

5. The **Show Field** options control which data are displayed for each probe window:
    a. **Cross correlation** determines how far the particles move between frames (or between every few frames, based on the **Frames Skipped** option). This field is a good diagnostic tool to help you optimize experiment parameters. The red dot will move further from the center as the flow velocity increases. The dot should be small and well defined to achieve the most reliable measurements. If the flow is too fast the red dot will move outside of the window, and uScope will not be able to measure the velocity. In this case, increase the window size, which will improve the signal-to-noise ratio.
    b. **Autocorrelation** is an indicator of resolution. The mass at the center of the window will become sharper with smaller particles and better focus.
    c. **Mean** shows the data that is being subtracted as part of the Background (based upon the **Background %** described above). Showing the Mean can be helpful for highlighting stuck particles and other anomalies in the flow.
    d. **RMS** is an indicator of the amount of useful signal available for the calculations.
    e. **Show Text** turns on and off the text-based velocity display.
    f. **Show Vector** displays an arrow in the direction of the flow. The size of the arrow will change with velocity. You can also set the **Scale** to increase or decrease the arrow size.

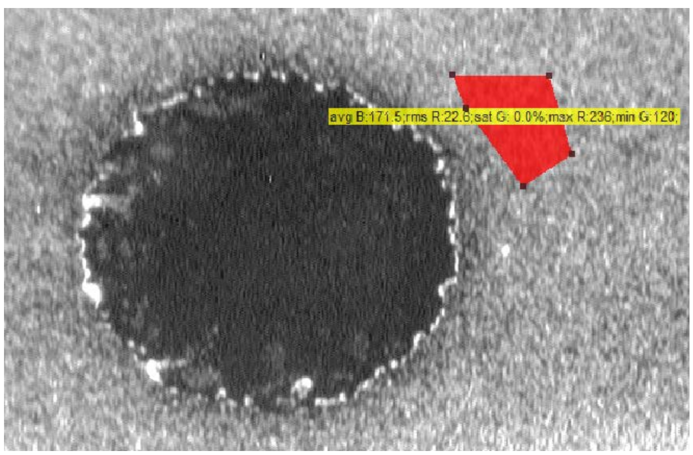
6.2 Polygon and Macropixel intensity probes

Intensity or polygon probes are used to track the color spectrum or fluorescence intensity inside a defined region. The advantages of the polygon probe are that (1) you can make the probe an arbitrary shape to fit your region of interest, and (2) for color images, the probe can independently track the intensity of the red, blue, and green signals. The macropixel probe is limited to a rectangular shape, however it can be broken into multi-pixel arrays to obtain spatially resolved intensity data. The macropixel probe also allows time averaging of probe output data.

6.2.1 Polygon intensity probes

To create a probe:

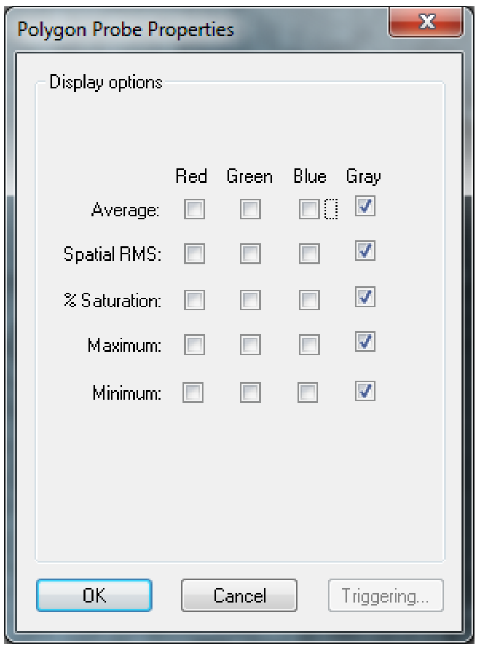
1. Click the **Intensity Probe** toolbar button  to highlight the button.
2. With your mouse curser over the image, right click on the mouse and select New Probe. Click on the image to draw the outline of the probe. When the shape is defined double click the mouse to close the polygon. A probe such as the one below will appear.



Intensity probe

3. Repeat step 2 to create as many probes as desired.
4. Once created, the probes can be moved by clicking and holding the mouse button over the probe and dragging it to the desired location. The shape of the probe can also be modified by dragging the polygon points to create the desired shape.

Intensity probe data displayed and recorded can be selected by selecting the probe (left click), then right click and select Properties. The following dialog box will appear:



Polygon Probe Properties dialog box

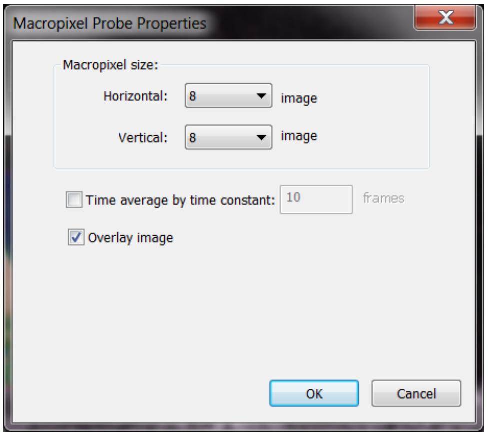
For images from the B&W or EPI optics module only the Gray displays are applicable.

6.2.2 Macropixel intensity probe properties

Macropixel intensity probes are used when spatially-resolved intensity data is needed. The probe is divided into an array of sub-probe sections based on the input pixel size.

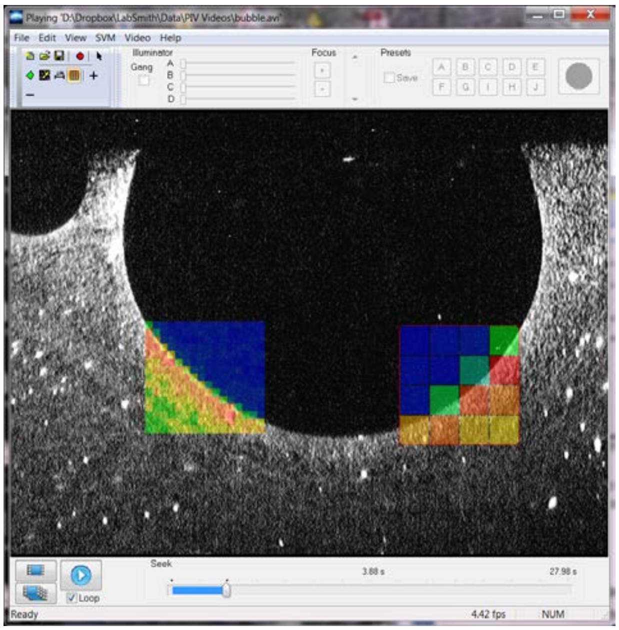
To create a probe:

1. Click on the macropixel button on the toolbar to highlight the button.
2. Right click on the image and select "insert new probe".
3. Double click where you would like to place the probe. The probe can be dragged on the screen to a new position, or resized by dragging a corner.
4. Right click on the probe and select "Properties..." brings up the following window.



Macropixel Probe Properties

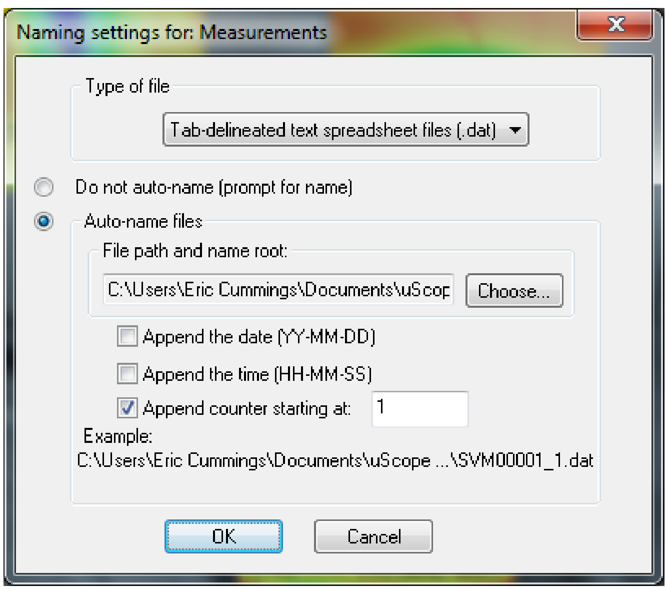
Changing the macropixel size changes the number of pixels per sub-probe. The probe data can also be time averaged to reduce noise. The following image shows two probes of different pixel size.


Example of macropixel probes. Probe on left had array of 8 x 8 pixel size; probe on right has 32 x 32 pixel size.

6.3 Recording probe data

Data can be recorded simultaneously from all probes. To record data:

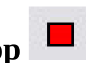
1. Choose **File >Measurement File Naming** to select how the recorded data will be saved:



Naming settings for new measurements dialog box

   a. If you choose **Do not auto-name**, uScope will prompt you for a file name and location for each new recording.
   b. Choose **Auto-name files** to automatically name each recording. Check **Append the date**, **Append the time**, and/or **Append counter** to add these values to the new file names. An example of how the name will appear is shown at the bottom of the dialog box.

Note: You can currently only save the probes in the tab-delineated text spreadsheet file format.

2. To begin recording choose **File >Record**, or click the **Start/Stop**  toolbar button. If Autonaming is selected, recording will begin immediately. Otherwise, recording will begin after you name the file and click **OK**.
3. To end recording, choose **File > Record** or click the **Start/Stop** button again.

Probe output file
Data from all recorded probes will be output into a single file.

PIV probe data
The PIV data will include four columns for each probe: the X and Y locations of its centroid, measured from the upper left of the window, and the X and Y velocity at each point in time. The X/Y location columns will only have entries in the first row.

Note: The probe data will only be recorded while the video is playing. Snap shot images or paused video will not record probe data.

Polygon probe data
The Polygon probe data output depends on the options selected in the *Polygon Probe Properties* window. The first two columns are the horizontal and vertical pixel location of the centeroid, referenced from the top, left corner of the image. The data columns are listed next and depend on the display options selected in the *Polygon Probe Properties* window.

Macropixel probe data
The macropixel probe data contains four columns for each probe.

<u>Macropixel sum from {X,Y}</u>defines the location of the macropixel probe. X and Y are the horizontal and vertical locations, respectively, of the top left corner of the probe.

<u>Span:{x, y, n)</u> defines number of pixels in the horizontal (x) and vertical (y) direction of each sub-probe; and the selected frame averaging (n).

The probe data column headings {a, b} are the position of the sub-probe in the array{horizontal, vertical}, with the bottom left corner sub-probe listed as position {0, 0}.

6.4 Saving probes

A set of probes can be saved to disk and recalled later:

1. Arrange the probes and set their Properties.
2. Choose **File >Save Probes As** to create a new probe file. Probe files are saved in the uScope file formate (*.usc).
3. Select the name and location for the file and click **Save**.

To recall a stored set of probes choose **File > Open**.

7 TROUBLESHOOTING

7.1 Getting help

This guide is your main source for information on operating the SVM340 and the uScope software. Check the LabSmith web site (www.labsmith.com) for user manual updates, application notes and information to help you use the SVM340.

If you are unable to find the help you need, call the LabSmith technical support at (925) 292 5161 or send an e-mail to support@labsmith.com. If you need support, please write down the serial number of your SVM340 (located on the bottom of the unit) and the version of the software you are using. To get the software version number, click Help>About uScope in the uScope main window.

7.2 Video imaging

Problem	Possible Cause	Resolution
no video signal (image does not change when the illumination is changed or your hand is waved over the video)	problem with video capture device	A video capture device is required to image video with an analog camera optics module (A-RS170-BW, A-RS170-Color, or A-EPI). Ensure the correct capture device has been selected (go to *Video>Video Capture Device...*) • StarTech capture device (SVID2USB2) is listed as: WDM2821 • Imaging Source capture device (DFG/USB2 PRO) is called: DFG/USB2pro • Hauppauge internal video card is called: Hauppauge WinTV Capture If your video capture device is not listed in the Detected Video Capture Hardware Window, ensure that the device drivers are correctly installed and the capture device is plugged into a USB port on the computer.
	s-video cable not installed	S-Video cable must be installed in the back of the SVM and in the Video Adapter. Check each end of the cable to ensure the 4 pins of the connector are intact.
	S-video input not selected	go to: *Video>Physical Input Connector...* and select S-video for the input
	optics module installed incorrectly	The optics module has two pins to guide it into place and is held to the SVM focus stage with magnets. Ensure that the module is squarely in place on the focus stage and that magnets are engaged.
	not focused on target or target not properly illuminated	If the optics module is not focused on an object it sometimes appears that you are not getting a signal. This is especially true with the EPI module (or a standard module when a filter is installed).

Very dim video image	imaging settings mis-adjusted	select *Video>Brightness/Contrast/Hue/etc...>VideoProc Amp* and adjust the Brightness and Contrast settings
	incorrect excitation or filter	• for fluorsecent imaging with B&W optics module: ensure the illuminator wavelength is the correct excitation for the fluorescent dye being used. Also, ensure that if a filter is installed (under the objective) its wavelength range is correct for the fluorescent emission. • for fluorsencent imaging with the EPI optics module: ensure the EPI optics module has the correct excitation/emission for the fluorescent dye being used.
SVM can't focus on target	target above maximum focus range	The top focus range of the SVM is limited to prevent interference between the illuminator module and the stainless steel stage. If the target can't be brought within the focus range one option is to use an objective spacer to increase the focus height by 1.25mm. This solution works best when using an objective with a long working distance (i.e. 4X) and without the 4-channel illuminator (i.e. with the EPI Optics Module).
no EPI illumination	incorrect optics module configuration	Select View>Camera Configuration and ensure Epifluorescence Illumination Type is selected. NOTE: ensure you have an EPI optics module installed before you change the configuration.
	EPI illuminator turned off	EPI illuminator adjustment replaces the Channel D adjustment slider/button when an EPI module is installed (Channel D illumination control is ganged with channel B)
Color camera images are in B&W	Imaging settings mis-adjusted	go to Video>Color Format> and ensure 24-bit RGB is selected.
		go to Video>Properties>Video Proc Amp and maximize the Saturation setting. Adjust

		Brightness, Contrast and Hue to optimize the image.
Error Message “Failed to connect to LUT converter” and/or “Cannot Give Graph to Builder”	incompatible video device selected or switching between video capture devices	If an incompatible video capture source is selected (such as VDP source) or if you switch between capture sources you may get errors, even when you go back and choose the correct source. Shut down the uScope software, turn off the SVM, and then restart the SVM and software and select the correct source. If the errors still persist, go to Video>Image Size and Format and select 720 x 480 for Output Size.

7.3 Video and image quality

Settings	Darkfield (Fluorescence)		Brightfield		Phase Contrast	
Module	B&W	EPI	Color	B&W	B&W	Color
Color Format	B&W or Fluor.	B&W or Fluor.	24-bit RGB	B&W or Fluor.	B&W or Fluor.	24-bit RGB
Video >Brightness/ Contrast/ Hue/etc.						
Brightness	adjust (typ low)	adjust (typ low)	adjust	adjust (typ low)	adjust (typ low)	adjust
Contrast	adjust (typ high)	adjust (typ high)	adjust	adjust (typ high)	adjust (typ high)	adjust
Hue	no effect	no effect	adjust	no effect	no effect	adjust
Saturation	min	min	max	min	min	max
Sharpness	min	min	adjust	min	min	adjust
Illuminator Settings						
White LEDs (typically channel C)	off	off	adjust	adjust	adjust	adjust
Colored LEDs	max	off	adjust	adjust	adjust	adjust
EPI LED (channel D/EPI)	n/a	max	n/a	n/a	n/a	n/a
External light	off	off	off	off	on	on

For fast moving flows we recommend using deinterlacing to eliminate “lines” across screen.

For steady images, use time averaging to improve signal to noise.

7.4 Dropped frames

The SVM uScope software uses a buffer as it is recording to minimize dropped frames. However, if the available RAM isn't sufficient you may still experience dropped frames.

Improving available RAM:

- Set the RAM buffer (should be > 500 MB): View>Video Buffer Settings
- Close anything running in the background that might be a resource hog: i.e., Windows Indexer, Antivirus scan, fetching and scanning emails, automated backup, etc.
- If you are using uScope Probes, close any that aren't necessary.
- Try running without interlacing and/or compression.
- Color Format: Running in true color (Video>Color Format>24-bit RGB) uses 3X more RAM compared to the B&W video options. If true color is not necessary, chose another option.

SPECIFICATIONS

Traverse	
Range	*x*: 50mm, *y*: 75 mm, focus: 4mm
Resolution	*x* and *y*: 10 µm, focus (*z*): 1 µm
Sample stage	
Dimensions	*X* × *Y*: 140mm × 200mm
Opening	55 × 80 mm
Camera module	
RS-170-BW	Analog, interlaced monochrome camera with 1/3” CCD 640 × 480 pixels, 30 frames/s
RS-170-C	Bayer-pattern analog color camera with 1/3” CCD 640 × 480 pixels, 30 frames/s
Objectives	10× plan 0.25/170 4× 20×
Illuminator modules	LED-B: 3 blue (460 nm, bandwidth 50 nm), one white bank LED-G: 3 green (560 nm, bandwidth 50 nm), one white bank LED-R: 3 red (660 nm, bandwidth 50 nm), one white bank LED-W: 4 white banks LED-X: 1 red, 1 green, 1 blue, 1 white bank.
Inputs	4 programmable digital inputs, TTL level
Outputs	Composite analog video out S-video out 3 programmable digital outputs TTL level 4 external illuminator trigger/drivers, TTL level
Communication	Serial RS232, 9 pin D-sub connector.
Physical	
Dimensions	W × L × H: 208 × 267 × 85 mm
Weight	2.8 kg
Power	90–240 VAC 47–63 Hz, 100 VA