First Ten Ångstroms

FTA1000 Cameras, Optics and Illuminators

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1. Introduction

This note will show you how to choose the optical path, the camera, microscope, and backlight illuminator, for your FTA1000 system. There are over a 1000 combinations, so there is something for every application, but you will need some guidance in narrowing the selection.

If you want a "quick start" guide, read this introductory section 1 and then jump to the last section 3 for examples of typical applications. Leave section 2 with all of its details to the engineers.

The following chart outlines the decision process. We will start with the camera first, and we will always start with the most likely general purpose "default" selection. It is the RS170 ½" camera with PCI frame grabber in this case. Now maybe your needs are special and you need something else: the center column shows likely alternatives and the reason why you might select them.

Pathway to Selecting Optical Path Components		
Camera first:		
Start with	If necessary switch to…	For this reason…
RS170 ½" with PCI bus frame grabber	USB 1.1	Minimal cost or need to operate from laptop
	USB 2 mono	Critical timing resolution not required and you want to avoid a PCI frame grabber inside your computer or you want the advantages of a megapixel camera
	USB 2 color	You need color and are willing to sacrifice frame rate and optical resolution (factor of 2) for it
	RS170 1/3" with PCI frame grabber	Lower cost than ½" at some loss of resolution, but this important only at higher mag
	High speed 360 or 2000 fps	You are measuring very rapid absorptions into, say, paper

Pathway to Selecting Optical Path Components continued		
Microscope next:		
Start with	If necessary switch to…	For this reason…
Fixed mag 93mm working distance microscope	Fixed mag 175mm, 6x zoom 175mm, or 12x zoom 165mm	Your samples are over 100mm in depth along viewing axis
	6x zoom or 12x zoom	You need the flexibility of a zoom microscope
	100mm fixed focus	Minimal cost, but works well with USB 1.1 camera
Illuminator last:		
Start with	If necessary switch to…	For this reason…
Blue LED source	Red LED	You want to power the LED directly from a USB port on your computer – one case is when you want battery-powered laptop
	White LED	You want color images – single color LEDs will make entire image shades of LED color
	Halogen	Maximum intensity so high speed cameras are not light-starved

You need to keep in mind that the various illuminators have different power options. The following chart, borrowed from the engineers in section 2, summarizes how the illuminators can be powered. You will have a FTA1000 controller on your system if you have any motors, such as pumps or moving stages. If you do not, you must use a computer USB port or purchase the optional power supply.

Illumination Source Power Options			
Source	FTA1000 Controller (software controlled 12V)	USB Port on Computer (fixed 5V)	"Z21" External Power Supply (fixed 12V)
Blue LED	✓		✓
White LED	✓		✓
Red LED		✓	
Halogen	✓		✓

2. Technical Discussion

Start off by thinking about whether you need a variable field of view (zoom microscope) or can use a simpler, fixed field of view. The fixed field of view (fixed magnification) makes magnification calibration easier, in addition to being less expensive. If you need to look at smaller drops, on the other hand, you may find the variable magnification zoom worthwhile.

Working distance is the free space between the mechanical frame of the microscope and the focal plane of the drop. Larger samples require longer working distances. However longer working distances require, for technical reasons, more magnification within the microscope even if the overall system magnification is the same. This is because they use attachment lens which first de-magnify the image before the main lens re-magnifies it. Therefore we must be concerned about optical resolution in long range systems, just as we obviously must be when we employ high magnification zoom lens.

The other big question is one of camera type. If you want to run from a laptop under battery power, there is really only one good choice: the USB 1.1 camera. The USB 2 camera can be used, but places a heavier load on the battery. If you are running from a desktop, you could place a frame grabber in the computer. Frame grabber based cameras offer superior timing resolution. This is important if you need to take fast movies; for example, ink jet drops or water absorbing into paper. If the experiment will run over several seconds or more, or you take only snap shots, USB camera timing is OK.

Different cameras come with different chip (sensor) sizes and this affects the overall magnification. Therefore some combinations of cameras and microscopes are not recommended because the resulting field of view is outside the range normally needed.

The first table details camera parameters. The important parameter is the “field of view” which is the active area of the sensor. For example, this might be 6.4mm horizontally by 4.8mm vertically. To get your captured image field of view, you divide the sensor’s field of view by the optical magnification of the microscope. Say you have a magnification of 1.2x and use this 6.4mm camera. Then your image field of view is 5.33mm horizontally (6.4 / 1.2) by 4mm vertically.

Camera Chip Formats				
Camera	Order Numbers	Format	Field of View (mm)	Comments
USB 1.1	B 0A, C 0A	¼" mono/color	3.6 H × 2.4 V	Can switch between color and monochrome OK; frame rate can be slower with color; has electronic 2x zoom and pan
USB 2 mono	B 0B, C 0B	½" mono	6.4 H × 4.8 V	Megapixel camera; has true 2x zoom and pan
USB 2 color	B 0C, C 0C	½" color	6.4 H × 4.8 V	Megapixel camera; has true 2x zoom and pan; does not provide a mono mode
RS170 1/3"	B 0D, C 0D	1/3" mono	4.8 H × 3.6 V	Uses full height PCI frame grabber within desktop computer; economical; stable timing
RS170 ½"	B 0E, C 0E	½" mono	6.4 H × 4.8 V	Uses full height PCI frame grabber within desktop computer; excellent resolution; stable timing
High Speed 360 fps	B 0F, C 0F	½" mono	6.4 H × 4.8 V	Uses full height PCI frame grabber within desktop computer; high speed; stable timing
High Speed 2000 fps	B 0G, C 0G	½" mono	6.4 H × 4.8 V	Uses full height PCI frame grabber within desktop computer; high speed; stable timing

The next table offers a similar detailed view of the microscope parameters. Most of the time you can quickly narrow down your choices by knowing what size drops you want and how big your sample is.

Microscope Formats				
Microscope + Working Distance (WD)	Order Numbers	Magnification	Fine Focus	Comments
Fixed mag, 92 mm	B 001, C 001	1.2	3 mm	Same high quality lens as in zoom microscopes, but fixed magnification
Fixed mag, 175 mm	B 002, C 002	1.2	3 mm	Same high quality lens as in zoom microscopes, but fixed magnification; above lens with WD extended by attachment lens
Fixed mag, 100 mm	B 003	0.75	No	Economical, but good, lens; focus by sliding lens in clamp, normally only at initial setup
Zoom 6x, 93 mm	B 00A, C 00A	0.7 → 4.5	12 mm	High quality zoom microscope
Zoom 6x, enhanced, 93 mm	B 00D, C00D	0.7 → 4.5	12 mm	A variable aperture and mechanical detents are added to the above zoom; detents allow you to go to the same zoom and thereby avoid recalibration after a zoom change
Zoom 6x, auto zoom/focus, 93 mm	C 00E	0.7 → 4.5	12 mm	Motorized zoom and focus and software to autofocus and to calibrate zoom magnification
Zoom 6x, 175 mm	C 00F	0.7 → 4.5	12 mm	Same as C 00A except uses an attachment lens to extend WD
Zoom 6x, enhanced, 175 mm	C 00G	0.7 → 4.5	12 mm	Same as C 00D except uses an attachment lens to extend WD
Zoom 6x, auto zoom/focus, 175 mm	C 00H	0.7 → 4.5	12 mm	Same as C 00E except uses an attachment lens to extend WD
Zoom 12x, enhanced, 86 mm	C 00J	0.58 → 7	12 mm	High quality zoom microscope with aperture and zoom detents
Zoom 12x, enhanced, 165 mm	C 00K	0.58 → 7	12 mm	Same as C 00J except uses an attachment lens to extend WD

The next table will combine the previous two into a summary of field-of-view (FOV) and working distance selections. The following table, two pages further, will detail illumination options for these cameras and microscopes.

Field of View and Working Distance Selection (all dimensions approximate)			
Camera(s)	Microscope(s) + Working Distance	Net Field of View (without possible electronic zoom to increase magnification and lower FOV)	Order Numbers
¼" Format Cameras:			
USB 1.1	Fixed mag, 92 mm, 175 mm	3.0 H × 2.0 V (small FOV, special work only)	B 0A1, C 0A1 B 0A2, C 0A2
USB 1.1	Fixed mag, 100 mm	4.8 H × 3.2 V (recommended lens for USB 1.1)	B 0A3
USB 1.1	Zoom 6x, 93 mm	5.1 H × 3.4 V → 0.8 H × 0.5 V (inexpensive camera with expensive lens: use only if portable laptop required)	B 0AA, C 0AA B 0AD, C0AD C 0AE
USB 1.1	Zoom 6x, 175 mm	5.1 H × 3.4 V → 0.8 H × 0.5 V (inexpensive camera with expensive lens: use only if portable laptop required)	C 0AF, C 0AG C 0AH
USB 1.1	Zoom 12x, 86 mm, 165 mm	6.2 H × 4.1 V → 0.5 H × 0.3 V (see note above)	C 0AJ, C0AK
½" Format Cameras:			
USB 2 mono, USB 2 color	Fixed mag, 92 mm, 175 mm	5.3 H × 4.0 V	B 0B1, C 0B1 B 0C1, C 0C1 B 0B2, C 0B2 B 0C2, C 0C2
RS170 ½"	Fixed mag, 92 mm, 175 mm	5.3 H × 4.0 V	B 0E1, C 0E1 B 0E2, C 0E2
High speed 360 fps, High speed 2000 fps	Fixed mag, 92 mm, 175 mm	5.3 H × 4.0 V	B 0F1, C 0F1 B 0G1, C 0G1 B 0F2, C 0F2 B 0G2, C 0G2
USB 2 mono, USB 2 color	Fixed mag, 100 mm	8.5 H × 6.4 V	B 0B3, B 0C3
RS170 ½"	Fixed mag, 100 mm	8.5 H × 6.4 V	B 0E3
High speed 360 fps, High speed 2000 fps	Fixed mag, 100 mm	8.5 H × 6.4 V	B 0F3, B 0G3

Field of View and Working Distance Selection continued			
Camera(s)	Microscope(s) + Working Distance	Net Field of View (without possible electronic zoom to increase magnification and lower FOV)	Order Numbers
½" Format Cameras (continued):			
USB 2 mono, USB 2 color	Zoom 6x, 93 mm	9.1 H × 6.9 V → 2.2 H × 1.1 V	B 0BA, C 0BA B 0CA, C 0CA B 0BD, C 0BD B 0CD, C 0CD C 0BE
USB 2 mono, USB 2 color	Zoom 6x, 175 mm	9.1 H × 6.9 V → 2.2 H × 1.1 V	C 0BF, C 0BG, C 0BH, C 0CF C 0CG, C 0CH
RS170 ½"	Zoom 6x, 93 mm	9.1 H × 6.9 V → 2.2 H × 1.1 V	B 0EA, C 0EA B 0ED, C 0ED C 0EE
RS170 ½"	Zoom 6x, 175 mm	9.1 H × 6.9 V → 2.2 H × 1.1 V	C 0EF, C 0EG C 0EH
High speed 360 fps, High speed 2000 fps	Zoom 6x, 93 mm	9.1 H × 6.9 V → 2.2 H × 1.1 V	C 0FA, C 0FD C 0FE, C 0GA C 0GD, C 0GE
High speed 360 fps, High speed 2000 fps	Zoom 6x, 175 mm	9.1 H × 6.9 V → 2.2 H × 1.1 V	C 0FF, C 0FG C 0FH, C 0GF C 0GG, C 0GH
USB 2 mono, USB 2 color	Zoom 12x, 86 mm, 165 mm	11.0 H × 8.3 V → 0.9 H × 0.7 V	C 0BJ, C 0CJ C 0BK, C 0CK
RS170 ½"	Zoom 12x, 86 mm, 165 mm	11.0 H × 8.3 V → 0.9 H × 0.7 V	C 0EJ, C 0EK
High speed 360 fps, High speed 2000 fps	Zoom 12x, 86 mm, 165 mm	11.0 H × 8.3 V → 0.9 H × 0.7 V	C 0FJ, C 0FK C 0GJ, C 0GK
1/3" Format Cameras:			
RS170 1/3"	Fixed mag, 92 mm, 175 mm	4.0 H × 3.0 V	B 0D1, C 0D1 B 0D2, C 0D2
RS170 1/3"	Fixed mag, 100 mm	8.0 H × 6.0 V	B 0D3
RS170 1/3"	Zoom 6x, 93 mm, 175 mm	6.9 H × 5.1 V → 1.1 H × 0.8 V	B 0DA, CODA B 0DD, C ODD C 0DE, C 0DF C 0DG, C 0DH
RS170 1/3"	Zoom 12x, 86 mm, 165 mm	8.3 H × 6.2 V → 0.7 H × 0.5 V	C 0DJ, C0DK

Illumination Selection		
Source	Order Numbers	Uses & Restrictions
LED, blue, 25 mm	B 000 1, C 000 1	LED array with 16 LEDs; very uniform; offers best resolution because of short wavelength of blue light (approximately 50% better than red); most important at long working distances (above 120mm); best general purpose choice
LED, white, 25 mm	B 000 2, C 000 2	LED array with 16 LEDs; very uniform; white light is necessary if you want to form color images (blue or red LEDs will make everything a shade of blue or red)
LED, red, 25 mm	B 000 3, C 000 3	LED array with 16 LEDs; very uniform; this is the *only* source that can be directly driven by a USB port – if you want to run from a battery powered laptop or you have a simple system with no remote control box and want to use your computer to power the source, choose this red array; this source must be powered from a USB port
LED, blue, 35 mm	C 000 4	Large format LED array with 25 LEDs; use only if you have optics for large fields of view (above 10mm) at long working distances (above 120mm)
Halogen white, 20 mm	B 000 A, C 000 A	Very high intensity halogen lamp useful for high speed cameras that have less time to gather light each image; not as uniform as LED arrays

All FTA1000 sources use a ground glass diffuser to make the light field more uniform. Those that are run from a controller, say B 000 001 or C 000 003, can be turned on and off by software and have three well-spaced illuminations selected from the program.

Red LEDs are the only ones that can be run from the power-limited +5V on a USB port and they can be powered only by a USB port.

If you order a non-red LED source and have no controller, you must purchase a power supply, order number "Z21", to supply +12V to the source. The following table summarizes how the sources can be powered.

Illumination Source Power Options			
Source	FTA1000 Controller (software controlled 12V)	USB Port on Computer (fixed 5V)	"Z21" External Power Supply (fixed 12V)
LED, blue	✓		✓
LED, white	✓		✓
LED, red		✓	
Halogen, white	✓		✓

3. Recommended Choices for Typical Applications

This table is the "bottom line" for most users. If your application does not seem to be covered, contact your distributor or www.sales@firsttenangstroms.com and we will help you decide.

Recommended Setups			
Application	Best Choice	Order Number	Comments
Portable and least expensive:			
Least expensive	USB 1.1 camera, fixed mag 100mm lens, red LED USB driven source	B 0A3 3	Camera and LED source plug into separate USB ports on computer
Laptop run and powered	Same as above	B 0A3 3	
Contact angle oriented:			
General purpose contact angle measurements on samples less than 100mm across and which do not absorb rapidly	USB 2.0 mono camera, fixed mag 92mm lens, blue LED source	B 0B1 1 C 0B1 1	The USB 2 camera is flexible and its built-in megapixel zoom and pan are useful; timing limitations prevent it from being used on fastest possible movies
General purpose contact angle measurements on rapidly absorbing materials	RS170 ½" camera, fixed mag 92mm lens, blue LED source	B 0E1 1 C 0E1 1	The RS170 camera requires a PCI bus frame grabber inside the computer, but offers superior timing resolution; you may want to upgrade to a zoom lens, as the next choice shows
General purpose contact angle measurements on rapidly absorbing materials, with magnification flexibility to handle a range of drop sizes	RS170 ½" camera, 6x zoom microscope, blue LED source	B 0EA 1 C 0EA 1	Comments same as above
Contact angle measurements on large samples	USB 2.0 mono camera, 6x, 175mm WD zoom microscope, blue LED source	C 0EF 1	Presumes you are not trying to do rapid adsorptions at long distances (a bad idea); if you can afford it, upgrade to the enhanced microscope "G" instead of "F" in order number
Contact angle measurements with the smallest drops possible on a FTA1000	RS170 ½" camera, 12x zoom microscope, blue LED source	C 0EJ 1	The 12x zoom offers superior resolution; do not consider working at greater than 86mm WD in this application

Recommended Setups continued			
Application	Best Choice	Order Number	Comments
Sample color is important:			
Color camera	USB 2.0 color camera, fixed mag 92mm lens, white LED source	B 0C1 2 C 0C1 2	You could substitute other microscopes; the USB 1.1 camera can operate in color mode and is slightly less expensive
Maximum speed is important:			
360 frames per second	High speed 360 fps camera, 6x enhanced zoom microscope, halogen source	B 0FD A C 0FD A	You could substitute other microscopes; this camera provides full height images up to 120 fps and reduced height images to 360 fps
2000 frames per second	High speed 2000 fps camera, 6x enhanced zoom microscope, halogen source	B 0GD A C 0GD A	You could substitute other microscopes; this camera provides full height images up to 500 fps and reduced height images to 2000 fps; halogen is a necessity for this camera
Unattended, script-driven measurements using FTA's Sequencer:			
Smaller samples	RS170 ½" camera, 93 mm auto zoom/focus microscope, blue LED source	C 0EE 1	Auto zoom/focus support scripts that accommodate sample and needle variations
Larger samples	RS170 ½" camera, 175 mm auto zoom/focus microscope, blue LED source	C 0EH 1	As above; blue illumination is a necessity here
Interfacial tension oriented:			
Liquid-vapor pendant drops, static	USB 2 camera, 92 mm fixed mag lens, blue LED source	B 0B1 1 C 0B1 1	Liquid-vapor pendant drops fall in a narrow range of sizes and the USB 2's zoom/pan provide whatever flexibility you need
Liquid-vapor pendant drops, dynamic + dilational stress	RS170 ½" camera, 92 mm fixed mag lens, blue LED source	B 0E1 1 C 0E1 1	You need the timing accuracy and resolution of the frame grabber for these measurements
Liquid-liquid drops (always pendant, even if inverted)	RS170 ½" camera, 93 mm enhanced 6x zoom microscope, blue LED source	B 0ED 1 C 0ED 1	Use the USB 2 camera here only if you want to avoid having a frame grabber inside the computer box; let the zoom provide FOV control
Liquid-liquid sessile drops	RS170 ½" camera, 86 mm 12x zoom microscope, blue LED source	C 0EJ 1	Sessile drops used for liquid-vapor IFT can be quite large, and this setup provides maximum FOV

Recommended Setups continued			
Application	Best Choice	Order Number	Comments
You want to emulate other FTA instruments:			
FTA125	RS170 1/3"camera, 100 mm fixed mag lens, red LED source	B 0D3 3	You might substitute a blue or white LED source if you do not want to use a USB port to power the LEDs
FTA188	RS170 ½" camera, 92 mm fixed mag lens, red LED source	B 0E1 3 C 0E1 3	As above
FTA200	RS170 1/3" camera, 93 mm 6x zoom microscope, red LED source	B 0DA 3 C 0DA 3	As above
FTA2000	RS170 1/3" camera, 175 mm auto zoom/focus microscope, red LED source	C 0DH 3	A blue LED source ("1" instead of "3") and the ½" camera ("E" instead of "D") would be better choices here
FTA4000	RS170 ½" camera, 86 mm 12x zoom microscope, halogen source	C 0EK A	This comes as close as possible to duplicating on an FTA1000 the high magnification of the FTA4000; the FTA4000 dispensers make smaller drops than the FTA1000 also; this setup could alternatively use high speed cameras instead of the RS170 camera

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