

FrogEye™ FC-2

Rugged Amphibious Digital Camera System



Operator's Manual

Version 2.42

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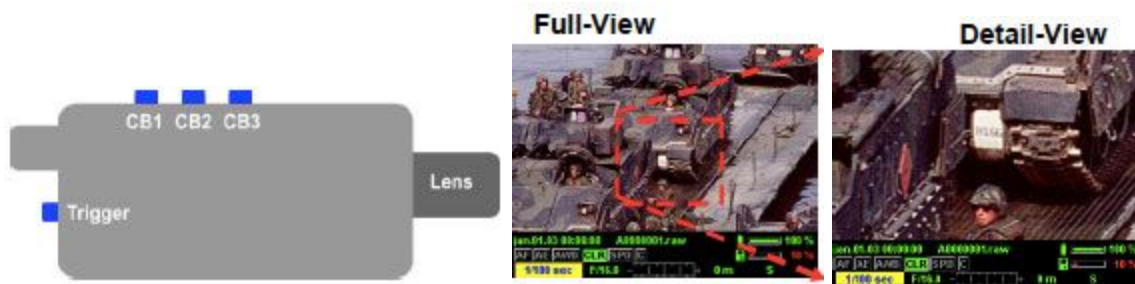
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1. Basic Operation

FrogEye™ Controls

FrogEye™ is controlled using onscreen information (the Status Bar) and menu commands (the Control Menu). Control buttons (the trigger, CB1, CB2 and CB3) are used to navigate and choose menu commands and settings. The following table and guided tour demonstrates the basic controls.



Button	In imaging mode (Status Bar visible)	In control menu (Control Menu visible)
Trigger	Shoots an image (press short) or movie (hold) <i>Note: see trigger menu item for special settings</i>	Selects highlighted menu item or list item
CB1 & CB2 pressed	Selects iris, focus or exposure time as 'active control' (yellow highlight in status bar)	No function
CB1	Active control (yellow highlight):	Moves menu selection highlight left or moves 'up' in a selected list (list item select)

	<p>If exposure time active: shorter exposure If aperture active: open (smaller F number)</p> <p>If focus active: shorter distance</p>	
CB2	<p>Active control (yellow highlight):</p> <p>If exposure time active: longer exposure</p> <p>If aperture active: close (larger F number)</p> <p>If focus active: greater distance</p>	Moves menu selection highlight right or moves 'down' in a selected list (menu select)
CB3	<p>Short press: toggles between detail and full view.</p> <p>Acquires new dark frame in night vision modes.</p> <p>Hold 1 sec: switch to control menu</p> <p>Hold 3 sec: switch status bar off.</p>	Short press: return to imaging mode .

Status Bar, Full-View, and Detail-View

1. The Status Bar is shown at the bottom of the display (see diagram on next page). Hold CB3 down for 3 seconds to turn it on; briefly press CB3 to turn it off.
2. The screen is in Full-view mode. Briefly press the CB3 button to place the image display in Detail-view. This view provides pixel-level digital magnification so you can check critical image detail and adjust focus with the CB1 and CB2 buttons, if necessary. Note: Detail-view has no impact on image acquisition. If you take a picture in this mode it will actually be a picture of Full-View Mode.
3. Press the CB3 button again to switch back to Full-view.

Adjusting the Focus and Exposure Target

1. The Focus Distance value is highlighted, this indicates the CB1 and CB2 buttons will adjust it.
2. To adjust exposure, press CB1 & CB2 simultaneously until the exposure time value is highlighted. Then, use CB1 and CB2 to make the exposure time shorter (CB1, less

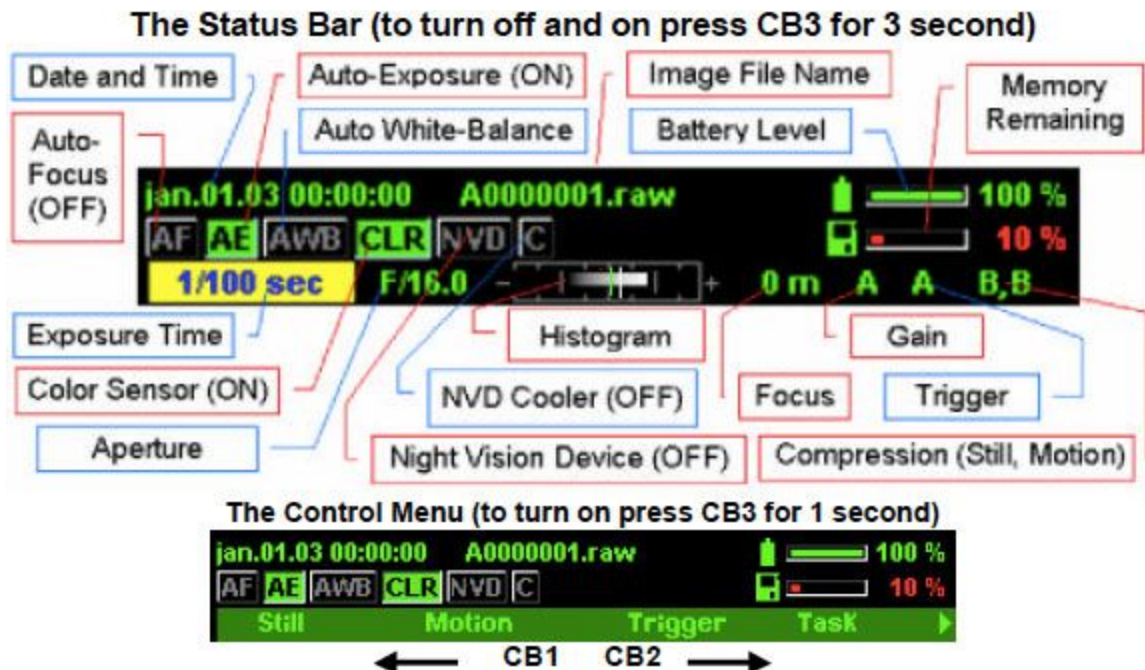
motion blur) or longer (CB2, less noisy: better color and shade definition). If auto exposure (AE) is ON (default setting), the control sets the 'exposure target' while exposure time automatically adjusts to light level. Max. exposure time in AE mode is 1/35 sec. Switch AE off for longer exposures.

The Control Menu

1. Hold CB3 down for 1 second to display the Control Menu at the bottom of the Status Bar (see example on next page).
2. Scroll to the right or left on this main menu using CB1 and CB2.
3. Using the Trigger, select any of the menu items that are not "grayed-out". (For most standard operations, use the **Program** menu to auto-configure the camera parameters for the operating conditions).
4. This will present you with either a setting to adjust or a "blind" list of sub-options to choose from (in a "blind" list you can only see one sub-option at a time as you scroll through them).
5. Use CB1 and CB2 to adjust a value or scroll up and down through the blind list.
6. Use the Trigger to select any of the sub-options, click CB3 to return to imaging mode.

Basic Operation (cont.)

The Status Bar (to turn off and on press CB3 for 3 second)



Menu Item	Settings (recommended for general terrestrial work in Bold)
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Program	Select standardized operating mode: Day Color, Underwater Color, Twilight, Night, Night Cooled, Underwater Bright, Underwater Murky, Underwater Dark
Task	Allows selection of a Task Identifier, to categorize image data. Task ID precedes file name. Available selections are A-F, they will be upper case for still frames and lower case for motion imagery. File-name example: A0000001.jpg
Still	Still Image File Format: Raw and JPG: Low, Med, High, or Best
Motion	Motion Image File Format: BTC Best or High
Trigger	Trigger function Options:
	AUTO: One image acquisition, then pause ½ sec, then full speed acquisition
	DELAY: Trigger occurs four seconds after hitting the button (for long telephoto)
	MOTION: Full speed acquisition as long as trigger is depressed
AE (Auto-Exposure)	OFF: Manual exposure time control
	ON: Exposure time and data processing controlled to reach Exposure Target.
Gain	Options: AUTO or 1x through 8x
Balance	NONE: No color balance. For underwater use, image intensifier use and monochromatic lights.
	AWB: Auto White Balance used to correct color during normal daylight situations.
	CWB: Constant white balance for most accurate color representation. Point at a white surface and select CWB to activate.

LUT (Look Up Table)	Normal: For regular images (as they are)
	Dual-Zone: For images with bright and dark areas (high-contrast).
Sensor	COLOR: 1004 x 1004 pixel color sensor for daylight and use with image intensifier tube night vision
	NVD: 658 x 496 pixel 'Single photon detector' night vision sensor.
Cooler	Switches cooler for SPD sensor ON or OFF . Cooler ON yields temporary sensitivity boost for the NVD sensor. Best performance reached after 30 seconds ; automatically switches OFF after three minutes.
NVD Mode	NVD (Night Vision sensor) operating mode
	DAY: Least sensitive & least image noise. Use in daylight/dawn/dusk
	TWILIGHT: More sensitive & more image noise. Use in darker conditions.
	NIGHT: Most sensitive & most image noise. Use at night, in darker conditions.
Darkframe	Enables/disables dark frame subtraction for improved very low light imaging (see night vision)
	OFF: Dark frame subtraction disabled. For day and moderate low-light use. CB3 controls full/detail view.
	ON: Dark frame subtraction. A new dark frame is acquired and used when pressing CB3.
	SILENT: Same as ON, but does not close iris to obtain a dark frame. Apply lens cap to darken before CB3.
Display	Adjust viewfinder brightness: DARK, 25%, 75% or BRIGHT. Use darker settings at night to reduce blinding.

Set INF	Calibrates camera to infinite point of new lens. Enables correct focus distance read-out on Status Bar. Set lens focus ring to infinite, then focus at a distance target and hit Set INF.
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1.1 Using the Standard Operating Modes

FrogEye™ can be configured for a number of typical operating scenarios by selecting one of several standard operating modes. Choose **Program** in the control menu, and then select the mode that best describes your conditions. For example **Day Color** is the mode normally used during the day, but you can switch to **Twilight** if it is getting dark or when shooting night scenes in a city or industrial area. As conditions get progressively darker, you might select the **Night or Night Cooled** programs.

The program modes operate by switching the control menu items to the settings most appropriate for the condition. You can use the programs as they are defined, or choose a program and then customize it by setting one or a few menu items as needed. We recommend that the program(s) to be used are specified in your mission planning, and that all cameras are set to the appropriate program at prior to the start of each deployment.

The table lists all available program modes and their corresponding settings.

Program	Use for...	T as k	St ill	Mot ion	Trig ger	A E	Ga in	Bala nce	Sen sor	Co le r	NVD Mode	Darkfr ame	Disp lay
Day Color	Stand ard daytim e color imagin g	A	R A W	BT C BE ST	AUT O	O N	AU TO	AWB	Col or	n/a	n/a	OFF	BRI GHT
Under water Color	Daytim e color imagin g under water	A	R A W	BT C BE ST	AUT O	O N	AU TO	NON E	Col or	n/a	n/a	OFF	BRI GHT
Twilig ht	Night operati ons in towns,	A	R A W	BT C	AUT O	O N	AU TO	n/a	NV D	OF F	TWILI GHT	OFF	BRI GHT

	industrial areas or to image fast moving objects in poor lighting conditions. Fully automatic and very easy to use.			BEST									
Night	Night operations in moonlight and similar darker conditions. Manual exposure allows for longer exposure times up to 1	A	R A W	BT C BEST	AUTO	O F F	AUTO	n/a	NVD	OFF	NIGHT	SILENT	75%

	sec. Dark frame subtraction and high intensifier setting enhance sensitivity.												
Night Cooled	Night operations in very dark conditions, where maximum sensitivity is required. The NVD cooler provides an additional sensitivity boost for up to two minutes of operation	A	R A W	B T C B E S T	A U T O	O F F	8x	n/a	N V D	O N	N I G H T	S I L E N T	75%

	before switching itself off.												
Under water Bright	Under water imaging with the NVD in relatively 'bright' conditions.	A	R A W	BT C BE ST	AUT O	O N	AU TO	n/a	NV D	OF F	DAY	OFF	BRI GHT
Under water Murky	Under water imaging with the NVD in darker conditions.	A	R A W	BT C BE ST	AUT O	O N	AU TO	n/a	NV D	OF F	NIGH T	OFF	BRI GHT
Under water Dark	Under water imaging with the NVD when light is minimal.	A	R A W	BT C BE ST	AUT O	O F F	8x	n/a	NV D	OF F	NIGH T	OFF	75%

Notes: These control menu items are not affected when selecting a program: LUT, Set INF

2. Image Retrieval

Image Retrieval Options:

- Via Firewire (fastest)
- Via RS-485 (if Firewire is not available)
- Open the camera and remove CF cards (if all interfaces have failed)

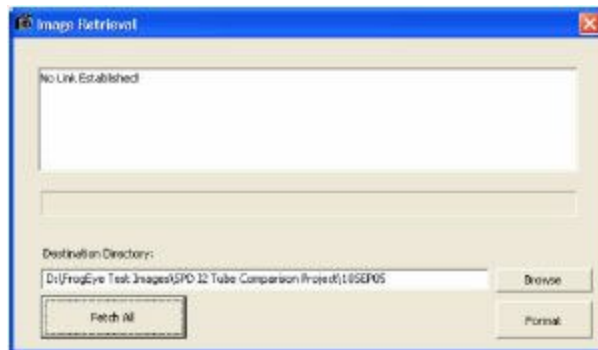


Image Retrieval Via Firewire:

1. Start the **ImageRetrieval** application on the PC. Switch the camera ON. **ImageRetrieval** displays 'No Link Established!'
2. Now connect the camera to the PC Firewire (IEEE 1384) port via the FCBL-A multi-function cable. The camera will be auto detected by the PC. **ImageRetrieval** displays 'Firewire Link Established!' and lists the image files on the camera.
3. Select Download from the File Menu
4. Choose a destination folder for the images.

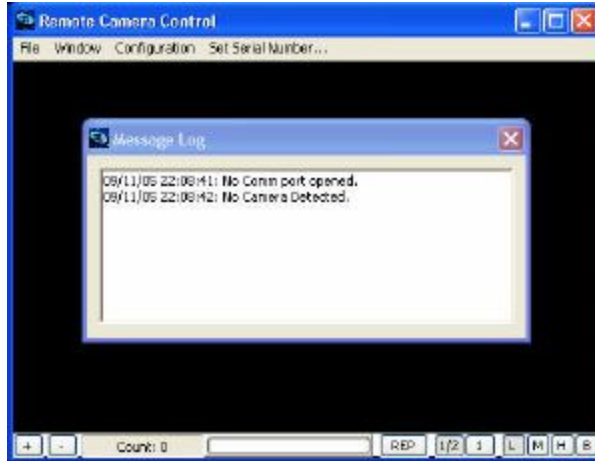


Image Retrieval via RS-485:

1. Connect the camera to the PC via the FADM -485 (Sealevel) USB-RS485 converter and the FCBL-A multi-function cable.
2. Start the **RemoteCAM** application.
3. Select **File**→**Download** Images.
4. Click on **Browse** to set the destination folder for the images.
5. Click **Get All** to retrieve all image files, or select a set of image files and then click **Get Selected**.

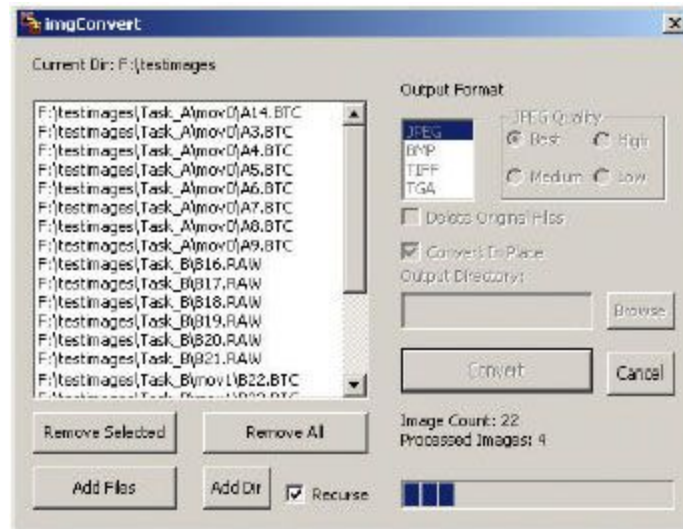
Removing the CF Cards

CAUTION!

You can remove the internal CF card and read it directly with a card reader on your PC. This should ONLY be done if other methods of data retrieval fail. The camera housing is sealed and filled with helium to keep moisture out and improve heat dissipation. For best operation, the camera should be re-filled with helium and the desiccant package inside should be re-charged (3 minutes in a microwave oven at HIGH) or replaced.

1. Unscrew the four bolts on the lens end-cap.
2. Gently leverage the end-cap away from the housing using a coin or large screw driver placed in the slot between the camera housing and end-cap. For camera models without a slot, connect a sturdy Canon lens (one with a metal base) and pull on the lens barrel. CAUTION: The force required to pull away the lens end-cap and attached electronics package may be significant and damage to the lens or camera can result when done improperly. Slowly build up the force while slightly swiveling the lens up and down. Brace yourself so that the two components will not fly apart when separation occurs.
3. Carefully slide the camera body away from the faceplate until the CF cards are exposed.
4. Unplug the CF cards, read them, and reassemble the camera.

3. Converting Image Formats



Images acquired with FrogEye™ in Raw or BTC formats can easily be converted to other common formats using the **imgConvert** software included with the purchase of FrogEye™. The control panel for **imgConvert** is shown above.

Input controls are on the left side of the window and output controls are on the right side. Add files or folders to the input list using the buttons below the list (check the **Recurse** box if you want it to convert files in sub-folders), then choose the output format and location before hitting the **Convert** button.

Tip: When converting you must choose the Look Up Table under *Advanced* that you want the pictures converted to

4. Lens and Filter Selection

Lens Selection Lens and filter selection is a critical consideration for target clarity, operator's mobility and special requirements such as detecting camouflage. FrogEye™ FC-2 integrates two lens mounts:

1. The Canon EF mount supports a large variety of lenses from Canon and other manufacturers. FrogEye™ FLH series lens hoods are available to seal these lenses against water and dust.
2. The FrogEye™ mount supports special-capability FrogEye™ lenses. FrogEye™ lenses are water and dust proof. The FL-400/200 lens for example is a very light -weight, collapsible and underwater transportable design for long- standoff work in rough environments and beach insertion missions.

Lens	Length/Weight	F-S top	Pixel resolution for target at 1km	Horizontal Field of View with Color (daytime) Sensor	Horizontal Field of View with SPD (night vision) Sensor	Application	Underwater compatibility
Canon EF 14mm	62 mm, 330g	2.8	0.54 m	30 deg (22 deg in water)	20 deg (15 deg in water)	Wide field for underwater use	With FLH-76 lens hood
Sigma 15mm	69 mm, 230g	2.8	0.50 m 27deg (21 deg in water)	18 deg (14 deg in water)	Wide field for underwater use	With FLH-76 lens hood	
Canon EF 28mm-105mm	75mm, 375 g	3.5-4.5	0.26–0.07 m	15–4.1 deg	10- 2.6 deg	General purpose zoom lens	With FLH-94 lens hood
Canon EF 50mm	50mm, 290g	1.4	0.15 m	8.5 deg	5.6 deg	High speed lens for night vision use.	With lens hood
Canon EF 400mm IS	232mm, 1940g	4	0.019 m	1.1 deg	0.7 deg	Long-stand off with image stabilizer. Detects people at up to 5 km, cars up to 15 km. Image stabilized.	No

FrogEye™ FL-200	139mm store, 200mm ops. 850g	2.7	0.038 m	2.2 deg	1.4 deg	Night operations in rough environments.	Transport underwater without hood
FrogEye™ FL-400	203mm store 380mm ops. 1075g	5.3	0.019 m	1.1 deg	0.7 deg	Long-stand off in rough environments. Detects people at up to 5 km, cars up to 15 km.	Transport underwater without hood

Long-Standoff Reconnaissance:

Use sufficient focal length to detect or recognize the target (see table). However, operating distance is often limited by atmospheric distortions. Try to gain a high vantage point to minimize atmospheric distortions.

Rough environment operations incl. diver beach insertion and reconnaissance from sea:

Portability and the ability of the lens to withstand shock, dirt and water may be of great concern. Use tough and lightweight FrogEye™ FL-400 lens or the shorter FL-200. Lens collapses and transports under water without protection. Extend lens prior to surfacing, then surface and wait 2-3 seconds for water to drain. Shoot and submerge.

Underwater Use

Use very short focal length lens such as Canon EF 14mm or Sigma EF 15 mm to maximize the field of view. Due to poor water quality, you will probably operate within a few tenths of a meter to a few meters of the target

Night Vision

The speed of the lens (low F number) is critical. Reducing focal length in favor of lens speed is often called for.

Filter Selection FrogEye™ operates with visible, near-infrared (NIR) and ultraviolet (UV) light. This capability can for example be used to better detect camouflaged personnel and equipment.

However, the different wavelengths also focus differently, and thus use of a filter to select the desired spectrum is necessary in order to obtain sharp images. (Images taken without a filter at

daylight will be somewhat blurred). Filters screw to the lens filter port. You must specify the filter size to match the lens.

Note: The FrogEye FL-400 lens has a built-in IR-cut filter for visible light operations. No filter is required.

- For **visible light** operations, use a Hot Mirror (IR-cut) filter such as Tiffen 'Standard Hot Mirror'
- **Near Infrared (NIR)** imaging helps detect personnel and equipment camouflaged in a life vegetation background. Use an IR filter such as Hoya Infrared R72.
- **UV Imaging** helps detect some types of snow camouflage against a snow background. Use a UV filter such as Hoya U-330 (broad band UV), Hoya U-340 (medium band UV) or Hoya U-360 (Narrow band UV).



Life vegetation appears bright in near infrared (NIR) images

5. Night Vision Modes

FrogEye™ supports three night vision modes.

- **NVD (Night Vision Device) mode** is FrogEye's primary night vision mode and uses the camera's built-in 'single photon detector' (SPD). The principal advantages are the highest target resolution (best target detail with a given lens), best contrast and effective wet environment / underwater use because no external intensifier module is required and the FL-400/200 lens and Canon lens hoods can be used. Target resolution is approximately 2x – 3x better than I2 mode, meaning the same target detail can be seen from 2-3 times greater distance than I2 mode or with ½ to 1/3 lens focal length as compared to I2 mode.

- **I2 mode** (image intensifier mode) requires an Astroscope 9350 image intensifier module from Electrophysics to be switched between the camera housing and the lens. For best resolution and contrast, the 9350 should be equipped with a GEN3 OMNI4 central intensifier unit, model 9350CIU3 -IV. The principal advantage is the wider field of view compared to NVD mode due to the larger size of the FrogEye color sensor. The wider field of view makes it easier to locate a target. Light sensitivity is about the same as NVD mode with dark frame subtraction and the cooler switched on. Because cooler operation in NVD mode is limited to three minutes per shoot, I2 mode also has the advantage of providing best sensitivity for continuous camera operation.
- **Dual-stage** operation is similar to I2 mode, except that the NVD sensor is selected instead of the color sensor. Thus, the light is first amplified in the intensifier unit and the image is then further intensified by the NVD sensor. The principal advantage is the ability to use very short exposure times (often 1/100 sec or less) even in dark environments. The camera can be swept about quickly and moving targets are easily captured. However, the short exposure time (few photons), the smaller size of the NVD sensor as compared to the color sensor and the lower resolution of the image intensifier module as compared to the NVD sensor by itself result in a somewhat blurry image.

Night Vision Mode	Image Resolution	Principal Advantage	Min. illum. @ F1 .4	Min. illum. @ F4
Color Sensor (daytime operations)	1004 x 1004 pixel	Best images are available with this sensor during the day.	0.6 Lux (full moon – deep twilight)	6 Lux (twilight)
NVD Mode	658 x 496 pixel	Best target resolution, contrast and ease of use in wet environments and underwater.	0.0001 Lux (moonless clear night)	0.0001 Lux (quarter moon)
I2 Mode (Requires Astrophysics 9350 image intensifier module)	1004 x 1004 pixel	Widest field of view eases target locating. Best sensitivity for continuous camera operations beyond the 3 minute limit of the NVD cooler.	0.0001 Lux (moonless clear night)	0.001 Lux (quarter moon)
Dual-Stage Mode	658 x 496 pixel	Shortest exposure time for working with moving targets	< 0.0001 Lux (moonless)	0.0001 Lux (moonless)

		and quickly sweeping the camera in dark conditions.	overcast night)	overcast night)
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Abandoned barracks at night:

NVD mode 1/3 sec exposure (left), I2 Mode 1 sec exposure (center), Dual Stage Mode 1/180 sec exposure (right)

Selecting a Night Vision Mode

NVD Mode Setup

1. **Twilight, Night or Night Cooled** on the **Program** menu. Each of these three standard modes selects the night vision sensor. Choose as follows:
 - **Twilight** mode provides greatest ease of use and also the best image quality for night imaging in towns, industrial areas etc. Image intensification (NVD Mode) is at a moderate setting to reduce noise in the image. This mode uses auto exposure, making operations very similar to day time color imaging..
 - **Night** mode is designed for darker conditions, such as when only moon light is available for illumination. Auto exposure is switched off, thereby allowing you to manually set exposure time up to one second. This mode uses the CB3 button for dark frame subtraction, as described below.
 - **Night Cooled** mode provides an additional sensitivity boost for very dark conditions by cooling the sensor. Sensor cooling becomes most effective about 30 seconds after activation, and is auto-disabled after 2 minutes. Operate the camera only for short periods when using this mode to allow cooler heat to dissipate. Just like in Night mode, the CB3 button controls dark frame subtraction.
2. When using the FL-400/200 lens, mount the lens such that the arrow on the lens base points down. This adjusts the lens with the night vision sensor for improved image sharpness.

Note: Condensation may develop on the sensor when the cooler is on if the camera has been opened and then not been properly sealed. The camera must be filled with helium and a fresh desiccant package placed inside prior to sealing. Condensation will disappear within a minute of switching the cooler off.

Image Intensifier (I2) Mode Setup

1. Mount the Astroscope 9350 intensifier assembly between the camera body and the lens.
2. Select **Day Color** on the program menu, and follow up with these manual settings: **AE:** OFF, **Balance:** NONE, **Darkframe:** SILENT (for darker conditions, or OFF for moderate conditions).
3. Both the camera and the lens must be focused: Set the lens to infinite distance, point at a distant target and then adjust the camera focus. Once the camera internal focus (back focus) is adjusted for use of the I2 assembly, leave it there. When imaging nearby targets, adjust the lens focus only.
4. Set the exposure manually. In most cases, exposure time will be 1/10 sec to 1 sec. For exposures of 1/4 sec and longer, use CB3 to initiate dark frame subtraction (see below).

Dual-Stage Mode Setup

- Select **Twilight** program mode and then follow the instructions for I2 mode setup above.
- You will be able to operate with very short exposure times, often 1/100 sec and less even in very dark conditions. However, images will appear blurred and with bright flashes.
- To significantly improve sharpness of a static dark scene, acquire about ten images of the scene. Then, use frame stacking software such as Registax (available free of charge on the web) to average the frames.

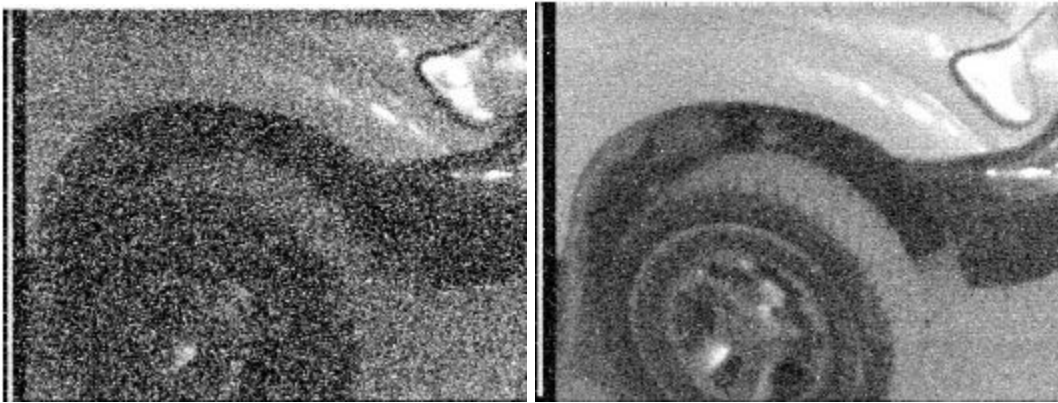
Dark Frame Subtraction FrogEye's dark frame subtraction mode improves low-light performance for all night vision modes. Dark frame subtraction works by acquiring and storing an image shot under dark conditions (such as with the lens cap applied or the aperture closed) and subtracting that image from any subsequent lit image. Dark frame subtraction strongly reduces 'dark noise' in the imagery, a temperature and exposure time dependent noise that affects all electronic image sensors. Dark frame subtraction is generally useful when exposure times of 1/10 sec or more are used and the benefit becomes very strong when exposure times of one second are used. Dark frame subtraction should always be used in I2 and dual stage modes. Dark frame subtraction is available for the NVD and color sensor. The principal disadvantage of dark frame subtraction is a frame rate reduction due to the additional image processing load.

1. Enable dark frame subtraction by selecting **On** or **Silent** on the **Darkframe** menu.
2. The **ON** mode is available when operating with Canon lenses with a motorized iris. If **ON** is selected, acquire an initial dark frame by pressing button CB3. A blue square will appear in the upper right viewfinder corner while the camera closes the iris (to darken the image as much as possible) and acquires the dark frame.

3. The **Silent** mode should be used if the iris noise is unacceptable or when operating with a lens that does not have a motorized iris, such as FL-400/200. If **Silent** is selected, darken the image by placing a lens cap on the lens or covering the lens with your hand. Then, press CB3. A blue square will appear in the upper right viewfinder corner while camera acquires the dark frame. Keep the lens darkened until the square disappears.
4. Now, continue with imaging. Repeat step #2 or #3 when dark noise starts becoming noticeable again, such as when changing the exposure time or if the camera temperature changes.

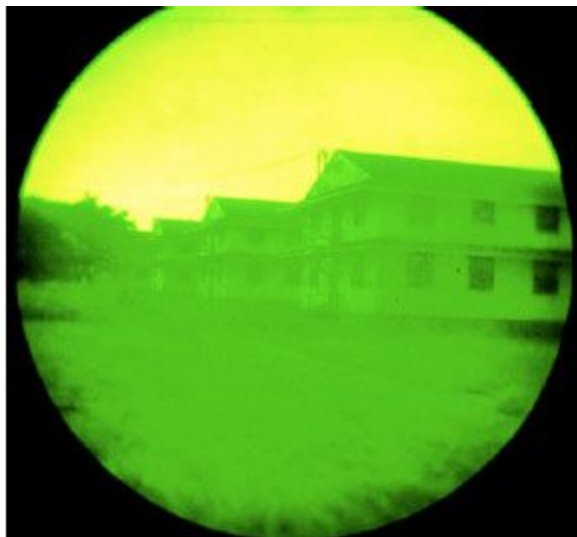
Be aware of these image artifacts associated with dark frame subtraction:

- The darkening of the image in **On** mode is not perfect because the iris of most lenses cannot be closed all the way. A 'shadow' will appear when acquiring a dark frame while the lens is pointed at a bright target, but then moving the lens to image darker regions. For best results, point the lens at a darker location when acquiring the dark frame or darken the lens by holding your hand in front of it.
- Shadows and colorful artifacts will appear when acquiring a dark frame while the image is not dark. Just acquire a new properly darkened image if this happens.
- Some brighter/darker horizontal banding may appear when dark frame subtraction is used with the NVD sensor when in DAY mode (bright scenes). Dark frame subtraction is not needed under these conditions and should be switched off.



NVD Image without (left) and with (right) dark frame subtraction at 1-sec exposure time

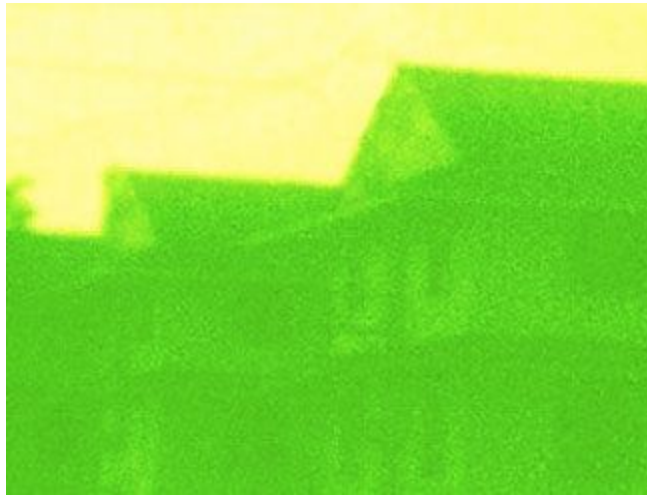
Comparing FrogEye™ NVD Mode Performance to Industry Standard Image Intensifier Devices



The images below compare the performance of FrogEye™ NVD mode to a Canon Rebel film camera (Kodak 400ASA High Definition) equipped with the Astroscope 9350CIU3-IV intensifier module. Both the FrogEye™ NVD image and the film camera image were shot with a Canon 28mm-105mm F/4.5 zoom lens in the 105mm setting. This is an area of abandoned barracks, shot on a moonless night with primary light being glow from adjacent towns. The Astroscope image (right, contrast enhanced) yields a much larger field of view than the FrogEye™ NVD image (below left) because the sensitive surface of the CIU is larger than the NVD sensor. However, when magnifying and cropping the Astroscope image (below right, contrast enhanced) to show the same field of view as the FrogEye™ NVD image, it becomes apparent that the NVD produces both better target detail and better contrast. This is a characteristic difference between FrogEye™ and most intensifier based night vision devices. FrogEye™ is better for long-standoff work where best target detail and contrast is needed, while conventional intensifier technology is better at short range where a combination of a wide field of view and good resolution is important.



FC-2 NVD Mode



Canon Rebel with Astroscope 9350CIU3-IV

6. Remote Operation

Remote control of FrogEye™ using a notebook computer allows the operator to remain in a safe or more comfortable location. Variables to consider in setting up remote cameras include camera battery life and the effect of wire length on image transmission speed.

Image Transmission Speeds Remote mode is through a thin twisted wire pair cable. Maximum operating distance is 1.3 km. Full-speed is available up to 100m, and declines thereafter, described by the following table.

Resolution	100 m	200 m	400 m	800 m	1.3 km
1000×1000	2.2 sec	4.4 sec	8.8 sec	17.6 sec	28.6 sec
500×500	0.56 sec	1.12 sec	2.24 sec	4.48 sec	7.4 sec
250×250	0.14 sec	0.28 sec	0.56 sec	1.12 sec	1.8 sec

Setting Up for Remote Operation Camera is linked to PC via: FCBL-A to 300' cable (FCBL-COM300), to the RS485 -USB Adapter Module (FADM-RS485), to the USB port of PC. For extended operations, power the camera directly from a BA-5590 battery (use cable FCBL- 5590) or from the external battery pack FHD-1, which contains a BA-5590 battery.



Remote Operation Switch the camera ON. Launch the **RemoteCAM** software on the PC and make sure the correct COM port is selected. **RemoteCAM** will indicate when the camera has been detected. Select the desired viewfinder resolution from the “fraction” buttons at the bottom of the screen. The image-loading progress bar indicates the speed of acquisition. Use the + and – keys to zoom in or out on image. To focus use the up and down arrow keys.



Compression settings: Four compression settings are available on the File menu for saving images, L, M, H, and B. L is lowest quality / highest speed, B is highest quality / lowest speed.

Control Bar Buttons

REP: Repeat mode - acquires images continuously.

1 or 1/2 : Full resolution or half resolution. Half resolution gives you 1/4 of the pixels (1/2 x 1/2), so it provides a transmission rate that is four times faster.

The Control Window:

Exposure buttons, auto exposure selector, focus +/- and fast ++/- including distance feedback.

Important File Menu items:

- **Save Image:** Pops up browser, saves current image
- **Set Save Directory:** Select directory into which to save a sequence of images
- **Save All Images:** Saves all images into specified directory. Name is 1.JPG, 2.JPG etc...

7. Underwater Use of FrogEye

Use of FrogEye™ underwater can take three forms; 1. taking underwater pictures 2. purely underwater transport such as beach insertions or 3. a combination of both.



Preparing FrogEye™ for underwater use or transport

- The lens port must be sealed with either a lens hood or the FL-400/200 lens.
- The dummy plug (CON00383) must be applied to the multi-function connector.
- For underwater operations, use a low-volume dive mask. This will keep your eye closest to the viewfinder and provide the best viewfinder picture.

Underwater photography with FrogEye™

- Use the lens hood for underwater imaging. Don't submerge a lens without the hood (or FrogEye™ lens) installed. The body of the camera is waterproof to 100 m with the lens hood or FrogEye™ lens attached.
- Proper lens selection is critical: use short focal length lens underwater because the distance to the target is usually shorter than in above-water photography. If your camera is used primarily for underwater work, we recommend the FrogEye™ model FC-2C which uses 'C-mount' lenses. C-mount lenses are available in shorter focal lengths (wider field of view) and with better sensitivity.
- For underwater operations during the day, select **Underwater Color** from the Program menu. This mode is very similar to the Day Color mode used on land, except that white balance is switched off because underwater images are often mostly blue or green.
- When conditions are dim and artificial light cannot be used or must be minimized, use the night vision sensor. This is enabled by any of the standard program modes **Underwater Bright**, **Underwater Murky** and **Underwater Dark**. The modes are similar, except for the

NVD intensification setting. Bright will give you the cleanest picture if enough light is available.

- Minimize distance to target, to maximize contrast. Minimize exposure time and steady yourself and the camera to minimize motion blur.

Use of the FL-400 or FL -200 lens for diver based reconnaissance

The FL-400/200 lens can be transported underwater. While very useful on land in rugged environments, the lenses can also be used by divers for reconnaissance of distant targets from sea. Follow this technique.

1. Focus the lens prior to the dive to reduce surface time during reconnaissance. Point at a target about the same distance as the reconnaissance target and carefully adjust focus.
2. Select AUTO or MOTION trigger mode, so that motion imagery will be available. Select the color or NVD sensor depending on anticipated conditions.
3. Keep the lens in the collapsed state for underwater transport. Keep the camera off.
4. Switch the camera ON and extend and secure the lens just prior to surfacing.
5. Surface by slightly kicking your fins (do not inflate the B/C), hold the lens above water and wait for the water to drain. This will take about three seconds. Use the time to find the target. If the lens fogs during imaging, submerge it briefly to clear.
6. Aim through the viewfinder, holding the camera and lens with both hands while keeping your elbows submerged for best support.
7. Use motion imagery (hold the trigger button pressed) to shoot many pictures of the target in a short period.
8. Stop kicking and point your fins down to quickly submerge.

With proper training, you will be able to obtain target images in a surface interval of 15 seconds.



Diver shot of building at 1km distance and detail (with FL-400 lens) framed by underwater shots at the same site

8. Trigger Modes, Motion Imagery, and Compression Settings

FrogEye™ offers trigger modes and image compression methods to support both individual stills and motion imagery.

Trigger Modes Trigger modes are selected through the *Trigger* menu.

- **Auto** is the most common setting. A still image is acquired as soon as the trigger button is pressed. Motion sequence acquisition starts after about ½ second and continues until the trigger button is released.
- **Motion** causes a motion sequence to start as soon as the trigger button is pressed. Offers fastest response for motion sequences.
- **Delay** shots a single still about five seconds after pressing the trigger. A yellow square appears in the upper right corner of the viewfinder and slowly turns orange. The square turns red at the moment of image acquisition. This mode is useful for long telephoto operation on tripod. The delay period allows tripod vibrations to subside before the image is acquired.

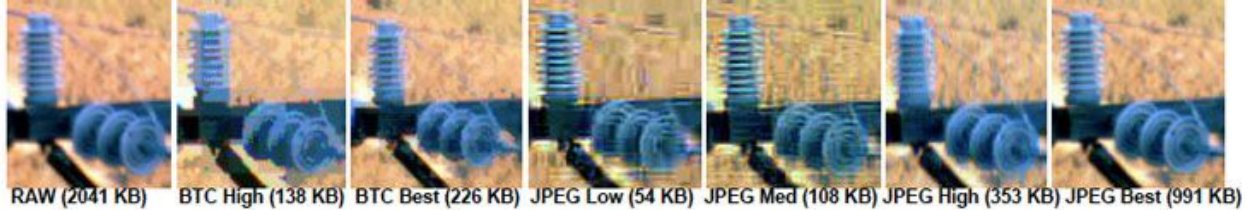
Compression Settings FrogEye™ can store raw images or compress images using multiple formats. The selection is made independently for *Still* and *Motion* images using the respective menu.



- **RAW** is generally recommended for still images. While the file size is largest (669 KB for the NVD sensor and 2041KB for the color sensor), this format maintains all image information including small detail and the full brightness range. **RAW** is not available for motion imagery.
- **JPG** (JPEG) is available in **LOW**, **MED**, **HIGH** and **BEST** settings. **LOW** produces the smallest file, while **BEST** produces the best image quality. File size varies from about 60KB to about 1000 KB for the color sensor. JPEG is only available for still images.
- **BTC** (block truncation coding) is a fast compression method suitable for motion imagery. BTC will maintain and sharpen edges, and is thus a good choice for imaging structures and machinery. It is available in **HIGH** and **BEST** settings, with file sizes of about 50 KB

to 250 KB for the color sensor. Block truncation coding is the only file format available for motion imagery. A **BTM** file extension indicates the file is part of a motion sequence.

Image Detail in available compression settings:



Motion Imagery FrogEye™ motion imagery shoots images at a constant rate from about 3.5 to 13 frames per second, depending on the sensor and compression selection. Motion imaging is available in the **Auto** and **Motion** trigger modes described above. Image quality is determined by the compression setting in the **Motion** menu. Select **High** for lower memory use and a slightly higher frame rate or **Best** for best image quality. Memory consumption is roughly 400/500 KB per second with the **High** setting and 600/800 KB per second with the **Best** compression setting for the NVD and color sensor respectively.

The principal purpose of motion imagery is to obtain many shots of a target during a short period of opportunity. Advantages are an improved probability of a 'good shot' of a moving target and the minimization of operator exposure. Motion imagery is also useful to document motion sequences.

Motion imagery is stored as individual image files with a .BTM extension. The **imgConvert** utility will sort each sequence into its own folder.

9. Exposure Control

FrogEye's overall exposure control system is designed to produce best available detail even under difficult conditions such as haze or when imaging a moving target in low light conditions. To control exposure, select your operating mode by choosing **Gain** and **AE (Auto Exposure)** options from the control menu. Set the lens **Aperture** as needed. When imaging, activate the **Exposure Control** and use the CB1 & CB2 buttons to tune exposure for best effect.

Gain The digital gain function on the control menu controls how the camera regulates image brightness and contrast.

- **AUTO** gain is recommended for most situations. The camera regulates both image brightness and contrast *independent of exposure time and aperture*. With **AUTO** gain, you can operate within a wide exposure range while maintaining good brightness. For example, image a twilight scene at 1/10 second exposure to best reproduce shades and colors of static objects, or shoot the same scene at 1/1000 second exposure time to 'freeze' and recognize moving vehicles and people. **AUTO** mode also regulates contrast,

making the darkest spot in the image black while making the brightest spot white. This improves the detection of recognition of details in foggy or hazy conditions. However, the resulting high contrast also highlights defects such as smudges on the lens or image sensor noise.

- Setting **x1 to x8** are fixed digital gain settings, similar to choosing a film speed in a traditional camera. Going from x1 to x8 increases image brightness eightfold. The image will become darker or brighter when you shorten or lengthen the exposure time. Use a fixed gain to produce an image with most accurate contrast and colors.



Motion blur control with AUTO Gain: 1/64 sec exposure (left) and 1/1500 sec exposure (right)





Contrast Enhancement with AUTO Gain: GAIN=x1 (left) and GAIN=AUTO (right)

Auto Exposure ON/OFF and Exposure Control

Auto Exposure is switched ON or OFF via the control menu.

- Switch auto exposure **OFF** to control exposure time directly in imaging mode. Auto exposure OFF is recommended for most night vision applications because exposure time control at night is used primarily to select the best trade-off between motion blur, image update rate and image quality. Use the AUTO gain setting when auto exposure is off, so that the image will always be displayed at the best brightness.
- When auto exposure is **ON**, the exposure control will adjust the exposure target while the camera sets the exposure time to meet the target. The exposure target defines the average 'fill level' of the pixels. The exposure target is displayed as a green line in the histogram graph (see Basic Operations). An exposure target of 50% (green line in the middle of the graph) provides least image noise but results in the longest exposure time. Move the line further to the left to reduce the exposure time for a given scene. This results in less motion blur, but the image will start exhibiting noise if AUTO gain is selected or become darker if a fixed gain is selected. Auto Exposure **ON** is recommended for most daytime or bright light imaging. Auto exposure limits exposure time to no more than 1/35 second in order to keep motion blur under control. Switch auto exposure **OFF** when longer exposure times are needed.

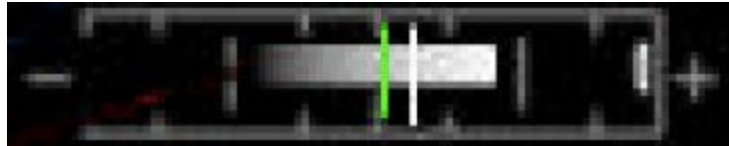
Aperture Control

Aperture is one of the three Active Controls on the status menu. Electronic aperture control is available for most Canon and compatible lenses, but not for the FL-400/200 lens. A greater F/ number means the lens aperture is more restricted and less light falls on the sensor. A smaller F/ number means the lens aperture is wider open and more light falls on the sensor. Open the aperture all the way for most night applications. During daytime, opt to close the aperture to about F/8 to obtain the sharpest image or to widen the distance range that is in focus (greater depth of field).

When using the night vision sensor at day time, the image will have better contrast when the aperture is closed sufficiently so that exposure times of 1/1000 sec or more can be used.

Use of the Histogram Display

The histogram display at the center of the status bar is available to optimize the information in the captured image, ensuring in both dark and bright portions of a scene. There are three pieces of information.



Histogram Display

- The histogram is a gray shaded band indicating the number of pixels at each level of brightness. The spectrum goes from black pixels (left) to white pixels (right). The more pixels fall into a given level of brightness, the brighter the histogram will be at that spot. If a white line or band appears at the very right (example above), then some pixels are completely full and information is lost in bright parts of the scene: reduce exposure time or target. If a white line or band appears at the very left, then some pixels are almost empty and information is lost in dark parts of the scene: increase the exposure time or target.
- The green line is the exposure target. When Auto Exposure is ON the exposure control will move this line left or right. Move the green line left to a lower average pixel fill level and smaller exposure time, or right for a greater average pixel fill level and greater exposure time.
- The white line is the average exposure of the scene. When Auto Exposure is ON the camera will change the exposure time until the white line matches the green line.

10. Power Supply Options and Battery Charging

Power Supply Options

Internal Buffer Battery (Rechargeable)

The standard power supply is an internal Nickel Metal Hydride (NiMH) battery. It lasts for about 1.5 hours, and can be recharged from multiple sources in about two hours. The internal batteries cannot be replaced without opening the camera body, which should only be done in a maintenance depot due to dry sealing requirements.

AC Power and car power point

For AC power charging and operation use the ACDC-U AC adapter. The FCBL-C cable is supplied for use of standard automotive 12V power.

BA-5590 External Battery and FHD-1 external hard drive (Long-life Power Supply)

The BA-5590 battery provides about 24 hours of continuous operation. The battery can be connected to the camera using the FCBL-5590 cable and the FCBL-A adapter. For weather and water-proof operations, use the external hard drive/battery housing, model FHD-1. This water and terrain proof case accommodates a BA-5590 battery as well as a 65GB hard drive.

Charging the Camera Internal Battery The camera internal battery is charged whenever external power over about 13V is connected. The camera internal battery can be charged from AC power using the ACDC-U adapter, from a BA-5590 battery, from a FHD-1 battery pack containing a BA-5590 battery or from car power using the FCBL-C cable. Note that car power charging will only occur when the car engine is running and the alternator is producing 13-14V. When the engine is off, the 12V battery voltage is not enough to initiate charging but sufficient enough to hold the battery at its current level.




The charge circuitry will initiate fast-charging when it detects external power and the battery is not full. Charging is fastest (1 Ampere charge current) when the camera is switched OFF. When the camera is ON, charge current is reduced to 0.3 Ampere. For best and most predictable results, switch the camera OFF and connect to an external power source for two or more hours. Following charge, check that the battery indicator shows nearly 100% remaining capacity.

FrogEye™ FC-2 indicates remaining battery capacity based on an estimation of energy consumption since the last charge. Following a charge, the remaining capacity indicator will decline from 100% until a 10% indication is reached. It will hold at 10%, and then decline towards zero once a low battery voltage (indicating near depletion of the battery charge) is reached.

The remaining charge indicator is green from 100% to 36%, yellow from 35% to 10% and red from 9% to 0% remaining capacity. If the remaining charge indicator jumps directly from the green to the red zone, then the battery has depleted prematurely. This may be the case with a new battery that has not yet been conditioned, or an old battery nearing the end of its useful life. Expect to run a new battery through about five charge/discharge cycles before it reaches full capacity.

Power and Battery Charge Viewfinder Symbols:

Button	Description
--------	-------------

	The camera is running on internal battery power. The adjacent remaining battery capacity indicator will slowly decline.
	The camera is running on external power, but the battery is not charging because the external voltage is too low (< 13V), the battery voltage is too high to start charging or charging is already completed. The remaining battery capacitor indicator will hold steady.
	Internal battery charging is in progress. The remaining battery capacitor indicator will count up.

11. Software Installation, Firmware Upgrade, Set Clock

FrogEye™ FC-2 is shipped with two installation CD ROM disks.

1. The Sealevel disk contains the device driver for the RS485-USB converter that is used for remote operations (**RemoteCAM**) and camera firmware download (**vis_term**). Connect the adapter to a USB port and follow the instructions in the installation wizard.
2. The FrogEye™ installation disk contains the **RemoteCAM** remote operation software, the **Image_Retrieval** Firewire image download software, the **imgConvert** software for converting RAW and BTC formatted image files to industry standard formats, and the **Vis_term** utility for installing new firmware on the camera. Insert the disk and follow the wizard instructions. The installation will place a **Desert Star Systems** entry in the Programs list of the Start menu.



remoteCam.exe



Image_Retrieval.exe



imgConvert.exe



Vis_term.exe

First-time Firewire Connection

Your PC will detect the FC-2 camera upon the first connection via Firewire. The New Hardware Detect wizard will ask you for the device driver vhp1394. Point the wizard browser to the FrogEye installation directory (normally C:\Program Files\Desert Star Systems\FrogEye), where this file is located.

Camera Firmware Upgrades Desert Star Systems updates the camera firmware on occasion to implement new features or correct bugs. In addition, firmware with customer specific capabilities or advanced camera functions may be available. Firmware is downloaded to the camera using the

Sealevel RS485-USB adapter and the **Vis_term** software. Ask your computer guru to follow this procedure:

1. Link the camera to the PC via the Sealevel RS485-USB adapter and the FCBL-A multi-function cable.
2. Start **Vis_term** and select the COM port assigned to the Sealevel adapter.
3. Switch the camera ON. A sound will emerge from the PC indicating the link is established. However, the camera will keep re-linking every few seconds as the camera's COP (computer operating properly) function attempts to force the main processor into imaging mode.
4. To disable the COP for firmware download, RESET the camera by briefly holding the supplied ring magnet close to the RESET indent on the viewfinder end-cap. Remove the magnet, and the camera should link one last time and the link should remain. *Note: Using the RESET magnet will also cause the battery state information to become invalid until after completion of a full discharge/charge cycle and the real-time clock to be set to 1970. So, don't do this unless downloading new firmware.*
5. Hit the **Download New Application** button and select the new firmware. The file name will be **frogeye_fcbm1a_xxx.vc**, where xxx is the version number.
6. Wait for the download to complete, then switch the camera OFF, wait at least five seconds and then switch it ON again to operate the new firmware.

Setting the Real-Time Clock Use the **RemoteCAM** software to set the camera's real-time clock. After establishing the link, select **Configuration**→**Autonomous Mode** and then hit the **Configure Camera** button. The camera clock will be synchronized with the PC clock.

12. Protection, Maintenance, and Upgrades

Housing protection

The housing is water proof to 100 meters, dust proof, sand proof, etc and impact resistant. The camera can survive a drop from 5 feet onto a concrete surface. It's not bulletproof though, so treat it with reasonable care. A protective hard case is generally not required, it can be either stuffed into your pack or clipped to your gear for ease of access.

Maintenance

The camera is nearly maintenance free. However, small gold contacts are exposed when the lens is removed and these need a good rinse if they are exposed to salt water or excessive dirt. If it gets dirty give it a good rinse. Also, periodically check the Lens Hood Seal O-ring for nicks or scrapes, and lubricate it with silicone if it seems to needs it. The connector next to the viewfinder should remain free of debris as well.

Control Buttons and Power Switch

All FrogEye™ controls are contact-less (magnetic) so there is no need for feed-through holes in the housing. Control buttons may become jammed by excessive dirt. If that happens, rinse with a high pressure water hose. If the jam is not resolved, remove the cover plate to clean the recessed area under the buttons.

Lenses and Lens Protection

FrogEye™ supports Canon EF lenses and a line of specialized FrogEye™ lenses tailored to the rigorous demands of field operations.

Canon lenses are excellent for general use, but must be protected by a FrogEye™ lens hood for underwater use or transport, or in dusty environments. The camera retains all functions with the hood attached, except for the zoom function. These hoods are waterproof to a depth of 100 meters. Canon lenses are somewhat fragile however. Avoid drops and shock when a Canon lens is attached to FrogEye™.

FrogEye™ lenses generally require no protection. The FL-400/200 lens, for example, is a collapsible, free-flooded telephoto lens. It can be transported underwater and will drain when surfacing. It is compact in the collapsed state for storage and is very light weight. Stuff FrogEye™ lenses into a convenient spot in your pack.

Upgrading Sensors and Memory

FrogEye™ is a modular system. The image sensor module and FLASH cards can be upgraded to keep the camera up to date. Upgrades for special tasks are available too. Upgrades are generally performed by Desert Star Systems. Alternatively, upgrades may be performed at the depot level by skilled electronics technicians.

13. FrogEye™ FC-2 Specifications

Size:	240mm x 105mm x 105mm (largest dimensions incl. brackets & connector)
Weight:	1100g in air, slightly positive buoyant with lens and lens hood in water
Operating Environments:	All air, land and underwater environments
Housing:	Sealed Delrin or Noryl plastic, helium filled, magnetic controls (no feed-through)

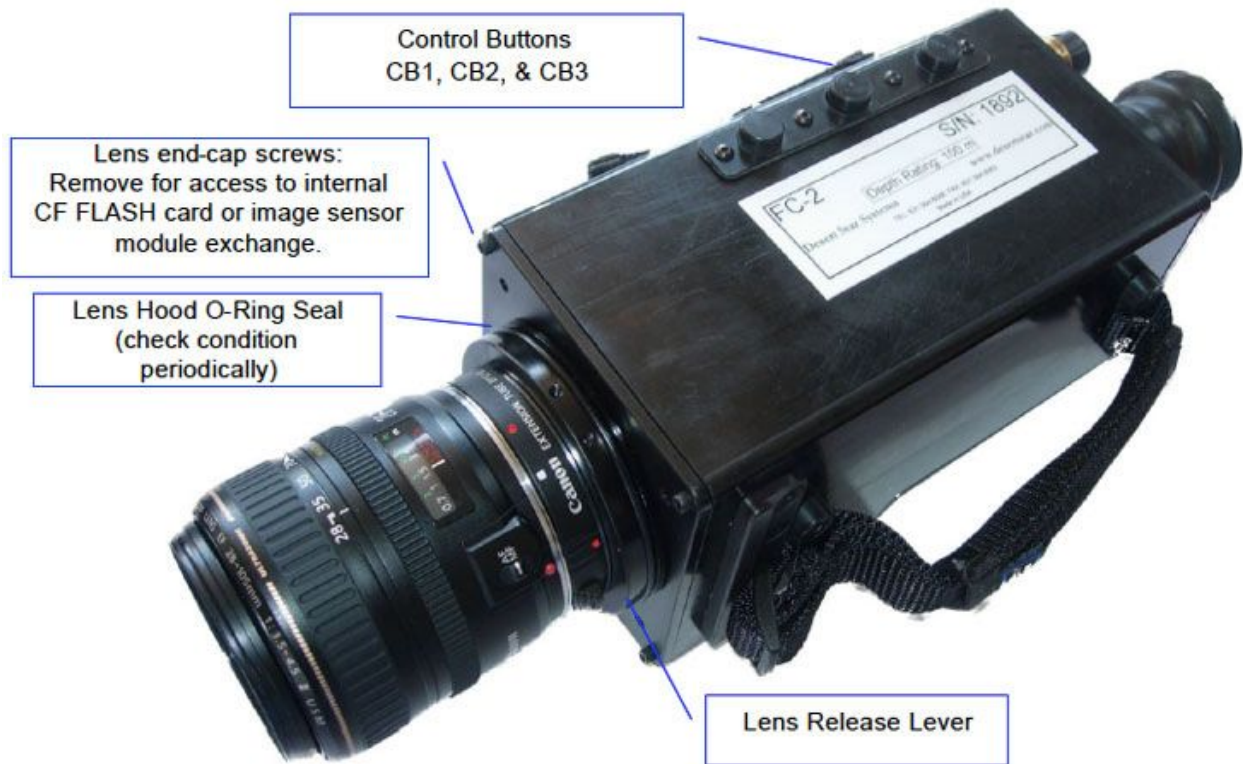
Depth Rating:	100m
Operating Temperature Range:	-15 deg C to +40 deg C
Internal Battery Type & Life:	NiMH, 8 x 'AA' cells, approx. 1.5 hour continuous operation per charge
External Power Options:	100-250 VAC, 12V DC, BA5590 Battery (>24hrs), FBP-2 waterproof battery case
Image Sensors:	Kodak KAI-1020 color daytime (1004×1004 pixel), min. 0.4 Lux TI TC -253 grayscale day/night sensor (656×496 pixel), min. 100 microlux
Night vision enhancement modes:	Image sensor cooling, dark frame subtraction, dual-stage intensification
Spectral Range:	Near Infrared (NIR), Visible Light and UV light. Filter selectable.
Lenses:	Exchangeable Canon EF and special-purpose FrogEye™ lenses
Frame rate:	4-6 fps (KAI-1020), 10-13 fps (TC-253) sustained
Image storage:	Internal CF FLASH card, 1GB standard, up to 8GB optional External waterproof hard disk case (FHD-65), 65 GB standard
Image formats:	RAW images, Block Truncation Coding (BTC), JPEG
Image retrieval:	Firewire, RS -485 or CF card removal
Operating modes:	Hand held (direct operation), remote control via twisted wire pair (up to 1.2km), Autonomous Operation

14. Accessories

 <p>AC/DC Power C AC</p>	 <p>Car Powe F</p>	 <p>BA5590 Ba FC</p>
 <p>FHD-65 Ext (65GB) and (shown with</p>	 <p>Multi- C</p>	 <p>Dummy-pl connecte</p>



15. FrogEye™ Parts





Development of the original FrogEye technology was funded in part by U.S. SOCOM under a SBIR contract. Desert Star Systems wishes to thank U.S. SOCOM for their technical and financial support.

